Product Market Competition and Unemployment

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfillment of
the requirement for the degree of

Doctor of Philosophy

by

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ABSTRACT

The objective of this thesis is to study, both theoretically and empirically, the relationship between product market competition and unemployment. The thesis comprises of four chapters. After a review of existing theories of unemployment in Chapter 1, Chapters 2 and 3 are theoretical analyses on the effects of product market competition on unemployment, wage and economic efficiency, while Chapter 4 contains quantitative analyses based the data of OECD countries.

The theoretical framework used in Chapters 2 and 3 combines models of imperfect competition with an efficiency wage model of unemployment based on Shapiro and Stiglitz (1984). An important feature of our theoretical framework is that a firm can raise the probability that a shirking worker is detected by increasing its effort or investment in the costly monitoring of workers. In terms of product market competition, we examine monopoly in Chapter 2 and Cournot oligopoly in Chapter 3. To be more specific, in Chapter 2 we show that, relative to the perfect competition, monopoly is associated with a higher unemployment rate, smaller output and less monitoring. Surprisingly, however, monopoly does not necessarily lead to lower welfare level than perfect competition. In Chapter 3, we find that more intensive competition in the product market, measured by an increase in the number of oligopolistic firms, does not necessarily lead to a lower unemployment rate or a higher wage for workers. Consequently, the relationship between the intensity of competition and the level of employment is not monotonic, and, in some instances, has an inverted-U shape. Moreover, we demonstrate that intensifying competition in the product market does not necessarily improve economic efficiency.

Chapter 4 explores the empirical relationship between unemployment rate and product market competition in eighteen OECD countries through three sets of quantitative analyses: panel-data analyses, structural vector autoregression approach and grouped panel-data regressions. These analyses indicate that the effect of product market competition on unemployment depends on the existing competition intensity and the relationship between them appears to be inverted-N shape – in countries where existing competition intensity is either high or low, an increase in competition tends to reduce unemployment rates significantly; but for countries where existing competition intensity is moderate, intensified competition is more likely to raise unemployment rates significantly.

Keywords: competition, unemployment, efficiency wage, economic efficiency

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Chapter 1

Theories of Unemployment: A Review

The objective of this thesis is to study, both theoretically and empirically, the relationship between product market competition and unemployment. The thesis comprises four chapters. After a review of existing theories of unemployment in Chapter 1, Chapters 2 and 3 are theoretical analyses on the effects of product market competition on unemployment, wage and economic efficiency, while Chapter 4 contains quantitative analyses based the data of OECD countries.

Given its objective, this thesis is aimed at an audience of industrial organization and microeconomics. Since the readers who specialize in these two areas are not necessarily familiar with the theories of unemployment, which figures prominently in macroeconomics but not in microeconomics, we present here a review of the existing theories of unemployment.

The possibility of unemployment is a central subject of macroeconomics (Romer, 2000). Why do unemployed workers sometimes choose to remain unemployed? How can we simultaneously have unemployed workers and unfilled vacancies? What factors determine the aggregate unemployment rates? How can apparently homogeneous workers in similar jobs end up earning different wages? A variety of theoretical frameworks have been constructed to help us find answers to such questions and identify the determinants of unemployment.

According to the classic demand-supply theory, in a world without any imperfections or distortions, unemployment should not exist in equilibrium. If there is an excess supply of labor (i.e. unemployment) in a Walrasian labor market, unemployed workers immediately bid the wage rate down until the supply and the demand are balanced. In reality, however, in almost any economy at almost any time, many individuals are seen to be involuntarily unemployed. That is, there are many people who want to work at less than the ongoing wage rate but are not able to.

Why don't firms cut wages to hire more workers and thereby increase their profits? The most likely reasons, as summarized in Romer (2000), are: (i) firms believe that higher wages improve the productivity or efficiency of labor and therefore they would not want to reduce wages; (ii) firms are willing to cut wages but explicit or implicit agreements with their workers prevent them from doing so, or firms incur a turnover cost that makes cutting wages unprofitable to firms; and (iii) firms do not accept the premise that the unemployed workers are identical to the firms' current employees due to heterogeneity among workers and jobs.

Theories of unemployment can therefore be classified according to their views on why firms do not cut wages to clear the labor market. Given the enormity of the literature on unemployment, we can only provide a general and compendious review of the existing theories in this chapter, focusing on the three representative frameworks, namely Efficiency Wage Models, Contracting Models, and Search and Matching Models.

1.1 Efficiency Wage Models

As summarized by Yellen (1984), there are four potential benefits for firms to pay a higher wage: (i) reducing shirking by employees due to a higher cost of job loss and providing their workers an incentive to exert effort on jobs and hence improving the productivity of labor; (ii) lowering costly labor turnover; (iii) improving the average quality of job applicants and mitigating adverse selection; and (iv) building loyalty among workers and hence inducing higher effort. Based on these four benefits, different models (such as Shirking Model, Labor Turnover Model, Adverse Selection Model and Sociological Models) are developed to explain why firms may find it unprofitable to cut wages in the presence of involuntary unemployment.

Among these frameworks, Shapiro-Stiglitz (1984) is undoubtedly the most remarkable one. In this model, there are a large number (N) of identical workers in the economy, each with a utility function as $U_L(w, e)$, where w is the wage and e is the level of effort put onto the job. For simplicity, the level of effort (e) is assumed to be a binary variable, taking on the values of 0 and some positive constant. $e = 0$ means no effort is supplied (i.e. the worker chooses to shirk), and $e > 0$ means the worker does not shirk. For simplicity, assume the utility function is separable and the workers are risk neutral. Therefore, the utility function can be normalized as $U_L(w, e) = w - e$. Accordingly, if the worker is employed and does not shirk, his utility is $w - e$; if he is employed and shirks, his utility is w ; if he is caught shirking, he will be fired immediately as a punishment and

will be given an unemployment benefit ($\bar{w}$) from some agencies other than the firm and in this case, his utility is $\bar{w} > 0$.

There are job separations for reasons other than being caught shirking, such as relocation. The separation rate, denoted by b , is defined as the ratio of separations to the number of workers employed, per unit time. For simplicity, the separation rate is assumed to be exogenous and identical for all firms. Therefore, the flow into the unemployment pool consists of workers who are separated from their jobs exogenously as well as those caught shirking. The flow out of unemployment is determined by new hires. Job acquisition rate (or the accession rate), denoted by a , is defined as the ratio of new hires to the number of workers unemployed, per unit time.

Firms can only imperfectly detect shirking. Consequently only a fraction of shirking workers are caught in each period. That is, to the worker who shirks, there is some probability (q) that he will be caught and then fired.

The worker's object is to maximize his expected present discounted value of utility by choosing his effort level. Assume the individual is infinitely lived, and he can neither borrow nor lend, then his objective function can be stated as:

$$\max_e \left\{ W = E \left[\int_0^{\infty} U_L(w(t), e(t)) \exp(-rt) dt \right] \right\} \quad (1.1)$$

where r is the intertemporal discount rate (or interest rate).

The worker chooses his level of effort (i.e. shirking or not shirking) to maximize his discounted utility stream. To do that, he has to compare the utility from shirking with the utility from not shirking. Let V_E^S denote the expected present discounted value of lifetime

utility if he is employed and shirking; V_E^N the expected present discounted value of lifetime utility if he is employed and not shirking; V_E the expected present discounted value of lifetime utility if he is employed; and V_U (taken as given) the expected present discounted value of lifetime utility if he is unemployed.

Finally, assume there are a large number (n) of firms in the economy and each individual firm simultaneously offers a wage rate w_i , $i = 1, 2, \dots, n$.

First, consider a short, discrete time interval: $[0, t]$. The asset value of a worker employed by firm i is:

$$V_E = w_i t + \exp(-rt) [bt \cdot V_U + (1 - bt) \cdot V_E] \quad (1.2)$$

where the term ($w_i t$) is the flow of wages, and the second expression is the discounted value of future outcomes. Note that $\exp(-rt) \approx 1 - rt$, then equation (1.2) can be rewritten as:

$$V_E = w_i t + (1 - rt) [bt \cdot V_U + (1 - bt) \cdot V_E] \quad (1.3)$$

Rearrange (1.3), we have:

$$V_E = \frac{w_i t + (1 - rt)btV_U}{1 - (1 - rt)(1 - bt)} = \frac{w_i t + btV_U - rbt^2V_U}{rt + bt - rbt^2} = \frac{w_i + bV_U - rbtV_U}{r + b - rbt} \quad (1.4)$$

Now, let us move into the continuous time case:

$$\lim_{t \rightarrow 0} V_E = \lim_{t \rightarrow 0} \frac{w_i + bV_U - rbtV_U}{r + b - rbt} = \frac{w_i + bV_U}{r + b} \quad (1.5)$$

Note that the discounted value of employment is the flow value of the wage minus the capital loss of unemployment scaled by its probability, that is

$$rV_E = w_i - b(V_E - V_U) \quad (1.6)$$

Next, consider the problem separately for a shirker versus a non-shirker. For a shirker, we have

$$rV_E^S = w_i + (b+q)(V_U - V_E^S) \quad (1.7)$$

And, for the non-shirker, we have

$$rV_E^N = w_i - e + b(V_U - V_E^N) \quad (1.8)$$

Solving V_E^S and V_E^N from equations (1.7) and (1.8), we obtain

$$V_E^S = \frac{w_i + (b+q)V_U}{r+b+q} \quad (1.9)$$

$$V_E^N = \frac{(w_i - e) + bV_U}{r+b} \quad (1.10)$$

Clearly, the worker will choose not to shirk if and only if $V_E^N \geq V_E^S$, which yields the so-called No-Shirking Condition (NSC):

$$w_i \geq rV_U + \left(1 + \frac{r+b}{q}\right)e \quad (1.11)$$

The NSC implies that everyone employed by firm i will choose to shirk if (i) $q \rightarrow 0$, that is, if there is little possibility that a shirk is detected; or (ii) $V_E^S = V_U$, which means there is no penalty associated with being unemployed, that is, a worker can get reemployed immediately after he is fired.

There is no reason for the firm to pay more than the necessary to prevent shirking. Thus, equation (1.11) holds with equality and no worker shirks. In this case, we must

have $V_E^S = V_E^N = V_E$. According to the definition of job acquisition rate (a), an unemployed worker will remain unemployed at the next instant with probability $(1-a)$; and will get hired by a firm other than i with probability a . Then, we have

$$V_U = \bar{w} + r[a\tilde{V}_E + (1-a)V_U] \quad (1.12)$$

where, $\tilde{V}_E = [w_{-i} + (b+q)V_U]/(r+b+q) = [(w_{-i} - e) + bV_U]/(r+b)$ denotes a worker's expected present discounted value of lifetime utility if he is employed by a firm other than i , from which he receives a wage of w_{-i} .¹

Similarly, recall the definition of the separation rate (b), if a worker is employed and he does not shirk, he will become unemployed at the next instant with probability b , or remain employed with probability $(1-b)$. Then,

$$V_E = w_i - e + r[bV_U + (1-b)V_E] \quad (1.13)$$

Solving equations (1.12) and (1.13) for V_U to obtain

$$V_U = \frac{(w_{-i} - e)a + \bar{w}(b+r)}{r(a+b+r)} \quad (1.14)$$

Substituting equation (1.14) into the equity form of (1.11), we find the no-shirking wage offered by firm i , which is the lowest wage rate that ensures its employees not to choose shirking:

$$w_i = \frac{(w_{-i} - e)a + \bar{w}(b+r)}{a+b+r} + \left(1 + \frac{b+r}{q}\right)e \quad (1.15)$$

¹ Since there are a large number of firms and workers in the economy, it is reasonable to assume that the firm that may hire an unemployed worker is not the firm which fired the worker. And thereby w_{-i} can be interpreted as the expected or average wage rate of the economy other than firm i .

In equilibrium, all firms offer the same wage rate, that is, $w_i = w_{-i}$. Then the equilibrium efficiency wage rate (w^*) can be solved as

$$w^* = \bar{w} + e + \frac{e}{q}(a + b + r) \quad (1.16)$$

In the steady state of the labor market, the flow into the unemployment pool per unit time is equal to the flow out of the unemployment pool per unit time. That is,

$$bL = a(N - L) \quad \text{or} \quad a = bL/(N - L) \quad (1.17)$$

where L is the aggregate employment and N is the total labor force.

Substituting equation (1.17) into (1.16), we have:

$$w^* = \bar{w} + e + \frac{e}{q} \left(\frac{bN}{N - L} + r \right) \quad (1.18)$$

Note that $(N - L)/N$ is the equilibrium unemployment rate (u). Therefore equation (1.18) can be rewritten as

$$w^* = e + \bar{w} + \frac{e}{q} \left(\frac{b}{u} + r \right) \quad (1.19)$$

Equation (1.19) implies $w^* \rightarrow \infty$ as $u \rightarrow 0$. That is, if there is little unemployment, then firms have to pay an extremely high wage to induce the workers not to shirk. This implies that in equilibrium there must be some unemployment in order to deter shirking; otherwise, every worker would choose shirking because he could get re-hired immediately after being fired.

1.2 Contracting Models

Theories in which bargaining and contracts affect labor market are known as contracting models. These theories are based on the observations that (i) incumbent employees are protected by explicit or implicit contracts; and (ii) firms incur labor turnover costs. Firms thereby would not cut wages to clear the labor market.

1.2.1. Efficient Contracts

It has been observed that firms and workers often enter into long-term relationships (see Hall (1982) for example). Firms may not hire workers afresh each period. Instead, many jobs involve long-term agreements and firm-specific skills, which imply that firms would not or do not have to adjust wages to clear the labor market each period. In this context, we present a simple version of the efficient contract model similar to Azariadis (1975).

Consider a firm whose profits are

$$\pi = AF(L) - wL \text{ with } F'(\cdot) > 0 \text{ and } F''(\cdot) < 0 \quad (1.20)$$

where L is the number of workers employed by the firm and w is the wage rate. A represents the random shock to firm's profitability.² A is discretely distributed and the probability that $A = A_i$ ($i = 1, 2, \dots, K$) is denoted by p_i . Let L_i and w_i denote the number of workers and the wage rate in the state that $A = A_i$. Thus, the firm's expected profits are

² The parameter A , for example, could reflect technology (so that a higher value means the firm can produce more output from a given amount of labor), or economy-wide output (so that a higher value means that the firm can obtain a higher relative price for a given amount of output).

$$E[\pi] = \sum_{i=1}^K p_i [A_i F(L_i) - w_i L_i] \quad (1.21)$$

Assume workers are risk-averse and each worker works the same amount. The representative worker's utility is

$$u = U(C) - V(L) \text{ with } U'(\cdot) > 0, U''(\cdot) < 0, V'(\cdot) > 0, V''(\cdot) > 0 \quad (1.22)$$

where $U(C)$ is the utility from consumption and $V(L)$ is the disutility from working.

Workers' consumption (C) is assumed to equal to their labor income (wL), that is, there is no outside insurance. Thus, the representative worker's expected utility is

$$E[u] = \sum_{i=1}^K p_i [U(C_i) - V(L_i)] \quad (1.23)$$

Assume that there is some reservation level of expected utility (u_0) that workers must attain in order to be willing to work for the firm, and that there is no labor mobility once workers agree to a contract. Thus, the only constraint on the contract involves the average level of utility it offers, not the level in any individual state.

One simple type of contract may just specify a wage and then let the firm choose employment once A is given. Workers, taking this wage into consideration, decide whether or not to work for the firm. Under such a contract, unemployment arises immediately. For example, a fall in labor demand will cause the firm to reduce employment while the labor supply does not change since the wage rate offered is fixed, and thus creates unemployment (or underemployment, if all workers work the same amount).

Alternatively, the firm may offer a contract specifying the wage and hours for each possible state of A (i.e. an implicit contract). The firm maximizes its profit, by choosing the wage and hours for each possible state (i.e. w_i and L_i), subject to the constraint that $E[u] \geq u_0$. Note that the firm's choice variables (w, L) can be equivalently replaced by (C, L) since the consumption (C) is determined by L and w . That is

$$\begin{aligned} \max_{\{C_i, L_i\}} & \left\{ E[\pi] = \sum_{i=1}^K p_i [A_i F(L_i) - C_i] \right\} \\ \text{s.t.: } & E[u] = \sum_{i=1}^K p_i [U(C_i) - V(L_i)] \geq u_0 \end{aligned} \quad (1.24)$$

The Lagrangian for the firm's profit-maximizing problem is therefore

$$\mathcal{L} = \sum_{i=1}^K p_i [A_i F(L_i) - C_i] + \lambda \left(\sum_{i=1}^K p_i [U(C_i) - V(L_i)] - u_0 \right) \quad (1.25)$$

The first order conditions yield

$$U'(C_i) = \frac{1}{\lambda} \quad (1.26)$$

$$p_i A_i F'(L_i) = \lambda p_i V'(L_i) \text{ or } A_i F'(L_i) = \frac{V'(L_i)}{U'(C_i)} \quad (1.27)$$

Equation (1.26) implies that the marginal utility of consumption is constant across states. That is, consumption is constant across states. Contracts of this type are called efficient contracts since the workers are fully insured by the firm under such contracts.

Equation (1.27) indicates that the cost to the firm of varying the amount of labor it uses may change greatly with its level of employment. Suppose the firm wants to hire an additional worker, it has to raise workers' wage to make them no worse off than before.

Since the expected utility cost to workers of the change is $p_i V'(L_i)$, C must rise by $p_i V'(L_i) / U'(C_i)$. Thus the cost to the firm of hiring the additional worker in a given state is proportional to $V'(L_i)$. If labor supply is inelastic (i.e. $V'(L_i)$ is sharply increasing in L_i), then the cost of labor in the firm will be much higher when employment is increased.

Efficient contract models imply strong real wage rigidity since workers' incomes are constant and provide a possible explanation for apparent unemployment. Consider that, when employment is low, the marginal disutility of working is low and the hourly wage (C / L_i) is high. Therefore workers would wish that they could work more at the wage the firm is paying. In the efficient contract models, however, workers are not free to choose their labor supply.

1.2.2. Insider-Outsider Model

The insider-outsider theory is concerned with the conflict of interest between insiders and outsiders in the labor market. "Insiders" are incumbent employees whose positions are protected by labor turnover costs, while "outsiders" enjoy no such protection. In effect, the labor turnover costs may be interpreted as the power of union or the entry barriers which make it difficult for workers to enter the labor market, such as the costs associated with dismissal of incumbent employees, and with hiring and training of new recruits. In this sense, labour turnover costs endue the insiders with a kind of market power.

Workers are divided into three groups: insiders, outsiders and entrants. When an outsider is hired, he becomes an entrant. Once an entrant has remained with the firm for a

sufficiently long period to become associated with the same labor turnover costs as the insiders, the entrant has an opportunity to renegotiate the wage and the entrant thereby turns into an insider. Although the outsiders cannot influence the outcome of the bargaining of wages and other employment terms between insiders and their employers directly, they may nevertheless do so indirectly through their influence on the employers' search costs or on the insiders' outside options (e.g., the insiders' reemployment probabilities if they are fired).

A simple insider-outsider model presented in Romer (2000) considers a firm with a number of insiders. The firm and the insiders bargain over the wage. Assume hours are fixed and therefore labor input can vary only through changes in the number of workers. The firm's profits are

$$\pi = AF(L_I + L_O) - w_I L_I - w_O L_O \quad (1.28)$$

where A , as before, is random, taking the value A_i with probability of p_i . L_I and L_O are the numbers of insiders and outsiders hired by the firm, and w_I and w_O are their wages. For simplicity, assume L_I is fixed. As mentioned above, w_I and w_O are related through labor turnover costs, denoted by LTC . For simplicity, assume

$$w_O = w_I - LTC, \text{ with } LTC \geq 0 \quad (1.29)$$

Moreover, assume the insiders have sufficient bargaining power and thus w_I is sufficiently high so that the firm is able to hire as many outsiders as it wants at the wage of $(w_I - LTC)$.

Suppose workers' utility depends only on their wages:

$$u_I = U(w_I), u_O = U(w_I - LTC), \text{ with } U'(\cdot) > 0, U''(\cdot) < 0 \quad (1.30)$$

Thus, the firm chooses L_O , w_I and w_O to maximize its profits, subject to the relation between w_I and w_O , and the constraint that the insiders' expected utility is no less than their reservation utility u_0 . That is

$$\begin{aligned} \max_{\{C_i, L_i\}} & \left\{ E[\pi] = \sum_{i=1}^K p_i [A_i F(L_I + L_{Oi}) - w_{Ii} L_I - w_{Oi} L_{Oi}] \right\} \\ \text{s.t.: (1)} & E[u] = \sum_{i=1}^K p_i U(w_{Ii}) \geq u_0 \\ & (2) w_O = w_I - LTC \end{aligned} \quad (1.31)$$

The first-order conditions,

$$A_i F'(L_I + L_{Oi}) = w_{Ii} - LTC \quad (1.32)$$

$$U'(w_{Ii}) = \frac{L_I + L_{Oi}}{\lambda}, \quad (1.33)$$

imply that employment is chosen to equate the marginal product of labor with the wage, rather than the marginal disutility from working (as in efficient contract models), because the outsiders are not involved in the original bargaining and the insiders and the firm maximize their joint surplus. They therefore agree to hire outsiders up to the point where their marginal product equals the wage they must be paid and therefore the outsiders' utility is ignored in the process of hiring.

The insider-outsider model suggests that higher labor turnover cost (i.e. stronger insider power) reduces employment by raising the wage and causing firms to move up their labor demand curves. In addition, as surveyed in Malcomson (1997), labor turnover costs may reduce employment due to the hold-up problem. Labor turnover costs turn

firm's choice of employment into an investment decision, generating economic rent and thereby driving a wedge between the highest wage the employer is willing to pay and the lowest wage the employee is willing to accept. Through wage bargaining, the insiders may be able to capture some of the return to this investment. As a result, firms may have an incentive to employ fewer people than they would otherwise.

1.3 Search and Matching Models

Search and matching theories are basically founded on the facts that (i) workers and jobs are heterogeneous; and (ii) there is no centralized market where buyers and sellers of labor meet and trade at a single price, as assumed in classical equilibrium theory. Based on this view, workers and jobs are distinct and as a result, the process of matching up workers and jobs occurs not through markets but through a complex process of search. Search and matching theories address frictions in the labor market: it takes time and other costly resources for a worker to land a job, especially a good job at a good wage, and for a firm to fill a vacancy.

Modeling heterogeneity is difficult, which makes search models relatively complicated. Here we only present a version of Mortensen-Pissarides matching model (1999) to help the reader understand the basic mechanism of search and matching theories.

Consider an economy where there are L workers who are employed and u workers who are unemployed, and there are f jobs that are filled and v jobs that are vacant. Suppose each job can have at most one worker, implying $f = L$. Assume the labor force is fixed at N and thus $L + u = N$, while vacancies can be endogenously created or eliminated at

no cost. However, there is a fixed cost of c per unit time of maintaining a job (either filled or vacant). If a worker is employed, he produces τ output per unit time and receives a wage of w per unit time. τ is exogenous and assumed to be greater than c , and w is determined endogenously. For simplicity, worker's costs of job search and effort put on job are ignored. Therefore,

$$\text{A worker's utility per unit time} = \begin{cases} w & \text{if employed} \\ 0 & \text{if unemployed} \end{cases}$$

$$\text{The firm's profits per unit time from a job} = \begin{cases} \tau - w - c & \text{if filled} \\ -c & \text{if vacant} \end{cases}$$

Assume the matching function, which describes the relation between search and recruiting activity and the outcome of the matching process, or the flow rate at which unemployed workers and vacant jobs matches, takes the Cobb-Douglas form

$$m(u, v) = s \cdot u^\alpha v^\beta \quad \text{with } 0 \leq \alpha \leq 1, 0 \leq \beta \leq 1 \quad (1.34)$$

Let a denote the rate per unit time that unemployed workers find jobs (i.e. job acquisition rate) and ρ the rate per unit time that vacant jobs are filled. Then

$$a = \frac{m(u, v)}{u} \quad (1.35)$$

$$\rho = \frac{m(u, v)}{v} \quad (1.36)$$

Additionally, there is an exogenous separation rate, denoted by b . In the steady state, the flow into the unemployment pool per unit time is equal to the flow out of the unemployment pool per unit time. That is

$$m(u, v) = bL \quad (1.37)$$

For each worker, the value of being employed (V_E) and the value of being unemployed (V_U) satisfies

$$rV_E = w - b(V_E - V_U) \quad (1.38)$$

where r is the intertemporal discount rate or interest rate. Equation (1.38) states that the discounted value of employment is the flow value of the wage minus the capital loss of unemployment scaled by its probability.

Similarly, we have

$$rV_F = (\tau - w - c)w - b(V_F - V_V) \quad (1.39)$$

$$rV_U = a(V_E - V_U) \quad (1.40)$$

$$rV_V = -c + \rho(V_F - V_V) \quad (1.41)$$

where V_F and V_V represent the value of being filled and vacant respectively.

Note that, when an unemployed worker and firm with a vacancy meet, both parties will choose a wage: it must be high enough so that the worker wants to work in the job; and low enough so that the employer wants to hire the worker. Since neither party can find a replacement immediately, there will be a range of wages that makes both parties better off than if they had not met. For simplicity, assume the worker and the employer set the wage such that the surplus is divided equally between them, that is

$$V_E - V_U = V_F - V_V \quad (1.42)$$

Therefore, equations (1.38) – (1.42) give us

$$rV_V = -c + \frac{\rho}{a + \rho + 2b + 2r} \tau \quad (1.43)$$

And equations (1.34) – (1.37), and $L + u = N$ imply

$$a = \frac{bL}{N - L} \quad (1.44)$$

$$\rho = s^{1/\beta} (bL)^{(\beta-1)/\beta} (N - L)^{\alpha/\beta} \quad (1.45)$$

Note that, equations (1.44) and (1.45) indicate a and ρ are functions of L , and $da/dL > 0$, $d\rho/dL < 0$. Equation (1.44) in turn implies that $d(rV_v)/dL < 0$. More specifically, as $L \rightarrow N$, $a \rightarrow \infty$ and $\rho \rightarrow 0$, and hence $rV_v \rightarrow -c$; and as $L \rightarrow 0$, $a \rightarrow 0$ and $\rho \rightarrow \infty$, and thus $rV_v \rightarrow \tau - c$. Then the equilibrium, as illustrated in Figure 1.1, can be characterized by the intersection of the rV_v locus reflecting (1.43) and the free-entry condition (i.e. vacancies can be costlessly created and eliminated), $rV_v = 0$. That is

$$-c + \frac{\rho(L)}{a(L) + \rho(L) + 2b + 2r} \tau = 0 \quad (1.46)$$

Moreover, equation (1.46) implies that a change in the economy (say in the labor demand or the productivity τ) induces complicated adjustment process for vacancies, unemployment and wages.

From this aspect, search and matching models provide a

straightforward explanation for frictional unemployment.

FIGURE 1.1 Unemployment in the Search and Matching Model

1.4 Summary

In this chapter, we have provided a compendious review of the existing theories of unemployment. Various theories have contributed to our understanding of unemployment from different perspectives. In particular, the efficiency-wage theories imply that equilibrium entails unemployment because firms have to raise their wages above the market-clearing levels in order to induce workers to exert effort on the job. Involuntary unemployment is created as a result. The contracting models, by taking into consideration the existence of labor turnover costs and/or long-term relationships between firms and their employees, are helpful for the understanding and explanation of wage rigidity. Finally, the search and matching theories, based on the fact that workers and jobs are heterogeneous, offer a straightforward explanation for frictional unemployment: it takes time and other costly resources for a worker to land a job, and for a firm to fill a vacancy.

In Chapters 2 and 3 of this paper, we construct models that incorporate the efficiency-wage unemployment. This allows us to examine the effects of product market competition on *involuntary* unemployment.

Chapter 2

Monopoly and Unemployment: Perspective from an Efficiency Wage Model

2.1 Introduction

It is well-known that monopoly causes inefficient allocation of resources. As illustrated by the standard textbook model of monopoly, deadweight losses arise because a monopolist sets its price above the marginal cost of production. In addition, productive inefficiencies and rent seeking activities have also been cited as reasons for efficiency losses of monopoly.

However, there is one area of potential efficiency losses of monopoly that so far has rarely been explored in microeconomic theory, that is, the effects of monopoly on unemployment. Since unemployment represents unutilized labor resource, it can be argued that an increase in unemployment rate, *ceteris paribus*, causes additional efficiency losses. Given that output is an increasing function of labor, reduction in output by a monopoly will normally cause a reduction in labor employed in the monopolized industry. To the extent that the surplus labor released by the monopolized industry is not entirely absorbed by other industries in the economy, more unemployment will result. Therefore, it seems plausible that monopoly may cause higher rate of unemployment.

Indeed, it has been argued by some economists (see Layard *et al.* (2005) and Geroski *et al.* (1995) for examples) that competition in the product market reduces unemployment. However, while the issue of unemployment figures prominently in other fields of

economics such as macro and labor economics, microeconomic analysis of monopoly is still confined to an equilibrium framework that, by its implicit assumption of a perfectly flexible labor market, is incapable of handling unemployment.

The main objective of this chapter is to analyze the efficiency and employment consequences of monopoly from the perspective of an efficiency wage model of unemployment based on Shapiro and Stiglitz (1984). In this model a monopolist has to offer a wage high enough to induce workers to expend efforts on the job. An important feature of our model is that a monopolist can raise the probability that a shirking worker is detected by increasing its effort or investment in the monitoring of workers.³ Using this model we study how the monopolist's decision with regard to employment, output and monitoring are affected by exogenous variables such as job separation rate, technological advances, market size, and unemployment benefits. Furthermore, we examine the efficiency consequences of monopoly by comparing the monopoly equilibrium with the competitive equilibrium. In this regard, the most important finding from our analysis is that while monopoly is associated with higher unemployment rate, smaller output, and less monitoring, it does not necessarily lead to lower welfare level. This result is surprising in light of the common belief about the welfare losses of monopoly.

The rest of this chapter is organized as follows. Section 2.2 presents the model and characterizes the monopoly equilibrium. In section 2.3 we analyze how the monopoly

³ Shapiro and Stiglitz (1984) discuss informally the case of endogenous monitoring. They indicate that in general it is not possible to ascertain whether the competitive equilibrium entails too much or too little employment.

equilibrium is affected by various parameters of the model, and in section 2.4 we compare the monopoly equilibrium with the benchmark of a competitive equilibrium. In section 2.5 we present the results from the simulations of our model with specific functional forms. Section 2.6 extends the one-firm model to an M -industry model. And conclusions of this chapter are in section 2.7.

2.2 The Model

Consider an industry served by a monopolist. The demand for the good produced by the monopolist is represented by $p = \alpha P(Q)$, where p is the price and Q is the output with $P'(Q) < 0$, and $\alpha > 0$ measures the market size. Additionally, we assume that $2P'(Q) + P''(Q) \cdot Q < 0$ to ensure that the monopolist's marginal revenue is decreasing in output. The monopolist produces the good according to the production function $Y = sF(eL)$ with the standard assumptions that $F'(\cdot) > 0$ and $F''(\cdot) < 0$, where Y is the output, L is the number of workers employed, e is the effort level expended by the representative worker, and s is an exogenous technology parameter. Hence, eL represents the effective amount of labor employed by the firm.

To incorporate unemployment into the model, we use the efficiency wage model of Shapiro and Stiglitz (1984), as presented in section 1.1. Specifically, we assume that workers can shirk (i.e. exerting no effort) on the job. The firm, on the other hand, cannot perfectly observe workers' effort.

Assume there are N identical workers who, because of their specialized skills, can find work only in this industry. Each worker has a utility function $U(w, e) = w - e$, where w is

the received wage and e is the worker's effort level on the job. For simplicity we assume that the level of effort, e , takes on only two values, zero and some positive constant. A value of 0 means that no effort is supplied (that is, the worker chooses to shirk), and $e > 0$ means the worker does not shirk. Thus, if the worker is employed and does not shirk, his utility is $w - e$; but if he shirks on the job, his utility is w . If a worker is caught shirking on the job, he is fired immediately. In addition, a worker may be separated from his job for reasons other than shirking. The natural separation rate, denoted by b , is defined as the ratio of job separations to the number of workers employed, per unit of time. An unemployed worker receives a utility $\bar{w} > 0$, the unemployment benefit. The flow out of the unemployment pool is determined by new hires. The job acquisition rate (or the accession rate), denoted by a , is defined as the ratio of new hires to the number of workers unemployed per unit of time. Each worker in the unemployment pool has the same opportunity to be hired, independent of the reason that has caused his unemployment (shirking or natural separation).

Firms can only monitor workers imperfectly. In other words, if a worker shirks, there is some probability, denoted by q , that the worker will be caught and fired. In the standard Shapiro and Stiglitz efficiency wage model, the detection probability q is taken as exogenous. In this model, we endogenize q by assuming that q is a function of the effort and/or investment by the firm in monitoring the workers. Let m denote the level of monitoring. We assume that $q(m)$ with $q'(m) > 0$ and $q''(m) < 0$. The monitoring of workers is costly to the firm, and the firm has to pay a wage high enough to discourage

workers from shirking. Using the same procedure presented in section 1.1, we obtain the equilibrium efficiency wage rate as

$$w^* = \bar{w} + e + \frac{e}{q(m)}(a + b + r) \quad (2.1)$$

where r is the intertemporal discount rate, and interest rate is often used as a proxy of it. Additionally, please note that we do not distinguish the firm's wage and the economy-wide wage since we assume that there is only one (representative) firm in this model. And the firm's objective function is:⁴

$$\pi = p \cdot Y - w^* \cdot L - H(m) \quad (2.2)$$

where π is the profit from the firm and $H(m)$ is the cost of monitoring workers with $H'(\cdot) > 0$ and $H''(\cdot) > 0$.⁵ Note that $\partial w^* / \partial m = -eq'(m)(a + b + r) / [q(m)]^2 < 0$, in words, the no-shirking wage w^* is decreasing in m . The firm can lower the wage paid to the workers without inducing shirking by investing more in monitoring. Since monitoring is costly to the firm, it faces a trade-off between monitoring costs and the wage paid to workers.

In the steady state of the labor market, the flow into the unemployment pool per unit time is equal to the flow out of the unemployment pool per unit time. That is

$$bL = a(N - L) \quad \text{or} \quad a = bL / (N - L) \quad (2.3)$$

⁴ In this paper, we assume that the manager is also the owner of the firm. That is, there is no principal-agent problem between the manager and the owner.

⁵ It should be noted that, in this paper, the monitoring cost is assumed to be independent of the number of workers. Alternatively, it may take the form of $h(m)L$, where $h(m)$ is an increasing and convex function of m . This alternative set-up is left for future research.

Taking into consideration the efficiency wage, the monopolist's optimization problem is written as:

$$\max_{\{m, L\}} \pi = \alpha P(sF(eL)) \cdot sF(eL) - \left[\bar{w} + e + \frac{e}{q(m)}(a + b + r) \right] L - H(m) \quad (2.4)$$

The first-order conditions are

$$\frac{q'(m)}{[q(m)]^2} e(a + b + r)L - H'(m) = 0 \quad (2.5)$$

$$\begin{aligned} \alpha s^2 e \cdot P'(sF(eL)) F'(eL) F(eL) + \alpha s e \cdot P(sF(eL)) F'(eL) \\ - \left[\bar{w} + e + \frac{e}{q(m)}(a + b + r) \right] = 0 \end{aligned} \quad (2.6)$$

Equation (2.5) implies that in equilibrium, the owner of the firm sets the marginal benefit of monitoring equal to the marginal cost of monitoring. In (2.6) the term $[\alpha s^2 e \cdot P'(sF(eL)) F'(eL) F(eL) + \alpha s e \cdot P(sF(eL)) F'(eL)]$ is the monopolist's marginal revenue product (*MRP*).⁶ Then, (2.6) indicates that the monopolist will choose the employment level such that the *MRP* equals the wage rate.

It is easy to derive that

$$\frac{\partial^2 \pi}{\partial m^2} \bigg|_{(m_m^*, L_m^*)} = \left\{ -\frac{2[q'(m_m^*)]^2}{[q(m_m^*)]^3} + \frac{q''(m_m^*)}{[q(m_m^*)]^2} \right\} eL_m^* \cdot (a + b + r) - H''(m_m^*) < 0 \quad (2.7)$$

⁶ For a monopolist, $MRP = MR \cdot MP$. Since the marginal revenue is decreasing in output ($\partial MR / \partial Q < 0$) and $\partial MP / \partial L = se^2 F''(eL) < 0$, we have $\partial MRP / \partial L = \partial MR / \partial Q \cdot MP^2 + \partial MP / \partial L \cdot MR < 0$, that is, the *MRP* is decreasing in the amount of labor employed.

$$\begin{aligned}
\left. \frac{\partial^2 \pi}{\partial L^2} \right|_{(m_m^*, L_m^*)} &= \alpha s^2 e^2 \left[F'(eL_m^*) \right]^2 \overbrace{\left[2P'(sF(eL_m^*)) + sF(eL_m^*)P''(sF(eL_m^*)) \right]}^{<0 \text{ by assumption}} \\
&\quad + \alpha s^2 e^2 F''(eL_m^*) \underbrace{\left[P'(sF(eL_m^*))F(eL_m^*) + \alpha s e^2 \cdot P(sF(eL_m^*)) \right]}_{>0 \text{ by FOC}} < 0
\end{aligned} \tag{2.8}$$

$$\left. \frac{\partial^2 \pi}{\partial m \partial L} \right|_{(m_m^*, L_m^*)} = \left. \frac{\partial^2 \pi}{\partial L \partial m} \right|_{(L_m^*, m_m^*)} = \frac{q'(m_m^*)}{[q(m_m^*)]^2} e(a+b+r) > 0 \tag{2.9}$$

To ensure that the second-order conditions for a maximum are satisfied, we assume

$$\left[\frac{\partial^2 \pi}{\partial L^2} \cdot \frac{\partial^2 \pi}{\partial m^2} \right]_{(m_m^*, L_m^*)} > \left[\frac{\partial^2 \pi}{\partial m \partial L} \right]_{(m_m^*, L_m^*)}^2 \tag{2.10}$$

Using the condition for the labor market equilibrium (2.3), we can state the two equilibrium conditions as

$$\frac{eL \cdot q'(m)}{[q(m)]^2} \left(\frac{bN}{N-L} + r \right) - H'(m) = 0 \tag{2.11}$$

$$\begin{aligned}
&\alpha s^2 e \cdot P'(sF(eL)) F'(eL) F(eL) + \alpha s e \cdot P(sF(eL)) F'(eL) \\
&\quad - \left[\bar{w} + e + \frac{e}{q(m)} \left(\frac{bN}{N-L} + r \right) \right] = 0
\end{aligned} \tag{2.12}$$

It is useful for later analysis to establish the properties of these two conditions in the space of (m, L) . Let $L = A_m(m)$ denote the functional relationship implied by equation (2.11); and $L = B_m(m)$ the functional relationship implied by equation (2.12). Thus, the intersection of these two curves is the equilibrium, denoted by (m_m^*, L_m^*) .

Lemma 2.1. *Both curves, $L = A_m(m)$ and $L = B_m(m)$, are strictly upward sloping in the (m, L) space.*

Proof. To simplify presentation, let $\Phi(m, L) = 0$ and $\Omega(m, L) = 0$ denote equations (2.11) and (2.12), respectively. And let Φ_j and Ω_j ($j = m, L, b, s, \alpha, \bar{w}$) denote the partial derivative of Φ and Ω with respect to j . Then, the slopes of the two curves at the equilibria can be presented as $A'_m(m^*) = -\Phi_m / \Phi_L$ and $B'_m(m^*) = -\Omega_m / \Omega_L$. It is easy to obtain

$$\Phi_L = \frac{eq'(m)}{[q(m)]^2} \left(\frac{bN}{N-L} + r \right) + \frac{ebNL \cdot q'(m)}{[q(m)]^2 (N-L)^2} \quad (2.13)$$

$$\Phi_m = \left\{ -\frac{2[q'(m)]^2}{[q(m)]^3} + \frac{q''(m)}{[q(m)]^2} \right\} eL \cdot \left(\frac{bN}{N-L} + r \right) - H''(m) \quad (2.14)$$

$$\begin{aligned} \Omega_L = & \alpha s^2 e^2 [F'(eL)]^2 [2P'(sF(eL)) + sF(eL)P''(sF(eL))] \\ & + \alpha s e^2 F''(eL) [P'(sF(eL))F(eL) + P(sF(eL))] \\ & - ebN[q(m)]^{-1} (N-L)^{-2} \end{aligned} \quad (2.15)$$

$$\Omega_m = \frac{eq'(m)}{[q(m)]^2} \left(\frac{bN}{N-L} + r \right) \quad (2.16)$$

By the assumptions that $q'(\cdot) > 0$, $q''(\cdot) < 0$, $H'(\cdot) > 0$ and $H''(\cdot) > 0$, we know that $\Phi_L > 0$, $\Phi_m < 0$ and $\Omega_m > 0$. Now, consider the sign of Ω_L . Note that in (2.15), the term $[2P'(sF(eL)) + sF(eL)P''(sF(eL))]$ is negative since the monopolist's marginal revenue is assumed to be decreasing in output; and the first order condition (2.11) implies that the term $[P'(sF(eL))F(eL) + \alpha s e^2 \cdot P(sF(eL))]$ is positive. These imply that $\Omega_L < 0$. Then,

$$A'_m(m) = -\Phi_m / \Phi_L > 0 \quad \text{and} \quad B'_m(m) = -\Omega_m / \Omega_L > 0$$

That is, both $L = A_m(m)$ and $L = B_m(m)$ are strictly upward slopping.

QED

Intuitively, $L = A_m(m)$ is upward slopping because a higher level of monitoring reduces the no-shirking wage and thus encourages the monopolist to hire more workers; on the other hand, $L = B_m(m)$ is upward slopping because a higher level of employment lowers the MRP of labor and this drives the monopolist to invest more on monitoring to reduce the wage rate in order to equate it to the reduced MRP .

Lemma 2.2. *At the equilibrium point (m_m^*, L_m^*) , the slope of $L = A_m(m)$ is greater than the slope of $L = B_m(m)$, that is, $A'_m(m_m^*) > B'_m(m_m^*)$.*

Proof. Denote Φ_L^* , Φ_m^* , Ω_L^* and Ω_m^* as the respective values at the equilibrium point (m_m^*, L_m^*) . Then, $A'_m(m_m^*) = -\Phi_m^* / \Phi_L^*$ and $B'_m(m_m^*) = -\Omega_m^* / \Omega_L^*$.

Substitute the labor market steady state condition $a = bN/(N-L)$ into the second order conditions (2.7) – (2.9), and compare them with Φ_L^* , Φ_m^* , Ω_L^* and Ω_m^* to obtain

$$\Phi_L^* > \partial^2 \pi / \partial m \partial L \Big|_{(m_m^*, L_m^*)} > 0 \quad (2.17)$$

$$\Phi_m^* = \partial^2 \pi / \partial m^2 \Big|_{(m_m^*, L_m^*)} < 0 \quad (2.18)$$

$$\Omega_L^* < \partial^2 \pi / \partial L^2 \Big|_{(m_m^*, L_m^*)} < 0 \quad (2.19)$$

$$\Omega_m^* = \partial^2 \pi / \partial L \partial m \Big|_{(m_m^*, L_m^*)} > 0 \quad (2.20)$$

Furthermore,

$$\begin{aligned} \left[\Phi_L^* - \partial^2 \pi / \partial m \partial L \Big|_{(m_m^*, L_m^*)} \right] \cdot \Omega_m^* &= \left\{ \frac{ebNL_m^* \cdot q'(m_m^*)}{[q(m_m^*)]^2 (N - L_m^*)^2} \right\} \cdot \left\{ \frac{eq'(m_m^*)}{[q(m_m^*)]^2} \left(\frac{bN}{N - L_m^*} + r \right) \right\} \\ &= \frac{e^2 bNL_m^* \cdot [q'(m_m^*)]^2}{[q(m_m^*)]^4 (N - L_m^*)^2} \cdot \left(\frac{bN}{N - L_m^*} + r \right) \end{aligned}$$

and

$$\begin{aligned} \left[\Omega_L^* - \partial^2 \pi / \partial L^2 \Big|_{(m_m^*, L_m^*)} \right] \cdot \Phi_m^* &> \left\{ \frac{ebN}{q(m_m^*)(N - L_m^*)^2} \right\} \cdot \left\{ \frac{2eL_m^* [q'(m_m^*)]^2}{[q(m_m^*)]^3} \left(\frac{bN}{N - nL_m^*} + r \right) \right\} \\ &> \frac{e^2 bNL_m^* \cdot [q'(m_m^*)]^2}{[q(m_m^*)]^4 (N - L_m^*)^2} \cdot \left(\frac{bN}{N - L_m^*} + r \right) \end{aligned}$$

That is,

$$\left[\Omega_L^* - \partial^2 \pi / \partial L^2 \Big|_{(m_m^*, L_m^*)} \right] \cdot \Phi_m^* > \left[\Omega_L^* - \partial^2 \pi / \partial m \partial L \Big|_{(m_m^*, L_m^*)} \right] \cdot \Omega_m^* \quad (2.21)$$

Using (2.10) and (2.17) – (2.21), we have

$$\begin{aligned} \left[\partial^2 \pi / \partial L^2 \cdot \partial^2 \pi / \partial m^2 \right]_{(m_m^*, L_m^*)} &> \left[\partial^2 \pi / \partial m \partial L \right]_{(m_m^*, L_m^*)}^2 \\ \Rightarrow \Omega_L^* \cdot \Phi_m^* &> \Phi_L^* \cdot \Omega_m^* \Rightarrow \Phi_m^* / \Phi_L^* < \Omega_m^* / \Omega_L^* \Rightarrow -\Phi_m^* / \Phi_L^* > -\Omega_m^* / \Omega_L^* \\ \Rightarrow A'_m(m_m^*) &> B'_m(m_m^*) \end{aligned}$$

That is, at the intersection (m_m^*, L_m^*) , the slope of $L = A_m(m)$ is greater than the slope of $L = B_m(m)$.

QED

Lemma 2.1 and Lemma 2.2 imply that the monopoly equilibrium can be illustrated as in Figure 2.1.

FIGURE 2.1 The Monopoly Equilibrium

2.3 Properties of the Monopoly Equilibrium

In this section we conduct comparative statics to analyze how the monopoly equilibrium is affected by various parameters of the model. The parameters we will examine are separation rate (b), technology shock (s), market size (α), and unemployment benefits ($\bar{w}$).

2.3.1. Separation Rate

First, conducting comparative statics with respect to b , we obtain,

$$\frac{dm^*}{db} = \frac{\Phi_L^* \cdot \Omega_b^* - \Omega_L^* \cdot \Phi_b^*}{\Delta} \quad (2.22)$$

$$\frac{dL^*}{db} = \frac{\Omega_L^* \cdot \Phi_b^* - \Phi_m^* \cdot \Omega_b^*}{\Delta} \quad (2.23)$$

where

$$\Phi_b^* = \frac{eL^* N q'(m^*)}{[q(m^*)]^2 (N - L^*)}, \quad \Omega_b^* = -\frac{eN}{q(m^*)(N - L^*)} \quad (2.34)$$

and $\Delta \equiv \Omega_L^* \cdot \Phi_m^* - \Phi_L^* \cdot \Omega_m^*$ is positive according to Lemma 2.2.

Then, $dm^* / db > 0$ if and only if

$$\begin{aligned} & \Phi_L^* \cdot \Omega_b^* - \Omega_L^* \cdot \Phi_b^* > 0 \\ \Leftrightarrow & -\frac{eq'(m^*)}{[q(m^*)]^2} \left(\frac{bN}{N - L^*} + r \right) \cdot \frac{eN}{q(m^*)(N - L^*)} - \frac{\partial MRP^*}{\partial L^*} \cdot \frac{eL^* N q'(m^*)}{[q(m^*)]^2 (N - L^*)} > 0 \\ \Leftrightarrow & -\frac{e}{q(m^*)} \left(\frac{bN}{N - L^*} + r \right) - L^* \cdot \frac{\partial MRP^*}{\partial L^*} > 0 \Leftrightarrow \left| \frac{\partial MRP^*}{\partial L^*} \right| > \frac{e}{q(m^*)L^*} \left(\frac{bN}{N - L^*} + r \right) \end{aligned}$$

On the other hand,

$$\Omega_m^* \cdot \Phi_b^* - \Phi_m^* \cdot \Omega_b^* = \left\{ -\frac{[q'(m^*)]^2}{[q(m^*)]^3} + \frac{q''(m^*)}{[q(m^*)]^2} \right\} eL^* \cdot \left(\frac{bN}{N - L^*} + r \right) - H''(m^*) < 0$$

Therefore,

Proposition 2.1. *An increase in separation rate reduces the equilibrium employment and thus raises the equilibrium unemployment rate, but has an ambiguous effect on the level of monitoring. To be more specific, it raises the level of monitoring if and only if*

$$\left| \frac{\partial MRP^*}{\partial L^*} \right| > \frac{e}{q(m^*)L^*} \left(\frac{bN}{N - L^*} + r \right)$$

Proposition 2.1 is illustrated in Figure 2.2. An increase in b causes the curve $L = A_m(m)$ to shift out and the curve $L = B_m(m)$ to shift down. The new equilibrium $\tilde{E}_m$

lies below the original equilibrium E_m .

However, $\tilde{E}_m$ may lie on the right or the left of E_m , depending on the condition derived above.

FIGURE 2.2 Effect of Separation Rate on Monopoly Equilibrium

2.3.2. Technology Shock

Using the same procedure of comparative statics as above, we can show that

$$\frac{dm^*}{ds} = \frac{\Phi_L^* \cdot \Omega_s^* - \Omega_L^* \cdot \Phi_s^*}{\Delta} \quad \text{and} \quad \frac{dL^*}{ds} = \frac{\Omega_m^* \cdot \Phi_s^* - \Phi_m^* \cdot \Omega_s^*}{\Delta} \quad (2.35)$$

where,

$$\Phi_s^* = 0$$

$$\Omega_s^* = \alpha e \cdot F'(eL^*) \cdot \left\{ 3P'(sF(eL^*)) \cdot sF(eL^*) + P''(sF(eL^*)) \cdot [sF(eL^*)]^2 + P(sF(eL^*)) \right\}$$

Recall $\Phi_L^* > 0$, $\Phi_m^* < 0$ and $\Delta > 0$, then $dm^*/ds > 0$ and $dL^*/ds > 0$ if and only if

$$\Omega_s^* > 0 \Leftrightarrow 3P'(sF(eL^*)) \cdot sF(eL^*) + P''(sF(eL^*)) \cdot [sF(eL^*)]^2 + P(sF(eL^*)) > 0$$

$$\Leftrightarrow P^* + sF^* \cdot (3P'' + sF^* P''') > 0 \Leftrightarrow P^* + 3sF^* \cdot P'' + [sF^*]^2 P''' > 0$$

$$\Leftrightarrow -\frac{P^*}{sF^* \cdot P''} - \frac{sF^* \cdot P'''}{P''} > 3 \Leftrightarrow \varepsilon_p^* + \sigma_p^* > 3$$

where, ε_p^* is the elasticity of demand with respect to price at the equilibrium point, and σ_p^* is the elasticity of the slope of the demand function at the equilibrium point. The sign of the latter is determined by the concavity or convexity of the demand function.

Proposition 2.2. *A positive technology shock increases the equilibrium employment (thus reducing the equilibrium unemployment rate) and raises the monopolist's monitoring level if and only if $\varepsilon_p^* + \sigma_p^* > 3$.*

Graphically, a change in s does not affect the curve $L = A_m(m)$ because s does not appear in (2.11). On the other hand, as the derivation below shows, an increase in s causes $L = B_m(m)$ to shift up if and only if $\varepsilon_p^* + \sigma_p^* > 3$. In (2.12),

$$\begin{aligned}
 m \downarrow &\Leftrightarrow q(m) \downarrow \Leftrightarrow \left[\bar{w} + e + \frac{e}{q(m)} \left(\frac{bN}{N-L} + r \right) \right] \uparrow \\
 &\Leftrightarrow \left[\alpha s^2 e \cdot P'(sF(eL)) F'(eL) F(eL) + \alpha s e \cdot P(sF(eL)) F'(eL) \right] \uparrow \\
 &\Leftrightarrow \partial \left[\alpha s^2 e \cdot P'(sF(eL)) F'(eL) F(eL) + \alpha s e \cdot P(sF(eL)) F'(eL) \right] / \partial s > 0 \\
 &\Leftrightarrow P(sF(eL)) + 3s \cdot F(eL) \cdot P'(sF(eL)) + [s \cdot F(eL)]^2 \cdot P''(sF(eL)) > 0 \\
 &\Leftrightarrow \varepsilon_p^* + \sigma_p^* > 3
 \end{aligned}$$

As shown in Figure 2.3, if $\varepsilon_p^* + \sigma_p^* > 3$, an increase in s causes the curve $L = B_m(m)$ to shift up, which implies that the levels of both employment and monitoring are higher in the new equilibrium. On the other hand, if $\varepsilon_p^* + \sigma_p^* < 3$, the curve $L = B_m(m)$ shifts

down as s increases, which implies that the levels of both employment and monitoring are lower in the new equilibrium.

Note from Proposition 2.2 that in the special case of linear demand function (i.e. $P''(\cdot) = 0$, thus $\sigma_p = 0$), the unemployment rate is decreasing in technology shocks if and only if $\varepsilon_p^* > 3$. Intuitively, a positive technology shock increases the amount of output produced by a given number of productive workers. That increase in output

FIGURE 2.3 Effect of Technology Shock on Monopoly Equilibrium

will cause a relatively small fall in the price if the demand is highly elastic. In such a situation, the firm is willing to hire additional workers to take advantage of the higher marginal product of labor brought about by the positive technology shock. With more workers, the marginal gain from an additional unit of monitoring is higher, and hence the monopolist invests more on monitoring. The opposite is true if the demand elasticity is small.⁷

⁷ Indeed, some of the recent empirical researches have uncovered evidence that positive technology shocks can raise the level of unemployment. Basu *et al.* (2004) and Galí (1999) find that positive technology shocks typically led to a short-run decline in employment during the post World-War II period in the United States.

2.3.3. Market Size

Straightforward comparative statics exercise shows that

$$\frac{dm^*}{d\alpha} = \frac{\Phi_L^* \cdot \Omega_\alpha^* - \Omega_L^* \cdot \Phi_\alpha^*}{\Delta} \quad \text{and} \quad \frac{dL^*}{d\alpha} = \frac{\Omega_m^* \cdot \Phi_\alpha^* - \Phi_m^* \cdot \Omega_\alpha^*}{\Delta} \quad (2.36)$$

where,

$$\Phi_\alpha^* = 0$$

$$\Omega_\alpha^* = s^2 e \cdot P'(sF(eL)) F'(eL) F(eL) + se \cdot P(sF(eL)) F'(eL)$$

Note that $\Phi_L^* > 0$, $\Phi_m^* < 0$ and $\Delta > 0$, then $dm^*/d\alpha > 0$ and $dL^*/d\alpha > 0$ if and only if

$$\Omega_\alpha^* > 0 \Leftrightarrow P'(sF(eL)) \cdot sF(eL) + P(sF(eL)) \Leftrightarrow \varepsilon_p^* > 1$$

This condition is satisfied because a monopolist always operates at a point where the elasticity of demand is greater than one.

Proposition 2.3. *A larger market size raises the levels of both employment and monitoring.*

As shown in Figure 2.4, an increase in

α does not affect the curve $L = A_m(m)$ but causes the curve $L = B_m(m)$ to shift up. Consequently, an increase of market size leads to higher levels of employment and monitoring.

FIGURE 2.4 Effect of Market Size on Monopoly Equilibrium

2.3.4. Unemployment Benefits

It is straightforward to derive:

$$\frac{dm^*}{d\bar{w}} = \frac{\Phi_L^* \cdot \Omega_{\bar{w}}^* - \Omega_L^* \cdot \Phi_{\bar{w}}^*}{\Delta} \quad \text{and} \quad \frac{dL^*}{d\bar{w}} = \frac{\Omega_m^* \cdot \Phi_{\bar{w}}^* - \Phi_m^* \cdot \Omega_{\bar{w}}^*}{\Delta} \quad (2.37)$$

where, $\Phi_{\bar{w}}^* = 0$ and $\Omega_{\bar{w}}^* = -1$. Then it is clear that $dm^*/d\bar{w} < 0$ and $dL^*/d\bar{w} < 0$ since $\Phi_L^* > 0$, $\Phi_m^* < 0$ and $\Delta > 0$. In other words,

Proposition 2.4. *An increase in unemployment benefits results in a decrease in the level of employment (thus an increase in the unemployment rate) and a reduction in the level of monitoring.*

As shown in Figure 2.5, an increase in unemployment benefits $\bar{w}$ only affects the curve $L = B_m(m)$. For any given L_m , an increase in $\bar{w}$ will force m to go up to satisfy equation (2.12). That is, the curve $L = B_m(m)$ will shift down if the unemployment benefits increase.

FIGURE 2.5 Effect of Unemployment Benefit on Monopoly Equilibrium

$$\begin{aligned} \uparrow \bar{w} &\xrightarrow{\text{Given } L_m \text{ unchanged}} \left[\alpha s^2 e \cdot P'(sF(eL_m)) F'(eL_m) F(eL_m) + \alpha s e \cdot P(sF(eL_m)) F'(eL_m) \right] \\ \Rightarrow \left[\bar{w} + e + \frac{e}{q(m_m)} (a + b + r) \right] &\Leftrightarrow q(m_m) \uparrow \Leftrightarrow m_m \uparrow \end{aligned}$$

The result that more generous unemployment benefits increases unemployment is not surprising. This finding is also supported by ample empirical evidence.⁸ What is new in this analysis is that more generous unemployment benefits also cause the monopolist to invest less in monitoring, which further reduces the level of employment.

2.4 Efficiency Consequences of Monopoly

The objective of this section is to analyze the efficiency consequences of monopoly in the presence of unemployment caused by efficiency wage considerations. We will do so by comparing the monopoly equilibrium with that of perfect competition.

2.4.1. Perfect Competition: The Benchmark Case

In a perfectly competitive industry, firms are price-takers. Therefore, the representative firm's optimization problem in our competitive benchmark is to choose the level of monitoring m_c and the number of workers L_c to:

$$\max_{\{m, L\}} \pi_c = \bar{p}Y - w^*L - H(m) \quad (2.38)$$

Using the production function and the non-shirking wage equation, we can re-write the firm's optimization problem as:

$$\max_{\{m, L\}} \left\{ \bar{p} \cdot sF(eL) - \left[\bar{w} + e + \frac{e}{q(m)}(a + b + r) \right] L - H(m) \right\} \quad (2.39)$$

The first-order conditions are:

⁸ The impact of a high benefit on unemployment is well documented by Layard *et al.* (2005). It is also confirmed by many other empirical studies, such as Nickell *et al.* (2005).

$$\frac{q'(m)}{[q(m)]^2} e(a+b+r)L - H'(m) = 0 \quad (2.40)$$

$$\bar{p}seF'(eL) - \left[\bar{w} + e + \frac{e}{q(m)}(a+b+r) \right] = 0 \quad (2.41)$$

Condition (2.40) implies that in the competitive equilibrium the firm invests in monitoring to the point where the marginal benefit of monitoring equals its marginal cost, while (2.41) indicates that the firm will set employment at the level such that the value of marginal product equals to the wage rate.

It is straightforward to derive that

$$\left. \frac{\partial^2 \pi_c}{\partial L^2} \right|_{(m_c^*, L_c^*)} = \bar{p}se^2 F''(eL_c^*) < 0 \quad (2.42)$$

$$\left. \frac{\partial^2 \pi_c}{\partial m^2} \right|_{(m_c^*, L_c^*)} = \left\{ \frac{q''(m_c^*)}{[q(m_c^*)]^2} - \frac{2[q'(m_c^*)]^2}{[q(m_c^*)]^3} \right\} e(a+b+r)L_c^* - H''(m_c^*) < 0 \quad (2.43)$$

$$\left. \frac{\partial^2 \pi_c}{\partial L \partial m} \right|_{(m_c^*, L_c^*)} = \left. \frac{\partial^2 \pi_c}{\partial m \partial L} \right|_{(m_c^*, L_c^*)} = \frac{q'(m_c^*)}{[q(m_c^*)]^2} e(a+b+r) > 0 \quad (2.44)$$

To ensure that the second-order conditions for a max are satisfied, we make the additional assumption that

$$\left[\frac{\partial^2 \pi_c}{\partial L^2} \cdot \frac{\partial^2 \pi_c}{\partial m^2} \right]_{(m_c^*, L_c^*)} > \left[\frac{\partial^2 \pi_c}{\partial m \partial L} \right]_{(m_c^*, L_c^*)}^2 \quad (2.45)$$

Equilibriums in the product and the labor markets require that $\bar{p} = \alpha \cdot P(sF(eL))$ and $bL = a(N-L)$ or $a = bL/(N-L)$. Using these conditions we rewrite the conditions that characterize the competitive equilibrium as:

$$eL \cdot \frac{q'(m)}{[q(m)]^2} \cdot \left[\frac{bN}{N-L} + r \right] - H'(m) = 0 \quad (2.46)$$

$$\alpha se \cdot P(sF(eL)) \cdot F'(eL) - \left\{ \bar{w} + e + \frac{e}{q(m)} \left[\frac{bN}{N-L} + r \right] \right\} = 0 \quad (2.47)$$

These two conditions jointly determine the equilibrium levels of employment L_c^* and monitoring m_c^* chosen by the competitive firm.

In what follows we explore the properties of (2.46) and (2.47) in the (m, L) space. These properties will be useful in the comparison of competitive and monopoly equilibriums. Let $L = A_c(m)$ be the curve implied by equation (2.46), and $L = B_c(m)$ the curve represented by equation (2.47). The intersection of these two curves is (m_c^*, L_c^*) , representing the levels of monitoring and employment in the competitive equilibrium.

Lemma 2.3. *Both curves, $L = A_c(m)$ and $L = B_c(m)$, are strictly upward sloping in the (m, L) space.*

Proof. Let $\hat{\Phi}(m, L) = 0$ and $\hat{\Omega}(m, L) = 0$ denote equation (2.46) and (2.47), respectively. And let $\hat{\Phi}_j$ and $\hat{\Omega}_j$ ($j = m, L$) denote the partial derivative of $\hat{\Phi}$ and $\hat{\Omega}$ with respect to j . Then, the slopes of the two curves at the equilibria can be presented as $A'_c(m^*) = -\hat{\Phi}_m / \hat{\Phi}_L$ and $B'_c(m^*) = -\hat{\Omega}_m / \hat{\Omega}_L$. It is easy to obtain

$$\hat{\Phi}_L = \frac{eq'(m)}{[q(m)]^2} \left(\frac{bN}{N-L} + r \right) + \frac{ebNL \cdot q'(m)}{[q(m)]^2 (N-L)^2} \quad (2.48)$$

$$\hat{\Phi}_m = \left\{ -\frac{2[q'(m)]^2}{[q(m)]^3} + \frac{q''(m)}{[q(m)]^2} \right\} eL \cdot \left(\frac{bN}{N-L} + r \right) - H''(m) \quad (2.49)$$

$$\hat{\Omega}_L = \alpha s^2 e^2 \cdot P'(sF(eL)) \cdot [F'(eL)]^2 + \alpha s e^2 \cdot P(sF(eL)) \cdot F''(eL) - ebN[q(m)]^{-1} (N-L)^{-2} \quad (2.50)$$

$$\hat{\Omega}_m = \frac{eq'(m)}{[q(m)]^2} \left(\frac{bN}{N-L} + r \right) \quad (2.51)$$

The assumptions $q'(\cdot) > 0$, $q''(\cdot) < 0$, $H'(\cdot) > 0$ and $H''(\cdot) < 0$ imply that $\hat{\Phi}_L > 0$, $\hat{\Phi}_m < 0$, $\hat{\Omega}_L < 0$ and $\hat{\Omega}_m > 0$. Then,

$$A'_c(m) = -\hat{\Phi}_m / \hat{\Phi}_L > 0 \quad \text{and} \quad B'_c(m) = -\hat{\Omega}_m / \hat{\Omega}_L > 0$$

That is, both $L = A_c(m)$ and $L = B_c(m)$ are strictly upward slopping.

QED

Lemma 2.4 *At the equilibrium point (m_c^*, L_c^*) , the slope of $L = A_c(m)$ is greater than the slope of $L = B_c(m)$, that is, $A'_c(m_c^*) > B'_c(m_c^*)$.*

Proof. Denote $\hat{\Phi}_L^*$, $\hat{\Phi}_m^*$, $\hat{\Omega}_L^*$ and $\hat{\Omega}_m^*$ as the respective values at the equilibrium point (m_m^*, L_m^*) . Then, $A'_c(m_m^*) = -\hat{\Phi}_m^* / \hat{\Phi}_L^*$ and $B'_c(m_m^*) = -\hat{\Omega}_m^* / \hat{\Omega}_L^*$. Substitute the labor market steady state condition $a = bN/(N-L)$ into the second order conditions (2.42) – (2.44), and then compare them with $\hat{\Phi}_L^*$, $\hat{\Phi}_m^*$, $\hat{\Omega}_L^*$ and $\hat{\Omega}_m^*$ to obtain

$$\hat{\Phi}_L^* > \partial^2 \pi_c / \partial m \partial L \Big|_{(m_c^*, L_c^*)} > 0 \quad (2.52)$$

$$\hat{\Phi}_m^* = \partial^2 \pi_c / \partial m^2 \Big|_{(m_c^*, L_c^*)} < 0 \quad (2.53)$$

$$\hat{\Omega}_L^* < \partial^2 \pi_c / \partial L^2 \Big|_{(m_c^*, L_c^*)} < 0 \quad (2.54)$$

$$\hat{\Omega}_m^* = \partial^2 \pi_c / \partial m \partial L \Big|_{(m_c^*, L_c^*)} > 0 \quad (2.55)$$

Furthermore,

$$\begin{aligned}
 & \left[\hat{\Phi}_L^* - \partial^2 \pi_c / \partial m \partial L \Big|_{(m_c^*, L_c^*)} \right] \cdot \hat{\Omega}_m^* \\
 &= \left\{ \frac{ebNL_c^* \cdot q'(m_c^*)}{[q(m_c^*)]^2 (N - L_c^*)^2} \right\} \cdot \left\{ \frac{eq'(m_c^*)}{[q(m_c^*)]^2} \left(\frac{bN}{N - L_c^*} + r \right) \right\} \\
 &= \frac{e^2 bNL_c^* \cdot [q'(m_c^*)]^2}{[q(m_c^*)]^4 (N - L_c^*)^2} \cdot \left(\frac{bN}{N - L_c^*} + r \right)
 \end{aligned}$$

and

$$\begin{aligned}
 & \left[\hat{\Omega}_L^* - \partial^2 \pi_c / \partial L^2 \Big|_{(m_c^*, L_c^*)} \right] \cdot \hat{\Phi}_m^* \\
 &> \left\{ \frac{ebN}{q(m_c^*)(N - L_c^*)^2} \right\} \cdot \left\{ \frac{2eL_m^* [q'(m_c^*)]^2}{[q(m_c^*)]^3} \left(\frac{bN}{N - nL_c^*} + r \right) \right\} \\
 &> \frac{e^2 bNL_c^* \cdot [q'(m_c^*)]^2}{[q(m_c^*)]^4 (N - L_c^*)^2} \cdot \left(\frac{bN}{N - L_c^*} + r \right)
 \end{aligned}$$

That is,

$$\left[\hat{\Omega}_L^* - \partial^2 \pi_c / \partial L^2 \Big|_{(m_c^*, L_c^*)} \right] \cdot \hat{\Phi}_m^* > \left[\hat{\Phi}_L^* - \partial^2 \pi_c / \partial m \partial L \Big|_{(m_c^*, L_c^*)} \right] \cdot \hat{\Omega}_m^* \quad (2.56)$$

Using (2.45) and (2.52) – (2.56), we obtain

$$\begin{aligned}
 & \left[\partial^2 \pi_c / \partial L^2 \cdot \partial^2 \pi_c / \partial m^2 \right]_{(m_c^*, L_c^*)} > \left[\partial^2 \pi_c / \partial m \partial L \right]_{(m_c^*, L_c^*)}^2 \\
 & \Rightarrow \hat{\Omega}_L^* \cdot \hat{\Phi}_m^* > \hat{\Phi}_L^* \cdot \hat{\Omega}_m^* \Rightarrow \hat{\Phi}_m^* / \hat{\Phi}_L^* < \hat{\Omega}_m^* / \hat{\Omega}_L^* \Rightarrow -\hat{\Phi}_m^* / \hat{\Phi}_L^* > -\hat{\Omega}_m^* / \hat{\Omega}_L^* \\
 & \Rightarrow A'_c(m_c^*) > B'_c(m_c^*)
 \end{aligned}$$

That is, at the intersection (m_c^*, L_c^*) , the slope of $L = A_c(m)$ is greater than the slope of $L = B_c(m)$.

QED

2.4.2. Comparison of Monopoly with Competitive Benchmark

To determine the efficiency consequences of monopoly, we compare the monopoly equilibrium with that under perfect competition.

Proposition 2.5 *Relative to a perfectly competitive market, a monopolist employs fewer workers and invests less in the monitoring of workers.*

Proof. Note from (2.11) and (2.46) that $L = A_c(m)$ and $L = A_m(m)$ are exactly the same curve in the $(m-L)$ space. Now, we consider the relationship between $L = B_c(m)$ and $L = B_m(m)$.

$$(2-47). L = B_c(m) : se \cdot P(sF(eL)) \cdot F'(eL) - \left[\bar{w} + e + \frac{e}{q(m)} \left(\frac{bN}{N-L} + r \right) \right] = 0$$

$$(2-11). L = B_m(m) : s^2 e \cdot P'(sF(eL)) \cdot F'(eL) \cdot F(eL) + se \cdot P(sF(eL)) \cdot F'(eL) - \left[\bar{w} + e + \frac{e}{q(m)} \left(\frac{bN}{N-L} + r \right) \right] = 0$$

Since $P'(\cdot) < 0$ and $F'(\cdot) > 0$, we find that for any given L ,

$$\begin{aligned} se \cdot P(sF(eL)) \cdot F'(eL) &> s^2 e \cdot P'(sF(eL)) \cdot F'(eL) \cdot F(eL) + se \cdot P(sF(eL)) \cdot F'(eL) \\ \Rightarrow \bar{w} + e + \frac{e}{q(m_c)} \left(\frac{bN}{N-L} + r \right) &> \bar{w} + e + \frac{e}{q(m_m)} \left(\frac{bN}{N-L} + r \right) \Rightarrow q(m_c) < q(m_m) \end{aligned}$$

Since $q'(\cdot) > 0$, the above inequality implies that $m_c < m_m$. That is, for any given L , the corresponding value of m on the curve $L = B_c(m)$ is always smaller than the corresponding value of m on the curve $L = B_m(m)$. In other words, the curve $L = B_m(m)$ must be everywhere below the curve $L = B_c(m)$.

Therefore, we can draw the three curves, $L = A(m)$, $L = B_c(m)$ and $L = B_m(m)$, in the m - L space in the same diagram as shown in Figure 2.6. Because $B_m(m)$ is completely below $B_c(m)$ and $A(m)$ is upward sloping, the monopoly equilibrium E_m must lie on the left and below to the

FIGURE 2.6 Monopoly Equilibrium vs. Competitive Equilibrium

competitive equilibrium E_c . From Figure 2.6 we see that both the level of employment and the level of monitoring are lower in the case of monopoly.

QED

Since the quantity produced is an increasing function of employment, Proposition 2.5 in turn implies that the monopolist produces a smaller output and accordingly sets a higher price than a competitive firm. On the surface, these output and price effects of monopoly appear to be the same as in the standard monopoly case. However, there are more factors at play in this model. Intuitively, a monopolist has a tendency to restrict output because it faces a downward sloping demand curve. As a result of this tendency,

employment level falls, which tends to push down the non-shirking wage. In our model this has an additional effect because it induces the monopolist to reduce the level of monitoring, causing a further fall in employment.

Indeed, from Figure 2.6 we can see that holding the level of monitoring (at the corresponding competitive monitoring level) and hence the detection rate $q(m)$ constant, monopoly would reduce the employment level from L_c^* to $\hat{L}_m^*$. But the lower investment in monitoring by the monopolist causes the employment level to drop further from $\hat{L}_m^*$ to L_m^* .

Note that the efficiency wage received by workers is actually

$$w^* = \bar{w} + e + \frac{e}{q(m)} \left(\frac{bN}{N-L} + r \right) \quad (2.57)$$

which implies that the wage rises with employment but decreases with monitoring, $\partial w^* / \partial L > 0$ and $\partial w^* / \partial m < 0$. Then, Proposition 2.5 suggests that the effect of monopoly on the wage rate is ambiguous since monopoly causes the levels of both employment and monitoring to fall.⁹

2.5 Simulations

In this section, we conduct numerical simulations using a version of our model with specific functional forms. The objectives of these simulations are to provide concrete examples for the ambiguous results in the general model, and more importantly, to

⁹ In the literature there is no consensus regarding the question whether product market power has positive effect on the wage. For example, Nickell (1999) argues that an overall rise in market power throughout the economy will lead to both higher unemployment and lower wages. In another paper, however, Nickell *et al.* (1994) show empirically that product market power does have a positive impact on wages.

quantify the welfare effects of monopoly. Specifically, the model is simulated to compare the consumer surplus, producer surplus and total surplus under monopoly and the competitive benchmark.

2.5.1. Functional Forms

Suppose that the inverse demand function is given by:

$$P(Q) = \alpha \cdot (A - B \cdot Q^\tau) \quad (2.58)$$

where α , A , B and τ are all positive parameters. Note that this function degenerates into a linear demand function when $\tau = 1$. The production function takes the form

$$Y = F(L) = s \cdot L^\rho \quad (2.59)$$

where $0 < \rho < 1$. In the above production function the worker's effort is normalized to one, $e = 1$. The monitoring technology is represented by

$$q(m) = \frac{\delta \cdot m}{m + \theta} \quad (2.60)$$

where $0 < \delta \leq 1$ and $\theta > 0$. The monopolist's monitoring cost function is

$$H(m) = \beta \cdot m^\gamma \quad \text{with } \beta > 0, \gamma > 1 \quad (2.61)$$

Using these functions, we solve the monopoly equilibrium and the competitive benchmark as follows. The monopolist's optimization problem can be presented as

$$\max_{\{m, L\}} \pi = \alpha \cdot \left[A - B \cdot (sL^\rho)^\tau \right] \cdot sL^\rho - \left[\bar{w} + 1 + \frac{m + \theta}{\delta m} (a + b + r) \right] L - \beta m^\gamma \quad (2.62)$$

The first order conditions yield

$$\frac{\theta(a + b + r)L}{\delta m^2} - \beta \gamma m^{\gamma-1} = 0 \quad (2.63)$$

$$\left(A - Bs^\tau L^{\rho\tau} \right) \cdot \alpha s \rho L^{\rho-1} - B\alpha \rho \tau s^{\tau+1} L^{\rho\tau+\rho-1} - \left[\bar{w} + 1 + \frac{m_m + \theta}{\delta m_m} (a + b + r) \right] = 0 \quad (2.64)$$

Using the labor market steady state condition $a = bL/(N - L)$, and rearranging the above equations, we have the following equilibrium conditions for the monopoly case

$$\theta \left[(N - L)r + Nb \right] L - \delta \beta \gamma (N - L) m^{\gamma+1} = 0 \quad (2.65)$$

$$\left(A - Bs^\tau L^{\rho\tau} \right) \cdot \alpha s \rho L^{\rho-1} - B\alpha \rho \tau s^{\tau+1} L^{\rho\tau+\rho-1} - \left[\bar{w} + 1 + \frac{m + \theta}{\delta m} \left(\frac{bN}{N - L} + r \right) \right] = 0 \quad (2.66)$$

In the competitive benchmark the firm's optimization problem can be written as:

$$\max_{\{m, L\}} \pi_c = \bar{p} \cdot s L^\rho - \left[\bar{w} + 1 + \frac{m + \theta}{\delta m} (a + b + r) \right] L - \beta m^\gamma \quad (2.67)$$

The first order conditions are

$$\frac{\theta(a + b + r)L}{\delta m^2} - \beta \gamma m^{\gamma-1} = 0 \quad (2.68)$$

$$\bar{p} \cdot s \rho L^{\rho-1} - \left[\bar{w} + 1 + \frac{m + \theta}{\delta m} (a + b + r) \right] = 0 \quad (2.69)$$

Substituting the product market clearing condition and the labor market steady state condition, $\bar{p} = P(F(L)) = \alpha \cdot \left[A - B \cdot (sL^\rho)^\tau \right]$ and $a = bL/(N - L)$, into the first order conditions, we obtain the following equilibrium conditions that characterize the competitive equilibrium:

$$\theta \left[(N - L)r + Nb \right] L - \delta \beta \gamma (N - L) m^{\gamma+1} = 0 \quad (2.70)$$

$$\left(A - Bs^\tau L^{\rho\tau} \right) \cdot \alpha s \rho L^{\rho-1} - \left[\bar{w} + 1 + \frac{m + \theta}{\delta m} \cdot \left(\frac{bN}{N - L} + r \right) \right] = 0 \quad (2.71)$$

2.5.2. Monopoly Equilibrium vs. Competitive Benchmark

In this section, we present the simulation results that illustrate the properties of the monopoly equilibrium. Those of the competitive benchmark are also presented to illustrate the effects of monopoly.

TABLE 2.1 Competitive Equilibrium vs. Monopoly Equilibrium Functions, Parameters & Results

Parameters & Values	Separation Rate (b)	Interest Rate (r)	Technology Shocks (s)	Market Size (α)	Unemployment Benefit ($\bar{w}$)	Total Labor (N)
	0.05	0.05	1.0	1.0	0.5	1000
Functions	Demand Function		Production Function		Monitoring Tech.	Monitoring Cost
	$p = 100 - 0.1Q^{1.5}$		$F(L) = L^{0.65}$		$q(m) = \frac{0.8m}{m+15}$	$H(m) = 6m^3$
Results	Employment		Monitoring Level		Percentage Change of employment $(L_c^* - L_m^*) / L_c^*$	Change of Unemployment Rate $(u_m^* - u_c^*)$
	L_c^*	L_m^*	m_c^*	m_m^*		
	672.29	324.04	3.451	2.543	51.80%	34.83%
	Equilibrium Price		Equilibrium Output		Efficiency Wage	
	Competitive (p_c^*)	Monopoly (p_m^*)	Competitive (Y_c^*)	Monopoly (Y_m^*)	Competitive (w_c^*)	Monopoly (w_m^*)
	42.8698	71.9564	68.851	42.844	2.8538	2.5689

Table 2.1 presents the simulation results from a particular set of parameter values. They confirm that relative to the competitive benchmark, monopoly in the product market indeed leads to a higher unemployment rate and a lower level of monitoring. As expected, the monopolist produces a smaller quantity and charges a higher price.

Interestingly, in this particular case the monopolist offers a lower efficiency wage despite the lower level of monitoring.

However, as has been observed in the discussion of the general model, monopoly may also lead to a higher wage rate. For example, if the value of s is changed from 1.0 to 2.0, the equilibrium wages become $w_m^* = 2.6507$ under monopoly and $w_c^* = 2.5707$ under perfect competition. These examples illustrate that, in general, monopoly has an ambiguous effect on the wage.

Recall from Proposition 2.1 that a higher separation rate b raises the unemployment rate but has an ambiguous effect on the monopolist's monitoring level. The following simulations, based on the parameters in Table 2.2, illustrate that this is indeed the case.

TABLE 2.2 Effects of Separation Rate Functions & Parameters

Parameters & Values	Separation Rate (b)	Interest Rate (r)	Technology Shocks (s)	Market Size (α)	Unemployment Benefit ($\bar{w}$)	Labors Force (N)
	0.0001 ~ 0.3	0.05	1.0	1.0	0.5	500
Functions	Demand Function	Production Function		Monitoring Tech.		Monitoring Cost
	$P(Q) = 100 - 0.1Q^{1.5}$	$F(L) = L^{0.5}$		$q(m) = \frac{0.8m}{m+15}$		$H(m) = 6m^3$

From Figure 2.7, we see that the equilibrium unemployment rate under monopoly indeed rises with b but the increasing rate falls as b becomes larger. Incidentally, we can see from the diagram that the unemployment rate under the competitive equilibrium displays the same pattern. The gap of unemployment rate between monopoly and the competitive benchmark, $\Delta u^* \equiv u_m^* - u_c^*$, falls as b increases.

Figure 2.8 illustrates that the higher separation rate can either raise or reduce the monopolist's monitoring. Note that the critical value of $\bar{b}$ is defined by $dm_m^*/db|_{b=\bar{b}} = 0$. For $b < \bar{b}$, a

higher separation rate raises the monopolist's monitoring level.

The opposite is true for $b > \bar{b}$. In addition, we see from Figure 2.8 that the relationship between the separation rate and the monitoring level under perfect competition displays the same pattern, with $\underline{b}$ being the critical value for the competitive case.

Recall from Proposition 2.2 that a positive technology shock may have either a positive or negative effect on both unemployment rate and monitoring level. Simulations based parameters in Table 2.3 confirm this general result.

FIGURE 2.7 Effect of Separation Rate on Unemployment Rate

FIGURE 2.8 Effect of Separation Rate on the level of Monitoring

Table 2.3 Effects of Technology Shocks
Functions & Parameters

Parameters & Values	Separation Rate (b)	Interest Rate (r)	Technology Shocks (s)	Market Size (α)	Unemployment Benefit ($\bar{w}$)	Labors Force (N)
	0.05	0.05	0.2 ~ 3.0	1.0	0.5	1000
Functions	Demand Function		Production Function		Monitoring Tech.	Monitoring Cost
	$P(Q) = 100 - 0.1Q^{1.5}$		$F(L) = L^{0.65}$		$q(m) = \frac{0.8m}{m+15}$	$H(m) = 6m^3$

The simulations are illustrated in Figures 2.9 and 2.10. They show that under monopoly, unemployment rate decreases and monitoring level increases with s if the value of s is below the critical value $\underline{s}$, and the opposite

is true if s is above $\underline{s}$. Incidentally, the unemployment and the level of monitoring in the competitive benchmark displays the same pattern, but its critical value, $\bar{s}$, is larger than $\underline{s}$.

FIGURE 2.9 Effects of Technology Shocks on Monitoring

Figure 2.10 Effects of Technology Shocks on Unemployment Rate

2.5.3. Welfare Effects of Monopoly

2.5.3.1. The Measures of Welfare

Given that this is a partial equilibrium model, we will use the total surplus as the measure of welfare. Note that compared with the standard textbook model of monopoly, we have an additional group of agents in our model, the workers. In principle, the measure of total welfare should also take into consideration the utility of workers. This raises an additional issue of how to treat the unemployment benefits. If the unemployment benefits are financed by lump sum taxes on consumers, they are merely a wealth transfer and as such should not be included in the total surplus. Alternatively, if there are no government transfer payments and the unemployment benefits merely represent the value that an unemployed worker obtain from home production, the unemployment benefits should be included in the total surplus. Therefore, in our simulations we use total surplus measures that include both cases. In addition, for completeness we also consider the conventional measure of total surplus that takes into consideration the welfare of consumers and the firms only (i.e. excluding the workers).

Therefore, in our welfare analysis we use the following three measures of total surplus:

- **Type I:** Use the traditional definition of the consumer surplus, producer surplus and total surplus.

$$\text{Consumer surplus: } CS \equiv \int_0^{Q^*} P(Q)dQ - P(Q^*) \cdot Q^*$$

$$\text{Producer surplus: } PS \equiv P(Q^*) \cdot Q^* - w^*L - H(m^*)$$

$$\text{Total surplus: } TS \equiv CS + PS = \int_0^{Q^*} P(Q)dQ - w^*L - H(m^*)$$

- **Type II:** Assume that workers are also consumers and thus include the workers' utility as a part of the consumer surplus. Recall that the worker's utility is defined as

$$U_L(w, e) = \begin{cases} w^* - e & \text{if employed} \\ \bar{w} & \text{if unemployed} \end{cases}$$

Moreover, assume that the unemployment benefits come from home production, so that the unemployment benefits are included in the calculation of surpluses.

$$CS \equiv \int_0^{Q^*} P(Q) dQ - P(Q^*) \cdot Q^* + (w^* - e) \cdot L^* + \bar{w} \cdot (N - L^*)$$

$$PS \equiv P(Q^*) \cdot Q^* - w^* L^* - H(m^*)$$

$$TS \equiv CS + PS = \int_0^{Q^*} P(Q) dQ - e \cdot L^* + \bar{w} \cdot (N - L^*) - H(m^*)$$

- **Type III:** This measure is the same as Type II except that we assume that the unemployment benefits are transfers and thus are not included in the calculations of surpluses.

$$CS \equiv \int_0^{Q^*} P(Q) dQ - P(Q^*) \cdot Q^* + (w^* - e) \cdot L^*$$

$$PS \equiv P(Q^*) \cdot Q^* - w^* L^* - H(m^*)$$

$$TS \equiv CS + PS = \int_0^{Q^*} P(Q) dQ - e \cdot L^* - H(m^*)$$

In countries where unemployment benefits take the form of income transfer from governments to unemployed workers, type III total surplus is the most appropriate type of welfare measure among the three presented here.

Note that the monopolist's costs of monitoring effort and/or investment are included in the calculation of producer surplus.

2.5.3.2. General Comparisons of Welfare

For Type I total surplus, we have

$$TS_c^I = \int_0^{Q_c^*} P(Q)dQ - w_c^* \cdot L_c^* - H(m_c^*) \text{ and } TS_m^I = \int_0^{Q_m^*} P(Q)dQ - w_m^* \cdot L_m^* - H(m_m^*)$$

It is clear that $\int_0^{Q_c^*} P(Q)dQ > \int_0^{Q_m^*} P(Q)dQ$ and $H(m_c^*) > H(m_m^*)$ since we have $L_c^* > L_m^*$ and $m_c^* > m_m^*$. And, as discussed in section 2.4.2, the competitive efficiency wage w_c^* may be *greater or less* than the monopoly efficiency wage w_m^* . Therefore, the term $w_c^* \cdot L_c^*$ may be greater or less than the term $w_m^* \cdot L_m^*$. That is to say, monopoly may generate a higher Type I total surplus than competition does. Specifically, $TS_m^I > TS_c^I$ if and only if

$$\underbrace{\left[w_c^* \cdot L_c^* - w_m^* \cdot L_m^* \right]}_{\substack{\text{Difference of} \\ \text{Total Wages} \\ \Delta W}} + \underbrace{\left[H(m_c^*) - H(m_m^*) \right]}_{\substack{\text{Difference of} \\ \text{Monitoting Cost} \\ \Delta H}} > \underbrace{\int_{Q_m^*}^{Q_c^*} P(Q)dQ}_{\substack{\text{Difference of Gross} \\ \text{Consumer Surplus} \\ \Delta CS_g}} \quad (2.72)$$

(2.72) indicates that monopoly may be superior to perfect competition in terms of Type I total surplus if and only if the difference of total production cost ($\Delta W + \Delta H$) is greater than the difference of gross consumer surplus (ΔCS_g).

Similarly, for Type II total surplus, we have

$$TS_c^{II} = \int_0^{Q_c^*} P(Q)dQ - e \cdot L_c^* + \bar{w} \cdot (N - L_c^*) - H(m_c^*)$$

and $TS_m^{II} = \int_0^{Q_m^*} P(Q)dQ - e \cdot L_m^* + \bar{w} \cdot (N - L_m^*) - H(m_m^*)$

Since $L_c^* > L_m^*$ and $m_c^* > m_m^*$, $\int_0^{Q_c^*} P(Q)dQ > \int_0^{Q_m^*} P(Q)dQ$, $e \cdot L_c^* > e \cdot L_m^*$, $H(m_c^*) > H(m_m^*)$ and $\bar{w} \cdot (N - L_c^*) < \bar{w} \cdot (N - L_m^*)$. Then, compared to monopoly, perfect competition possibly results in a lower *Type II* total surplus. And $TS_m^{II} > TS_c^{II}$ if and only if

$$\underbrace{\left[e \cdot (L_c^* - L_m^*) \right]}_{\substack{\text{Difference of} \\ \text{Total Efforts} \\ \text{exerted by workers} \\ \Delta E}} + \underbrace{\left[\bar{w} \cdot (L_c^* - L_m^*) \right]}_{\substack{\text{Difference of Total} \\ \text{Unemployment Benefits} \\ \Delta \bar{W}}} + \underbrace{\left[H(m_c^*) - H(m_m^*) \right]}_{\substack{\text{Difference of} \\ \text{Monitoting Cost} \\ \Delta H}} > \underbrace{\int_{Q_m^*}^{Q_c^*} P(Q)dQ}_{\substack{\text{Difference of Gross} \\ \text{Consumer Surplus} \\ \Delta CS_g}} \quad (2.73)$$

(2.73) implies that monopoly may generate a higher *Type II* total surplus than perfect competition does in case that the difference of total pay-outs (the workers: ΔE ; the society: $\Delta \bar{W}$; the firm/manager: ΔH) is greater than the difference of gross consumer surplus.

Finally, for *Type III* total surplus, we have

$$TS_c^{III} = \int_0^{Q_c^*} P(Q)dQ - e \cdot L_c^* - H(m_c^*) \quad \text{and} \quad TS_m^{III} = \int_0^{Q_m^*} P(Q)dQ - e \cdot L_m^* - H(m_m^*)$$

It is easy to obtain $\int_0^{Q_c^*} P(Q)dQ > \int_0^{Q_m^*} P(Q)dQ$, $e \cdot L_c^* > e \cdot L_m^*$, $H(m_c^*) > H(m_m^*)$ because $L_c^* > L_m^*$ and $m_c^* > m_m^*$. Thus, monopoly may also lead to a higher *Type III* total surplus than perfect competition does. Specifically, $TS_m^{III} > TS_c^{III}$ if and only if

$$\underbrace{\left[e \cdot (L_c^* - L_m^*) \right]}_{\substack{\text{Difference of} \\ \text{Total Efforts} \\ \text{exerted by workers} \\ \Delta E}} + \underbrace{\left[H(m_c^*) - H(m_m^*) \right]}_{\substack{\text{Difference of} \\ \text{Monitoting Cost} \\ \Delta H}} > \underbrace{\int_{Q_m^*}^{Q_c^*} P(Q)dQ}_{\substack{\text{Difference of Gross} \\ \text{Consumer Surplus} \\ \Delta CS_g}} \quad (2.74)$$

The left hand side of (2.74) is the sum of the difference of worker's efforts put into production (ΔE) and the difference of monitoring cost (ΔH). And the right hand side is the difference of gross consumer surplus (ΔCS_g).

These general analyses imply that, no matter which measure is used, monopoly may possibly generate a higher total welfare than perfect competition.

2.5.3.3. Simulations of Welfare Effects of Monopoly

Our simulation results show that the total surplus under monopoly is not necessarily lower than that under perfect competition. This is true for all the three measures of total surplus. In what follows we present a number of examples to illustrate.

Figures (2.11) and (2.12) show that monopoly may improve welfare as defined by the textbook version of total surplus (i.e. Type I). Figure 2.11 is based on the simulation results using the parameter values in Table 2.2. It shows that if separation rate is big enough ($b > 0.24$), monopoly generates higher total surplus than competition does. Figure 2.12 is based on the simulations results using the parameter values in Table 2.3. From this graph we see that for s in a particular interval ($0.3 \leq s \leq 0.8$), the total surplus under monopoly is larger than that under perfect competition.

FIGURE 2.11 Effects of Separation Rate on Welfare (Type I)

FIGURE 2.12 Effects of Technology Shocks on Welfare (Type I)

To illustrate that monopoly may improve welfare as measured by Type II and Type III total surplus, we present the simulation results for the case where $s = 0.35$.

Figures 2.13 and 2.14 show how the Type II total surplus varies as the value of either α or $\bar{w}$ changes. From Figure 2.13 we see that Type II total surplus under monopoly exceeds that under perfect competition if the market size parameter α is greater than 2.42. The same can be said about Figure 2.14 for the case where unemployment benefits $\bar{w}$ is lower than 0.948.

FIGURE 2.13 Effects of Market Size on Welfare (Type II)

FIGURE 2.14 Effects of Unemployment Benefit Welfare (Type II)

The same simulations are done by using Type III total surplus, and the results are qualitatively similar to those using Type II total surplus. As we can see from Figures (2.15) and (2.16), monopoly improves welfare if, *ceteris paribus*, s is relatively large or $\bar{w}$ is relatively small.

FIGURE 2.15 Effects of Market Size on Welfare (Type III)

FIGURE 2.16 Effects of Unemployment Benefit on Welfare (Type III)

These numerical simulations, together with the general analysis in section 2.5.3.2, demonstrate that

Proposition 2.6. *Monopoly is not always dominated by perfect competition in terms of economic efficiency if an efficiency wage is offered and unemployment is taken into consideration.*

2.5.4. The Role of Endogenous Detection Rate q

An important feature of our model is that the probability of detection q is endogenous. In this sub-section we explore the role of this endogeneity in the welfare effects of monopoly. We will do so by first making an observation on the general model and then present a number of examples from the simulation exercises.

To determine the role played by the endogenous detection rate, we consider a restricted version of our model where m and accordingly q are fixed at the level of the competitive equilibrium; in other words, the value of m is fixed at m_c^* , and the value of q is fixed at q_c^* . As illustrated in Figure 2.17, the level of employment in the equilibrium of this restricted model is lower than that in the competitive equilibrium. It turns out we can make a similar statement about welfare measured in terms of Type II and Type III total surplus. From the definition of Type II total surplus, we find that for fixed m , $\partial TS^II / \partial L^* = P(sF(eL^*)) \cdot seF'(eL^*) - (\bar{w} + e) > 0$ for all $L < L_c^*$. In determining the sign of this derivative we have used the first-order condition of the competitive firm's profit-maximization problem. Since $\hat{L}_m^* < L_c^*$, we know that $TS_c^II > \widehat{TS}_m^II$. Similarly, we can show that for Type III total surpluses, $TS_c^III > \widehat{TS}_m^III$. That is, when workers' utilities are included in the total surplus,

FIGURE 2.17 Role of Endogenous Detection Rate (q)

monopoly with an exogenous detection rate always reduces welfare.

FIGURE 2.18 Comparison of Type II Total Surplus
Endogenous q vs. Exogenous q

FIGURE 2.19 Comparison of Type III Total Surplus
Endogenous q vs. Exogenous q

This finding implies that when measured by Type II and Type III total surplus, the ambiguous welfare effect of monopoly in our model is driven by endogenous detection rate. Indeed, simulation results show that under some range of parameter values endogenizing q can increase Type II and III total surplus. One set of such examples are presented in Figures 2.18 and 2.19, which are based on the parameter values in Table 2.3

except a different market size. They show that for a large enough s , Type II and Type III total surpluses are higher under monopoly with endogenous q than that with exogenous q .

It should be pointed out that the above conclusions about Type II and Type III total surplus do not apply to Type I total surplus. The example in Figure 2.20, from simulations using the parameter values in Table 2.3, illustrate the possibility that (i) even with exogenous detection rate, Type I total surplus may still be higher under monopoly than under perfect competition; and (ii) endogenous choice of monitoring (and hence endogenous detection rate) may improve the total surplus in the monopoly equilibrium despite the lower employment and smaller output. As we can see from Figure 2.20, $\widehat{TS}_m > TS_c$ if $0.286 < s < 0.789$. Furthermore, since $TS_m > \widehat{TS}_m$ in this case, for s in this range the Type I total surplus under monopoly with endogenous q is larger than that under perfect competition.

FIGURE 2.20 Comparison of Total Surplus (Type I)
Perfect Competition vs.
Monopoly with Exogenous q

2.6 Extension

So far in the model, we have assumed that there is only one firm (the monopolist or the representative competitive firm) in the economy. Therefore, the wage rate offered by the firm is also the wage rate of the economy. In this section, we extend the one-firm model to an M -firm case: assume there are M monopolized industries in the economy. All firms face identical downward slopping demand and have identical concave production technology represented by (2.75) and (2.76), respectively.¹⁰

$$p_i = \alpha P(Q_i), \quad i = 1, 2, \dots, M \quad (2.75)$$

$$y_i = sF(eL_i), \quad i = 1, 2, \dots, M \quad (2.76)$$

In this case, we need to distinguish firm i 's wage rate to the aggregate wage rate. Enlightened by our discussion in section 1.1, we may write the no-shirking wage offered by firm i as

$$w_i = \frac{(w_{-i} - e)a + \bar{w}(b + r)}{(a + b + r)} + \left[1 + \frac{b + r}{q(m)} \right] e \quad (2.77)$$

where w_{-i} represents the average wage rate of the economy other than firm i .

Each monopolist chooses his own employment L_i and monitoring m_i to maximize its profit. That is, for firm i

$$\max_{\{m_i, L_i\}} \pi_i = \alpha P(sF(eL_i)) \cdot sF(eL_i) - \left\{ \frac{(w_{-i} - e)a + \bar{w}(b + r)}{(a + b + r)} + \left[1 + \frac{b + r}{q(m_i)} \right] e \right\} L_i - H(m_i) \quad (2.78)$$

The first-order conditions are

¹⁰ The properties of these functions are same as what we have assumed in section 2.1.

$$\frac{q'(m_i)}{[q(m_i)]^2} e(b+r)L_i - H'(m_i) = 0 \quad (2.79)$$

$$\begin{aligned} \alpha s^2 e \cdot P'(sF(eL_i)) F'(eL_i) F(eL_i) + \alpha s e \cdot P(sF(eL_i)) F'(eL_i) \\ - \left\{ \frac{(w_{-i} - e)a + \bar{w}(b+r)}{(a+b+r)} + \left[1 + \frac{b+r}{q(m_i)} \right] e \right\} = 0 \end{aligned} \quad (2.80)$$

At equilibrium, $w_i = w_{-i}$ for all i since all firms are identical. Then, we may derive w_i from (2.77) as

$$w_i = \bar{w} + e + \frac{e}{q(m_i)} (a+b+r) \quad (2.81)$$

Substituting the labor market steady state condition $a = bML_i / (N - ML_i)$ and (2.81) into the first order conditions, we obtain

$$\frac{q'(m_i)}{[q(m_i)]^2} e(b+r)L_i - H'(m_i) = 0 \quad (2.82)$$

$$\begin{aligned} \alpha s^2 e \cdot P'(sF(eL_i)) F'(eL_i) F(eL_i) + \alpha s e \cdot P(sF(eL_i)) F'(eL_i) \\ - \left[\bar{w} + e + \frac{e}{q(m_i)} \left(\frac{bN}{N - ML_i} + r \right) \right] = 0 \end{aligned} \quad (2.83)$$

Similarly, we may derive the equilibrium conditions for a competitive benchmark case as

$$\frac{q'(m_{ci})}{[q(m_{ci})]^2} e(b+r)L_{ci} - H'(m_{ci}) = 0 \quad (2.84)$$

$$\alpha s e \cdot P(sF(eL_{ci})) F'(eL_{ci}) - \left[\bar{w} + e + \frac{e}{q(m_{ci})} \left(\frac{bN}{N - ML_{ci}} + r \right) \right] = 0 \quad (2.85)$$

Using the same technique as in section four, it is not difficult to prove that, at equilibrium every monopolist employs fewer workers compared to the competitive benchmark case, $L_i^* < L_{ci}^*$. Therefore, the aggregate equilibrium employment under monopoly ($L^* \equiv ML_i^*$) will be lower than the aggregate equilibrium employment under perfect competition ($L_c^* \equiv ML_{ci}^*$), $L^* < L_c^*$. Moreover, relative to the competitive benchmark, every monopolist puts less effort or investment into monitoring, $m_i^* < m_{ci}^*$. Additionally, it is easy to demonstrate that the properties of this M -industry model are the same with what we have derived for the one-firm model in section 2.3.

Furthermore, numerical simulations (to avoid verbosity, we do not present them here) also suggest that monopoly may generate higher welfare, measured by the three types of total surplus, than perfect competition does.

2.7 Conclusions

In this chapter we have analyzed the efficiency and employment consequences of monopoly in the presence of unemployment caused by efficiency wage considerations. We have shown that in addition to a smaller output and a higher price, monopoly also leads to higher unemployment rate than the competitive equilibrium.

It is worth noting that the effects of monopoly on the wage rate and total welfare, however, are ambiguous. Numerical simulations of the model indicate that under certain range of parameter values, monopoly generates higher total surplus than perfect competition. Therefore, by introducing an additional distortion (i.e. unemployment) into

the model, it is no longer the case that monopoly is always dominated by perfect competition in terms of economic efficiency.

Another contribution of this chapter is that we have constructed an efficiency-wage model that takes into consideration the demand condition that the firm faces and the firm's choice of monitoring. The introduction of these additional considerations has generated some interesting results. For example, we have found that the effects of a technology shock on unemployment and the firm's monitoring depend on the properties of the product demand function; a positive technology shock that raises the marginal product of labor may in fact reduce the level of employment if product demand is not sufficiently elastic.

Chapter 3

Unemployment and Product Market Competition: Perspective from an Efficiency Wage Model

3.1 Introduction

How does the intensity of product market competition affect unemployment and the wage? The answer, based on standard textbook theory, seems to be that an increase in competition intensity should reduce unemployment and raise the wage. This is because more intense competition in the product market reduces price and increases the quantity produced. A larger output implies that more labor is employed in production, and with an upward-sloping labor supply curve, a stronger labor demand also bids up the wage.

This conclusion has been supported by the majority of recent theoretical analyses on the question. These include Nickell (1999), Gerbach (2000), Blanchard and Giavazzi (2003), Ebell and Haefke (2003), and Spector (2004). Nickell (1999) argues that, due to augmented output and the resulting outward shift in the labor demand curve, increased product market competition will lead to higher employment and (possibly) higher real wages through the wage-bargaining schedule. Gersbach (2000), by using a simple general equilibrium model, shows that lower markups achieved through product market competition always have a positive impacts on employment. Blanchard and Giavazzi (2003) and Spector (2004) demonstrate, in the context of a monopolistic competition model with collective wage bargaining, that increased product market competition will

increase the level of employment. A similar result is also obtained by Ebell and Haefke (2003) from a monopolistic competition model where unemployment is caused by the Mortensen-Pissarides matching mechanism.

However, there are at least two exceptions to this mainstream view on the relationship between product market competition and unemployment. They are Koskela and Stenbacka (2005) and Amable and Gatti (2004). Using a deterministic model with product and labor market imperfections, Koskela and Stenbacka (2005) investigate the implications of product market imperfections for profit sharing, wage negotiation and equilibrium unemployment and show that reduced distortions in the product market do not necessarily improve the performance of the labor market. Specifically, intensified product market competition will hurt employment if the product market imperfection is “sufficiently strong” and the relative bargaining power of the trade union is not “high enough”. Amable and Gatti (2004) construct a model of monopolistic competition with efficiency-wage unemployment, where both the hiring rate and the job separation rate are endogenously determined. They show that an increase in product market competition may generate employment losses because it raises the job separation rate and pushes up the efficiency wage.

In this chapter we contribute to the debate over the impact of product market competition on unemployment by studying a model where oligopolistic firms compete in quantity and unemployment is caused by efficiency wage considerations (Shapiro and Stiglitz 1984). Our modeling of efficiency wage unemployment differs from that of Amable and Gatti (2004) in that (i) we maintain Shapiro-Stiglitz’s original assumption of

a constant job separation rate, and (ii) we endogenize the probability of catching a shirker by making it a function of a firm's monitoring. These differences from Amable and Gatti (2004) allow us to uncover a different mechanism through which an increase in competition affects unemployment.

We show that while more intensive competition in the product market (measured by an increase in the number of firms in the market) increases output and reduces price, it does not necessarily lead to a lower unemployment rate or a higher wage rate for workers. Consequently, the relation between the intensity of competition and the level of employment is not always monotonic, and, in some instances, has an inverted-U shape. A key factor that drives our result is the effort or investment in monitoring put by each firm. By reducing the equilibrium price and the level of output produced by each firm, more intense competition lowers the marginal benefit of monitoring effort. Consequently, firms reduce their investments in monitoring effort, which, *ceteris paribus*, pushes up the wage rate. This, in turn, tends to reduce total employment.

This chapter is organized as follows. We set up the model in section 3.2, and characterize and establish the existence and uniqueness of a symmetric Nash equilibrium in section 3.3. The effects of competition on the equilibrium are studied in section 3.4, and the welfare consequences of competition are discussed in section 3.5. In section 3.6 we present the results from the numerical simulations of our model. Conclusions are in section 3.7.

3.2 The Model

Consider a market with n identical firms that produce a homogenous product under the same production technology, which is represented by

$$y_i = s \cdot F(e \cdot l_i), \text{ with } F'(\cdot) > 0 \text{ and } F''(\cdot) \leq 0, i = 1, 2, \dots, n \quad (3.1)$$

In (3.1), s represents technological shocks, l_i is the number of workers employed by firm i , and e is each individual worker's effort while on the job. The value of e equals zero if the worker shirks, and equals a positive constant if he does not. Let $Y \equiv \sum_i y_i$ be the total output of the industry.

Suppose the industry faces an inverse demand function given by

$$p = \alpha \cdot P(Q) \quad (3.2)$$

where p is price, Q is quantity, and $\alpha > 0$ is a measure of market size. We make the standard assumption that $P'(Q) < 0$ and $P'(Q) + Q \cdot P''(Q) \leq 0$ for all $Q \geq 0$.¹¹ Note that these assumptions imply that, (i) each individual firm's marginal revenue is decreasing in its own output; and (ii) each firm's marginal revenue is decreasing in its rivals' output.

Suppose that there are a total of N workers in the economy who possess the skills necessary for working in this industry.¹² Workers are perfectly mobile across firms in this industry. As mentioned in Chapter 2, workers may shirk and the firm can only

¹¹ This assumption is equivalent to $\sigma \leq 1$, where $\sigma \equiv -Q \cdot P''(Q) / P'(Q)$ is a measure of the demand curve's concavity/convexity. The demand curve is linear if $\sigma = 0$; it is concave if $\sigma > 0$; and it is convex if $\sigma < 0$. The assumption $\sigma \leq 1$ thus means that the demand curve can be convex, linear or a little bit concave.

¹² We assume that the labor market for the rest of the economy is fully flexible and hence does not have unemployment.

imperfectly detect the shirking. If a worker is caught shirking, he will be fired, in which case he collects an unemployment benefit, $\bar{w}$, from the government. To induce the workers not to shirk, a firm has to offer them a sufficiently high wage. As derived in section 1.1, firm i 's non-shirking wage is:

$$w_i = \frac{(w_{-i} - e)a + \bar{w}(b + r)}{(a + b + r)} + \left[1 + \frac{b + r}{q(m_i)} \right] e \quad \text{with } q'(\cdot) > 0 \text{ and } q''(\cdot) < 0 \quad (3.3)$$

where w_{-i} represents the aggregate wage rate of the industry other than firm i ; a is the job acquisition rate; b is the separation rate; r is the intertemporal discount rate; and q is the probability that a shirking worker is detected. As in Chapter 2, we assume that q is an increasing and concave function of the firm's monitoring (m_i). The costs of monitoring are represented by function $H(m_i)$ with $H'(\cdot) > 0$ and $H''(\cdot) > 0$.

In the steady state of the labor market, the flow into the unemployment pool per unit time is equal to the flow out of the unemployment pool per unit time. That is,

$$bL = a(N - L) \quad \text{or} \quad a = bL/(N - L) \quad (3.4)$$

where, $L \equiv l_1 + l_2 + \dots + l_n$ is the aggregate employment.

Finally, in this chapter, we assume that there is no principal-agent problem between the manager and the owner of a firm. That is, the manager is also the owner of the firm. Then firm i 's profit can be expressed as

$$\pi_i = p \cdot y_i - w_i \cdot l_i - H(m_i) \quad (3.5)$$

Each firm chooses its own output y_i and monitoring m_i to maximize its own profit, taking as given output and the wage of all other firms. All firms make their decisions

simultaneously. Since labor is the only input of production, choosing y_i is equivalent to choosing l_i . Hence, firm i 's optimization problem can be stated as

$$\max_{\{m_i, l_i\}} \left\{ \alpha P(sF(el_i) + Y_{-i}) sF(el_i) - \left[\frac{(w_{-i} - e)a + \bar{w}(b+r)}{(a+b+r)} + \left[1 + \frac{b+r}{q(m_i)} \right] e \right] l_i - H(m_i) \right\} \quad (3.6)$$

where $Y_{-i} \equiv \sum_{j=1}^n y_j - y_i$ represents the total output of firm i 's rivals.

3.3 The Unique Symmetric Nash Equilibrium

In this section we establish the existence and the uniqueness of a symmetric equilibrium. The equilibrium concept used here is a straightforward extension of that in the standard Cournot model.

Definition 3.1. A Nash equilibrium in this model is a vector $(m_1^*, m_2^*, \dots, m_n^*; l_1^*, l_2^*, \dots, l_n^*)$ such that $\pi_i(m_i^*, l_i^*; m_{-i}, l_{-i}) \geq \pi_i(m_i, l_i; m_{-i}, l_{-i})$ for all $(m_1, \dots, m_n) \geq 0, (l_1, \dots, l_n) \geq 0$, and for all $i \in [1, n]$, where $(m_{-i}, l_{-i}) = (m_1, \dots, m_{i-1}, m_{i+1}, \dots, m_n, l_1, \dots, l_{i-1}, l_{i+1}, \dots, l_n)$.

To characterize the equilibrium, we first derive the first-order conditions for firm i 's profit-maximizing problem (3.6):

$$\frac{e \cdot q'(m_i)}{[q(m_i)]^2} (b+r) \cdot l_i - H'(m_i) = 0 \quad (3.7)$$

$$s^2 e \alpha P'(sF(el_i) + Y_{-i}) F(el_i) F'(el_i) + s e \alpha P(sF(el_i) + Y_{-i}) F'(el_i) - \left[\frac{(w_{-i} - e)a + \bar{w}(b+r)}{(a+b+r)} + \left(1 + \frac{b+r}{q(m_i)} \right) e \right] = 0 \quad (3.8)$$

Equation (3.7) implies that each individual firm sets its own level of monitoring such that the marginal benefit of monitoring equals the marginal cost of monitoring; while equation (3.8) indicates that every firm will choose its own employment level such that the marginal revenue product (*MRP*) equals the wage rate offered by it. These two conditions suggest that firm *i*'s best response, (m_i^*, l_i^*) , depends on the total output of all other firms in the industry. That is, $m_i^* = m_i(Y_{-i})$ and $l_i^* = l_i(Y_{-i})$.

Regarding the second-order conditions of (3.6), we have

$$\left. \frac{\partial^2 \pi_i}{\partial m_i^2} \right|_{(m_i^*, l_i^*)} = e \cdot \left(-\frac{2[q'(m_i^*)]^2}{[q(m_i^*)]^3} + \frac{q''(m_i^*)}{[q(m_i^*)]^2} \right) \cdot (b+r) \cdot l_i^* - H''(m_i^*) < 0 \quad (3.9)$$

$$\left. \frac{\partial^2 \pi_i}{\partial m_i \partial l_i} \right|_{(m_i^*, l_i^*)} = \left. \frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right|_{(m_i^*, l_i^*)} = \frac{e \cdot q'(m_i^*)}{[q(m_i^*)]^2} (b+r) > 0 \quad (3.10)$$

$$\begin{aligned} \left. \frac{\partial^2 \pi_i}{\partial l_i^2} \right|_{(m_i^*, l_i^*)} &= \alpha P''(sF(el_i^*) + Y_{-i}) [seF'(el_i^*)]^2 sF(el_i^*) \\ &\quad + \alpha P(sF(el_i^*) + Y_{-i}) \cdot se^2 F''(el_i^*) \\ &\quad + 2\alpha P'(sF(el_i^*) + Y_{-i}) [seF'(el_i^*)]^2 \\ &\quad + \alpha P'(sF(el_i^*) + Y_{-i}) \cdot se^2 F''(el_i^*) \cdot sF(el_i^*) < 0 \end{aligned} \quad (3.11)$$

To ensure there is a solution to firm *i*'s profit-maximizing problem, we assume that

$$\left[\frac{\partial^2 \pi_i}{\partial l_i^2} \cdot \frac{\partial^2 \pi_i}{\partial m_i^2} \right]_{(m_i^*, l_i^*)} > \left[\frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right]_{(m_i^*, l_i^*)}^2 \quad (3.12)$$

Since all n firms are identical, we focus on the symmetric equilibria where $m_i^* = m_j^* = m^*$ and $l_i^* = l_j^* = l^*$ for all $i, j \in [1, n]$.¹³

In a symmetric equilibrium, all firms offer the same wage rate to the workers, that is,

$$w_i = \frac{(w_{-i} - e)a + \bar{w}(b+r)}{(a+b+r)} + \left[1 + \frac{b+r}{q(m)}\right]e = w_{-i}$$

The equilibrium efficiency wage rate (w^*) can then be solved as

$$w^* = \bar{w} + e + \frac{e}{q(m)}(a+b+r) \quad (3.13)$$

Furthermore, substituting (3.13) and the labor market steady state condition, equation (3.4), into firm i 's reaction functions, (3.7) and (3.8), we may obtain the following two equilibrium conditions:

$$\frac{e \cdot q'(m)}{[q(m)]^2}(b+r) \cdot l - H'(m) = 0 \quad (3.14)$$

$$\begin{aligned} s^2 e \cdot \alpha P'(nsF(el)) \cdot F(el) \cdot F'(el) + se \cdot \alpha P(nsF(el)) \cdot F'(el) \\ - \left[\bar{w} + e + \frac{e}{q(m)} \left(\frac{bN}{N-nl} + r \right) \right] = 0 \end{aligned} \quad (3.15)$$

Adopting the same technique used in Chapter 2, we treat the above two equations as two curves in the (m, l) space, with $l = A(m)$ representing the relationship implied by (3.14), and $l = B(m)$ representing the relationship implied by (3.15). The intersections of these two curves are the symmetric Nash equilibria, (m^*, l^*) .

Lemma 3.1. *Under the assumptions we have made, there is a unique symmetric Nash equilibrium.*

¹³ In cases where the first-order conditions (3.7) and (3.8) are non-linear, there may be multiple equilibria, some of which may be asymmetric.

Proof. The proof proceeds in three steps.

(1). Properties of $l = A(m)$ and $l = B(m)$:

Totally differentiating (3.14) with respect to m and l , we have

$$\left\{ -\frac{2el[q'(m)]^2}{[q(m)]^3} \left(\frac{bN}{N-nl} + r \right) + \frac{elq''(m)}{[q(m)]^2} \left(\frac{bN}{N-nl} + r \right) - H''(m) \right\} dm + \left\{ \frac{e \cdot q'(m)}{[q(m)]^2} (b+r) \right\} dl = 0$$

Rearranging, we obtain

$$\frac{dl}{dm} = \frac{\frac{2el[q'(m)]^2}{[q(m)]^3} \left(\frac{bN}{N-nl} + r \right) + \frac{-elq''(m)}{[q(m)]^2} \left(\frac{bN}{N-nl} + r \right) + H''(m)}{\frac{e \cdot q'(m)}{[q(m)]^2} (b+r)} \quad (3.16)$$

By assumptions $q'(\cdot) > 0$, $q''(\cdot) < 0$ and $H''(\cdot) > 0$, it is clear that both the numerator and the denominator are positive. Then $dl/dm > 0$. That is, the curve $l = A(m)$ is strictly upward-sloping in (m, l) space.

Similarly, totally differentiating (3.15) with respect to m and l and then rearranging, we obtain

$$\begin{aligned} dl/dm = & - \left\{ eq'(m)[q(m)]^{-2} (b+r) \right\} / \\ & \left\{ (n+1)e^2s^2[F'(el)]^2 \alpha P'(nsF(el)) + e^2s\alpha P(nsF(el))F''(el) \right. \\ & \quad + e^2s^2F(el)\alpha P'(nsF(el))F''(el) \\ & \quad \left. + ne^2s^3F(el)[F'(el)]^2 \alpha P''(nsF(el)) - ebnN[q(m)]^{-1}(N-nl)^{-2} \right\} \end{aligned} \quad (3.17)$$

Note that the assumptions $P'(Q) < 0$ and $P'(Q) + Q \cdot P''(Q) \leq 0$ imply that each firm's marginal revenue is decreasing in the total output of other firms, that is, $P'(Y_{-i} + y_i) + P''(Y_{-i} + y_i) \cdot y_i < 0$, which in turn implies that the denominator of (3.17) is negative. On the other hand, the numerator is also negative given the assumptions made. Consequently, $dl/dm > 0$. That is, the curve $l = B(m)$ is strictly upward-sloping in the (m, l) space.

Therefore, both of the two curves, $l = A(m)$ and $l = B(m)$, are strictly upward sloping in the (m, l) space. The intuition behind this result is similar to that in the case of monopoly. That is, $l = A(m)$ is upward sloping because a higher level of monitoring reduces the no-shirking wage and thus encourages the firms to hire more workers; on the other hand, $l = B(m)$ is upward sloping because a higher level of employment lowers the MRP of labor and this drives the firms to invest more on monitoring to reduce the wage rate in order to equate it to the reduced MRP .

(2). Relation between these two curves:

Let $\Phi = 0$ and $\Omega = 0$ represent equation (3.14) and (3.15), respectively. And use Φ_j and Ω_j ($j = m, l, n, b, s, \alpha, \bar{w}$) to denote the partial derivative of Φ and Ω with respect to variable j . Then, the slopes of the two curves at the equilibria can be presented as $A'(m^*) = -\Phi_m / \Phi_l$ and $B'(m^*) = -\Omega_m / \Omega_l$. Specifically,

$$\Phi_l = \frac{eq'(m^*)}{[q(m^*)]^2} (b+r) \quad (3.18)$$

$$\Phi_m = -\frac{2el^* [q'(m^*)]^2}{[q(m^*)]^3} (b+r) + \frac{e^* l q''(m^*)}{[q(m^*)]^2} (b+r) - H''(m^*) \quad (3.19)$$

$$\begin{aligned} \Omega_l = & (n+1)e^2 s^2 [F'(el^*)]^2 \alpha P'(nsF(el^*)) + e^2 s \alpha P(nsF(el^*)) F''(el^*) \\ & + e^2 s^2 F(el^*) \alpha P'(nsF(el^*)) F''(el^*) \\ & + ne^2 s^3 F(el^*) [F'(el^*)]^2 \alpha P''(nsF(el^*)) - ebnN(N-nl^*)^{-2} [q(m^*)]^{-1} \end{aligned} \quad (3.20)$$

$$\Omega_m = \frac{eq'(m^*)}{[q(m^*)]^2} \left(\frac{bN}{N-nl} + r \right) \quad (3.21)$$

Rewriting the second-order conditions (3.9) – (3.11) by using equation (3.13), (3.4)

and $m_i^* = m_j^* = m^*$ and $l_i^* = l_j^* = l^*$, we have

$$\left. \frac{\partial^2 \pi_i}{\partial m_i^2} \right|_{(m^*, l^*)} = -\frac{2el^* [q'(m^*)]^2}{[q(m^*)]^3} (b+r) + \frac{el^* q''(m^*)}{[q(m^*)]^2} (b+r) - H''(m^*) < 0 \quad (3.22)$$

$$\left. \frac{\partial^2 \pi_i}{\partial m_i \partial l_i} \right|_{(m^*, l^*)} = \left. \frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right|_{(m^*, l^*)} = \frac{e \cdot q'(m^*)}{[q(m^*)]^2} (b+r) > 0 \quad (3.23)$$

$$\begin{aligned} \left. \frac{\partial^2 \pi_i}{\partial l_i^2} \right|_{(m^*, l^*)} = & 2[seF'(el^*)]^2 \alpha P'(nsF(el^*)) + e^2 s \alpha P(nsF(el^*)) F''(el^*) \\ & + e^2 s^2 F(el^*) \alpha P'(nsF(el^*)) F''(el^*) \\ & + e^2 s^3 F(el^*) [F'(el^*)]^2 \alpha P''(nsF(el^*)) < 0 \end{aligned} \quad (3.24)$$

Comparing (3.18) and (3.21) with (3.23), and (3.19) with (3.22), we obtain

$$\Phi_l = \left. \frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right|_{(m^*, l^*)} > 0 \quad (3.25)$$

$$\Phi_m = \left. \frac{\partial^2 \pi_i}{\partial m_i^2} \right|_{(m^*, l^*)} < 0 \quad (3.26)$$

$$\begin{aligned}
\Omega_l - \frac{\partial^2 \pi_i}{\partial l_i^2} \Big|_{(m^*, l^*)} &= - \underbrace{\frac{e}{q(m^*)} \frac{nbN}{(N - nl^*)^2}}_{<0} \\
&\quad + \underbrace{(n-1) \left[seF'(el^*) \right]^2 \left[\overbrace{\alpha P'(nsF(el^*)) + sF(el^*) \alpha P''(nsF(el^*))}^{<0 \text{ by assumption}} \right]}_{<0} < 0
\end{aligned} \tag{3.27}$$

$$\Omega_m - \frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \Big|_{(m^*, l^*)} = \frac{eq'(m^*)}{[q(m^*)]^2} \frac{nbl}{N - nl^*} > 0 \tag{3.28}$$

Moreover,

$$\begin{aligned}
\left[\Omega_l - \frac{\partial^2 \pi_i}{\partial l_i^2} \Big|_{(m^*, l^*)} \right] \cdot \Phi_m &> \left[- \frac{e}{q(m^*)} \frac{nbN}{(N - nl^*)^2} \right] \left\{ - \frac{2el[q'(m^*)]^2}{[q(m^*)]^3} (b+r) \right\} \\
&= \left\{ \frac{eq'(m^*)}{[q(m^*)]^2} \right\}^2 \frac{nbl(b+r)}{N - nl^*} \frac{2N}{N - nl^*} \\
&> \left\{ \frac{eq'(m^*)}{[q(m^*)]^2} \right\}^2 \frac{nbl(b+r)}{N - nl^*}
\end{aligned} \tag{3.29}$$

and

$$\begin{aligned}
\Phi_l \cdot \left[\Omega_m - \frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \Big|_{(m^*, l^*)} \right] &= \frac{eq'(m^*)}{[q(m^*)]^2} (b+r) \frac{eq'(m^*)}{[q(m^*)]^2} \frac{nbl}{N - nl^*} \\
&= \left\{ \frac{eq'(m^*)}{[q(m^*)]^2} \right\}^2 \frac{nbl(b+r)}{N - nl^*}
\end{aligned} \tag{3.30}$$

Finally,

$$\begin{aligned}
& \Omega_l \cdot \Phi_m - \left[\frac{\partial^2 \pi_i}{\partial l_i^2} \cdot \frac{\partial^2 \pi_i}{\partial m_i^2} \right]_{(m^*, l^*)} \\
&= \left[\Omega_l - \frac{\partial^2 \pi_i}{\partial l_i^2} \right]_{(m^*, l^*)} + \frac{\partial^2 \pi_i}{\partial l_i^2} \bigg|_{(m^*, l^*)} \cdot \Phi_m - \left[\frac{\partial^2 \pi_i}{\partial l_i^2} \cdot \frac{\partial^2 \pi_i}{\partial m_i^2} \right]_{(m^*, l^*)} \\
&= \frac{\partial^2 \pi_i}{\partial l_i^2} \bigg|_{(m^*, l^*)} \cdot \frac{\partial^2 \pi_i}{\partial m_i^2} \bigg|_{(m^*, l^*)} + \left[\Omega_l - \frac{\partial^2 \pi_i}{\partial l_i^2} \right]_{(m^*, l^*)} \cdot \Phi_m - \left[\frac{\partial^2 \pi_i}{\partial l_i^2} \cdot \frac{\partial^2 \pi_i}{\partial m_i^2} \right]_{(m^*, l^*)} \\
&= \left[\Omega_l - \frac{\partial^2 \pi_i}{\partial l_i^2} \right]_{(m^*, l^*)} \cdot \Phi_m
\end{aligned} \tag{3.31}$$

$$\begin{aligned}
& \Phi_l \cdot \Omega_m - \left[\frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right]_{(m^*, l^*)}^2 \\
&= \Phi_l \cdot \left[\Omega_m - \frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right]_{(m^*, l^*)} + \frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \bigg|_{(m^*, l^*)} - \left[\frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right]_{(m^*, l^*)}^2 \\
&= \Phi_l \cdot \left[\Omega_m - \frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right]_{(m^*, l^*)}
\end{aligned} \tag{3.32}$$

Substituting (3.29) – (3.32) into (3.12), we have

$$\begin{aligned}
& \left[\frac{\partial^2 \pi_i}{\partial l_i^2} \cdot \frac{\partial^2 \pi_i}{\partial m_i^2} \right]_{(m^*, l^*)} > \left[\frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right]_{(m^*, l^*)}^2 \\
&\Rightarrow \left[\frac{\partial^2 \pi_i}{\partial l_i^2} \cdot \frac{\partial^2 \pi_i}{\partial m_i^2} \right]_{(m^*, l^*)} + \left[\Omega_l - \frac{\partial^2 \pi_i}{\partial l_i^2} \right]_{(m^*, l^*)} \cdot \Phi_m > \left[\frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right]_{(m^*, l^*)}^2 + \Phi_l \cdot \left[\Omega_m - \frac{\partial^2 \pi_i}{\partial l_i \partial m_i} \right]_{(m^*, l^*)} \\
&\Rightarrow \Omega_l \cdot \Phi_m > \Phi_l \cdot \Omega_m \Rightarrow \frac{\Phi_m}{\Phi_l} < \frac{\Omega_m}{\Omega_l} \Rightarrow -\frac{\Phi_m}{\Phi_l} > -\frac{\Omega_m}{\Omega_l} \\
&\Rightarrow A'(m^*) > B'(m^*)
\end{aligned}$$

That is, the slope of $l = A(m)$ is greater than that of $l = B(m)$ at an equilibrium point.

(3). Unique intersection of these two curves:

Suppose there are more than one (say two) intersections of curves $l = A(m)$ and $l = B(m)$, as shown in Figure 3.1. Then, at one of these two intersection points $E(m^*, l^*)$, the slope of $l = A(m)$ must be greater than the slope of $l = B(m)$, while at the other intersection point $\hat{E}(\hat{m}^*, \hat{l}^*)$, the slope of $l = A(m)$ must be less than the slope of $l = B(m)$.

However, this contradicts our earlier conclusion that at an intersection of these two curves, the slope of $l = A(m)$ must be greater than the slope of $l = B(m)$. Consequently, the intersection $\hat{E}(\hat{m}^*, \hat{l}^*)$ is impossible.

Thus, the two curves, $l = A(m)$ and $l = B(m)$, can only intersect once. That is, there is a unique symmetric Nash equilibrium, as illustrated by Figure 3.2.

FIGURE 3.1 Proof of Uniqueness of the Symmetric Nash Equilibrium

FIGURE 3.2 The Unique Symmetric Nash Equilibrium

3.4 Effects of Competition

In this subsection we examine the effects of product market competition on equilibrium employment level, the wage rate, output level and price. In our model the intensity of product market competition is measured by the number of firms, n . Accordingly, the effects of competition intensity are determined by conducting comparative statics with respect to the number of firms, n .¹⁴ Note that

$$\Phi_n = 0 \quad (3.33)$$

$$\begin{aligned} \Omega_n = s^2 \alpha e F(el^*) F'(el^*) & \left[P'(nsF(el^*)) + sF(el^*) P''(nsF(el^*)) \right] \\ & - ebNl^* / [q(m^*)(N - nl^*)^2] \end{aligned} \quad (3.34)$$

Then totally differentiating the pair of Nash equilibrium conditions, (3.14) and (3.15), yields

$$\Phi_m \cdot \frac{dm^*}{dn} + \Phi_l \cdot \frac{dl^*}{dn} + \Phi_n = 0 \quad (3.35)$$

$$\Omega_m \cdot \frac{dm^*}{dn} + \Omega_l \cdot \frac{dl^*}{dn} + \Omega_n = 0 \quad (3.36)$$

Solve (3.35) and (3.36) for dm^* / dn and dl^* / dn

$$\frac{dm^*}{dn} = \frac{\Phi_l \cdot \Omega_n - \Omega_l \cdot \Phi_n}{\Omega_l \cdot \Phi_m - \Phi_l \cdot \Omega_m} = \frac{\Phi_l \cdot \Omega_n}{\Omega_l \cdot \Phi_m - \Phi_l \cdot \Omega_m} \quad (3.37)$$

$$\frac{dl^*}{dn} = \frac{\Omega_m \cdot \Phi_n - \Phi_m \cdot \Omega_n}{\Omega_l \cdot \Phi_m - \Phi_l \cdot \Omega_m} = \frac{-\Phi_m \cdot \Omega_n}{\Omega_l \cdot \Phi_m - \Phi_l \cdot \Omega_m} \quad (3.38)$$

¹⁴ We also conducted comparative statics with respect to other parameters in the model, including the separation rate (b), technology shock (s), market size (α), unemployment benefit ($\bar{w}$) and total labor force (N). These results are presented in Appendix 1.

The effects of competition intensity on equilibrium can be examined on the basis of equations (3.37) and (3.38).

3.4.1. Monitoring and Employment Level at Each Firm

To determine the sign of (3.37), note that $\Phi_l > 0$ from (3.25) and $\Omega_n < 0$ because $P'(nsF(el^*)) + sF(el^*)P''(nsF(el^*))$ is negative and $F'(\cdot) > 0$. Moreover, in the proof of Lemma 3.1, we have already shown that the denominator $\Delta \equiv \Omega_l \cdot \Phi_m - \Phi_l \cdot \Omega_m$ is positive. Therefore, we have $dm^*/dn < 0$. That is, each firm will invest less in monitoring efforts if the intensity of competition increases.

As for the employment level, note that $\Omega_n < 0$, $\Delta > 0$ and $\Phi_m < 0$ in (3.38). Hence, $dl^*/dn < 0$. That is, as the number of active firms increases, every individual firm will employ fewer workers. Therefore,

Proposition 3.1. *An increase in the number of firms in the market reduces both the levels of employment and monitoring at each firm.*

Graphically, if the number of firms increases, the curve $l = A(m)$ will remain unchanged since n does not appear in (3.14). On the other hand, the curve $l = B(m)$ shifts downward, because

$$\partial \left\{ s^2 e \alpha P' \cdot F \cdot F' + s e \alpha P \cdot F' - \left[\bar{w} + e + \frac{e}{q} \left(\frac{bN}{N - nl} + r \right) \right] \right\} / \partial n = \Omega_n < 0$$

and

$$\partial \left\{ s^2 e \alpha P' \cdot F \cdot F' + s e \alpha P \cdot F' - \left[\bar{w} + e + \frac{e}{q} \left(\frac{bN}{N-nl} + r \right) \right] \right\} / \partial m = \Omega_m > 0$$

implying that for any given l , m has to decrease to satisfy (3.15) in response to an increase of n . The effects on equilibrium are shown in Figure 3.3 by a movement from point E to point $\tilde{E}$.

Intuitively, an increase in the number of firms reduces the marginal revenue product of labor at each firm, which, for

Figure 3.3 Effects of Competition on Equilibrium

a fixed level of monitoring, lowers the level of employment. A lower level of employment reduces the marginal benefit of monitoring effort. This causes the firm to cut back monitoring effort or investment, which causes the employment level to fall even further.

3.4.2. Aggregate Monitoring Costs and Aggregate Employment

Given the increase in the number of firms, a reduction in monitoring cost and employment level per firm does not necessarily mean that the aggregate of each of these two variables for the whole economy will be smaller. To examine this further, consider first the total monitoring cost, $TH \equiv n \cdot H(m)$.

$$\begin{aligned}\frac{dTH(m^*)}{dn} &= H(m^*) + n \cdot H'(m^*) \frac{dm^*}{dn} \\ &= H(m^*) \cdot \left\{ 1 + \left[\frac{m^*}{H(m^*)} \cdot \frac{dH(m^*)}{dm^*} \right] \cdot \left[\frac{dm^*}{dn} \cdot \frac{n}{m^*} \right] \right\}\end{aligned}$$

Define $\varepsilon_{m,n} \equiv -\frac{dm}{dn} \cdot \frac{n}{m}$ as the elasticity of monitoring with respect to the number of active firms, and $\varepsilon_{H,n} \equiv \frac{dH(m)}{dm} \cdot \frac{m}{H(m)}$ as the elasticity of monitoring cost with respect to the monitoring. Then, the total monitoring cost is decreasing in the intensity of competition, i.e., $dTH^* / dn < 0$, if and only if

$$1 - \varepsilon_{H,m}^* \cdot \varepsilon_{m,n}^* < 0 \Leftrightarrow \varepsilon_{H,m}^* \cdot \varepsilon_{m,n}^* > 1 \quad (3.39)$$

Intuitively, the total monitoring cost is more likely to decrease if $\varepsilon_{m,n}^*$ is large, because in such a situation a given increase in n causes a large reduction in the level of monitoring by each firm.

Next, we examine the relationship between the aggregate equilibrium employment, $L^* \equiv nl^*$, and the number of competitors (n):

$$\frac{dL^*}{dn} = l^* + n \cdot \frac{dl^*}{dn} = l^* \cdot \left[1 + \frac{dl^*}{dn} \cdot \frac{n}{l^*} \right]$$

Define $\varepsilon_{l,n} \equiv -\frac{dl}{dn} \cdot \frac{n}{l}$ as the elasticity of each individual firm's employment (l) with respect to the number of active firms (n). Then

$$dL^* / dn > 0 \text{ if and only if } \varepsilon_{l,n}^* < 1 \quad (3.40)$$

To be more specific, note that

$$\varepsilon_{l,n}^* = -\frac{dl^*}{dn} \cdot \frac{n}{l^*} = \frac{\Phi_m \cdot \Omega_n}{\Omega_l \cdot \Phi_m - \Phi_l \cdot \Omega_m} \cdot \frac{n}{l^*}$$

and

$$\begin{aligned} n \cdot \Phi_m \cdot \Omega_n - l^* \cdot [\Omega_l \cdot \Phi_m - \Phi_l \cdot \Omega_m] &= l^* \cdot \Phi_l \cdot \Omega_m + \Phi_m \cdot [n \cdot \Omega_n - l^* \cdot \Omega_l] \\ &= l^* \cdot \underbrace{\left[\frac{eq^{**}}{q^{*2}}(b+r) \right]}_{>0} \underbrace{\left[\frac{eq^{**}}{q^{*2}} \left(\frac{bN}{N-nl} + r \right) \right]}_{>0} + \underbrace{\left[-\frac{2elq^{**2}}{q^{*3}}(b+r) + \frac{elq^{***}}{q^{*2}}(b+r) - H^{***} \right]}_{<0} \\ &\quad \cdot \underbrace{\left[n \cdot s^2 \alpha e F^* F^{**} \left[P^{**} + s F^* P^{***} \right] \right]}_{<0} \\ &\quad - l^* \cdot \underbrace{\left[(n+1)e^2 s^2 F^{**2} \alpha P^{**} + e^2 s \alpha P^* F^{***} + e^2 s^2 \alpha F^* P^{**} F^{***} + ne^2 s^3 F^* F^{**2} \alpha P^{***} \right]}_{<0} \end{aligned}$$

which is ambiguous in sign. Consequently, $\varepsilon_{l,n}^*$ may be greater or less than one. Then, the effect of competition on aggregate employment is generally uncertain.

Note that one sufficient condition for $dL^*/dn > 0$ is that production technology exhibits constant-returns-to-scale, i.e. $F'' = 0$.¹⁵

Another sufficient condition for $dL^*/dn > 0$ is that

$$\begin{aligned} n \cdot \Omega_n - l^* \cdot \Omega_l &< 0 \\ \Leftrightarrow n \cdot \frac{\partial MRP^*}{\partial n} &< l^* \cdot \frac{\partial MRP^*}{\partial l} \\ \Leftrightarrow -\frac{\partial MRP^*}{\partial n} \cdot \frac{n}{MRP^*} &> -\frac{\partial MRP^*}{\partial l} \cdot \frac{l^*}{MRP^*} \end{aligned} \quad (3.41)$$

¹⁵ Since labor is assumed to be the only input factor, a constant-return-to-scale production technology implies a linear production function. Proposition 3, which will be presented later in section 4.3, states that a larger number of firms in the product market always raises the aggregate output. Therefore, increased product market competition will improve employment definitely in case where there is a CRS production technology.

The left hand side of (3.41) is the elasticity of MRP with respect to the number of firms, $\varepsilon_{MRP, n}^*$, while the right hand side is the elasticity of MRP with respect to individual firm's employment, $\varepsilon_{MRP, l}^*$. That is, intensified competition improves aggregate employment if $\varepsilon_{MRP, n}^* > \varepsilon_{MRP, l}^*$.

Proposition 3.2. *In general an increase in the number of firms has an ambiguous effect on aggregate employment and total monitoring cost. However, aggregate employment rises with competition intensity if either $F'' = 0$ or $\varepsilon_{MRP, n}^* > \varepsilon_{MRP, l}^*$. Total monitoring cost decreases with competition intensity if and only if $\varepsilon_{m, n}^* > 1 / \varepsilon_{H, m}^*$.*

3.4.3. Wage Rate, Output and Price

To determine the effects of product market competition on the equilibrium wage rate, we rewrite (3.13) in terms of equilibrium values of (m^*, l^*) :

$$w^* = \bar{w} + e + \frac{e}{q(m^*)} \left(\frac{bN}{N - nl^*} + r \right) \quad (3.13')$$

Then

$$\begin{aligned} \frac{dw^*}{dn} &= \frac{e}{q(m^*)} \left\{ \frac{-q'(m^*)}{q(m^*)} \left(\frac{bN}{N - nl^*} + r \right) \frac{dm^*}{dn} + \frac{nbN}{(N - nl^*)^2} \frac{dl^*}{dn} + \frac{bNl^*}{(N - nl^*)^2} \right\} \\ &= \frac{e}{q^*} \left\{ \frac{1}{n} \left(\frac{bN}{N - nl^*} + r \right) \left(\frac{dq^*}{dm^*} \frac{m^*}{q^*} \right) \left(-\frac{dm^*}{dn} \frac{n}{m^*} \right) - \frac{bNl^*}{(N - nl^*)^2} \left(-\frac{dl^*}{dn} \frac{n}{l^*} \right) + \frac{bNl^*}{(N - nl^*)^2} \right\} \end{aligned}$$

Define $\varepsilon_{q,m} \equiv \frac{dq}{dm} \cdot \frac{m}{q}$ as the elasticity of shirking detection rate (q) with respect to the monitoring (m), and use the definition of $\varepsilon_{l,n}$ and $\varepsilon_{m,n}$ to rewrite the above equation, we obtain

$$\frac{dw^*}{dn} = \frac{e}{q^*} \left[\frac{1}{n} \left(\frac{bN}{N-nl^*} + r \right) \varepsilon_{q,m}^* \cdot \varepsilon_{m,n}^* + \frac{bNl^*}{(N-nl^*)^2} \cdot (1 - \varepsilon_{l,n}^*) \right] \quad (3.42)$$

Then, $dw^*/dn > 0$ if and only if

$$\frac{1}{n} \left(\frac{bN}{N-nl^*} + r \right) \varepsilon_{q,m}^* \cdot \varepsilon_{m,n}^* + \frac{bNl^*}{(N-nl^*)^2} \cdot (1 - \varepsilon_{l,n}^*) > 0 \quad (3.43)$$

The above analysis implies that the sign of dw^*/dn is generally ambiguous. That is, competition in the product market has an ambiguous effect on the wage rate. But a sufficient condition for $dw^*/dn > 0$ is $\varepsilon_{l,n}^* < 1$, or equivalently $dL^*/dn > 0$. Intuitively, an increase in product market competition lowers the monitoring at each firm, which directly raises the efficiency wage. If intensified competition in the product market raises total employment (nl^*) simultaneously, the stronger demand for labor reinforces the first effect, in which case the wage rate unambiguously rises. On the other hand, if more intensive competition reduces total employment, the equilibrium efficiency wage tends to be reduced due to the shrunken labor demand. The total effect of increasing competition on the wage rate then depends on which of these two effects is stronger.

Turning to the effects of competition on equilibrium levels of output and price, note from Proposition 3.2 that intensified competition has an ambiguous impact on total employment. This seems to raise the possibility that the equilibrium output would be

lower and price would be higher. A careful analysis of the equilibrium conditions, however, indicates that this is not the case.

Proposition 3.3. *An increase in product market competition raises the equilibrium output level and lowers the equilibrium price. It has an ambiguous effect on the wage rate, but it raises the wage rate in the event that total employment is higher as a result.*

Proof. We have already proved the result on the wage rate. Here we only need to consider how product market competition affects output and price. Since price is a decreasing function of quantity, it suffices to show that a larger n raises Q . In the case where a larger n leads to a higher total employment, equilibrium output must be higher. This is because with non-increasing returns to scale in production technology, the aggregate output will not fall if the same amount of labor is evenly allocated among more firms. Consequently, a higher total employment can only lead to a larger aggregate output.

Next, consider the case where a larger n leads to a fall in total employment. Suppose there exists some n (with the corresponding equilibrium output Q^*) such that Q^* is larger than $\hat{Q}^*$ (equilibrium output associated with $\hat{n}$) for $\hat{n} > n$.

Recall that the assumption $P'(Q) + Q \cdot P''(Q) \leq 0$ implies that each individual firm's marginal revenue is decreasing in the aggregate output. Then

$$\begin{aligned} & s^2 e \cdot \alpha P'(nsF(el^*)) \cdot F(el^*) \cdot F'(el^*) + se \cdot \alpha P(nsF(el^*)) \cdot F'(el) \\ & < s^2 e \cdot \alpha P'(\hat{n}sF(e\hat{l}^*)) \cdot F(e\hat{l}^*) \cdot F'(e\hat{l}^*) + se \cdot \alpha P(\hat{n}sF(e\hat{l}^*)) \cdot F'(e\hat{l}^*) \end{aligned}$$

From equilibrium conditions (3.14)

and (3.15), it is clear that a smaller Q and nl^* shift the B curve to the left while keeping the A curve in the same position (see Figure 3.4). Then, we obtain $\hat{l}^* > l^*$ and $\hat{m}^* > m^*$. This, however, contradicts Proposition 3.1.

FIGURE 3.4 Proof of Proposition 3.3

Furthermore, $\hat{l}^* > l^*$ implies that

every individual firm's output is increased, and so should the aggregate output (i.e. $\hat{Q}^* > Q^*$), which is a contradiction to the presumption that $\hat{Q}^* < Q^*$.

QED

Propositions 3.2 and 3.3 raise the intriguing possibility that in equilibrium larger total output and lower total employment occur simultaneously, both caused by increased product market intensity. A necessary condition for this scenario to arise is that production technology exhibits decreasing returns to scale, in which case output would rise if a fixed amount of labor is evenly allocated to a larger number of firms.

3.5 Effects of Competition on Welfare

3.5.1. Welfare Effect in a Standard Cournot Model

To understand the effect of efficiency wage on welfare, before discussing the effect of product market competition on welfare in our model, we first consider the case where n

identical firms play a standard Cournot game where there is no efficiency wage problem and the firms offer an exogenously fixed wage rate.

The total cost of this industry is $TC = w \cdot n \cdot l(Q/n)$, where Q/n is the output level of each firm, and $l(\cdot)$ is the inverse function of $F(\cdot)$ with $l'(\cdot) > 0$ and $l''(\cdot) \geq 0$ since $F(\cdot)$ is an increasing and concave function. Then, for a given number of firms, the marginal cost of this industry is

$$MC(n) = \frac{\partial TC}{\partial Q} = w \cdot l'(Q/n) \quad (3.44)$$

Clearly, $MC(n_2) < MC(n_1)$ for $n_2 > n_1$ since $l''(\cdot) > 0$ and output per firm is reduced when the number of firms increases. In Figure 3.5, $\alpha P^*(n_1)$ and $Q^*(n_1)$ are the price and output in the initial equilibrium with n_1 firms. When the number of active firms is increased from n_1 to n_2 , the equilibrium price is reduced to $\alpha P^*(n_2)$ and the output is increased from $Q^*(n_1)$ to $Q^*(n_2)$. Consequently, total surplus is increased from area $ABGK$ to area $ACFH$.

Algebraically, the standard total surplus is $TS^0 = \int_0^{Q^*} \alpha P(Q) dQ - w^* n l^*$. Differentiating it with respect to n yields

$$\frac{dTS^0}{dn} = \alpha P^* \frac{dQ^*}{dn} - w^* l^* - n w^* \frac{dl^*}{dn} > 0 \quad (3.45)$$

Therefore, in the standard Cournot model, there is a positive relationship between the intensity of competition and the level of welfare since more intense competition reduces the deadweight loss caused by pricing above marginal cost.¹⁶

FIGURE 3.5 Welfare Effect of Competition in a Standard Cournot Model

3.5.2. Welfare Effect in the Present Model

In the following analysis, we adopt the same welfare measures as in Chapter 2 and consider three types of total surplus:

- Type I Total Surplus follows the standard definition of total surplus which is

equal to the sum of consumer surplus $\left[\int_0^{Q^*} \alpha P(Q) dQ - \alpha P(Q^*) \cdot Q^* \right]$ and

producer surplus $\left[\alpha P(Q^*) \cdot Q^* - w^* L^* - H(m^*) \right]$. Hence,

¹⁶ Note that this conclusion has to be modified if there is a fixed cost of production. In that case, welfare calculations have to take into account the increase in the fixed costs of all firms as a result of having more firms in the industry. See Mankiw and Whinston (1986).

$$TS^I \equiv \int_0^{Q^*} \alpha P(Q) dQ - w^* L^* - n \cdot H(m^*) \quad (3.46)$$

- Type II Total Surplus adds to TS^I the incomes of both employed and unemployed workers, $[(w^* - e) \cdot L^*]$ and $[\bar{w} \cdot (N - L^*)]$. That is,

$$TS^{II} \equiv \int_0^{Q^*} \alpha P(Q) dQ - e \cdot L^* + \bar{w} \cdot (N - L^*) - n \cdot H(m^*) \quad (3.47)$$

- Type III Total Surplus excludes the unemployment benefits, $[\bar{w}(N - L^*)]$, from

Type II Total Surplus:

$$TS^{III} \equiv \int_0^{Q^*} \alpha P(Q) dQ - e \cdot L^* - n \cdot H(m^*) \quad (3.48)$$

Recall that in the three versions of total surplus defined above, the equilibrium employment (L^*), the output (Q^*), the monitoring (m^*) and the efficiency wage rate (w^*) are all functions of n . Differentiating equation (3.45) with respect to n , we obtain

$$\begin{aligned} \frac{dTS^I}{dn} &= \alpha P^* \frac{dQ^*}{dn} - w^* l^* - \frac{dw^*}{dn} \cdot l^* - n \cdot \frac{dl^*}{dn} \cdot w^* - H(m^*) - n \cdot H'(m^*) \cdot \frac{dm^*}{dn} \\ &= \underbrace{\left[\alpha P^* \frac{dQ^*}{dn} - w^* l^* - n \cdot \frac{dl^*}{dn} \cdot w^* \right]}_{A1} - \underbrace{[H(m^*)]}_{A2} - \underbrace{\left[n H'(m^*) \frac{dm^*}{dn} \right]}_{A3} - \underbrace{\left[l^* \cdot \frac{dw^*}{dn} \right]}_{A4} \end{aligned} \quad (3.49)$$

In (3.49), the effect of competition on Type I welfare is decomposed into four parts:

- **A1**, which has been proved to be positive by (3.45), is the effect of competition on welfare if the wage rate is fixed and there is no efficiency wage problem (and hence no monitoring cost);
- **A2**, which is positive, is the monitoring cost incurred by an additional firm;

- $\Delta 3$ is the change in total monitoring costs in the industry holding the number of firms constant; it is negative because the entry of an additional firm reduces the monitoring effort of every firm;
- $\Delta 4$, which can be positive or negative by (3.43), is the change in the wages paid by each individual firm.

Therefore, the total effect of competition on Type I welfare is generally ambiguous. Consequently, although the effect of competition on welfare is positive in case of a fixed wage rate and zero monitoring cost, intensified competition in the product market may reduce the level of social welfare when an efficiency wage is offered and there is a monitoring cost.

Similarly, we have

$$\begin{aligned}\frac{TS^{II}}{dn} &= \alpha P^* \frac{dQ^*}{dn} - (\bar{w} + e) \frac{dL^*}{dn} - H(m^*) - nH'(m^*) \frac{dm^*}{dn} \\ &= \underbrace{\alpha s P^* F - (e + \bar{w})n \frac{dl^*}{dn} - nH'(m^*) \frac{dm^*}{dn}}_{(+)} + \underbrace{ne\alpha P^* s F' \frac{dl^*}{dn} - (e + \bar{w})l^* - H(m^*)}_{(-)}\end{aligned}$$

and

$$\begin{aligned}\frac{TS^{III}}{dn} &= \alpha P^* \frac{dQ^*}{dn} - e \left(l^* + n \frac{dl^*}{dn} \right) - H(m^*) - nH'(m^*) \frac{dm^*}{dn} \\ &= \underbrace{\alpha s P^* F - ne \frac{dl^*}{dn} - nH'(m^*) \frac{dm^*}{dn}}_{(+)} + \underbrace{ne\alpha P^* s F' \frac{dl^*}{dn} - el^* - H(m^*)}_{(-)}\end{aligned}$$

Therefore, the effects of increased competition on Type II and Type III welfare are also ambiguous. In section 3.6.5 below, we will show through numerical simulations that more intensive competition in the product market can indeed reduce the level of welfare.

It has been shown in the literature (in particular, Mankiw and Whinston 1986) that, in cases where oligopolistic firms have to incur fixed set-up costs, there may be a tendency toward excessive entry relative to the social optimum. This is because a firm's decision to enter a market is based on the comparison of the profit it expects to earn post entry and the fixed set-up costs, and part of that profit comes from selling to customers that it attracts away from the incumbent firms. But this part of the profit does not affect total surplus because it is merely a transfer from one firm to another. This business stealing effect (see Mankiw and Whinston 1986) is behind the tendency toward excessive entry. In our model, the monitoring cost incurred by each firm, while endogenously determined, plays a similar role as the fixed set-up costs in Mankiw and Whinston (1986). Viewed from this perspective, the terms $A1$ and $A2$ in (3.49) represent those factors that have been studied in Mankiw and Whinston (1986). However, since the monitoring cost per firm falls in response to entry, the endogeneity of monitoring cost mitigates the business stealing effect. This is captured by the term $A3$ in (3.49). In addition, $A4$ in (3.49) represents the effect of the change in the wages in response to entry. But this last effect vanishes in Type II and Type III welfare because the wages in these cases are a kind of transfer from firms to workers/consumers.

Finally, it is worth noting that, given the oligopolistic market structure, the equilibrium of this model is not socially optimal. In Appendix 2 we show that the equilibrium level of employment can be either higher or lower than the socially optimal employment, and that compared with the social optimum each individual firm may put less or excessive efforts/investments into monitoring.

3.6 Simulations

In this section, we conduct numerical simulations of our model with specific functional forms. The objectives of these simulations are to provide concrete examples for the ambiguous results in the general model (e.g. the effect of competition on employment), and more importantly, to quantify the welfare effects of competition.

Suppose the production function takes the form

$$y_i = s \cdot (l_i)^\rho, \quad i = 1, 2, \dots, n \quad (3.50)$$

where $0 < \rho < 1$. The total output is, therefore, $Y = \sum_{i=1}^n s \cdot (l_i)^\rho$. Note in the above production function, the worker's effort is normalized to one, $e = 1$.

The industry faces an inverse demand function given by:

$$P(Q) = \alpha \cdot (A - B \cdot Q^\tau) \quad (3.51)$$

where α , A , B and τ are all positive parameters. Note that this function degenerates into a linear demand function when $\tau = 1$.

The monitoring technology is represented by

$$q(m) = \frac{\delta \cdot m}{m + \theta} \quad \text{with } 0 < \delta \leq 1 \text{ and } \theta > 0 \quad (3.52)$$

The monitoring cost is

$$H(m) = \beta \cdot m^\gamma \quad \text{with } \beta > 0, \gamma > 1 \quad (3.53)$$

Using these functions, we rewrite the equilibrium conditions (3.14) and (3.15) as

$$\frac{\theta}{\delta m^2} (b + r) \cdot l - \beta \gamma m^{\gamma-1} = 0 \quad (3.54)$$

$$\alpha \rho s l^{\rho-1} \left[A - B (n s l^{\rho})^{\tau} \right] - B \alpha \rho \tau s^{\tau+1} l^{\rho \tau + \rho - 1} n^{\tau-1} - \left[\bar{w} + 1 + \frac{m + \theta}{\delta m} \left(\frac{b n l}{N - n l} + r \right) \right] = 0 \quad (3.55)$$

By picking specific values for the parameters in these functions, we conduct numerical simulations to illustrate the effects of intensified competition (i.e. increased n) on the equilibrium employment, monitoring, efficiency wage and welfare.

3.6.1. Effect of Competition on Equilibrium Employment

In section 3.4, we have shown theoretically that intensified competition in the product market has an ambiguous effect on total employment. Figure 3.6 illustrates the results from a numerical simulation based on the functions and parameters presented in Table 3.1. It confirms that the level of total employment can indeed go either up or down with the number of firms.

TABLE 3.1 Functions & Parameters

Parameters & Values	Separation Rate (b)	Interest Rate (r)	Technology Shocks (s)	Market Size (a)	Unemployment Benefit ($\bar{w}$)	Total Labors (N)
	0.05	0.05	0.35	2.75	0.5	500
Number of Firms: $n = 1 \sim 200$						
Functions	Demand Function	Production Function	Monitoring Tech.	Monitoring Cost		
	$P(Q) = 100 - 0.1Q^{1.5}$	$F(L) = L^{0.95}$	$q(m) = \frac{0.8m}{m+5}$	$H(m) = m^2$		

To be more specific, Figure 3.6 demonstrates that intensified competition results in increased total employment if the number of firms is less than 18. However, if the number of firms exceeds 18, stronger competition leads to a reduction in total

employment. Therefore, the relationship between the intensity of product market competition and aggregate employment has an inverted-U shape.¹⁷

3.6.2. Effects of Competition on Equilibrium Output and Price

Figure 3.7 illustrates the effect of competition on output based on the same functions and parameters as in Table 3.1. It confirms our general finding that the output of each individual firm y_i^* decreases but the aggregate equilibrium output Y^* increases with the number of

FIGURE 3.6 Effect of Competition on Employment

active firms. This implies that equilibrium price falls with the number of firms.

FIGURE 3.7 Effects of Competition on Output

¹⁷ In addition, it should be noted that monopoly hires the least number of workers, a result that is consistent with the conclusion derived in Chapter 2.

3.6.3. Effects of Competition on Monitoring

Figure 3.8, which is based on the functions and parameters in Table 3.1, illustrates that as the number of active firms increases, the monitoring of each firm decreases monotonically, but the total equilibrium monitoring cost $n \cdot H(m^*)$, in this particular case, increases monotonically.

Figure 3.8 Effects of Competition on Monitoring and Total Monitoring Cost

Figure 3.9 Effects of Competition on Monitoring and Total Monitoring Cost : Another Example

On the other hand, Figure 3.9 shows an example where the total equilibrium monitoring cost $n \cdot H(m^*)$ varies non-monotonically with the number of active firms,

even though each individual firm's monitoring is strictly decreasing. This example is obtained from changing the value of ρ to 0.5 while keeping the values of all other parameters the same as in Table 3.1.

3.6.4. Effect of Competition on Efficiency Wage

TABLE 3.2 Functions & Parameters

Parameters & Values	Separation Rate (b)	Interest Rate (r)	Technology Shocks (s)	Market Size (α)	Unemployment Benefit ($\bar{w}$)	Total Labors (N)
	0.05	0.05	0.2	1.0	0.5	500
Number of Firms: $n = 1 \sim 300$						
Functions	Demand Function	Production Function	Monitoring Tech.	Monitoring Cost		
	$P(Q) = 100 - 0.4Q^{1.2}$	$F(L) = L^{0.65}$	$q(m) = \frac{m}{m + 2.5}$	$H(m) = m^2$		

To confirm our result in section 3.4.3 that more competition in the product market does not necessarily lead to a higher wage for workers, we conduct numerical simulations using the functions and parameters in Table 3.2. The result is illustrated in Figure 3.10a.

FIGURE 3.10a Effect of Competition on Wage Rate

Figure 3.10a shows that when the number of firms is below 123, intensified competition has a positive impact on the wage rate. However, if the number of firms

exceeds 123, an increase in the intensity of competition induces a negative effect on the equilibrium efficiency wage.

Of course, the inverted-U shape in Figure 3.10a is not the only possibility for the relation between competition and the wage. The simulation based on the functions and parameters in Table 3.1 shows that the equilibrium wage may be strictly increasing in the

FIGURE 3.10b Effect of Competition on Wage Rate: Another Example

intensity of product market competition (see Figure 3.10b). This example demonstrates that the equilibrium wage rate could be higher even in the case where aggregate employment decreases (see Figure 3.6).

3.6.5. Effects of Competition on Welfare

The simulations based on the functions and parameters in Table 3.1 show that the relationship between competition and welfare has an inverted-U shape for each of the three measures of welfare (see Figure 3.11).

These numerical simulations, as well as the general analyses presented in section 3.5, demonstrate that

Proposition 3.4. *When an efficiency wage is offered and unemployment is taken into consideration, intensifying competition in the product market does not necessarily improve economic efficiency.*

Moreover, a comparison of Figure 3.11 with Figure 3.6 indicates that the number of firms that maximizes social welfare is not the same as the one that maximizes employment.

FIGURE 3.11 Effects of Competition on Welfare

3.7 Conclusions

In this chapter, we have analyzed the employment and efficiency consequences of product market competition using a model where oligopolistic firms compete in quantity and unemployment is caused by efficiency wage considerations. We have shown that more intense competition in the product market generates a higher output and thus a lower price. However, unless production technology exhibits constant-returns-to-scale,

intensified competition does not necessarily create more jobs. Numerical examples demonstrate that the relationship between the intensity of product market competition and the aggregate employment may have an inverted-U shape.

It should be emphasized that the effects of competition on the wage rate and total welfare are ambiguous in general. Numerical simulations of the model indicate that the relationship between the intensity of product market competition and various measures of total welfare may also be an inverted-U shape. Consequently, when unemployment is introduced into the model as another distortion in addition to imperfect competition, it is no longer the case that intensified competition always improves economic efficiency.

Chapter 4

In Search of the Effects of Competition on Unemployment: Evidence from OECD Countries

4.1 Introduction

For decades, the issue of unemployment has been of great concern to economists and policy makers. Recent reports from the International Labor Organization (ILO) indicate that global unemployment in 2006 soared to an unprecedented height of approximately 195 million, or around 6.3% of the three billion workforces.¹⁸ Moreover, the overall unemployment rates in the next ten years are expected to keep increasing. Against such a background, the importance of understanding the factors that influence a country's unemployment cannot be overstated.

Labor market institutions and distortions, such as the employment protection legislations, wage taxes, union and wage coordination, are arguably among the most significant factors. An important mechanism through which the labor market institutions and distortions affect unemployment is that they have direct or indirect influences on the wage rate. Indeed, a large amount of theoretical and empirical analyses have shown that reducing labor market imperfections can have positive effects on employment because it

¹⁸ It should be noted that these data are collected from the labor force sample surveys and general household sample surveys, the social insurance statistics and the employment office statistics or the official estimates based on those combined information. The real figure, as suggested by ILO, is believed to be even higher.

leads to more flexible real wages and thus results in a lower equilibrium unemployment rate.¹⁹

However, as observed and argued by many economists, the labor market institutions and distortions cannot fully explain the high unemployment rates. For example, Nickell *et al.* (2005) find that changes in labor market institutions can only explain about 55% of the rise in European unemployment from the 1960s to the first half of the 1990s. Recently, more attention has been directed at the product market imperfections and distortions, especially product market power, as a possible reason for the increasing unemployment rates. It appears to be a widely accepted view among economists that intensified competition in product market improves employment. For example, Layard *et al.* (2005) and Nickell (1999) argue that for a given labor market structure, promoting competition in the product market will reduce unemployment. Gersbach (2000) demonstrates that product market reforms would help reduce unemployment under most circumstances if the wage rate is assumed to be rigid and not affected by product market reforms. Additionally, Blanchard and Giavazzi (2003) use a general equilibrium model with rents and bargaining to show that intensified competition in the product market leads to a fall in unemployment.

On the other hand, a number of theoretical studies show that the relationship between employment and product market competition may be more complex. For example, Koskela and Stenbacka (2005) and Amable and Gatti (2004) demonstrate that an increase in product market competition may reduce employment under certain circumstances. In

¹⁹ See Baker *et al.* (2005) and Bertola (1990) for examples.

Chapter 3 of this thesis, we also show that the relationship between product market competition and employment is not monotonic and may have an inverted-U shape.

Given the theoretical ambiguity, it is useful to examine the empirical evidence on this relationship. As far as we know, however, there is surprisingly little empirical work on this subject. The empirical studies that do shed some light on this subject assess the aggregate long-run effects of product market regulation on employment, and they find cross-country evidence suggestive of a positive impact. See, for example, Boeri *et al.* (2000) and Nicoletti *et al.* (2005).

Therefore, the objective of this chapter is to search for the effects of product market competition on unemployment by using data from eighteen OECD countries. Using a set of panel data from these countries, we conduct three sets of quantitative analyses. First, we estimate a simple econometric model using the entire sample and find an ambiguous relationship between the unemployment rate and product market competition. Second, we use a structural vector autoregression (SVAR) model to analyze the impulse response of the unemployment rate to shocks to product market competition in individual countries and find that the relationship between the two is positive in some countries but negative in others. Third and finally, we separate the eighteen countries into two groups based on their existing levels of competition intensity and conduct econometric estimation for each group separately. The analysis indicates that the effect of competition on employment depends on the existing competition intensity and the relationship between the level of employment and the intensity of competition appears to be *N*-shaped – in countries where existing competition intensity is either high or low, an increase in competition tends to

raise the level of employment significantly; while for countries where existing competition intensity is moderate, intensified competition is more likely to reduce the level of employment significantly.

The rest of this chapter is organized as follows. Section 4.2 gives the list of estimation variables and discusses the measures of product market competition. In section 4.3, a panel-data analysis is conducted to examine the effects of competition on the unemployment rate. Then in section 4.4, we use the structural vector autoregression (SVAR) approach to analyze the impulse response of the unemployment rate to product market competition. In section 4.5, grouped panel-data analyses are conducted to explore the relationship between employment and competition. Conclusions are summarized in section 4.6. A complete list of the regression results are reported in Appendices 3-6.

4.2 Variables, Database and Proxies

4.2.1. The Variables and the Database

As discussed in Chapter 1, the wage rate is commonly treated as the core factor to explain unemployment, since almost all distortions or institutions in the labor market affect unemployment ultimately through the wage. As mentioned in section 4.1, however, the labor market institutions and distortions cannot fully explain the high unemployment rates. Therefore, in our estimations, additional variables are included to help us identify the effect of product market competition on unemployment. These variables include productivity, interest rate, inflation and population. In what follows we explain intuitively the relationships between unemployment and these variables.

1. Labor Compensation (w)

The labor compensation in the OECD database is defined as the total remuneration, in cash or in kind, payable by an enterprise to an employee in return for work done by the latter. Compensation of employees has two main components: (i) wages and salaries payable in cash or in kind; and (ii) the value of the social contributions payable by employers: these may be actual social contributions payable by employers to Social Security schemes or to private funded social insurance schemes to secure social benefits for their employees; or imputed social contributions by employers providing unfunded social benefits. Therefore, the labor compensation roughly corresponds to the wage variable in theoretical models.

Although it is difficult to say whether the wage determines unemployment or unemployment determines the wage, there is no doubt that wage rate is naturally and closely associated with both the demand and supply of labor and thus tends to be the core of unemployment related theories. The well-known wage equation, for example, displays a clear negative relation between unemployment and the wage rate (see, for example, Layard *et al.*, 2005). Moreover, taking into consideration the income effect of demand for goods, the wages or labor incomes actually capture part of the interactions between the product and labor markets. Intuitively, suppose the overall wage rate is bid up for some reason (e.g. union strength, minimum wage, unemployment benefit or insurance). The higher wage rate tends to decrease firms' demand for labor; while an overall increase in labor incomes expands the aggregate demand for product, which may shift up the firms' demand for labor.

2. Productivity (s)

There is no consensus on the relation between productivity and unemployment, and the debate over whether technical progress creates unemployment has been a popular topic among economists for a long time. Intuitively, advances in productivity probably lead to higher output and thus lower the price, which tends to increase the real wage rate and then shift up the supply of labor. On the other hand, technical progress raises the marginal productivity of labor, which can have ambiguous effects on firms' demand for labor.²⁰ Indeed, there are some empirical evidences that positive technology shocks destroy jobs, especially in the short run. For example, Basu *et al.* (2004) and Gali (1999) show that positive technology shocks led to a short-run decline in employment during the post World-War II period in the United States. On the other hand, many economists, e.g. Saint-Paul (1998), believe that technical progress reduces overall unemployment rather than increases it because nominal aggregate demand rises in line with productivity growth, although there may be negative effects of technical progress on employment in some specific sectors. Additionally, there are also some economists who would rather treat technical progress as neutral when dealing with unemployment related issues because the unemployment rates viewed over the very long run (e.g. over the past century) appear to be untrended in most nations (Layard *et al.*, 2005), despite the tremendous increases in productivity.

²⁰ Theoretically, the comparative static conducted in Appendix 1 implies an ambiguous relationship between employment and technology shock.

3. Total Labor Force (N)

A larger labor force increases competition in the labor market and then tends to bid down the wage rate, which induces firms to expand their demand for labor. Moreover, if the increase of total labor force is caused by the growth of population, the aggregate demand in the product market would be increased and therefore firms are stimulated to employ more workers. That is, with the growth of population or total labor force, the absolute number of employment (L) should increase. Intuitively, however, the effect of total labor force on the unemployment rate seems to be ambiguous since $u = (N - L) / N$. Indeed, some empirical analyses, for example, the study on Spain by Eguía and Echevarría (2004), suggest that there is no clear pattern concerning the long-run relationship between population growth and changes in the unemployment rate.

4. Price Level (p)

It has been demonstrated by vast empirical evidences that there is a strong negative relationship between the inflation rate and the unemployment rate although most economists no longer use the Phillips curve in its original form because it has been shown that it simply did not work.²¹ For example, Layard *et al.* (2005) illustrate a positive relationship between the change in the inflation rate and the level of employment for the OECD as a whole from 1965 to 1990, as displayed in Figure 4.1. Additionally, Kitov *et al.* (2006, 2007) show that there is a strong linear lagged relationship between inflation,

²¹ A cursory analysis of US inflation and unemployment in Blanchard (2000) demonstrates that there is no single curve that will fit the data 1953-92, but there are three rough aggregations – 1955-71, 1974-84, and 1985-92 – each of which shows a general, downwards slope, but at three very different levels with the shifts occurring abruptly.

unemployment and labor force change for several developed countries, including the United States, Japan and some European countries.

FIGURE 4.1 Employment and Change in the Inflation Rate²²

Source: Layard *et al.* (2005), pp. 8-9, pp. 77

5. Interest Rate (r)

Basic economic theory states that changes in the interest rates affect the overall expense of borrowing and thus the expenditures undertaken with the borrowed funds. Therefore, higher interest rate would result in a decrease in expenditures and lead to a reduction in aggregate demand, which in turn tends to reduce equilibrium employment. Moreover, the price level and inflation are closely related to the interest rate. Therefore, the interest rates may indirectly affect unemployment via the price level. Furthermore, the interest rate, as well as the inflation rate, is the key indicator of the capital market, which can capture, at least partly, the interactions between the capital and labor markets.

²² The corresponding estimated equation to Figure (2-1) is $\Delta^2 p = 7.32(3.2) - 0.95(3.5)u + 0.17(2.3)t$, where $\Delta^2 p$ is the annual change in inflation (% points), u is the unemployment rate (%) and $t = \text{date} - 1990$. See Layard *et al.* (2005), pp. 77.

In addition, as suggested by empirical research (see Amable *et al.* (2006) for example), Employment Protection Legislation (*EPL*), union density, education and many other variables have strong impacts on the level of unemployment. However, it should be noted that the effects of these variables on unemployment can be captured through the labor compensation, which is already adopted as an explanatory variable in our estimation. Thus, it is reasonable to omit those variables.

A complete list of variables and their proxies used in our estimations is provided below in Table 4.1. Our data sample mainly spans over the period 1970-2005 and crosses eighteen OECD countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Ireland, Japan, Italy, Luxembourg, Netherlands, New Zealand, Norway, Sweden, the United Kingdom and the United States of America.²³

TABLE 4.1 The Variables and Proxies

<i>u</i>	unemployment rate: ratio of unemployed to economically active population
<i>r</i>	interest rate: the nominal annual interest rate (long term)
<i>N</i>	total labor force: the economically active population
<i>s</i>	technical progress: uses the productivity index as the proxy
<i>p</i>	price level: consumer price index
<i>w</i>	labor compensation: total labor compensation divided by total labor force
<i>COM</i>	intensity of product market competition: <i>discussed later</i>

Note: All the data sets are directly collected from the Source OECD Statistics or calculated based on OECD publications.

²³ For some reasons, the required data sets for the other OECD countries, such as Korea, German, Spain and Switzerland, are not integral over 1970-2005 in the OECD database.

4.2.2. Measuring Product Market Competition

Competition is a non-monetary concept which makes it hard to measure. There are at least two theoretical measures that are often used to identify the degree of competition in the product market:

- (1). The Herfindahl index (*HHI*), which is defined as the sum of the squares of the individual firms' market shares. More competitors and/or more equally distributed market shares result in a lower value of the Herfindahl index, indicating increased competition. The Herfindahl index is more appropriate for measuring the degree of competition at the industry level;
- (2). The Price Cost Margin (*PCM*) or the Lerner Index, which measures the mark-up that firms charge. A low degree of product market competition is expected to be associated with high mark-ups.

In this chapter, we use the Price Cost Margin (*PCM*) to measure the degree of product market competition because of the following advantages that it has over the Herfindahl index:

- (i). The *PCM* can be approximated by using the industry level data or the macro level data, while the Herfindahl index requires firm level data that is difficult to collect for the whole economy; and
- (ii). The Herfindahl index may be a less accurate measure of product market competition in cases where competition is globalized, since the market power of domestic firms may be constrained by competition in the global market. On the

other side, however, the *PCM* can capture the competitions on both the home and foreign markets.

It should be noted, however, that the robustness of *PCM* as a measure of competition intensity has been questioned by many economists. For example, Rosenthal (1980), Stiglitz (1989) and Amir (2002) show theoretically that more intensive competition may lead to higher *PCM* instead of lower margins. Moreover, as demonstrated by many economists, maximizing profit may not be the objective of firms, at least not the unique objective, especially in the short-run. In this sense, profitability (and thus the *PCM*) may not be a robust measure of competition. Additionally, some economists believe that *PCM* may be endogenous to firms in some cases. For example, in the analyses of Tybout (2003) and Clarke and Davies (1982), *PCM* is treated as an endogenous variable. In fact, our analysis of structural vector autoregression presented in section 4.4 takes the *PCM* as endogenous too. And, some economists argued that a high *PCM* could be the outcome of scale effects. Indeed, in the cross-section or cross-country dimension, a high *PCM* might be the outcome of scale effects or lack of competition, or a combination of these. However, in the time series dimension scale effects can be ignored.

Despite these weaknesses of *PCM* as a measure of competition, however, there is no other practical measure for competition intensity at the macroeconomic level. While new measures of competition intensity have recently been developed, they are not suitable for an analysis at the macroeconomic level. In particular, Boone (2000) has proposed the

Relative Profits (RP) as a measure of competition intensity.²⁴ Although RP has been successfully applied empirically at the industry-level (see Griffith et al. (2005) for example), it cannot be used in our study because it requires detailed firm-level data that are extremely difficult or even impossible to collect for an entire economy. For this reason, in this chapter we still use PCM as the measure of competition.

Now, consider the calculation of PCM at the macro level. The following data sets are available in the database of the Source OECD Statistics:

- (1).Gross Value Added (GVA): the value of output less the value of intermediate consumption;
- (2).Gross Operating Surplus (GOS): the surplus generated by operating activities after the labor factor input has been recompensed;
- (3).Consumption of Fixed Capital (CFC): it represents the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage;
- (4).Taxes Less Subsidies on products ($T-S$): it refers to the taxes paid by the producers and reduced by the subsidies received by the producers.

The GOS can be used as a proxy for the total pre-tax profits and therefore the Net Operating Surplus (NOS), which is used as a proxy for the net profits, can be computed

²⁴ In a nutshell, RP is the ratio of the difference (or change) in profits to the difference (or change) in average variable costs. This measure is based on the idea that in a more competitive industry, firms are punished more harshly in terms of profits for cost inefficiency. For example, comparing two firms in an industry, where one is more efficient than the other, the more efficient firm will have higher profits than the less efficient firm. As the industry becomes more competitive, for given efficiency levels of the firms, the profits of the more efficient firm go up relative to the profits of the less efficient firm.

by $NOS = GOS - CFC - (T - S)$. And, the GVA can be used as a proxy for the value of final products. Thus, the aggregate PCM can be calculated via

$$PCM = \frac{NOS}{GVA} = \frac{GOS - CFC - (T - S)}{GVA} \quad (4.1)$$

Furthermore, in this chapter, $COM \equiv 1 - PCM$ is used as the proxy for the degree of product market competition. Hence, COM is a number between zero and one, and a larger value of COM (thus a lower profitability) represents a more intensive competition product market.

4.3 Panel-Data Regression with Lagged Variables

To examine the effect on unemployment rate (u) of product market competition (COM), price level (p), labor compensation (w), interest rate (r), total labor force (N) and productivity (s), we start with a panel-data (time-series cross-section) model. The advantage of a panel-data model is that it enables us to use a large number of data points and hence improves the efficiency of econometric estimates by increasing the degrees of freedom and reducing the collinearity among explanatory variables.

4.3.1. The Estimation Equation

The estimations are mainly based on the well-known Wage Equation (see Layard *et al.* (2005) for detailed reference). However, we amend the wage equation by adding more variables to explain unemployment. Moreover, due to the observed stickiness of unemployment and its delayed response to changes in economic variables, we use a model with lagged independent variables (i.e. a dynamic process) to describe and explain

the unemployment rate. Furthermore, since there are omitted variables, e.g. Employment Protection Legislation (*EPL*), union density and education, which probably have different gross effects across countries, we use a country-specific intercept to capture those effects. In this respect, Beck and Katz (1995, 1996) have become the most influential reference and their “panel corrected standard errors” (PCSE) estimator is widely used in comparative political economy. Using this estimation method in our fixed effect time-series cross-section model, which is basically applying the GLS with modified standard errors, we can take account of the panel heteroskedasticity and the contemporaneous correlation of the error terms.

Let $u_{i,t}$ be the observation for unemployment rate at time t for country i . Let $\mathbf{x}_{i,t}$ be the observations for a vector of the explanatory variables, (p, w, s, r, N, Com) . The regression equation can be stated as

$$u_{i,t} = \alpha_i + \sum_{k=0}^Q \beta_k \cdot \mathbf{x}_{i,t-k} + \varepsilon_{i,t}$$

with $i = 1, 2, 3, \dots, 18$ and $t = 1972, 1973, \dots, 2005$ (4.2)

where $\beta_k = (\beta_{r(k)}, \beta_{N(k)}, \beta_{s(k)}, \beta_{p(k)}, \beta_{w(k)}, \beta_{COM(k)})'$ is the slope coefficient vector of k^{th} lagged independent variables, and α_i is the cross-section fixed effect (country-specific constant). Moreover, since all the data sets are collected annually, it is reasonable to assume that the values of the independent variables in year t have no or little effects on the unemployment rate in the year $t+2$. Therefore, in the following panel-data regressions, one-period lag is applied. That is, $Q = 1$.

4.3.2. The Regression Results

To see more clearly the impact of competition on unemployment, we conduct two regressions: the first one excludes the variable of competition intensity (*COM*), while in the second regression, we add it in. Table 4.2 displays the regression results with PCSE estimators and the complete regression reports are presented in Appendix 3. The reported results show that all the independent variables (including lagged variables), except the contemporaneous technology index (s_t), have statistically significant relations to the unemployment rate in both regressions. Moreover, we find that the inclusion of competition intensity (*COM*) in the second regression does not cause significant changes in the coefficients compared with those in the first one.

The empirical results indicate that there is not a simple inverse relation between the inflation rate and the unemployment rate: contemporaneous inflation has a significantly negative impact on the unemployment rate; however, the effect of inflation in the previous year is significantly positive, and a steady inflation is more likely to increase unemployment rather than decrease it. For example, a sustained inflation at 2.5% may cause an approximate 0.1% increase of the unemployment rate in each year.²⁵ We also find that higher labor compensation decreases the contemporaneous unemployment rate but increases the unemployment rate in the next year significantly, and the overall effect of labor compensation on unemployment is more likely to be positive. For example,

²⁵ The average inflation rates in the last ten years are around 2.2%, 2% and 2.7% for Canada, UK and USA.

annually increasing labor compensation at the rate of 4% probably increases the unemployment rates by 0.09% each year.²⁶

Additionally, productivity growth tends to decrease unemployment instead of increasing it, while a higher interest rate will raise the unemployment rate. And, a sustained growth of total labor force tends to decrease the unemployment rate. For example, a 1.5% annually increase in economically active population can reduce the unemployment rates by 0.14% each year.²⁷

TABLE 4.2 Panel-Data Regression Results

Explanatory Variable	#1	#2
p_t	-0.359156 *	-0.362129 *
p_{t-1}	0.396755 *	0.401480 *
$\log(w_t)$	-14.01174 *	-13.01221 *
$\log(w_{t-1})$	16.35585 *	15.26283 *
s_t	0.023938 **	-0.004423
s_{t-1}	-0.078136 *	-0.048781 *
r_t	0.055446 *	0.046219 *
r_{t-1}	0.222642 *	0.229598 *
$\log(N_t)$	-20.19961 *	-18.90145 *
$\log(N_{t-1})$	10.65544 *	9.560489 *
COM_t		-2.220691 *
COM_{t-1}		4.355663 *

Note: * and ** denote significant at the critical level of 5% and 10%, respectively.

It is interesting to find that product market competition is indeed significantly related the unemployment rates, and the overall effect of competition on unemployment appears

²⁶ The average annual growth rates of labor compensation in the last ten years are around 3.2%, 4.5% and 4.2% for Canada, UK and USA, respectively.

²⁷ The average annual growth rates of the economically active population in the recent ten years are around 1.7%, 0.9% and 1.1% for Canada, UK and USA, respectively.

to be positive. However, we note that, when the variable *COM* is added into the regression, some statistic measures of regression appear to be reduced. For examples, the adjusted R^2 : 0.957012→0.953030, the unweighted R^2 : 0.890347→0.879219 and the F -statistic: 519.6249→441.0908. How could this happen? One possible reason is that the responses of the unemployment rates to the changes in product market competition are more complex, probably country-specific.²⁸ That is, for some countries, increasing competition in product market lowers the unemployment rates; while for other countries, the effect is in the opposite direction.

Therefore, while the above panel-data analysis provides us with some useful information about the relationship between competition and unemployment, the country-specific characters are probably obliterated because the slope coefficients are assumed to be identical for all countries.

Moreover, the empirical results indicate that in almost all instances, lagged variables have significant impact on unemployment. This suggests that it may be informative to investigate the long-run and accumulative effects of those variables on unemployment.

4.4 A Structural VAR Approach

In comparison with the panel-data analysis in section 4.3, a Structural Vector Autoregression Model allows us to (i) analyze long-run and accumulative effects of economic variables on unemployment; and (ii) characterize country-specific responses of the unemployment rates to the changes in the economic variables.

²⁸ Another possibility is that there is correlation between *COM* and other data sets. However, our analyses of impulse response in section 4.4 suggest that this may not be a major factor.

4.4.1. The SVAR Modeling

The Structural Vector Autoregression (SVAR) is commonly used for estimating and forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on a system of variables,²⁹ and it sidesteps the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system. The SVAR approach to modeling dynamic behavior of economic variables has provided some interesting insights and appears to bring some real benefits for estimation and forecasting.

Following the basic idea of SVAR modeling, an economy can be described by a structural form equation as

$$\mathbf{G}(L)y_t = \varepsilon_t \quad (4.3)$$

where y_t is a k -vector of observable endogenous variables; $\mathbf{G}(L)$ is a matrix polynomial in the lag operator L ; and ε_t is a $k \times 1$ vector of observed structural disturbances, which is serially uncorrelated. Let $\mathbf{\Omega} = \text{var}(\varepsilon_t)$, then $\mathbf{\Omega}$ is a diagonal matrix where the diagonal elements are the variances of structural disturbances, if the structural disturbances are assumed to be mutually uncorrelated.

A reduced form of (4-1) may be written as

$$y_t = \mathbf{B}(L)y_t + v_t \quad (4.4)$$

²⁹ For example, Kim and Roubini (2000) use the Structural VAR methodologies with non-recursive contemporaneous restrictions to conduct an empirical analysis on the effects of monetary policy on the exchange rate in major industrial countries.

where $\mathbf{B}(L)$ is another matrix polynomial (without the constant term) in the lag operator L ; v_t is the $k \times 1$ unobservable reduced form residuals, which are linear combinations of the uncorrelated shocks ε_t , with positive definite covariance matrix $\Sigma = E[v_t v_t']$.

To recover the parameters in the structural form equations from the estimated parameters in the reduced form equation, one popular and convenient way is to impose restrictions on only contemporaneous structural parameters by orthogonalizing reduced form disturbances using Cholesky decomposition, which is the so-called Recursive Structure. Bernanke (1986), Blanchard and Watson (1986) and Sims (1986) develop a generalized method in which non-recursive structures are allowed while the restrictions are still given only on contemporaneous structural parameters.

Let $\mathbf{G}_0$ be the nonsingular coefficient matrix on L^0 in $\mathbf{G}(L)$, i.e. the contemporaneous coefficient matrix in the structural form. And let $\mathbf{G}^0(L)$ be the coefficient matrix in $\mathbf{G}(L)$ without the contemporaneous coefficient matrix $\mathbf{G}_0$. That is,

$$\mathbf{G}(L) = \mathbf{G}_0 + \mathbf{G}^0(L) \quad (4.5)$$

From equations (4.3), (4.4) and (4.5) we may obtain the relation between the parameters in the structural form equation and the parameters in the reduced form equation as

$$\mathbf{B}(L) = -\mathbf{G}_0^{-1} \mathbf{G}^0(L) \quad (4.6)$$

Consequently, the structural disturbances and the reduced form residuals are related by

$$\varepsilon_t = \mathbf{G}_0 v_t \quad (4.7)$$

4.4.2. Identifying Restrictions

Note that equation (4.7) implies

$$\Sigma = G_0^{-1} \Omega (G_0^{-1})' \quad (4.8)$$

Equation (4.8) indicates that, as long as the matrix G_0 is well restricted, the structural system is identified. The estimates of Ω and G_0 (by maximum likelihood) can be obtained only through sample estimates of Σ . Note that the right hand side of equation (4-6) has $[k \times (k+1)]$ parameters to be estimated and Σ contains $[k \times (k+1)/2]$ parameters. Consequently, we need at least $[k \times (k+1)/2]$ restrictions. Further, by normalizing the k diagonal elements of G_0 to be 1s, we need at least $[k \times (k-1)/2]$ restrictions on G_0 to achieve identification.

In our model, the variable vector is (s, N, r, p, w, COM, u) . The identifying assumptions can be summarized in the following contemporaneous relationship between the structural disturbances and the residuals in the SVAR equations:

$$\begin{bmatrix} \varepsilon_s \\ \varepsilon_N \\ \varepsilon_r \\ \varepsilon_p \\ \varepsilon_w \\ \varepsilon_{COM} \\ \varepsilon_u \end{bmatrix} = \begin{bmatrix} g_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & g_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & g_{33} & 0 & 0 & 0 & 0 \\ g_{41} & g_{42} & g_{43} & g_{44} & g_{45} & g_{46} & 0 \\ g_{51} & g_{52} & g_{53} & 0 & g_{55} & 0 & 0 \\ g_{61} & g_{62} & g_{63} & 0 & g_{65} & g_{66} & 0 \\ g_{71} & g_{72} & g_{73} & g_{74} & g_{75} & g_{76} & g_{77} \end{bmatrix} \begin{bmatrix} v_s \\ v_N \\ v_r \\ v_p \\ v_w \\ v_{COM} \\ v_u \end{bmatrix} \quad (4.9)$$

where $\varepsilon_s, \varepsilon_N, \varepsilon_r, \varepsilon_p, \varepsilon_w, \varepsilon_{COM}, \varepsilon_u$ are the structural disturbances, that is, productivity shocks, population shocks, interest rate shocks, price shocks, wage shocks, competition

shocks and unemployment rate shocks, respectively; and $v_s, v_N, v_r, v_p, v_w, v_{COM}$, and v_u are the residuals in the reduced form equations, which represent unexpected movements (given information in the system) of each variable.

- (1). The first three equations in (4.9) assume that productivity (s), economically active population (N) and interest rate (r) are not affected by any other variables. That is, the values of these variables are exogenously determined by some factors out of the product and the labor markets.
- (2). The fourth equation represents that the price level (p) depends on productivity (s), economically active population (N), interest rate (r), labor compensation (w) and the intensity of competition for the well-known reasons that, (i) productivity directly affects the output level and thus shifts up the supply in the product market, and therefore induces a change in the price level; (ii) there is a delicate relation between the price level (or inflation) and the interest rate, and this is the basis on which central banks use interest rate as an effective instrument to fight inflation; (iii) a change in the size of the labor force has an impact on aggregate demand, which obviously affects the price level; (iv) labor compensation is directly related to firms' production costs and thus affects firms' output decision; on the other hand, labor compensation has an immediate impact on consumers' demand for products; and (v) firms will adjust their own prices in response to changes in the intensity of competition.

- (3). We assume that, as displayed by the fifth equation in (4.9), labor compensation is related to productivity (s), economically active population (N) and interest rate (r),³⁰ for the following reasons: (i) productivity progress improves marginal product of labor, which in turn implies that there should be a strong relation between productivity and labor compensation, although the wage rate may not equal the marginal product of labor in a distorted labor market; (ii) change of economically active population shifts the labor supply and thus affects the equilibrium wage; (iii) as a measure of the price of capital, interest rate can affect firms' optimal mix of capital and labor, which at the aggregate level influences the demand for labor and consequently labor compensation. Moreover, changes in the interest rates affect consumers' behaviour and thus influence aggregate demand for product and ultimately the wage rate.
- (4). The sixth equation in (4.9) states that the disturbance of competition intensity can be decomposed as a combination of the reduced form residuals of productivity (s), economically active population (N), interest rate (r), labor compensation (w) and itself, since (i) productivity affects aggregate supply; (ii) economically active population influences aggregate demand; (iii) interest rate and wage rate reflect the marginal costs of the two main input factors of production, capital and labor. Note that we assume there is no contemporaneous effect of price level on the degree of competition.

³⁰ Note that, to avoid over-identification problem and due to the observed rigidity and delayed response of wages, we assume competition intensity and the price level have no contemporaneous effects on labor compensation. However, as illustrated in the fourth and the sixth equations in (4.9), it does not mean that the wage or labor compensation has no connections to competition and price level.

(5). The last equation is the arbitrage equation describing the unemployment rate, in which we assume that all the variables have contemporaneous effects on unemployment rate.

Appendix 4 reports the estimated contemporaneous coefficients in this SVAR model. From it we can see that, in some cases, there are a few large standard errors relative to the corresponding estimators (for examples, g_{46} for Austria and g_{74} for Canada). However, this does not mean that we have made the wrong identifying assumptions since the likelihood test of over-identifying restrictions indicates that for almost all countries, our identifying restrictions are not rejected at any conventional significance level. Moreover, as shown later, the moderate standard errors for impulse responses suggest that total uncertainty is not that high.

4.4.3. Structural Impulse Response of Unemployment to Competition

Using the structural factorization matrices estimated in the SVAR process, we may further estimate the structural impulse response function, which traces the structural effect of a one-time shock (i.e. a temporary shock) to one of the innovations on current and future values of the endogenous variables.

The general form of impulse response function (matrix) $\mathbf{IRF}_q$ is defined as

$$IRF_{ij}^{(q)} = \frac{\partial y_{i,t+q}}{\partial \varepsilon_{jt}} \quad q = 0, 1, 2, \dots, +\infty, \quad t = 1, 2, 3, \dots, T \quad (4.10)$$

where $IRF_{ij}^{(q)}$ is the (i, j) element in $\mathbf{IRF}_q$.

FIGURE 4.2 Structural Impulse Response of Unemployment to a Temporary positive Shock of Competition

Figure 4.2 illustrates the structural impulse responses (over ten years³¹) of the unemployment rates to a one-time one-standard-deviation positive shock of product market competition for each country. The scale (solid blue curve) shows the percentage deviations from an underlying growth path, and the upper and lower dashed curves plotted in each graph are one-standard-error bands.

These diagrams show that the responses of the unemployment rates to competition vibrate around the zero line, implying that a temporary positive shock to competition in the base year may have positive or negative effects on the unemployment rates in the current and future years. Specifically, in response to a one-time positive shock to competition, the unemployment rates in some countries (e.g. Canada, UK and USA) increase significantly in the first several years; while in other countries (e.g. Finland, Italy and Norway), the unemployment rates decrease significantly in the first several years.

Moreover, the magnitude of the effect of competition on unemployment rate differs among countries. For example, the maximum positive and negative effects for Australia are 0.43 and 0.68, while they are only 0.035 and 0.069 for Luxembourg. These facts demonstrate that the effects of competition on unemployment are indeed country-specific, both quantitatively and directionally.

³¹ For most countries, after ten periods, the standard errors of the responses turn to be very large and therefore the tendencies of the responses become uncertain and insignificant.

4.4.4. Accumulated Structural Impulse Response of Unemployment to Competition

The accumulated structural impulse response function (matrix) **AIRF** can be presented as

$$AIRF_{ij} = \sum_{q=0}^{+\infty} IRF_{ij}^{(q)} = \sum_{q=0}^{+\infty} \frac{\partial y_{i,t+q}}{\partial \varepsilon_{jt}} \quad t = 1, 2, 3, \dots, T \quad (4.11)$$

where $AIRF_{ij}$ is the (i, j) element in the **AIRF** matrix.

The accumulated response refers to the accumulated sum of the impulse responses, and it can be interpreted as the response to a permanent shock or a step impulse where the same shock occurs in every period from the first.³²

Figure 4.3 illustrates the accumulated impulse responses of the unemployment rates to a structural one-standard-deviation positive shock of those variables over ten years. The solid curve shows the percentage deviations from an underlying growth path. The upper and lower dashed curves plotted in each graph are one-standard-error bands. The response graphs show that for some countries (e.g. Canada, UK and USA), permanently increased competition in the product market raise the unemployment rates significantly in the first several years; while for other countries (e.g. Finland, Italy and Norway), it decreases the unemployment rates significantly in the first several years.

³² For some countries, there may be permanent increases of competition caused by some exogenous events, such as adoptions of new policies/regulations (e.g. trade liberalization agreements) and legislations (e.g. adoption of a new competition law, such as the Competition Act in Canada in 1986).

FIGURE 4.3 Accumulated Structural Impulse Response of Unemployment to a Permanent Shock of Competition

So far, it has been demonstrated that the effects of competition on unemployment are significantly distinct across countries. That is, the relationship between competition and unemployment is not simply positive or negative.

4.4.5. Effects of Competition on Labor Compensation

Intuitively, stronger competition in the product market may induce firms to compete more intensively for human resource in the labor market. This tends to drive up labor compensation. On the other hand, intensified competition in the product market may reduce the scope for rent-sharing. The literature in this respect suggests that there is no consensus regarding the question whether more competition in the product market increases the wage. For examples, Nickell (1999) argues that an overall rise in market power throughout the economy leads to both higher unemployment and lower wages. In another paper, however, Nickell *et al.* (1994) find that product market power has a positive impact on wages. Furthermore, Symeonidis (2007), using a panel data set of UK manufacturing industries over 1954-1973, finds that there is no evidence of any effect of collusion on wages of manual or non-manual workers.

Additionally, our general analyses and numerical simulations presented in Chapters 2 and 3 also demonstrate that product market competition has an ambiguous effect on the wage. And, the empirical result from the general panel-data model in section 4.3 shows no clear pattern on the relationship between competition and labor compensation.

Analysis of the structural impulse response suggests that the effect of product market competition on labor compensation indeed varies across countries. As can be seen from Figure 4.4, intensified competition in the product market has a statistically significant positive effect on the labor compensation in Austria, Ireland and New Zealand; while in Australia, Belgium, Denmark, Greece, Italy, Luxembourg, Netherland, Norway and

Sweden, the effect seems to be the inverse; and, for Canada, Finland, France, Japan, UK and USA, competition in product market has no obvious effect on the labor compensation.

FIGURE 4.4 Structural Impulse Response of Labor Compensation to a Permanent Shock of Competition

4.5 Grouped Panel-Data Analysis

As demonstrated by the analysis of structural impulse response in section 4.4, the effects of product market competition on unemployment are significantly distinct across countries. Nevertheless, it cannot diminish our enthusiasm for searching a more general and more precise relationship between competition and unemployment.

4.5.1. Grouping by Impulse Response

In section 4.4, we find that the responses of the unemployment rates to the intensity of product market competition are country-specific – for some countries, more competition in the product market tends to reduce the unemployment rates; while for other countries, intensified competition increases unemployment significantly. Therefore, according to their specific response of unemployment to competition, the eighteen countries can be classified into two groups, as displayed in Table 4.3. Then we conduct a panel-data regression for each group.

TABLE 4.3 Grouping by Impulse Response

Group	Countries	Common Character
A	Australia, Belgium, Canada France, Greece, Japan New Zealand, Sweden, UK, USA	$\uparrow COM \rightarrow u \uparrow$
B	Austria, Denmark, Finland Ireland, Italy, Luxembourg Netherlands, Norway	$\uparrow COM \rightarrow u \downarrow$

Table 4.4 reports the estimation results for these two groups. Complete regression results are presented in Appendix 5.

TABLE 4.4 Grouped Panel-Data Regression Results
(Grouped by Impulse Response)

Explanatory Variable	A	B
p_t	-0.197657 *	-0.448371 *
p_{t-1}	0.240962 *	0.550987 *
$\log(w_t)$	-12.25641 *	-10.51440 *
$\log(w_{t-1})$	13.81247 *	11.56017 *
s_t	-0.045345 **	0.109289 *
s_{t-1}	-0.028562	-0.170578 *
r_t	-0.026496	0.139167 *
r_{t-1}	0.193028 *	0.259185 *
$\log(N_t)$	-16.57523 *	1.715364
$\log(N_{t-1})$	11.01813 *	-17.03692 *
COM_t	1.063067 *	-2.833391 *
COM_{t-1}	12.59265 *	-2.033106 *

Note: * and ** denote significance at the critical levels of 5% and 10%, respectively.

Just as expected, for those countries in Group A, increasing competition in the product market will increase unemployment significantly; while for the countries in Group B, intensified competition in product market reduce the unemployment rates significantly. More specifically, a one-percent increase in product market competition will raise the unemployment rate by approximately 0.13% in two years for countries in Group A; and reduce the unemployment rate in two years by roughly 0.048% for countries in Group B.³³

³³ The average rate of increase in competition intensity in the eight years after the adoption of Competition Act in Canada is around 1.09%.

Moreover, we find that, as illustrated in Figure 4.5, the average competition intensity of Group A is higher than that of Group B over 1970-2005. Therefore, the empirical result from this group panel-data regression *seems* to suggest a *U-shaped* relationship between unemployment and the intensity of product market competition. That is, as illustrated in Figure 4.6, when an economy is in such a situation that the intensity of competition has exceeded its optimal level (for employment), lessening competition will actually reduce the unemployment. On the other

FIGURE 4.5 Average Intensity of Competition

FIGURE 4.6 *U-Shaped* Relation between Competition and Unemployment

hand, if the competition intensity is lower than the optimum, increasing competition in the product market would also bring the unemployment down to a lower level.

However, a closer examination of the ranking of competition intensity across countries suggests that the relationship between unemployment and the intensity of competition may be more complex. Suppose the relationship between unemployment and competition is *U-shaped*, then we would expect that, in a country where existing competition intensity is high, increasing competition should increase unemployment; while in a country where

existing competition intensity is low, intensified competition should reduce unemployment. In other words, countries in Group A should have higher competition intensity than countries in group B.

TABLE 4.5 Average Intensity of Competition

Country	Group	Average Intensity of Competition ($\uparrow$)	
Greece	A	0.509174357	D _L
Luxemburg	B	0.735863454	
Italy	B	0.738866699	
Ireland	B	0.756146347	
Japan	A	0.772045048	C
New Zealand	A	0.777843656	
Canada	A	0.827443469	
USA	A	0.836445117	
Netherlands	B	0.841354966	
Australia	A	0.843551061	
Belgium	A	0.849021465	
Norway	B	0.857324047	
France	A	0.871354498	D _H
Austria	B	0.884357567	
Finland	B	0.90062676	
UK	A	0.900998865	
Sweden	A	0.921480577	
Denmark	B	0.947884889	

However, as displayed in Table 4.5, most countries in Group A, where competition has positive effects on unemployment, are not those countries that have the highest competition intensity. Instead, most countries in Group A have an intermediate intensity of competition, while most countries in Group B have either the lowest or the highest competition intensity.

This finding suggests that our conjecture – a *U*-shaped relation between unemployment and competition – is not accurate. To assess the effect of competition on employment

more accurately, we need to regroup these eighteen countries according to another scheme.

4.5.2. Grouping by the Intensity of Competition

In light of Table 4.6, we regroup those eighteen countries according to the intensity of competition: one group (C) is composed of the nine countries (Japan, New Zealand, Canada, USA, Netherlands, Australia, Belgium, Norway, France) that have an intermediate intensity of competition; another group (D) includes the four countries (Greece, Luxemburg, Italy, Ireland) that have the lowest competition intensity and the five countries (Austria, Finland, UK, Sweden, Denmark) with the highest intensity of competition.

Table 5-3 reports the estimation results for these two groups. Complete regression results are presented in Appendix 6.

This regression result shows that for those countries where competition intensity is medium (i.e. Group C), increasing product market competition will increase the unemployment rates; while for those countries whose competition intensity at either the high or the low end (i.e. Group D), intensified competition in product market tends to reduce the unemployment rates.³⁴

³⁴ Note that, for Group C, the effect of competition on the contemporaneous unemployment rate is statistically insignificant; for Group D, the effect of competition on next period's unemployment rate is insignificant.

Table 4.6 Grouped Panel-Data Regression Results
(Grouped by Impulse Response)

Explanatory Variable	C	D
p_t	-0.164559 *	-0.406813 *
p_{t-1}	0.148068 *	0.426115 *
$\log(w_t)$	-5.510587 *	-13.53308 *
$\log(w_{t-1})$	11.59782 *	15.24213 *
s_t	-0.110827 *	0.024911
s_{t-1}	0.022537	-0.076128 **
r_t	-0.128123 *	0.062993
r_{t-1}	0.110894 *	0.168190 *
$\log(N_t)$	-36.76861 *	3.007705
$\log(N_{t-1})$	25.85197 *	3.727524
COM_t	0.451076	-3.155832 *
COM_{t-1}	8.816740 *	-1.221837

Note: * and ** denote significance at the critical levels of 5% and 10%, respectively.

This finding implies that the effect of competition on unemployment depends on the existing competition intensity and the relation between unemployment and the intensity of competition, as illustrated in Figure 4.7, is more likely to be inverted- N shaped rather than U -shaped. That is, in a country where existing competition intensity is either high or low, increasing competition tends to decrease unemployment; while in a country where existing competition intensity is

FIGURE 4.7 Inverted- N Shaped Relation between Unemployment and Competition

moderate, intensified competition more likely increases unemployment.

4.6 Conclusions

In this chapter, we use the macro data from eighteen OECD countries to examine the relationship between product market competition and unemployment. Our analysis suggests that there does not appear to be a simple monotonic relationship between these two variables. Rather, the relationship appears to be inverted-*N* shaped, with the effect of product market competition on unemployment depending on the existing competition intensity. That is, in countries where existing competition intensity is either high or low, increased competition in the product market tends to reduce unemployment significantly, but for countries where existing competition intensity is moderate, intensified competition more likely increases unemployment significantly. Therefore, our findings do not support the common belief among economists that increased competition in the product market always improves the level of employment.

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Appendices

Appendix 1. Properties of the Cournot Nash Equilibrium

Here we present the results from comparative statics with respect to parameters other than n . These parameters are separation rate (b), technology shock (s), market size (α), unemployment benefits ($\bar{w}$) and total labor force (N). Additionally, we will discuss how the equilibrium is affected in the case that monitoring costs less.

A1.1. Separation Rate (b)

$$\Phi_b = \frac{el^* q'(m^*)}{[q(m^*)]^2}, \quad \Omega_b = -\frac{eN}{q(m^*)(N - nl^*)} \quad (\text{A1.1})$$

Solve the following two equations for dm^*/db and dl^*/db

$$\Phi_m \cdot \frac{dm^*}{db} + \Phi_l \cdot \frac{dl^*}{db} + \Phi_b = 0, \quad \Omega_m \cdot \frac{dm^*}{db} + \Omega_l \cdot \frac{dl^*}{db} + \Omega_b = 0 \quad (\text{A1.2})$$

We have

$$\frac{dm^*}{db} = \frac{\Phi_l \cdot \Omega_b - \Omega_l \cdot \Phi_b}{\Delta} \quad (\text{A1.3})$$

$$\frac{dl^*}{db} = \frac{\Omega_m \cdot \Phi_b - \Phi_m \cdot \Omega_b}{\Delta} \quad (\text{A1.4})$$

Substituting (3.19), (3.21) and (A1.1) into (A1.4), we find

$$\begin{aligned} \Omega_m \cdot \Phi_b - \Phi_m \cdot \Omega_b &= \underbrace{\frac{e^2 l^* [q'(m^*)]^2}{[q(m^*)]^4} \cdot \left[\frac{(b-1)N}{N - nl^*} + \left(r - \frac{N}{N - nl^*} \right) \right]}_{<0 \text{ (since } b < 1 \text{ \& } r < 1)} \\ &+ \underbrace{\left\{ \frac{elq''(m^*)}{[q(m^*)]^2} (b+r) - H''(m^*) \right\}}_{<0} \cdot \underbrace{\frac{eN}{q(m^*)(N - nl^*)}}_{>0} < 0 \end{aligned}$$

That is, $dl^* / db < 0$ and thus $dL^* / db < 0$ since $dL^* / db = n \cdot dl^* / db$.

On the other hand, the effect of separation rate on monitoring intensity is generally ambiguous. $dm^* / db > 0$ if and only if

$$\begin{aligned} & \Phi_l \cdot \Omega_b - \Omega_l \cdot \Phi_b > 0 \\ \Leftrightarrow & -\frac{eq'(m^*)}{[q(m^*)]^2}(b+r) \cdot \frac{eN}{q(m^*)(N-nl^*)} - \frac{\partial MRP^*}{\partial l^*} \cdot \frac{el^*q'(m^*)}{[q(m^*)]^2} > 0 \\ \Leftrightarrow & -\frac{e(b+r)N}{q(m^*)(N-nl^*)} - \frac{\partial MRP^*}{\partial l^*} \cdot l^* > 0 \Leftrightarrow -\frac{\partial MRP^*}{\partial l^*} \cdot \frac{l^*}{MRP^*} > \frac{e(b+r)N}{q(m^*)(N-nl^*)} \cdot \frac{1}{MRP^*} \end{aligned}$$

Define $\varepsilon_{MRP,l} \equiv \frac{\partial MRP}{\partial l} \cdot \frac{l}{MRP}$ as the elasticity of individual firm's marginal revenue product with respect to labor. Then,

$$\frac{dm^*}{db} > 0 \text{ if and only if } \varepsilon_{MRP,l}^* > \frac{e(b+r)N}{q(m^*)(N-nl^*)} \cdot \frac{1}{MRP^*} \quad (\text{A1.5})$$

Note that the condition (A1.5) can be rewritten as

$$\frac{dm^*}{db} > 0 \text{ if and only if } b < \left| \partial MRP^* / \partial l^* \right| \cdot \frac{q(m^*)(N-nl^*)l^*}{eN} - r \quad (\text{A1.5}')$$

(A1.5') implies that, when the separation rate is small, it is more likely that an increase in separation rate raises monitoring intensity. Intuitively, in this situation, firms are willing to put more effort or investment into monitoring to

FIGURE A1.1 Effects of Separation Rate

prevent or mitigate the rise of the wage rate caused by the increase in separation rate. However, when the separation rate is large, the firms would choose a lower monitoring intensity to cut down the monitoring cost so as to partially offset the growing production cost caused by the higher wage due to a larger separation rate.

Graphically, we may see from Figure (A1.1) that, if there is an increase in separation rate, the curve $l = A(m)$ shifts out since for any given m , l has to decrease to satisfy equation (3-8); and the curve $l = B(m)$ shifts down since for any given l , m has to go up to satisfy equation (3-9).

Proposition A1.1 *An increase in separation rate (b) results in a decrease in equilibrium employment, that is, $dL^* / db < 0$. On the other hand, it raises each firm's monitoring intensity if and only if*

$$\varepsilon_{MRP,l}^* > \frac{e(b+r)N}{q(m^*)(N-nl^*)} \cdot \frac{1}{MRP^*}.$$

Note that Proposition A1.1 implies that the separation rate has an ambiguous effect on the equilibrium wage rate.

A1.2. Technology Shocks (s)

$$\Phi_s = 0 \tag{A1.6}$$

$$\begin{aligned} \Omega_s = & eP(nsF(el^*))F'(el^*) + (n+2)eP'(nsF(el^*))sF(el^*)F'(el^*) \\ & + enP''(nsF(el^*))[sF(el^*)]^2 F'(el^*) \end{aligned} \tag{A1.7}$$

Solve the following two equations for dm^* / ds and dl^* / ds

$$\Phi_m \cdot \frac{dm^*}{ds} + \Phi_l \cdot \frac{dl^*}{ds} + \Phi_s = 0, \quad \Omega_m \cdot \frac{dm^*}{ds} + \Omega_l \cdot \frac{dl^*}{ds} + \Omega_s = 0 \quad (\text{A1.8})$$

We have

$$\frac{dm^*}{ds} = \frac{\Phi_l \cdot \Omega_s}{\Delta}, \quad \frac{dl^*}{ds} = \frac{-\Phi_m \cdot \Omega_s}{\Delta} \quad (\text{A1.9})$$

Since $\Phi_l > 0$ and $\Phi_m < 0$, then $dm^* / ds > 0$ and $dl^* / ds > 0$ if and only if

$$\Omega_s > 0$$

$$\Leftrightarrow P(nsF(el^*)) + sF(el^*) \left[(n+2)P'(nsF(el^*)) + nsF(el^*)P''(nsF(el^*)) \right] > 0$$

$$\Leftrightarrow P(nsF(el^*)) + (n+2)sF(el^*)P'(nsF(el^*)) + n[sF(el^*)]^2 P''(nsF(el^*)) > 0$$

$$\Leftrightarrow -\frac{P(nsF(el^*))}{sF(el^*)P'(nsF(el^*))} - \frac{nsF(el^*)P''(nsF(el^*))}{P'(nsF(el^*))} > n+2$$

$$\Leftrightarrow \varepsilon_p^* + \sigma_p^* > n+2$$

where ε_p^* is the elasticity of demand with respect to price at the equilibrium, and σ_p^* , the elasticity of slope of the demand function at the equilibrium, measures the concavity / convexity of the demand curve.

Since $dL^* / db = n \cdot dl^* / db$, we have the following result.

Proposition A1.2 *A positive Technology Shock (s) increases the equilibrium employment and monitoring intensity if and only if $\varepsilon_p^* + \sigma_p^* > n+2$.*

Graphically, we see from Figure (A1.2) that, if there is a positive technology shock that raises the value of s , the curve $l = A(m)$ remains unchanged since technology shocks

does not appear in the equation (3-7); and the other curve, $l = B(m)$ shifts up if and only if $\varepsilon_p^* + \sigma_p^* > n + 2$. The latter is because for any given l , m has to fall in order to satisfy equation (3-8) if there is a positive technology shock and $\varepsilon_p^* + \sigma_p^* > n + 2$.

FIGURE A1.2 Effects of Technology Shocks

The intuition behind this result is quite interesting. A positive technology shock directly leads to an increase in output. In the case where demand is relatively inelastic, this increase in output causes a sharp fall in price, which tends to lower the firms' profit. To respond to this change, a firm may take two possible actions: (i) cut down the wages paid to the workers to lower production costs; or (ii) reduce output to bring the price back to a higher level. However, a reduction in the wage causes workers to shirk. To meet the efficiency wage constraint, the firm can raise monitoring intensity. But that is also costly. Consequently, a firm will find it more beneficial to reduce output and hire fewer workers. Thus, a technological improvement may lead to a decline in total employment.³⁵

In addition, Proposition A1.2 implies a surprising corollary that technology improvements may reduce the wage rate since $\partial w^* / \partial m^* < 0$ and $\partial w^* / \partial L^* > 0$. Intuitively, if a technology improvement raises total employment, the larger employment

³⁵ Empirically, many studies indicate that technological progress, especially sector-specific productivity shocks, has a negative impact on employment, at least in the short-run. For example, Basu *et al.* (2004) and Gali (1999) show that positive technology shocks typically lead to a short-run decline in employment during the post World-War II period in the United States.

reinforces the output increase brought about by the improved technology, which drives the price down even further. At the same time, the increase in total labor demand tends to bid up the wage rate. To offset the tendency for the wage to rise, firms will have to raise monitoring intensity, which allows them to reduce the efficiency wage. On the other hand, if the technology improvement reduces the total employment and thus lowers the wage rate, the reduction of price in this situation will be smaller. Then the firms will respond by lowering the effort or investment into monitoring, which tends to push up the efficiency wage. So, the total effect of technology shocks on the wage is possibly negative.³⁶

A1.3. Market Size (α)

$$\Phi_{\alpha} = 0 \quad (\text{A1.10})$$

$$\Omega_{\alpha} = esP\left(nsF(el^*)\right)F'(el^*) + esP'\left(nsF(el^*)\right)sF(el^*)F'(el^*) \quad (\text{A1.11})$$

Solve the following two equations for dm^*/ds and dl^*/ds

$$\Phi_m \cdot \frac{dm^*}{d\alpha} + \Phi_l \cdot \frac{dl^*}{d\alpha} + \Phi_{\alpha} = 0, \quad \Omega_m \cdot \frac{dm^*}{d\alpha} + \Omega_l \cdot \frac{dl^*}{d\alpha} + \Omega_{\alpha} = 0 \quad (\text{A1.12})$$

We have

$$\frac{dm^*}{d\alpha} = \frac{\Phi_l \cdot \Omega_{\alpha}}{\Delta}, \quad \frac{dl^*}{d\alpha} = \frac{-\Phi_m \cdot \Omega_{\alpha}}{\Delta} \quad (\text{A1.13})$$

³⁶ This result is also supported by some empirical studies. For example, Acemoglu (2002) points out that the average and median wage have remained constant in real terms since the mid-1970s. However, the real wages in the bottom of the wage distribution have fallen substantially. In particular, the real wage for males in the 10th wage percentile declined by 30 percent in real terms from 1970 to 1990.

Note that the general equilibrium condition (3-8) implies $\Omega_\alpha > 0$, and we already have $\Phi_l > 0$ and $\Phi_m < 0$. Then $dm^*/d\alpha > 0$ and $dl^*/d\alpha > 0$, thus $dL^*/d\alpha > 0$.

Graphically, we may see from Figure (A1.3) that, if there is an increase in market size, the curve $l = A(m)$ will remain unchanged since market size does not appear in equation (3-7); and the other curve, $l = B(m)$ shifts up because for any given l , m has to go down to satisfy equation (3-8).

FIGURE A1.3 Effects of Market Size

Proposition A1.3 *An increase in market size (α) raises the equilibrium employment and monitoring intensity; that is, $dL^*/d\alpha > 0$ and $dm^*/d\alpha > 0$.*

A1.4. Unemployment Benefit ($\bar{w}$)

$$\Phi_{\bar{w}} = 0, \quad \Omega_{\bar{w}} = -1 \quad (\text{A1.14})$$

Solve the following two equations for $dm^*/d\bar{w}$ and $dl^*/d\bar{w}$

$$\Phi_m \cdot \frac{dm^*}{d\bar{w}} + \Phi_l \cdot \frac{dl^*}{d\bar{w}} + \Phi_{\bar{w}} = 0, \quad \Omega_m \cdot \frac{dm^*}{d\bar{w}} + \Omega_l \cdot \frac{dl^*}{d\bar{w}} + \Omega_{\bar{w}} = 0 \quad (\text{A1.15})$$

We have

$$\frac{dm^*}{d\bar{w}} = \frac{-\Phi_l}{\Delta}, \quad \frac{dl^*}{d\bar{w}} = \frac{\Phi_m}{\Delta} \quad (\text{A1.16})$$

Since $\Phi_l > 0$ and $\Phi_m < 0$, $dm^*/d\bar{w} < 0$ and $dl^*/d\bar{w} < 0$. Then $dL^*/d\bar{w} < 0$ since $dL^*/d\bar{w} = n \cdot dl^*/d\bar{w}$. Graphically, we see from Figure (A1.4) that, if there is an increase in unemployment benefits, the curve $l = A(m)$ will remain unchanged since unemployment benefit does not appear in equation (3-7); and the other curve, $l = B(m)$ shifts down since for any given l , m has to go up to satisfy equation (3-8).

FIGURE A1.4 Effects of Unemployment Benefit

Intuitively, an increase in unemployment benefit tends to lower employment since it raises the efficiency wage rate. On the other hand, since monitoring is costly, the increase of unemployment benefit will discourage the firms from investing in monitoring effort, which leads to a further reduction of employment.

Proposition A1.4 *An increase in unemployment benefit ($\bar{w}$) leads to a decrease in the equilibrium employment and monitoring intensity; that is, $dL^*/d\bar{w} < 0$ and $dm^*/d\bar{w} < 0$.*

A1.5. Total Labor Force (N)

$$\Phi_N = 0, \quad \Omega_N = \frac{bnl^*}{(N - nl^*)^2} \quad (\text{A1.17})$$

Solve the following two equations for $dm^*/d\bar{w}$ and $dl^*/d\bar{w}$

$$\Phi_m \cdot \frac{dm^*}{dN} + \Phi_l \cdot \frac{dl^*}{dN} + \Phi_N = 0, \quad \Omega_m \cdot \frac{dm^*}{dN} + \Omega_l \cdot \frac{dl^*}{dN} + \Omega_N = 0 \quad (\text{A1.18})$$

We have

$$\frac{dm^*}{dN} = \frac{\Phi_l \cdot \Omega_N}{\Delta}, \quad \frac{dl^*}{dN} = \frac{-\Phi_m \cdot \Omega_N}{\Delta} \quad (\text{A1.19})$$

Since $\Phi_l > 0$ and $\Phi_m < 0$, $dm^*/dN > 0$ and $dl^*/dN > 0$. Then $dL^*/dN < 0$ since $dL^*/dN = n \cdot dl^*/dN$. Graphically, we

see from Figure (A1.5) that, if there is an increase in total labor force, the curve $l = A(m)$ will remain unchanged since N does not appear in equation (3-7); and the other curve, $l = B(m)$ shifts up since for any given l , m has to decrease to satisfy equation (3-8).

FIGURE A1.5 Effects of Total Labor Force

Intuitively, an increase in total labor force intensifies the competition in the labor market and hence mitigates the workers' tendency to shirk. It in turn increases the supply of labor since more are willing to work at a lower wage rate. Firms, since the efficiency wage is bid down, then have incentive to hire more workers to equate the marginal revenue product to the reduced wage rate. Consequently, employment is improved.

Proposition A1.5 *An increase in total labor force (N) leads to an increase in the equilibrium employment and monitoring intensity; that is, $dL^*/dN < 0$ and $dm^*/dN < 0$.*

A1.6. Cheaper Monitoring Cost

Suppose, due to some reasons, monitoring becomes “cheaper”, say $H(m) \rightarrow \tau \cdot H(m)$ with $0 < \tau < 1$. In this case, clearly, the curve $l = A(m)$ will shift outward since for given level of m , l has to decrease to satisfy equation (3-8); while the curve $l = B(m)$ remains unchanged because monitoring cost does not appear in equation (3-9). As illustrated in Figure (A1.6), the result is

Proposition A1.6. *A cheaper monitoring cost $H(m)$ leads to an increase in the equilibrium employment and monitoring intensity.*

Intuitively, cheaper monitoring cost gives firms an incentive to increase monitoring since the marginal cost of monitoring is reduced. And thereby it tends to reduce the efficiency wage. As a result, firms are willing to hire more workers since the marginal cost of labor is decreased.

FIGURE A1.6 Effects of Cheaper Monitoring Cost

Appendix 2. The Social Optimum vs. the Nash Equilibrium

The purpose of this section is to compare the socially optimal employment and monitoring intensity with the Nash equilibrium employment and monitoring intensity. Given the number of firms (n), the social optimum can be solved from the maximization of total welfare. Given that we have three measures of total welfare, we will analyze each maximization problem in turn.

We start with the Type I total surplus.

$$\max_{\{m, l\}} \left\{ TS^I = \int_0^{nsF(el)} \alpha P(Q) dQ - nl \left[\bar{w} + e + \frac{e}{q(m)} \left(\frac{bN}{N - nl} + r \right) \right] - nH(m) \right\} \quad (A2.1)$$

Assume that there exists a unique interior solution to (A2.1), denoted by (m_l^*, l_l^*) . Then it satisfies the following first-order conditions:

$$\frac{\partial TS^I}{\partial m} \bigg|_{(m_l^*, l_l^*)} = 0 \Rightarrow \frac{e \cdot q'(m_l^*)}{[q(m_l^*)]^2} \left(\frac{bN}{N - nl_l^*} + r \right) \cdot l_l^* - H'(m_l^*) = 0 \quad (A2.2)$$

$$\begin{aligned} \frac{\partial TS^I}{\partial l} \bigg|_{(m_l^*, l_l^*)} = 0 \Rightarrow & se \cdot \alpha P(nsF(el_l^*)) \cdot F'(el_l^*) \\ & - \left[\bar{w} + e + \frac{e}{q(m_l^*)} \left(\frac{bN}{N - nl_l^*} \right) \right] - \frac{ebnNl_l^*}{(N - nl_l^*)^2 q(m_l^*)} = 0 \end{aligned} \quad (A2.3)$$

Note that $\partial^2 TS^I / \partial m^2 < 0$ and $\partial^2 TS^I / \partial l^2 < 0$ for all $m > 0$ and $l > 0$ by our assumptions.

Recall the Nash equilibrium conditions

$$\frac{e \cdot q'(m^*)}{[q(m^*)]^2} (b + r) \cdot l^* - H'(m^*) = 0 \quad (3.14)$$

$$s^2 e \cdot \alpha P'(nsF(el^*)) \cdot F(el^*) \cdot F'(el^*) + se \cdot \alpha P(nsF(el^*)) \cdot F'(el^*) - \left[\bar{w} + e + \frac{e}{q(m^*)} \left(\frac{bN}{N - nl^*} + r \right) \right] = 0 \quad (3.15)$$

Comparing (A2.2) with (3.8), and (A2.3) with (3-9), it is clear that $(m_l^*, l_l^*) \neq (m^*, l^*)$ in general. That is, the Nash equilibrium is not the social optimum. Moreover, since

$$\frac{bN}{N - nl} > b, \text{ then } \left. \frac{\partial TS^I}{\partial m} \right|_{(m^*, l^*)} > 0. \text{ Furthermore, } \left. \frac{\partial TS^I}{\partial l} \right|_{(m^*, l^*)} > 0 \text{ if and only if}$$

$$\begin{aligned} & -s^2 e \cdot \alpha P'(nsF(el^*)) \cdot F(el^*) \cdot F'(el^*) - \frac{ebnNl^*}{(N - nl^*)^2 q(m^*)} > 0 \\ \Leftrightarrow & \left[-\frac{dp^*}{dl^*} \cdot \frac{l^*}{p^*} \right] \cdot \frac{p^* sF(el^*)}{l^*} - \frac{ebnNl^*}{(N - nl^*)^2 q(m^*)} > 0 \\ \Leftrightarrow & -\frac{dp^*}{dL^*} \cdot \frac{L^*}{p^*} > \frac{ebNL^{*2}}{(N - L^*)^2 q(m^*) p^* nsF(el^*)} \end{aligned}$$

Define $\varepsilon_{p,L} \equiv -\frac{dp}{dL} \cdot \frac{L}{p}$ as the elasticity of price with respect to the aggregate employment,

and $R \equiv pnsF(el)$ as the total revenue of the industry. Then, $\left. \frac{\partial TS^I}{\partial l} \right|_{(m^*, l^*)} > 0$ if and only

if

$$\varepsilon_{p,L}^* > \frac{ebNL^{*2}}{(N - L^*)^2 q^* R^*} = \left[\frac{\partial w^*}{\partial L^*} \cdot \frac{L^*}{w^*} \right] \cdot \frac{w^* L^*}{R^*} \quad (A2-4)$$

Case 1: Suppose the inequality (A2.4) holds, i.e. $\left. \partial TS^I / \partial l \right|_{(m^*, l^*)} > 0$. Since

$$\left. \partial TS^I / \partial m \right|_{(m^*, l^*)} > 0, \text{ then } m_l^* > m^*, l_l^* > l^* \text{ and thus } L_l^* > L^*. \text{ That is, the}$$

equilibrium employment and monitoring intensity are lower than their socially optimal values.

Case 2: Suppose the inequality (A2.4) does not hold, i.e. $\partial TS' / \partial l \big|_{(m^*, l^*)} < 0$. Since

$$\partial TS' / \partial m \big|_{(m^*, l^*)} > 0, \quad \partial^2 TS' / \partial m^2 < 0 \quad \text{and} \quad \partial^2 TS' / \partial l^2 < 0, \quad \text{then} \quad m_l^* > m^*,$$

$l_l^* < l^*$ and thus $L_l^* < L^*$. That is, the Nash equilibrium employment exceeds the socially optimal employment, while the Nash equilibrium monitoring intensity is lower than the socially optimal monitoring intensity.

The above discussion indicates that the Cournot Nash equilibrium monitoring intensity is lower than the socially optimal monitoring intensity. However, the Cournot Nash equilibrium employment can be either higher or lower than the Type I socially optimal employment.

Similarly, for the maximization of Type II and Type III total surplus, we have

$$\frac{\partial TS''}{\partial m} \bigg|_{(m^*, l^*)} < 0 \quad \text{and} \quad \frac{\partial TS''}{\partial l} \bigg|_{(m^*, l^*)} > 0, \quad \frac{\partial^2 TS''}{\partial m^2} < 0 \quad \text{and} \quad \frac{\partial^2 TS''}{\partial l^2} < 0 \quad (\text{A2.5})$$

$$\frac{\partial TS'''}{\partial m} \bigg|_{(m^*, l^*)} < 0 \quad \text{and} \quad \frac{\partial TS'''}{\partial l} \bigg|_{(m^*, l^*)} > 0, \quad \frac{\partial^2 TS'''}{\partial m^2} < 0 \quad \text{and} \quad \frac{\partial^2 TS'''}{\partial l^2} < 0 \quad (\text{A2.6})$$

(A2.5) and (A2.6) suggest that, relative to the *Type II* or the *Type III* social optimum, the Nash equilibrium involves a lower employment level ($L^* < L_{II}^*$, $L^* < L_{III}^*$) and a higher monitoring intensity ($m^* > m_{II}^*$, $m^* > m_{III}^*$). Note that the Type II and Type III social optima require zero monitoring intensity since $\partial TS'' / \partial m < 0$ and $\partial TS''' / \partial m < 0$ for all $m \geq 0$. Intuitively, this is because in type II and III total surplus the wages are a transfer

from firms to workers while monitoring involves resource costs. Consequently, it is optimal to set monitoring level at zero and pay a high wage rate to discourage shirking.

To summarize, (i) the Nash equilibrium is not socially optimal no matter which measure of total welfare we use; (ii) Cournot competition in the product market generates a level of employment that can be higher or lower than the socially optimal employment; and (iii) relative to the Type I social optimum, individual firms invest less in monitoring, while firms put excessive monitoring effort or investment relative to the Type II and Type III social optima.

Appendix 3. Panel-Data Regression Results

A3.1. Regression Results without Competition, $x = (p, w, s, r, N)$

TABLE A3.1 Panel-Data Regression Results: #1

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<i>Constant</i>	132.4484	6.310761	20.98771	0.0000
p_t	-0.359156	0.021686	-16.56149	0.0000
p_{t-1}	0.396755	0.022018	18.01917	0.0000
$\log(w_t)$	-14.01174	0.866046	-16.17898	0.0000
$\log(w_{t-1})$	16.35585	0.870524	18.78850	0.0000
s_t	0.023938	0.014552	1.645056	0.1005
s_{t-1}	-0.078136	0.014094	-5.543968	0.0000
r_t	0.055446	0.017359	3.194084	0.0015
r_{t-1}	0.222642	0.016524	13.47368	0.0000
$\log(N_t)$	-20.19961	2.075552	-9.732167	0.0000
$\log(N_{t-1})$	10.65544	2.078504	5.126494	0.0000
Country-Specific Effects (Cross-Section Fixed)				
Australia:	4.298937		Japan:	7.386921
Austria:	-5.695473		Italy:	17.20409
Belgium:	-1.488845		Luxembourg:	-38.17811
Canada:	10.22883		Netherlands:	1.579492
Denmark:	-12.50070		New Zealand:	-11.18338
Finland:	-5.597754		Norway:	-16.86216
France:	16.71770		Sweden:	-9.193936
Greece:	2.635911		UK:	18.72639
Ireland:	-7.427863		USA:	29.34996
Weighted Statistics				
R-squared:	0.958857		Mean dependent var:	3.551275
Adjusted R-squared:	0.957012		S.D. dependent var:	10.27369
S.E. of regression:	0.983789		Sum squared resid:	582.6397
F-statistic:	519.6249		Durbin-Watson stat:	1.313154
Prob (F-statistic):	0.000000			
Unweighted Statistics				
R-squared:	0.890347		Mean dependent var:	5.954059
Sum squared resid:	1552.827		Durbin-Watson stat:	0.312980

A3.2. Regression Results with Competition, $x = (p, w, s, r, N, Com)$

TABLE A3.2 Panel-Data Regression Results: #2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<i>Constant</i>	128.2767	6.745672	19.01614	0.0000
p_t	-0.362129	0.022486	-16.10455	0.0000
p_{t-1}	0.401480	0.022769	17.63275	0.0000
$\log(w_t)$	-13.01221	0.904059	-14.39310	0.0000
$\log(w_{t-1})$	15.26283	0.909690	16.77806	0.0000
s_t	-0.004423	0.016401	-0.269668	0.7875
s_{t-1}	-0.048781	0.015774	-3.092457	0.0021
r_t	0.046219	0.017937	2.576726	0.0102
r_{t-1}	0.229598	0.017178	13.36587	0.0000
$\log(N_t)$	-18.90145	2.186423	-8.644917	0.0000
$\log(N_{t-1})$	9.560489	2.179183	4.387190	0.0000
COM_t	-2.220691	0.929500	-2.389124	0.0172
COM_{t-1}	4.355663	0.900221	4.838438	0.0000
Country-Specific Effects (Cross-Section Fixed)				
Australia:	4.159269		Japan:	7.479190
Austria:	-5.776650		Italy:	17.01836
Belgium:	-1.488856		Luxembourg:	-37.27097
Canada:	10.00457		Netherlands:	1.458208
Denmark:	-12.44849		New Zealand:	-10.93967
Finland:	-5.642910		Norway:	-16.58093
France:	16.28288		Sweden:	-9.183884
Greece:	3.175018		UK:	18.13594
Ireland:	-7.067410		USA:	28.68632
Weighted Statistics				
R-squared:	0.955196		Mean dependent var:	4.591611
Adjusted R-squared:	0.953030		S.D. dependent var:	9.103077
S.E. of regression:	0.974681		Sum squared resid:	570.0021
F-statistic:	441.0908		Durbin-Watson stat:	1.270360
Prob (F-statistic):	0.000000			
Unweighted Statistics				
R-squared:	0.879219		Mean dependent var:	5.954059
Sum squared resid:	1536.587		Durbin-Watson stat:	0.310950

Appendix 4. Contemporaneous Coefficients in the Structural VAR Model

TABLE A4.1 Contemporaneous Coefficients in the SVAR Model

Coefficients	Australia	Austria	Belgium	Canada	Denmark	Finland
g_{11}	0.759094 (0.093438)	0.883299 (0.108727)	0.753557 (0.091382)	0.988561 (0.121683)	0.526142 (0.064764)	0.485348 (0.059742)
g_{22}	0.003850 (0.000474)	0.004058 (0.000500)	0.004102 (0.000497)	0.004526 (0.000557)	0.003798 (0.000467)	0.006845 (0.000842)
g_{33}	1.388503 (0.170913)	0.438932 (0.054029)	0.752187 (0.091216)	0.889981 (0.109549)	1.072125 (0.131970)	0.651220 (0.080160)
g_{41}	-0.261440 (0.090558)	0.044964 (0.050676)	-0.256704 (0.070896)	-0.194652 (0.056494)	-0.062104 (0.027555)	0.115028 (0.074720)
g_{42}	0.123646 (0.086005)	0.143035 (0.053361)	-0.157672 (0.066504)	-0.237067 (0.058899)	-0.041595 (0.026964)	0.366918 (0.086153)
g_{43}	-0.248013 (0.089984)	0.139490 (0.053219)	0.391101 (0.079414)	0.325012 (0.064946)	0.248964 (0.040497)	0.178694 (0.076592)
g_{44}	0.265771 (0.032714)	0.278932 (0.034334)	0.323938 (0.039283)	0.157083 (0.019336)	0.133226 (0.016399)	0.417669 (0.051411)
g_{45}	-0.382600 (0.070337)	0.077012 (0.049473)	0.154599 (0.060875)	0.239413 (0.041822)	0.045847 (0.025865)	-0.028807 (0.073280)
g_{46}	-0.139407 (0.049345)	0.001585 (0.048556)	-0.095438 (0.056748)	0.066214 (0.028533)	-0.057248 (0.024239)	-0.048452 (0.072951)
g_{51}	0.005127 (0.001488)	-0.001006 (0.000659)	0.005137 (0.001532)	0.003340 (0.001983)	-0.001195 (0.001393)	0.011851 (0.002375)
g_{52}	-0.005369 (0.001501)	0.003114 (0.000752)	0.001039 (0.001406)	0.000129 (0.001940)	0.004993 (0.001515)	0.003655 (0.001927)
g_{53}	0.019062 (0.002706)	-0.000250 (0.000648)	0.003232 (0.001454)	-0.000305 (0.001940)	0.009300 (0.001797)	-0.001272 (0.001880)
g_{55}	0.007741 (0.000953)	0.003717 (0.000458)	0.008163 (0.000990)	0.011143 (0.001372)	0.007955 (0.000979)	0.010763 (0.001325)
g_{61}	0.001302 (0.001573)	-0.007896 (0.001256)	0.000163 (0.001093)	-0.007159 (0.001298)	-0.000487 (0.000886)	-0.003201 (0.001480)
g_{62}	-0.001147 (0.001571)	0.000786 (0.000801)	-0.000336 (0.001094)	-0.004330 (0.001091)	0.000459 (0.000886)	-0.008837 (0.001794)
g_{63}	0.005098 (0.001686)	-0.000354 (0.000796)	-0.002316 (0.001128)	0.002502 (0.001001)	-0.006450 (0.001188)	0.007557 (0.001703)
g_{65}	-0.005068 (0.030861)	-0.074258 (0.013601)	-0.086864 (0.064032)	0.065737 (0.042493)	-0.247560 (0.067091)	-0.179098 (0.085023)
g_{66}	0.001227 (0.001558)	0.001663 (0.000768)	0.002228 (0.001059)	0.001261 (0.000940)	-0.000671 (0.000880)	-0.002323 (0.001398)
g_{71}	0.008905 (0.001096)	0.004255 (0.000524)	0.005970 (0.000724)	0.005324 (0.000655)	0.005035 (0.000620)	0.007862 (0.000968)
g_{72}	-0.069451 (0.057366)	-0.110892 (0.027719)	-0.148514 (0.075732)	-0.143572 (0.050597)	-0.144198 (0.086328)	-0.198162 (0.106004)
g_{73}	-0.237194 (0.063798)	0.127234 (0.028763)	0.175718 (0.076583)	-0.222730 (0.054767)	0.138961 (0.086197)	0.009073 (0.103166)
g_{74}	-0.040781 (0.056947)	-0.016820 (0.024214)	0.046877 (0.073778)	-0.001512 (0.047411)	0.234393 (0.089274)	0.040756 (0.103282)

g_{75}	0.059795 (0.056246)	0.099563 (0.020781)	-0.002836 (0.073558)	0.108557 (0.045488)	-0.228012 (0.079685)	-0.264049 (0.097906)
g_{76}	0.266776 (0.045068)	0.020803 (0.016586)	0.201961 (0.069361)	0.025375 (0.043369)	0.066035 (0.074134)	-0.163917 (0.090122)
g_{77}	0.177245 (0.021817)	0.057854 (0.007121)	0.368281 (0.044661)	0.239636 (0.029497)	0.343363 (0.042265)	0.471718 (0.058064)
Coefficients	France	Greece	Ireland	Italy	Japan	Luxembourg
g_{11}	0.406387 (0.050023)	1.784142 (0.219613)	1.451789 (0.178703)	0.613294 (0.074373)	1.161578 (0.142980)	1.051085 (0.129380)
g_{22}	0.002475 (0.000305)	0.013540 (0.001667)	0.007608 (0.000937)	0.006317 (0.000766)	0.003390 (0.000417)	0.003957 (0.000487)
g_{33}	0.862132 (0.106121)	1.305411 (0.160685)	0.797962 (0.098222)	0.782828 (0.094932)	0.766924 (0.094402)	1.293139 (0.159174)
g_{41}	0.064704 (0.033641)	0.081559 (0.085511)	-0.265268 (0.068423)	-0.156863 (0.048899)	-0.281988 (0.127007)	0.295678 (0.069432)
g_{42}	0.069141 (0.033774)	-0.003916 (0.084921)	-0.163212 (0.063396)	-0.029251 (0.045187)	0.031720 (0.122234)	0.086158 (0.060072)
g_{43}	0.357426 (0.054808)	0.276882 (0.091504)	0.145034 (0.062723)	0.313284 (0.058929)	0.297788 (0.127552)	0.232824 (0.065708)
g_{44}	0.138979 (0.017107)	0.376783 (0.046379)	0.291619 (0.035896)	-0.234104 (0.028389)	0.425807 (0.052413)	0.315188 (0.038797)
g_{45}	-0.022972 (0.032562)	0.297933 (0.076593)	0.154030 (0.057062)	-0.057272 (0.044509)	0.449102 (0.108950)	0.097493 (0.057898)
g_{46}	0.124139 (0.028615)	-0.085125 (0.066421)	0.102686 (0.052314)	-0.104458 (0.042099)	-0.330986 (0.084582)	-0.080790 (0.055761)
g_{51}	0.002075 (0.001320)	0.008330 (0.003726)	0.009752 (0.001785)	-0.003647 (0.001494)	0.003547 (0.001682)	-0.000965 (0.002559)
g_{52}	0.000122 (0.001295)	-0.005797 (0.003652)	0.005405 (0.001479)	1.50E-05 (0.001427)	-0.002040 (0.001644)	-0.004967 (0.002628)
g_{53}	0.002947 (0.001344)	-0.014276 (0.003990)	-0.001109 (0.001328)	0.007365 (0.001684)	-0.000261 (0.001625)	0.014405 (0.003111)
g_{55}	0.007437 (0.000915)	0.020576 (0.002533)	0.007590 (0.000934)	-0.008322 (0.001009)	0.009332 (0.001149)	0.014685 (0.001808)
g_{61}	0.001783 (0.000653)	0.003493 (0.001552)	-0.012571 (0.002774)	-0.005172 (0.001307)	-0.005549 (0.001013)	-0.011731 (0.004302)
g_{62}	-0.002720 (0.000701)	0.000665 (0.001493)	-0.011730 (0.002718)	-0.001359 (0.001159)	-0.001189 (0.000762)	-0.011055 (0.004275)
g_{63}	-0.000536 (0.000619)	-0.007899 (0.001780)	0.011255 (0.002687)	0.007097 (0.001434)	0.001630 (0.000774)	-0.005330 (0.004105)
g_{65}	0.201541 (0.048296)	-0.142612 (0.064065)	-0.032976 (0.082644)	-0.070738 (0.034466)	-0.064713 (0.010214)	0.022142 (0.016024)
g_{66}	-0.000189 (0.000615)	0.000380 (0.001490)	0.000455 (0.002302)	-0.002864 (0.001093)	-0.001312 (0.000730)	0.007064 (0.003958)
g_{71}	0.003530 (0.000435)	0.008556 (0.001053)	0.013219 (0.001627)	0.006043 (0.000733)	0.004090 (0.000503)	0.022183 (0.002731)
g_{72}	0.043269 (0.069659)	-0.201689 (0.085795)	0.303201 (0.099673)	0.110143 (0.047715)	-0.148252 (0.022881)	-0.028857 (0.020803)
g_{73}	-0.113793 (0.070854)	0.289238 (0.089510)	0.502914 (0.111238)	-0.066744 (0.046517)	-0.006214 (0.013824)	0.061521 (0.021852)
g_{74}	0.003228 (0.069456)	-0.114981 (0.083335)	0.104033 (0.093304)	-0.187148 (0.051121)	-0.043527 (0.014807)	-0.039898 (0.021078)

g_{75}	0.086945 (0.068626)	-0.227160 (0.077218)	-0.145719 (0.090664)	0.141252 (0.042484)	-0.026869 (0.013401)	0.008440 (0.020471)
g_{76}	0.233131 (0.061412)	0.159219 (0.069258)	-0.186301 (0.085863)	-0.092189 (0.037236)	0.005360 (0.012970)	-0.071239 (0.018469)
g_{77}	0.238044 (0.029301)	0.353943 (0.043567)	0.474181 (0.058368)	0.194647 (0.023604)	0.036729 (0.004521)	0.090711 (0.011166)
Coefficients	Netherlands	New Zealand	Norway	Sweden	UK	USA
g_{11}	0.658751 (0.079885)	1.423271 (0.177909)	0.773094 (0.093751)	0.652476 (0.079124)	0.910189 (0.110377)	0.699413 (0.086092)
g_{22}	0.004741 (0.000575)	0.008338 (0.001042)	0.007107 (0.000862)	0.002804 (0.000340)	0.004340 (0.000526)	0.003057 (0.000376)
g_{33}	0.715614 (0.086781)	0.822158 (0.102770)	0.664346 (0.080564)	0.738799 (0.089593)	0.850277 (0.103111)	0.799687 (0.098435)
g_{41}	0.037443 (0.075582)	-0.381940 (0.096590)	-0.307697 (0.100808)	-0.540055 (0.141693)	-0.238628 (0.088121)	-0.131879 (0.069414)
g_{42}	-0.203843 (0.079392)	0.166997 (0.086522)	-0.089767 (0.094278)	-0.110532 (0.126363)	-0.055690 (0.083508)	-0.049187 (0.067760)
g_{43}	0.169423 (0.078193)	0.280848 (0.091010)	0.283946 (0.099777)	0.114542 (0.126415)	0.068151 (0.083644)	0.333211 (0.078975)
g_{44}	0.368811 (0.044725)	0.468042 (0.058505)	0.328182 (0.039798)	0.591534 (0.071734)	0.452946 (0.054928)	0.276298 (0.034010)
g_{45}	0.076242 (0.074877)	0.079744 (0.083372)	0.427968 (0.077951)	0.191691 (0.123481)	0.053356 (0.082982)	0.196618 (0.063000)
g_{46}	-0.227362 (0.068999)	0.013697 (0.082757)	-0.085526 (0.057230)	0.387469 (0.111801)	-0.165962 (0.080244)	0.187904 (0.053370)
g_{51}	0.008362 (0.001577)	0.011850 (0.003429)	-0.003767 (0.002418)	-0.003091 (0.001903)	-0.002476 (0.002930)	0.001812 (0.001064)
g_{52}	0.001027 (0.001214)	0.002449 (0.003107)	-0.003276 (0.002408)	0.003983 (0.001927)	0.000660 (0.002915)	0.001928 (0.001067)
g_{53}	-0.001898 (0.001229)	0.009736 (0.003323)	0.004966 (0.002450)	-0.002863 (0.001898)	0.004083 (0.002956)	0.002098 (0.001071)
g_{55}	0.007039 (0.000854)	0.017493 (0.002187)	0.013846 (0.001679)	0.010880 (0.001319)	0.016993 (0.002061)	0.005974 (0.000735)
g_{61}	-0.001582 (0.001164)	-0.004158 (0.001437)	-0.019040 (0.003371)	-0.004339 (0.001855)	-0.003413 (0.001729)	-0.002510 (0.000569)
g_{62}	0.001575 (0.001164)	0.006689 (0.001580)	0.007765 (0.002631)	-0.002013 (0.001795)	0.000957 (0.001683)	-0.000395 (0.000480)
g_{63}	-0.004423 (0.001267)	0.002250 (0.001369)	-0.009301 (0.002703)	0.001328 (0.001786)	-0.000309 (0.001679)	-0.001687 (0.000521)
g_{65}	0.049740 (0.050500)	-0.321674 (0.073400)	-0.055157 (0.043456)	-0.092874 (0.035804)	0.081324 (0.054777)	-0.183020 (0.045911)
g_{66}	-0.000302 (0.001148)	0.005052 (0.001182)	-0.001358 (0.002451)	-0.001157 (0.001773)	0.005912 (0.001518)	0.000727 (0.000469)
g_{71}	0.006689 (0.000811)	0.005653 (0.000707)	0.014259 (0.001729)	0.010305 (0.001250)	0.007802 (0.000946)	0.002644 (0.000325)
g_{72}	0.035609 (0.052485)	0.040314 (0.085487)	-0.043848 (0.047533)	0.046513 (0.051122)	-0.065392 (0.075393)	-0.207077 (0.059727)
g_{73}	0.174183 (0.056411)	-0.333883 (0.094997)	-0.004800 (0.047239)	-0.110606 (0.052550)	0.173756 (0.077880)	-0.241634 (0.061662)
g_{74}	-0.016528 (0.052345)	-0.185183 (0.088422)	-0.154803 (0.050829)	0.062659 (0.051375)	0.083485 (0.075656)	-0.535444 (0.085215)

g_{75}	0.054364 (0.051890)	-0.041721 (0.085179)	0.010557 (0.047218)	0.061213 (0.050265)	0.031828 (0.074876)	0.005470 (0.054010)
g_{76}	0.046067 (0.051165)	0.084629 (0.084358)	-0.100094 (0.045613)	0.190080 (0.044046)	0.291178 (0.065914)	0.099714 (0.052593)
g_{77}	0.292357 (0.035453)	0.347371 (0.043421)	0.250372 (0.030362)	0.198172 (0.024032)	0.314184 (0.038100)	0.229806 (0.028287)

* The numbers in the brackets are the corresponding standard errors.

Appendix 5. Regression Results of the Grouped Panel Data Model (Grouped by the Impulse Response)

A5.1. Group A: Australia, Belgium, Canada, France, Greece Japan, New Zealand, Sweden, UK, USA

TABLE A5.1 Group Panel-Data Regression Results: A

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<i>Constant</i>	73.04094	10.67759	6.840582	0.0000
p_t	-0.197657	0.038157	-5.180117	0.0000
p_{t-1}	0.240962	0.037410	6.441067	0.0000
$\log(w_t)$	-12.25641	1.471487	-8.329267	0.0000
$\log(w_{t-1})$	13.81247	1.484388	9.305163	0.0000
s_t	-0.045345	0.030386	-1.492290	0.1366
s_{t-1}	-0.028562	0.029322	-0.974068	0.3307
r_t	-0.026496	0.032727	-0.809588	0.4188
r_{t-1}	0.193028	0.030188	6.394099	0.0000
$\log(N_t)$	-16.57523	4.248251	-3.901659	0.0001
$\log(N_{t-1})$	11.01813	4.093565	2.691572	0.0075
COM_t	1.063067	2.880748	0.369025	0.7123
COM_{t-1}	12.59265	2.941767	4.280643	0.0000
Country-Specific Effects (Cross-Section Fixed)				
Australia:	-1.410208		Japan:	-1.877501
Belgium:	-4.931769		New Zealand:	-10.40583
Canada:	2.667469		Sweden:	-12.23085
France:	5.895985		UK:	6.423533
Greece:	2.977715		USA:	12.89146
Weighted Statistics				
R-squared:	0.926863		Mean dependent var:	5.576727
Adjusted R-squared:	0.922180		S.D. dependent var:	4.967019
S.E. of regression:	0.996003		Sum squared resid:	325.3835
F-statistic:	197.9397		Durbin-Watson stat:	0.819441
Prob (F-statistic):	0.000000			
Unweighted Statistics				
R-squared:	0.849480		Mean dependent var:	6.161342
Sum squared resid:	669.6583		Durbin-Watson stat:	0.289364

A5.2. Group B: Austria, Denmark, Finland, Luxembourg
Ireland, Italy, Netherlands, Norway

TABLE A5.2 Group Panel-Data Regression Results: B

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<i>Constant</i>	219.7956	18.01650	12.19968	0.0000
p_t	-0.448371	0.078356	-5.722201	0.0000
p_{t-1}	0.550987	0.077778	7.084138	0.0000
$\log(w_t)$	-10.51440	2.935610	-3.581674	0.0004
$\log(w_{t-1})$	11.56017	2.812589	4.110151	0.0001
s_t	0.109289	0.046598	2.345368	0.0198
s_{t-1}	-0.170578	0.046762	-3.647815	0.0003
r_t	0.139167	0.046307	3.005297	0.0029
r_{t-1}	0.259185	0.043482	5.960715	0.0000
$\log(N_t)$	1.715364	6.031328	0.284409	0.7763
$\log(N_{t-1})$	-17.03692	6.242015	-2.729394	0.0068
COM_t	-2.833391	0.933404	-1.901636	0.0281
COM_{t-1}	-2.033106	0.707310	-1.814672	0.0372
Country-Specific Effects (Cross-Section Fixed)				
Austria:	4.842245		Italy:	36.99549
Denmark:	-1.447014		Luxembourg:	-46.44347
Finland:	1.860486		Norway:	-7.348487
Ireland:	-3.577543		Netherlands:	15.11830
Weighted Statistics				
R-squared:	0.879625		Mean dependent var:	4.056682
Adjusted R-squared:	0.870829		S.D. dependent var:	3.260137
S.E. of regression:	0.968346		Sum squared resid:	243.8004
F-statistic:	159.99597		Durbin-Watson stat:	0.684989
Prob (F-statistic):	0.000000			
Unweighted Statistics				
R-squared:	0.709772		Mean dependent var:	5.694955
Sum squared resid:	490.3465		Durbin-Watson stat:	0.281127

Appendix 6. Regression Results of the Grouped Panel Data Model (Grouped by the Intensity of Competition)

A6.1. Group C: Australia, Belgium, Canada, France Japan, Netherlands, New Zealand, Norway, USA

TABLE A6.1 Group Panel-Data Regression Results: C

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<i>Constant</i>	123.8604	12.27129	10.09351	0.0000
p_t	-0.164559	0.055984	-2.939375	0.0036
p_{t-1}	0.148068	0.052737	2.807681	0.0054
$\log(w_t)$	-5.510587	2.323884	-2.371283	0.0186
$\log(w_{t-1})$	11.59782	2.125573	5.456329	0.0000
s_t	-0.110827	0.047257	-2.345217	0.0199
s_{t-1}	0.022537	0.046001	0.489917	0.6247
r_t	-0.128123	0.040813	-3.139270	0.0019
r_{t-1}	0.110894	0.039407	2.814047	0.0053
$\log(N_t)$	-36.76861	6.425623	-5.722185	0.0000
$\log(N_{t-1})$	25.85197	6.275319	4.119626	0.0001
COM_t	0.451076	3.762975	0.119872	0.9047
COM_{t-1}	8.816740	3.888228	2.267547	0.0243
Country-Specific Effects (Cross-Section Fixed)				
Australia:	-2.411667		Netherland:	-0.89444
Belgium:	-8.955371		New Zealand:	-16.99403
Canada:	4.612986		Norway:	-28.66314
France:	12.29970		USA:	26.17584
Japan:	-14.72745			
Weighted Statistics				
R-squared:	0.896386		Mean dependent var:	3.958612
Adjusted R-squared:	0.888134		S.D. dependent var:	4.307931
S.E. of regression:	0.996647		Sum squared resid:	285.6328
F-statistic:	154.7820		Durbin-Watson stat:	0.827315
Prob (F-statistic):	0.000000			
Unweighted Statistics				
R-squared:	0.826801		Mean dependent var:	5.886673
Sum squared resid:	301.4763		Durbin-Watson stat:	0.352983

A6.2. Group D: Austria, Denmark, Finland, Greece, Ireland
Italy, Luxemburg, Sweden, UK

TABLE A6.2 Group Panel-Data Regression Results: D

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<i>Constant</i>	-107.2943	20.31632	-5.281189	0.0000
p_t	-0.406813	0.068832	-5.910264	0.0000
p_{t-1}	0.426115	0.071852	5.930451	0.0000
$\log(w_t)$	-13.53308	2.454105	-5.514465	0.0000
$\log(w_{t-1})$	15.24213	2.450305	6.220503	0.0000
s_t	0.024911	0.043628	0.570989	0.5685
s_{t-1}	-0.076128	0.042276	-1.800744	0.0729
r_t	0.062993	0.046020	1.368811	0.1722
r_{t-1}	0.168190	0.039233	4.286904	0.0000
$\log(N_t)$	3.007705	6.520813	0.461247	0.6450
$\log(N_{t-1})$	3.727524	6.711755	0.555372	0.5791
COM_t	-3.155832	0.869567	-2.432297	0.0103
COM_{t-1}	-1.221837	1.482884	-1.305315	0.1838
Country-Specific Effects (Cross-Section Fixed)				
Austria:	-1.891614		Italy:	-5.096298
Denmark:	-1.018702		Luxemburg:	-9.495558
Finland:	6.016877		Sweden:	-8.331159
Greece:	2.520930		UK:	-2.782754
Ireland:	-8.067051			
Weighted Statistics				
R-squared:	0.900567		Mean dependent var:	4.463515
Adjusted R-squared:	0.893301		S.D. dependent var:	4.122547
S.E. of regression:	0.975852		Sum squared resid:	287.4667
F-statistic:	123.9382		Durbin-Watson stat:	0.703988
Prob (F-statistic):	0.000000			
Unweighted Statistics				
R-squared:	0.769598		Mean dependent var:	6.021444
Sum squared resid:	742.3138		Durbin-Watson stat:	0.272481