PARTIAL AND GENERAL EQUILIBRIUM IMPLICATIONS OF AN ALTERNATIVE APPROACH TO X-EFFICIENCY

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INTRODUCTION

The importance of imperfect competition has long been recognised in many areas of economics. In the field of industrial economics the assumption that firms are price-makers and not price-takers is pervasive and has led to the modelling of different kinds of competitive interaction among firms. Labour economics too has departed from the perfect competition paradigm to model the impact of trade unions on labour market outcomes. Eventually, at the beginning of the 80s, macroeconomics has joined in by relaxing the assumption of perfectly competitive markets in the analysis of monetary and fiscal policies.

However, most papers from the different areas of economics focus on just one consequence of imperfect competition, namely the allocative distortion of resources. So monopolies and oligopolies are inherently 'bad' because they lead to an inefficient allocation, and, consequently, to lower output. Lower production means, in turn, lower employment. This follows from the assumption that a firm extracts the maximum output from any given input irrespective of the structure of the market in which it operates. Thus, labour is as productive in a monopolistic firm as it is in a competitive one, so that, if output increases with competition, so does employment.

The view that firm efficiency is uncorrelated to product market competition has been challenged in recent years by the growing, though still relatively small, literature on x-efficiency. Broadly speaking, this term refers to the idea that factor productivity is actually linked to the level of competition in the product market. Specifically, the more competitive is the market, the more efficient are the firms that compete in that market so that the higher is the level of output they obtain from a given amount of input. The idea that competition drives firms towards efficient ways of production is not recent. Already at the beginning of the 50s Friedman [1953] argued that only firms that maximise profits, i.e. minimise costs, survive in a competitive environment. However, it is to Leibenstein [1966] that we owe the term x-efficiency and it is by Hart [1983] the first fully-fledged model of x-efficiency. Though more contributions followed Hart's paper during the 80s and 90s, the theoretical support in favour of the x-efficiency argument is not overwhelming. Quite to the contrary, a few authors have argued, somehow counter-intuitively, that the opposite of x-efficiency holds. That is, according to their view, firm efficiency decreases in the level of product market competition.

Whatever the conclusion of the different papers that study the relationship between firm efficiency and product market competition, they all share a common feature: they are all nested into a partial equilibrium framework. In fact, to my knowledge, no general equilibrium model of x-efficiency has yet been constructed. In other words, general equilibrium models of imperfect competition still stick to the hypothesis that firm efficiency is uncorrelated with market structure and, on the basis of this assumption, they derive the effects of competition on output, employment, and welfare. Specifically, product market competition is invariably found to be raising all these three variables.

The aim of this work is to provide a new approach to x-efficiency and to nest it into a general equilibrium framework. In particular, the work is structured as follows.

In Chapter 1 we give a brief introduction to the literature on x-efficiency and to the economics of imperfect competition. We do not describe any model of x-efficiency in detail, as our approach to it substantially differs from those followed in the existing literature. More formal is, instead, the discussion of the economics of imperfect competition. This involves the analysis of both the output and the labour market. In the case of the latter, we focus on the economics of trade unions. Concerning the former, we introduce a simple general equilibrium model that reproduces one of the main findings of the literature, namely the suboptimality of the equilibrium when the product market is characterised by monopolistic competition. An extension of this model is then used in the last part of this work to analyse the general equilibrium impact of x-efficiency.

In Chapter 2 we introduce our approach to x-efficiency. Using very general revenue and cost functions, we derive the conditions under which an increase in competition raises firm efficiency. The level of aggregation is the lowest as we analyse the behaviour of a single firm in an environment in which factor prices (wage rate and cost of capital) are fixed and revenue depends only on product market competition and on the observed firm's level of production/price. Firm factor demand and production are also discussed as well as the impact of product market competition on these variables. The chapter is concluded with an example, in which we use a Cobb-Douglas production function and a demand schedule characterised by constant price elasticity.

In Chapter 3 the approach followed in the previous chapter is extended to a whole sector of the economy. The analysis is conducted at a lower level of generality as a symmetric model is used in which all firms have the same Cobb-Douglas production function and face identical CES demand functions. Thus, the model is an extension of the example presented in the final part of Chapter 2. The main difference is that now there are many firms each of them facing a demand schedule that depends on the level of production/price of all firms operating in the same industry and on the amount of income spent by the consumers on goods from this industry. Such income is exogenously given and so are factor prices. Moreover, and probably most importantly, we give in this chapter a formal justification for assumptions made in Chapter 2. These assumptions, that were crucial in determining the x-efficiency result, become now the outcome of a process of utility maximisation. Finally, the main findings of this chapter are illustrated by means of a numerical example.

Chapter 4 undertakes a last extension of the model by analysing the general equilibrium implications of our approach. To this end we model the factor markets. That is, we add a sector producing the capital input and a labour supply function. Now the industry analysed in Chapter 3 is assumed to be the only one in the economy for consumption goods. The consequences of these extensions are that factor prices as well as income become endogenous. Further, as we are using a general equilibrium framework, we are able to discuss the implications of x-efficiency not only for output and employment, but also for welfare. The chapter is concluded by a numerical example.

Conclusions and a mathematical appendix complete this work.

CHAPTER 1

Imperfect competition and x-efficiency: an overview

1.1 Introduction

This chapter contains a brief review of the literatures on trade unions, imperfectly competitive product markets, and x-efficiency.

As to the economics of trade unions, we take into consideration partial as well as general equilibrium models. However, none of them is used in the remainder of this work. This is because our approach will focus on a particular aspect of union behaviour that has been so far neglected in the literature. This aspect is the impact of product market competition on the union's preferred level of employment. Nevertheless, since in our model unions set employment, there is a similarity between our results and those of that part of the literature that deals with wage-employment bargaining. This similarity will be highlighted throughout the work as it emerges.

As far as the second area is concerned (imperfectly competitive product markets), most of the relative section is devoted to the discussion of a particular finding of the literature: the suboptimality of the general equilibrium outcome when there is imperfect competition in the product market and perfect competition in the labour market. The reason for focusing on this finding is that it is particularly relevant for the remainder of this work. So in section

1.2.2 a model is set up to show the impact of monopolistic competition on employment/output and welfare. A similar model is then used in Chapter 4.

As to x-efficiency, this term has different meanings and can be interpreted in different ways. In general it is used to describe a link between product market competition and firm efficiency. None of the models from the literature on x-efficiency is formally presented, as none of them is used in any subsequent chapter. The approach to x-efficiency adopted in Chapters 2 to 4 is in fact new and does not build on any existing model of x-efficiency.

Since all current approaches to x-efficiency are nested into a partial equilibrium framework, general equilibrium models of imperfect competition and x-efficiency models are discussed separately. However, an obvious link exists between them as both try to assess the consequences of imperfect competition in the product market. This link has been ignored by the general equilibrium literature, as this consistently assumes that firms are perfectly efficient, whatever the degree of product market competition. It seems therefore worthwhile to develop a general equilibrium approach that accounts for a possible link between product market competition and firm efficiency. This is done in Chapter 4 where a general equilibrium model of imperfect competition with endogenous x-efficiency will be discussed.

1.2 Imperfect competition

The importance of imperfect competition has long been recognised in many areas of economics, perhaps most obviously in industrial economics and in the labour economics of trade unions. Despite the clear divergence of output and labour markets from the competitive paradigm in most countries, macroeconomics has instead tended to stick to the Walrasian market-clearing approach. However, over the last two decades a shift has begun away from a concentration on the Walrasian price-taker towards a world where firms, unions, and governments may act strategically. In particular, models have been built that look at the implications in terms of general equilibrium of having imperfectly competitive output and labour markets.

In the next two sections we give a brief introduction to the economics of trade unions and to the literature discussing imperfect competition in the product market. We begin with the economics of trade unions.

1.2.1 The economics of trade unions

An obvious observation about the labour markets is that they are far from being perfectly competitive. One of the main reasons is the presence of trade unions. The economic analysis of trade unions has experienced a remarkable development since the mid-70s when it was still considered a ‘Cinderella’ topic within economics (Johnson [1975]). In particular, considerable attention has been devoted over many years to the construction of theories of union objectives and behaviour. Most of them were developed within partial equilibrium frameworks. We start therefore by analysing trade unions within this type of setting[1].

<u>Partial equilibrium analysis and trade unions</u>

In this section we examine the interaction between a union and a firm. How union and firm relate to each other depends in the first instance on the respective objectives. The general view is that the union maximises a utility function defined over the levels of wage and employment of their members. Specifically, it is often assumed that the union maximises the expected utility of a representative union member, which is given by

$$(1.1) \qquad E(U)=\frac{N}{T}U(w)+\left(1-\frac{N}{T}\right)U(\overline{w}) \qquad\qquad U'(w)>0,\ \ U''(w)\leq 0$$

[1] For an introduction to the economics of trade unions in partial equilibrium analysis see Sapsford and Tzannatos [1993]. A more specific reference is Booth [1995a].

where w is the wage that every employee receives from the firm, $\overline{w}$ is the wage rate available elsewhere in the economy, T is the total number of union members, and N corresponds to the number of union members that are going to be employed by the firm[2].

The firm is as usual assumed to maximise profit. If labour is the only factor of production, the objective function of the firm looks as follows

$$\text{(1.2)} \qquad \pi(w, N) = f(N) - wN$$

where $f(N)$ is the production function and the price of the good produced was set equal to 1. From maximisation of (1.2) with respect to N we obtain firm's labour demand, N^D. Under the assumption of decreasing returns to scale, N^D is a decreasing function of w. So

$$\text{(1.3)} \qquad N^D = g(w) \qquad g'(w) < 0$$

We now use equations (1.1) to (1.3) to describe three different types of interaction between the firm and the union. We first assume that the union sets the wage and the firm sets employment. Then, we assume that union and firm bargain over wage while the firm retains the right to unilaterally decide upon employment. Finally, we consider the case in which firm and union bargain over both wage and employment.

In the literature, the first approach (union sets wage, firm sets employment) is commonly referred to as *monopoly-union* model. Formally, this model boils down to maximisation of (1.1) subject to $N = N^D$. Substituting N^D for N into (1.1) and differentiating with respect to w yields, after simplification, the following first order condition

$$\text{(1.4)} \qquad g'(w)[U(w) - U(\overline{w})] + g(w)U'(w) = 0$$

Denoted by w^m the solution to (1.4), it is easy to see that $w^m > \overline{w}$. If $\overline{w}$ corresponds to the competitive wage, as it is usually assumed, then the monopoly-union model gives rise to higher wage and lower employment than it would be the case if the labour market was perfectly competitive.

[2] Since all union members are assumed to be identical, the firm chooses among them at random. Hence each

The monopoly-union model can be seen as a special case of the second type of approach (union and firm bargain over wage, firm sets employment), which is commonly referred to as the *right-to-manage* model. As this approach involves bargaining over wage, the question arises of how the bargaining outcome should look like. One popular way to solve this problem is provided by Nash [1950]. Specifically, the generalised Nash solution to the bargaining problem is given by the wage that maximises the following expression

(1.5) $$\left[E(U)-U(\overline{w})\right]^{q}\left[\pi(w,N)\right]^{1-q}$$

where $q \in [0,1]$ denotes the bargaining power of the union, $N = N^{D}$, and $U(\overline{w})$ is the utility of the representative union member if no agreement is reached (the corresponding gain for the firm is equal to zero). Once the wage has been set, the firm chooses employment according to (1.3). If q=1, the right-to-manage model is identical to the monopoly-union model.

In terms of equilibrium employment and wage, if 0<q<1, the right-to-manage model delivers a wage level, w^{rtm}, that it is lower than w^{m} but still larger than $\overline{w}$. Accordingly, employment is larger than in the monopoly-union model but still lower than the one associated with $\overline{w}$. If q=1, $w^{rtm} = w^{m}$.

As noted by McDonald and Solow [1981], the monopoly-union model and, by extension, the right-to-manage model suffer from one major drawback, in that their solution is inefficient in the Paretian sense. That is, there are alternative wage-employment combinations for which both profit and union's utility are higher than in the right-to-manage equilibrium. In particular, they show that if union and firm bargain over both wage and employment a whole range of different Pareto efficient equilibria can be attained.

These equilibria have two major features: first, they all entail a higher level of employment and a lower level of wage than in the right-to-manage case; second, they are all off the labour demand curve; in fact, given the bargained wage, the bargained level of employment is larger than the profit maximising one.

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union member has a probability of *N*/*T* of being employed.

Models in which through bargaining over wage and employment a Pareto efficient equilibrium is reached are known in the literature as *efficient-bargain* models. These models usually adopt the Nash bargaining approach to predict the specific wage-employment combination that firm and union will choose. The Nash solution, in this case, is given by the pair of wage and employment that maximises (1.5).

We now look at the general equilibrium implications of trade unionism.

General equilibrium analysis and trade unions

The literature on general equilibrium models of imperfect competition is quite recent. Its development has taken place mainly within the realm of macroeconomics and has its origin in the desire to make prices endogenous in the fix price models of the 1970s. The literature took off with Hart's [1982] paper and has been developing through the 80s and 90s.

One of the issues this field of economics has been concerned with is whether the conclusions about the impact of trade unions on employment and wage, which were drawn within a partial equilibrium setting, retain their validity in a general equilibrium framework.

As far as the right-to-manage model is concerned, the answer is yes. In fact, an economy characterised by perfect competition in the output market and by the presence of wage setting unions[3] in the labour market has a higher level of wage and a lower level of total output and employment than a perfectly competitive economy (see Hart [1982], Blanchard and Kiyotaki [1987], Dixon and Rankin [1994]). This outcome stems from the fact that the unions mark up the wage over the disutility of labour. Moreover, this implies the existence of involuntary unemployment, with the employed being ready to work more for less.

In the case of the efficient-bargain model the answer is less clear-cut. The issue is taken up by Layard and Nickell [1990], who construct a model of an economy with n identical firm-union pairs engaged in Nash bargaining with the objective defined by (1.5). They come to the conclusion that (a) if we start from a fully competitive labor market and then move to one in which firms and unions bargain over wage, employment falls; and (b) "if unions bargain over employment as well as wages, employment will be the same as if they

[3] These unions may be enterprise as well as sectoral unions. Assuming the existence of a single economy-wide wage setting union would lead to the same conclusions.

bargain over wages only, provided that the production function is Cobb-Douglas. (Employment will be higher if the elasticity of substitution between labor and capital is smaller than unity.)" (Layard and Nickell [1990], p. 773).

While finding (a) is standard, finding (b) is, to a certain extent, counterintuitive. Layard and Nickell give the following explanation: "if unions can bargain over employment (and not only over wages), this gives them more power. They may thus secure higher wages. And the effects of extra power may outweigh the employment gains from giving more expression to the unions' concerns over employment„ (Layard and Nickell [1990], pp. 777-8).

Layard and Nickell's results hinge on the assumptions that (i) for each union $\overline{w}$ is equal to the wage bargained by the other unions and (ii) unions' bargaining strength (the parameter q in (1.5)) is the same over both wage and employment. Dixon and Santoni [1995] show that relaxing these assumptions leads to different conclusions. In particular, if one relaxes (i) by setting $\overline{w}$ equal to the competitive wage and retains (ii), then bargaining over both wage and employment leads to the same level of employment, N^*, that would be obtained if the labour market were perfectly competitive. If, in addition to setting $\overline{w}$ equal to the competitive wage, one relaxes (ii) as well by allowing the unions to have differential bargaining strength over wages and employment, then employment will be larger than N^* if the union has more bargaining power over employment and lower than N^* if the union has more bargaining power over wage[4].

In this work we model unions' behaviour in quite an unusual way. In fact, in our framework unions set employment but not the wage rate. This is done only for simplicity. The aim of this work is to show that if unions can affect employment firms are inefficient and that, if product market competition increases, firms become more efficient. This result is achieved independently of how the wage rate is determined, so that whether unions

[4] Different bargaining powers over wage and employment are formally obtained by adopting a two stage Nash bargaining structure. In each stage Nash bargaining takes place over a different variable. Specifically, unions and firms first bargain over wages and, having done that, they bargain over employment (see also Manning [1987]). Note that employment can exceed the level reached under perfect competition in the labour market because both Layard and Nickell [1990] and Dixon and Santoni [1995] assume imperfect competition in the product market (see also section 1.2.2).

bargain over it or not becomes irrelevant. Moreover, most secondary results of our approach would also retain their validity even if unions bargained over the wage rate[5].

Having examined the main issues of the trade unions literature, we now discuss the consequences of the existence of imperfect competition in the product market.

1.2.2 The economics of imperfectly competitive product markets

The remark made at the beginning of the previous section and concerned with labour markets certainly extends to the output markets. In fact, most product markets diverge substantially from the perfectly competitive paradigm. This has consequences for employment, output, and welfare. This section discusses what these consequences look like.

Generally speaking, in a *partial* equilibrium framework, if a firm or the firms of a particular industry face a downsloping demand curve they will tend to price above marginal cost, with consequent welfare loss. Such a result is to hold long-term if the firm is a monopolist and no entry is allowed. If we consider an oligopolistic or otherwise imperfectly competitive product market, price competition may lead over time to the same result as perfect competition, i.e. price equal marginal cost. However, this does not need to be the case as prices may lie in the short as well as in the long run above marginal cost[6].

As far as *general* equilibrium models are concerned, the literature has mainly focused on the effectiveness of fiscal and monetary policies[7]. Since in our model there is no money[8] and no government, we skip this issue and concentrate, instead, on a different aspect, namely the suboptimality of the equilibrium when product markets are not perfectly competitive.

In fact, one of the main findings of the literature is that an economy characterised by perfect competition in the labour market and imperfect competition in the output market

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[5] See discussion in the conclusions at the end of this work.
[6] See Tirole [1987], Chapters 1 and 7.
[7] On this point see the surveys by Dixon and Rankin [1994], Silvestre [1993], and Lane [1999].

may have a lower level of output, employment, and welfare than a perfectly competitive economy (see D'Aspremont *et al.* [1990], Silvestre [1990], Dixon and Hansen [1999]).

As it will become clear later, this result is particularly important in the context of this work. We proceed therefore to its formal derivation.

A GENERAL EQUILIBRIUM MODEL WITH IMPERFECT COMPETITION IN THE OUTPUT MARKET

We first outline the basic building blocks of the model, the firms, the households and markets in which they interact[9].

Households

There is a continuum of households $i \in [0,1]$. They derive utility from consumption of leisure and of differentiated goods, each of them denoted by the subscript $j \in [0,1]$. Preferences of the representative consumer over goods are expressed by a symmetric CES utility function. Formally

$$U\left(c_{ij}, l_i\right) = \left(\int_{j=0}^{1} c_{ij}^{\lambda} dj\right)^{\frac{1}{\lambda}} - \frac{\gamma}{\gamma+1} l_i^{\frac{\gamma+1}{\gamma}} \qquad \forall i \in [0,1]$$

where $\lambda \in (0,1)$. The first term is the utility of consumption while the utility of leisure is represented by the second term, which is formally the disutility of labour (l_i). c_{ij} is consumption of good *j* by household *i* and γ is a positive parameter.

The budget constraint of household *i* is

$$PC_i = wl_i + \pi_i \equiv I_i \qquad \forall i \in [0,1]$$

where C_i is identically equal to the first term in the utility function, *w* is nominal wage, π_i is nominal profit, and *P* is the consumer price index given by

[8] The introduction of money, however, would make no difference, i.e. money would be neutral as all real variables are determined exclusively by the parameters of the model.
[9] The model is a simplified version of Dixon and Hansen [1999].

$$P=\left(\int_{j=0}^{1} p_j^{\frac{\lambda}{\lambda-1}} dj\right)^{\frac{\lambda-1}{\lambda}}$$

Households are assumed to maximise utility subject to the budget constraint. The resulting aggregate demand for any good *m*, $m \in [0,1]$, is

$$c_m=\left(\frac{p_m}{P}\right)^{-\frac{1}{1-\lambda}} \frac{I}{P} \qquad \text{where} \qquad I \equiv \int_{i=0}^{1} I_i di$$

while labour supply is

$$l=\left(\frac{w}{P}\right)^{\gamma}$$

where γ represents the wage elasticity.

Firms

The production function is the same for all firms, exhibits constant returns to labour[10] and is given by

$$x_j = n_j \qquad \forall j \in [0,1]$$

where x_j is the level of output of firm *j* and n_j is the amount of labour employed by firm *j*.

All firms take nominal wage *w*, price index *P*, and nominal income *I* as exogenous, and set the optimal price for their own goods by maximising profit. The fact that firms take the price index *P* as exogenous reflects the idea that, if the number of firms is large, each of them neglects the impact of a change in their good price on the price index (see, for example, Dixit and Stiglitz [1977]). Here, each good *j* is produced by a different firm so that, since there is a continuum of goods, there is a continuum of firms too. It follows that the number of firms we are considering is infinite. In this case, the impact of a change in

[10] The results of the model hold for decreasing returns to labour as well (see Dixon and Rankin [1994]).

any single good price on P is infinitely small and 1/(1-λ) is an exact approximation for the price elasticity of demand for any good.

Moreover, 1/(1-λ) corresponds to the elasticity of substitution between any two goods produced in the economy. As λ approaches 1 all goods in the economy become perfect substitutes; so, the larger is λ, the higher is the level of competition in the economy. In other words, the only difference between the economy of this model and a perfectly competitive economy is that goods are not perfect substitutes. In what follows we shall therefore approximate an increase in competition by an increase in goods substitutability. That is, by an increase in λ.

The symmetry of the model implies that all monopolistic firms choose the same price. In particular we have the following pricing equation

$$p_j = \frac{w}{\lambda} \qquad \forall j \in [0,1]$$

Hence the price lies above marginal cost. If the monopolistic competitors were to behave as price takers, price would be equal to marginal cost ($p_j = w$).

General equilibrium

The general equilibrium is derived under the assumption that the labour market is perfectly competitive.

The equilibrium value of employment/production can be easily obtained by noting that $P = p_j$. So, using the pricing equation and the labour supply function we obtain the equilibrium level of employment, n^*, and output, x^*

(1.6) $$n^* = x^* = \lambda^\gamma$$

As a measure of welfare we take the utility function. Its equilibrium value, U^*, is given by

(1.7) $$U^* = \lambda^\gamma \left(1 - \frac{\gamma}{\gamma+1}\lambda\right)$$

It is easy to see that, as long as $\gamma>0$, the presence of imperfect competition leads to an inefficient allocation. In fact, welfare is increasing in the level of product market competition λ, and so are employment and production. Thus, even though the labour market is perfectly competitive, so that it is always cleared, the allocation turns out to be suboptimal.

This result is a direct consequence of having the price lying above marginal cost. The higher is the mark-up over marginal cost, the lower is real wage and, since labour supply depends exclusively on real wage, the lower is the level of employment. Thus, when there is imperfect competition in the product market, real wage and labour supply are lower (and so are production and welfare) than in the Walrasian case of price taking firms.

The main result of the model can be summarised as follows

PROPOSITION 1.1 *In general equilibrium, if the labour market is perfectly competitive and the product market is not, the levels of employment, production, and welfare are in general all suboptimal and increasing in the degree of product market competition,* λ.

Proof: see equations (1.6) and (1.7). ©

Proposition 1.1 states that imperfect competition in the product market has *in general* a negative effect on the equilibrium. We say in general because this result does not hold when $\gamma=0$, i.e. when labour supply is completely inelastic. In fact, in this case, labour supply is independent of real wage and, therefore, imperfect competition in the product market has no impact on the equilibrium. Moreover, whatever the value of γ, since the labour market is perfectly competitive there is no involuntary unemployment.

The absence of involuntary unemployment and the crucial role of the elasticity of labour supply are features proper of this model. Alternative general equilibrium approaches to imperfect competition suggest that monopolistic competition in the product market may be sufficient to cause unemployment and a suboptimal allocation of resources, independently of the elasticity of labour supply (see D'Aspremont *et al.* [1990], Silvestre [1990] and [1993]).

In Chapter 4 we check the robustness of Proposition 1.1 to the introduction of x-efficiency. The literature on x-efficiency is discussed in the next section.

1.3 X-efficiency

In this section we briefly review the literature on x-efficiency. We limit ourselves to give a general introduction to this area of research without providing a formal proof of any of the results as none of the existing models will be used in the remainder of this work.

The term x-efficiency was firstly introduced by Leibenstein [1966]. His starting point was the empirical evidence on allocative efficiency. The estimates on the benefits from eliminating monopolies and trade restrictions suggested that such benefits were of very small magnitude if only allocative efficiency was accounted for. However, large gains appeared to be attainable in terms of firm efficiency. This observation led Leibenstein to call attention to a source of economic inefficiency, which was given the name x-efficiency.

Leibenstein uses the term x-efficiency to denote a situation in which a firm does not extract from the inputs it uses the maximum amount of output that, given the available technology, those inputs would allow to obtain. In other words, the term x-efficiency reflects the idea that "firms and economies do not operate on an outer-bound production possibility surface consistent with their resources" (Leibenstein [1966], p. 413). This is due mainly to low levels of managerial effort which, in turn, are traced back to a lack of competitive pressure. In particular, "In situations where competitive pressure is light, many people will trade the disutility of greater effort (…) for the utility of feeling less pressure and of better interpersonal relations. But in situations where competitive pressures are high (…) they will exchange less of the disutility of effort for the utility of freedom from pressure, etc." (Leibenstein [1966], p. 413). It follows that, as the economy becomes more competitive, firms move towards their production possibility frontier and become therefore more efficient.

A critical assessment of the very concept of x-efficiency can be found in Stigler [1976]. Stigler argues that within the framework of orthodox economic theory, there is no scope for x-efficiency. In fact, a corollary of profit maximisation is that firms operate on the production possibility frontier, i.e. they extract the maximum possible output from any given input. Which in turn excludes x-efficiency. So, from a theoretical point of view, to obtain x-efficiency we have to give up profit maximisation. But this would be an "abandonment of formal theory, and one which we shall naturally refuse to accept until we are given a better theory" (Stigler [1976], p. 215).

A reconciliation of profit maximisation and x-efficiency has been reached in various contributions of the past two decades. The device is the separation between ownership and management. While company owners aim at maximising profit, managers have a different objective. The managers' aim is, in fact, the maximisation of their own utility. Specifically, it is assumed that managers have an informational advantage over the company owners about the cost structure of the company and that they exploit this advantage to minimise effort (principal-agent problem). In this context, competition matters in that the existence of monopoly rents gives the managers the potential to capture these rents in the form of slack. Since asymmetric information is what allows managers to reduce effort, some authors have established a link between managerial effort and competition by arguing that a major influence of competition is the disclosure of information. So Holmstrom [1982] and Nalebuff and Stiglitz [1983] suggest that managerial effort should be increasing in the number of firms in the market (and hence in competition), because of the greater opportunity for comparison of performance. Similarly, Bertoletti and Poletti [1997] argue that, if stochastic shocks across firms are correlated, owners can refer to other firms' performance in writing the managerial contract. The assumption of common shocks across firms is used by Hart [1983] as well. However, in his model, it is the lowering of the monopolistic rent associated with increases in competition, rather than the disclosure of information, that forces managers to raise their effort. Specifically, Hart assumes the existence within a particular industry of managerial firms, where the manager runs but does not own the company, and of entrepreneurial firms, in which the owner runs the company. Entrepreneurial firms are profit maximisers and their share of the total number of firms in the industry is seen as a measure of product market competition. If (marginal) costs fall for all firms (the common shock), entrepreneurial firms expand production, while the managers of the managerial firms just increase slack. However, the higher the proportion of entrepreneurial firms, i.e. the higher product market competition, the higher the increase in industry production, the lower the price and, hence, the scope for slack in the managerial firms. All this, though, holds only as long as managers are not highly responsive to monetary incentives, otherwise competition leads to more slack (Scharfstein [1988]).

An alternative approach relies on the assumption that as competition increases, profits become more responsive to managerial effort, with the consequence that the owners are given greater incentive to reduce managerial slack. Yet, an increase in competition is often associated not only with an increase in firm's product demand elasticity, but also with a reduction in demand for the individual firm. The latter effect works in the opposite direction with respect to the former, that is, as demand for the individual firm falls the loss from a low level of managerial effort diminishes. So depending on which effect dominates competition will either raise or reduce managerial effort (Willig [1987]). Less ambiguous are the models constructed by Martin [1993] and Horn, Lang, and Lundgren [1994]. Both papers find that competition reduces managerial effort. This result is obtained by adopting a two-stage structure where first marginal costs are determined and then product market competition takes place. In both papers marginal costs are shown to increase in the degree of competition. And since marginal costs are assumed to be negatively correlated to managerial effort, the conclusion is that competition lowers managerial effort.

As to Martin [1993], Bertoletti and Poletti [1996] proved that his result does not depend on asymmetric information, but it is simply a consequence of increasing returns to scale. In fact, as the number of firms augments, their individual levels of output shrink and the (efficient) level of marginal cost increases. Hence the positive relationship between competition (number of firms) and firm inefficiency (marginal costs). More robust appears the result by Horn, Lang, and Lundgren [1994]. They consider an industry with two firms and three different market interactions: Bertrand competition, Cournot competition, and output cartel. These can be seen as successively less competitive frameworks. Horn, Lang, and Lundgren show that marginal cost and thus firm inefficiency are highest under the most competitive setting, i.e. Bertrand competition. The reason is that with Bertrand competition each firm increases its profit by reducing its output volume. Hence the owner wants to lower effort incentives. However, a year later, the same authors publish another paper where, by opening up the market to international competition, they come to the opposite conclusion (see Horn, Lang, and Lundgren [1995]).

Consistent with x-efficiency is the model by Schmidt [1997], who points out that competition raises the probability of liquidation so that managers are urged to improve efficiency to avoid bankruptcy. He extends his model to include also workers' behaviour. Because of the increased risk of liquidation workforce resistance to employment reductions diminishes with competition. In other words, workers become more willing to accept job reductions, respectively lower the cost of a job reduction for the management, as competition increases. It is implicit in this argument that, if competition is sufficiently low no lay-off actually occurs. In this case, it can be argued that workers share the monopolistic rent in terms of higher employment. In a different framework, workers may capture such rents in the form of higher wages and/or reduced effort. This is the case of the paper by Nickell and Nicolitsas [1997], who develop a model in which firms and unions bargain over both wages and effort. They show that increases in product market competition lead to higher effort and lower wages.

Another way to link competition and efficiency of production is through the research and development argument. In general, the more competitive the market, the higher the profit gains from an increase in productivity and therefore the higher the incentive to invest in research and development. However, following Schumpeter [1943], it can be argued the other way round, in the sense that it is the availability of monopolistic profits that allows firms to invest in research and development. Further, firms in concentrated markets can more easily appropriate the returns from their investment, and the more concentrated the market, the lower the uncertainty, and, hence, the higher the incentive to innovate[11].

[11] According to Levine *et al.* [1985] rather than at the market structure, one should look at technological opportunities and appropriability conditions to explain research and development investments and the correlated productivity gains.

In conclusion, we can say that the hypothesis of a positive link between productive efficiency and product market competition does not seem to enjoy a particularly strong theoretical support[12].

The approach to x-efficiency that we are going to follow in the remainder of this work is different as we link firm efficiency to the presence of labour setting unions. Nevertheless, this can be seen as a special case of x-efficiency *á la* Leibenstein in which managers share market rents with the workers simply because this makes their life more comfortable (see Nickell [1996]).

1.4 Conclusion

In this chapter we gave a brief overview of the literatures on trade unions, imperfectly competitive product markets, and x-efficiency. The aim was to describe the fields of research most related to the analysis presented in the next chapters.

As our approach differs substantially from those followed by previous contributions, none of the existing x-efficiency or trade unions models will be used in the remainder of this work. On the contrary, in Chapter 3 and 4 we will introduce models of imperfect competition that are very similar to the one described in section 1.2.2.

[12] For more references on x-efficiency models and on empirical works in this area see Nickell [1996] and Nickell [1999].

CHAPTER 2

Imperfect competition and firm efficiency: the firm case

2.1 Introduction

This chapter introduces a new approach to x-efficiency based on the capital to labour ratio used in the production of goods. We start by applying this approach to the case of a single firm. The same framework is then extended to the analysis first of an industry (Chapter 3) and then of the whole economy (Chapter 4).

The demand and production functions are held as general as possible in order to derive the conditions under which the assumptions of the model give rise to x-efficiency. However, in section 2.6 an example is provided in which specific demand and production functions are used.

Although the focus will be on x-efficiency other interesting results of the model will be discussed, in particular those concerning output and employment.

Apart from introducing the basic framework, the present chapter defines a series of terms that will be widely used in the remainder of this work. In particular the precise meaning of terms such as unionism, non-unionism, firm efficiency, and x-efficiency is explained. Moreover, a distinction is made between strong and weak unionism and important assumptions are made about the behaviour of the unions. A formal justification for these assumptions is given in the next chapter.

2.2 Some preliminary definitions and assumptions

In this section we introduce a few definitions that are relevant not only for this chapter but in general for the whole work. Let us start with the definitions of firm efficiency and x-efficiency.

A firm produces a good (*x*) using two production factors, capital (*k*) and labour (*n*). The production function is given by

$$x = q(n,k)$$

q is assumed to be continuous and everywhere twice differentiable with $q_n > 0$ $\forall$ *k*>0, $q_k > 0$ $\forall$ *n*>0, $q_{nn} \leq 0$, $q_{kk} < 0$ $\forall$ *n*>0, $q_{nk} \geq 0$ $\forall$ *n*>0 and $\forall$ *k*>0, and $q_{kn}^2 - q_{kk}q_{nn} \leq 0$ $\forall$ *n*>0 and $\forall$ *k*>0. The features of the production function imply the existence of a unique cost minimising capital/employment combination for each level of output. This leads us to the following definition of firm efficiency

FIRM EFFICIENCY: *a firm is said to be perfectly efficient if it minimises production costs. If this is the case, the following condition must hold*

$$\frac{w}{r} = \frac{q_n}{q_k}$$

where $w>0$ *is wage and* $r>0$ *is the cost of capital.*

As a measure of firm efficiency we shall take the variable σ, which is defined as follows

$$\sigma \equiv \sigma(n,k) \equiv \frac{q_n(n,k)}{q_k(n,k)} \frac{r}{w}$$

If σ is equal to 1, the firm is perfectly efficient, i.e. it is employing labour and capital in the cost minimising ratio, while it is inefficient when σ is different from 1. In particular, if σ is smaller than 1 too much labour (too little capital) is used, while if σ is larger than 1 too much capital (too little labour) is utilised.

The definition of firm efficiency and its measure are used to define x-efficiency. In particular, denoted by the letter λ the degree of product market competition (the higher is λ the more competitive is the product market), we have

X-EFFICIENCY: *A firm is said to be x-efficient if and only if*

$$\frac{dH}{d\lambda} < 0$$

where $H \equiv |\sigma - 1|$.

Hence, in the presence of x-efficiency, how close firms are to cost minimisation depends on the degree of competition in the product market. The more competitive is the product market, the closer to the minimum of the cost function firms are producing.

The definition of x-efficiency adopted in this work differs from the one used by Leibenstein. For Leibenstein a firm is x-efficient if it does not extract the maximum amount of output from the inputs it employs. Leibenstein argues that this type of inefficiency is reduced if competition in the product market is increased (see p. 23).

Our definition of x-efficiency also implies that a firm becomes more efficient as it undergoes increasing competitive pressure. However, we use a different concept of firm efficiency.

In Leibenstein's approach, a firm is inefficient if, given the available technology, it does not produce the maximum output from the inputs it utilizes. In our framework, instead, firms are inefficient as long as they fail to employ factors according to their relative prices.

It follows that in Leibenstein's approach a firm becomes more efficient if it increases the amount of output it extracts from the inputs it utilizes. In our setting, instead, a firm becomes more efficient if it reduces the gap between the factor price ratio and the technical rate of substitution between capital and labour.

Notably the type of inefficiency highlighted by Leibenstein is absent in our setting. In fact, firms always locate on their production possibility frontier and extract therefore the maximum amount of output from the employed inputs.

We shall discuss the existence of x-efficiency under three different settings: non-unionism, strong unionism, and weak unionism. In the first case the firm is not unionised, while in the other two it is. Under all three settings firm demand for capital is set unilaterally by the management. They differ, though, with respect to the determination of firm demand for labour. In particular we have

NON-UNIONISM: *firm demand for capital and firm demand for labour are both set unilaterally by the management;*

STRONG UNIONISM: *firm demand for capital is set unilaterally by the management; firm demand for labour is set unilaterally by the firm union;*

WEAK UNIONISM: *firm demand for capital is set unilaterally by the management; firm demand for labour is set unilaterally by the firm union; however, demand for labour cannot exceed the highest between current level of employment and firm demand for labour under non-unionism.*

So, under non-unionism the management sets both inputs, capital and labour, while under unionism (both weak and strong) the firm union sets the level of labour while the management sets the level of capital.

The difference between strong and weak unionism is that under the former the firm union has a general and unconstrained right to decide on the size of the workforce, while under the latter the firm union can at most prevent job losses, as it is unable to force the management to hire new workers.

Strong unionism corresponds broadly to the case in which management and firm union bargain over the total level of employment within the firm, while weak unionism corresponds largely to bargaining over layoffs. In fact, under weak unionism the firm union is involved only when job reductions are undertaken.

Note that the definition of unionism (both weak and strong) implies that actually no bargaining over employment occurs, as this is determined solely by the firm union. This hypothesis is adopted only for simplicity. In fact, as explained in the final section of this work, introducing employment bargaining would not change the results of the analysis.

Wage and cost of capital are always taken as given by both the management and the union. This means that no bargaining occurs over the level of wage. Again wage-taking behaviour is assumed for simplicity. In fact, if the union, beside determining employment, bargained over wages, the main conclusions of our analysis would still retain their validity[13].

We now introduce a few conventions:

- the term *competition* always refers to product market competition;
- the term *unionism* used on its own refers to both weak and strong unionism;
- the term *efficiency* used on its own refers always to *firm efficiency*;
- the term *union* is always used to indicate the union representing the workers of a single firm;
- all equilibrium values under non-unionism are denoted by the superscript '^';
- all equilibrium values under unionism are denoted by the superscript '¯'
(as explained below, equilibrium under weak and strong unionism turns out to be the same).

Under non-unionism, equilibrium levels of employment, capital, output, and efficiency are denoted, respectively, by

$$\hat{n}; \quad \hat{k}; \quad \hat{x}; \quad \hat{\sigma}$$

while the corresponding equilibrium values under unionism are denoted by

[13] On this point see the discussion in the conclusions of this work.

$\bar{n}$; $\bar{k}$; $\bar{x}$; $\bar{\sigma}$

If employment is the same under both settings, than capital stock, output, and efficiency will be the same as well. That is

$$\bar{n} = \hat{n} \quad \Rightarrow \quad \bar{k} = \hat{k} \quad \text{and} \quad \bar{x} = \hat{x} \quad \text{and} \quad \bar{\sigma} = \hat{\sigma}$$

The reason is that firm demand for capital is determined by the management under all settings (non-unionism, weak and strong unionism). This means that it is always chosen to maximise profit. Since for any given level of labour there is just one profit maximising level of capital, $\bar{n} = \hat{n}$ implies $\bar{k} = \hat{k}$; output and efficiency are simply functions of capital and labour so that if labour and capital are the same under non-unionism and under unionism, then output and efficiency must be the same as well.

Throughout this work we shall assume that at a given point in time a technological shock occurs such that profit maximisation requires a reduction in labour input. Firm unions are supposed to accept a certain number of layoffs so that the equilibrium value of employment under unionism is lower than the initial one. Thus

ASSUMPTION 1 $\bar{n} < n'$

where n' denotes the pre-technological shock level of firm employment.

Assumption 1 has the nice property to reduce the number of equilibria to no more than two: one under non-unionism and one under unionism. In fact, Assumption 1 implies that firm labour demand is the same under both weak and strong unionism. As a consequence firm demand for capital is the same as well and so will be output and efficiency (see explanation above).

Firm labour demand is equal under both unionisms because the union's preferred level of labour demand is lower than the initial one. This means that the constraint represented by n' under weak unionism is slack. As this constraint is the only difference between strong and weak unionism, its slackness implies that strong and weak unionism deliver the same outcome. By contrast, if Assumption 1 did not hold, employment under strong unionism could be larger than initial employment, in which case we would have two different equilibria under unionism: under weak unionism we would have $n = n'$ and under strong unionism we would have $n = \overline{n} > n'$. Having two separate equilibria, however, would only complicate the analysis without adding any new insight. So it seems worthwhile to assume $\overline{n} < n'$. Another reasonable assumption is the following one

ASSUMPTION 2 $\overline{n} > \hat{n}$

i.e. the level of employment under unionism is larger than under non-unionism.

Assumption 1 and Assumption 2 imply that employment under non-unionism is lower than initial employment, that is $\hat{n} < n'$. This, in turn, ensures the existence of different outcomes for non-unionism and weak unionism. In fact, if the profit maximising level of labour were larger than the initial one, i.e. if $\hat{n} > n'$, then we would have $n = \hat{n}$ under weak unionism as well, in which case weak unionism would just deliver the same outcome as non-unionism. As a consequence, the analysis of the impact of competition under weak unionism would be limited to the case in which employment decreases with competition under non-unionism.

In summary, Assumption 1 and Assumption 2 state that, following a technological shock, employment falls under all settings (non-unionism, weak and strong unionism) but less under unionism than under non-unionism. A formal justification for Assumption 2 is given in the next chapter.

Once the two equilibria (non-unionism and unionism) are worked out their sensitivity to changes in the degree of product market competition is evaluated. Under non-unionism the impact of an increase in product market competition on the equilibrium values of employment, capital, output, and efficiency is denoted, respectively, by

$$\hat{n}_\lambda; \quad \hat{k}_\lambda; \quad \hat{x}_\lambda; \quad \hat{\sigma}_\lambda$$

As far as unionism is concerned, the distinction between weak and strong unionism becomes relevant. In fact, if the equilibrium under weak and strong unionism is the same, the impact of product market competition on the equilibrium may be different. The reason is that under weak unionism employment is, in general, not allowed to rise while it is under strong unionism. As an increase in competition may affect the equilibrium differently under the two settings, the change in the equilibrium values of capital, labour, output, and efficiency have different notations. Under strong unionism the impact of an increase in product market competition on the equilibrium values of employment, capital, output, and efficiency is denoted, respectively, by

$$\bar{n}_{\lambda}^{SU}; \quad \bar{k}_{\lambda}^{SU}; \quad \bar{x}_{\lambda}^{SU}; \quad \bar{\sigma}_{\lambda}^{SU}$$

The corresponding notation under weak unionism is

$$\bar{n}_{\lambda}^{WU}; \quad \bar{k}_{\lambda}^{WU}; \quad \bar{x}_{\lambda}^{WU}; \quad \bar{\sigma}_{\lambda}^{WU}$$

As stated above, the difference between strong and weak unionism is that, under the former, the union can force the management to hire new workers while, under the latter, the union can not obtain a rise in employment without the agreement of the management.

Formally, this means that employment can increase under strong unionism but in general can not under weak unionism, i.e.

$$(2.1) \qquad \bar{n}_{\lambda}^{WU} = \begin{cases} \bar{n}_{\lambda}^{SU} & \text{if} \quad \bar{n}_{\lambda}^{SU} < 0 \\ 0 & \text{otherwise} \end{cases}$$

However, (2.1) holds only when $\bar{n}$ is sufficiently large. By sufficiently large we mean that the following condition must be satisfied

$$(2.2) \qquad \hat{n} + \hat{n}_{\lambda} < \bar{n}$$

i.e. the new optimal level of employment for the management after the increase in competition must be lower than current employment $\bar{n}$. If it is not, i.e. if $\hat{n}_{\lambda}$ is positive and relatively large, employment actually increases under weak unionism as well and weak unionism collapses to the non-unionism case. Hence we are to assume that (2.2) always holds.

Note again that if the impact of competition on employment is the same under weak and strong unionism, then the impact on capital, output, and efficiency will be the same as well. Formally

$$\bar{n}_{\lambda}^{WU} = \bar{n}_{\lambda}^{SU} \quad \Rightarrow \quad \bar{k}_{\lambda}^{WU} = \bar{k}_{\lambda}^{SU} \text{ and } \bar{x}_{\lambda}^{WU} = \bar{x}_{\lambda}^{SU} \text{ and } \bar{\sigma}_{\lambda}^{WU} = \bar{\sigma}_{\lambda}^{SU}$$

In other words, weak unionism differs from strong unionism only as long as $\bar{n}$ is a positive function of competition under the latter. Otherwise, they are the same. The reason is that weak and strong unionism differ only with respect to the determination of firm demand for labour. If this reacts to competition in the same way under the two settings, then all the remaining variables will respond in the same way as well.

Finally, note that $\hat{n}_{\lambda}$, $\hat{k}_{\lambda}$, $\hat{x}_{\lambda}$, $\hat{\sigma}_{\lambda}$, $\bar{n}_{\lambda}^{SU}$, $\bar{k}_{\lambda}^{SU}$, $\bar{x}_{\lambda}^{SU}$, $\bar{\sigma}_{\lambda}^{SU}$, $\bar{n}_{\lambda}^{WU}$, $\bar{k}_{\lambda}^{WU}$, $\bar{x}_{\lambda}^{WU}$, $\bar{\sigma}_{\lambda}^{WU}$ are *total* derivatives. Nevertheless, for any other variable *y* we stick to the usual convention according to which y_i is the *partial* derivative of *y* with respect to *i*.

2.3 Firm equilibrium under non-unionism and under unionism

We now derive the equilibrium under non-unionism and under unionism for the firm case. We work out and compare first the levels of efficiency and then those of employment, capital, and output.

A firm produces a good (*x*) using two production factors, capital (*k*) and labour (*n*). The firm is initially employing $n = n'$ units of labour input. At some point a new way of producing output becomes available. The new production function is given by

$$x = q(n, k)$$

where *q* has the features described in the previous section.

Under non-unionism the management has no constraint on its input choice, so that the chosen labour ($\hat{n}$) and capital ($\hat{k}$) maximise profit. Consequently, the firm is perfectly efficient. So

$$\hat{\sigma} \equiv \sigma(\hat{n},\hat{k}) = \frac{q_n(\hat{n},\hat{k})}{q_k(\hat{n},\hat{k})}\frac{r}{w} = 1$$

At the optimum, marginal revenue and marginal cost must be equal. Hence

$$\hat{R}_q \equiv R_q\left(q(\hat{n},\hat{k}),\lambda\right) = C_q\left(q(\hat{n},\hat{k})\right) \equiv \hat{C}_q \tag{2.3}$$

where the LHS is marginal revenue, the RHS is marginal cost, and λ is a positive parameter indicating the level of competition in the product market. The larger λ the more competitive the product market. Marginal revenue is assumed to be either constant or decreasing in *q*, i.e. $R_{qq} \leq 0 \ \forall \ q>0$, while marginal cost is either constant or increasing in output, that is, $C_{qq} \geq 0 \ \forall \ q>0$. The second derivative of profit is taken to be strictly negative, i.e. $R_{qq} - C_{qq} < 0 \ \forall \ q>0$. From Assumption 1 and Assumption 2 follows that the level of employment chosen by the management is lower than the initial one ($\hat{n} < n'$).

Under unionism, the firm is not allowed to freely adjust the size of the workforce, as this is set unilaterally by the union. The level of employment under unionism, denoted by $\bar{n}$, is larger than $\hat{n}$ by Assumption 2. So $\bar{n} > \hat{n}$. Once the union has set employment, the management is left with the choice of *k*. Let us denote by $\tilde{k}$ the cost minimising level of capital stock when $n = \bar{n}$. Then we have

$$\frac{w}{r} = \frac{q_n(\bar{n},\tilde{k})}{q_k(\bar{n},\tilde{k})}$$

It is easy to see that $\tilde{k}$ is not profit maximising. In fact, inserting $\bar{n}$ and $\tilde{k}$ in the profit maximising condition (2.3) yields

$$R_q\left(q(\bar{n},\tilde{k}),\lambda\right) < C_q\left(q(\bar{n},\tilde{k})\right) \tag{2.4}$$

In general, marginal revenue in (2.4) is lower than in (2.3) while marginal cost is higher. Hence, the management will not expand capital to minimise costs. On the contrary, it will choose a level of capital stock $\bar{k}$ smaller than $\tilde{k}$ in order to equate marginal revenue and marginal cost. So

$$\bar{R}_q \equiv R_q\left(q(\bar{n},\bar{k}),\lambda\right) = \frac{r}{q_k(\bar{n},\bar{k})} \tag{2.5}$$

where the RHS is marginal cost when employment is set at $\bar{n}$. As a consequence the labour/capital combination is suboptimal and the firm is not efficient[14]. In particular we have

$$\bar{\sigma} \equiv \sigma(\bar{n},\bar{k}) = \frac{q_n(\bar{n},\bar{k})}{q_k(\bar{n},\bar{k})}\frac{r}{w} < 1$$

We can therefore conclude that the firm minimises production costs under non-unionism and it does not under unionism.

As far as production, input levels, and welfare are concerned, non-unionism and unionism deliver in general different outcomes. For employment and output, the following relationships hold

$$\bar{n} > \hat{n} \qquad \bar{x} > \hat{x}$$

The first inequality does not need particular comments: employment is larger under unionism, as $\hat{n}$ is smaller than $\bar{n}$ by Assumption 2.

As for production, this is always larger under unionism. In fact, marginal cost under unionism is smaller than under non-unionism so that the equilibrium level of output is larger when the union sets *n* (see Appendix A1).

The fact that output is larger under unionism implies that, under this setting, the level of production may be nearer its welfare maximising level. In fact, as long as the firm faces a downsloping demand curve ($R_{qq} < 0$), the firm is price-making and sets the price above marginal cost. Hence $\hat{x}$ is too low from a social point of view. On the other hand, if the

[14] It is implicitly assumed that a) firm's profit is non-negative under (2.5) and b) for the firm it is always convenient to adopt the new technology.

firm is price-taking ($R_{qq} = 0$) its behaviour is socially optimal. It follows that, as long as $R_{qq} < 0$, $\bar{x}$ might be closer than $\hat{x}$ to its socially optimal level x^*. In particular, if $\bar{x}$ lies to the left of x^*, then $\bar{x}$ is certainly closer to its socially optimal level than $\hat{x}$. However, if it lies to the right of x^* (overproduction) then the following situation might arise: $\bar{x} - x^* > x^* - \hat{x}$. In this case, $\bar{x}$ is further away from the socially optimal value of x than $\hat{x}$. In any case, $\bar{x}$ is produced inefficiently. This implies that even if $\bar{x} = x^*$, welfare might be higher under non-unionism, since the production of $\bar{x}$ requires a larger labour input than strictly necessary, whereby labour has a negative impact on welfare[15].

Further, note that if $R_{qq} = 0$, i.e. if the firm is price-taking, there might be nothing to bargain over. In fact, unless some market imperfections are built into the model, there is no rent to share. And bargaining over layoffs can occur only as long as there is a rent. So, if the economy is perfectly competitive, production is equal to x^* and no bargaining occurs.

The fact that production and employment are larger when the level of employment is directly affected by the union is neither a surprising nor a new result. To the same conclusion come in fact McDonald and Solow [1981], who develop a partial analysis model in which firm and union bargain over both employment and wage, with the result that for the negotiated wage the firm employs more workers than the management would like to[16].

As far as capital stock is concerned, its level under unionism, $\bar{k}$, might lie above or below $\hat{k}$ depending on the specified production and revenue functions.

We summarise the findings of this section in the following proposition

Proposition 2.1 *In the presence of imperfect competition unionism leads in comparison to non-unionism to*

(a) higher employment and production;

(b) lower firm efficiency, whereby under non-unionism the firm is perfectly efficient.

Proof: see Appendix A1 and previous observations. ◎

[15] For a proper welfare analysis see Chapter 4.

[16] See also Chapter 1, section 1.2.1.

2.4 The impact of competition on employment, capital, and output

In this section we analyse the impact of product market competition on the equilibrium levels of employment, capital, and output. We discuss in turn the non-unionism setting and the unionism one. As mentioned in section 2.2, we make a distinction between weak and strong unionism. In section 2.5 we will then analyse the impact of competition on firm efficiency.

2.4.1 The impact of competition under non-unionism

Under non-unionism the impact of competition on the different variables is given by the following expressions (see Appendix A2)

$$\text{(2.6)} \qquad \hat{n}_\lambda = \frac{\hat{R}_{q\lambda}}{\left(\hat{C}_{qq} - \hat{R}_{qq}\right)\left(\hat{q}_n + \hat{q}_k \dfrac{d\hat{k}}{d\hat{n}}\right)}$$

$$\text{(2.7)} \qquad \hat{k}_\lambda = \frac{\hat{R}_{q\lambda}}{\left(\hat{C}_{qq} - \hat{R}_{qq}\right)\left(\hat{q}_k + \hat{q}_n \dfrac{d\hat{n}}{d\hat{k}}\right)}$$

$$\text{(2.8)} \qquad \hat{x}_\lambda = \hat{q}_k \hat{k}_\lambda + \hat{q}_n \hat{n}_\lambda$$

where

$$\frac{d\hat{k}}{d\hat{n}} = \frac{\hat{q}_{nk}\hat{q}_n - \hat{q}_{nn}\hat{q}_k}{\hat{q}_{nk}\hat{q}_k - \hat{q}_{kk}\hat{q}_n} \geq 0$$

and $\hat{q} \equiv q(\hat{n}, \hat{k})$. The above equations state that the impact of competition on inputs and output depends solely on the derivative of marginal revenue with respect to competition. In fact, the denominators of (2.6) and (2.7) are always positive. Specifically, if marginal revenue is increasing (decreasing) in competition, inputs and output are all increasing (decreasing) as well. The reason is that competition does not affect marginal cost. So, if marginal revenue is increased by competition, the LHS of (2.3) becomes larger than the RHS, i.e. marginal profit becomes positive. In this case, the management is given incentive to expand output, that is employment and capital. Employment, capital, and production move therefore all in the same direction.

2.4.2 The impact of competition under unionism

We now turn to unionism. To simplify the analysis we introduce the variable $\overline{\phi}$, which is defined as the ratio between employment under unionism and employment under non-unionism. Thus

$$\overline{\phi} \equiv \frac{\overline{n}}{\hat{n}}$$

Assumption 2 implies $\overline{\phi} > 1$. This variable expresses the union's willingness to give up employment and it is assumed to be non-increasing in competition, that is

<u>ASSUMPTION 3</u> $\overline{\phi}$ *is a non-increasing function of* λ*, i.e.* $\overline{\phi} = \overline{\phi}(\lambda)$ *and* $\overline{\phi}_\lambda \leq 0$

Assumption 3 states that, in general, $\overline{\phi}$ gets smaller as competition increases. This is equivalent to saying that an increase in competition softens the position of the enterprise union. A formal justification for this assumption, as well as for Assumption 2, is given in the next chapter. As already mentioned, the impact of competition can be different under weak and strong unionism. The difference between the two is that employment is allowed to rise under strong unionism while it is not under weak unionism. Thus, under weak and strong unionism, equilibrium changes according to the following expressions (see Appendix A3)

(2.9) $$\overline{n}_{\lambda}^{SU} = \frac{\hat{R}_{q\lambda}}{\left(\hat{C}_{qq} - \hat{R}_{qq}\right)\left(\hat{q}_n + \hat{q}_k \frac{d\hat{k}}{d\hat{n}}\right)}\overline{\phi} + \hat{n}\overline{\phi}_{\lambda} = \hat{n}_{\lambda}\overline{\phi} + \hat{n}\overline{\phi}_{\lambda}$$

(2.1) $$\overline{n}_{\lambda}^{WU} = \begin{cases} \overline{n}_{\lambda}^{SU} & \text{if} \quad \overline{n}_{\lambda}^{SU} < 0 \\ 0 & \text{otherwise} \end{cases}$$

(2.10) $$\overline{k}_{\lambda}^{i} = a - b\overline{n}_{\lambda}^{i} \qquad i=WU,\, SU$$

(2.11) $$\overline{x}_{\lambda}^{i} = \overline{q}_k\overline{k}_{\lambda}^{i} + \overline{q}_n\overline{n}_{\lambda}^{i} \qquad i=WU,\, SU$$

where

$$a = -\frac{\overline{R}_{q\lambda}}{\overline{R}_{qq}\overline{q}_k + r\frac{\overline{q}_{kk}}{\overline{q}_k^2}} \qquad\qquad b = \frac{\overline{R}_{qq}\overline{q}_n + r\frac{\overline{q}_{kn}}{\overline{q}_k^2}}{\overline{R}_{qq}\overline{q}_k + r\frac{\overline{q}_{kk}}{\overline{q}_k^2}}$$

and $\overline{q} \equiv q\left(\overline{n}, \overline{k}\right)$. The signs of all but one change in response to an increase in competition are ambiguous. The only exception is given by $\overline{n}_{\lambda}^{WU}$, whose sign is non-positive by assumption. The impact of competition on employment under strong unionism, $\overline{n}_{\lambda}^{SU}$, is the result of two effects: the change in $\hat{n}$ (first term on the RHS of (2.9)) and that in $\overline{\phi}$ (second term on the RHS of (2.9)). The latter is non-positive by Assumption 3, while the former has no predetermined sign. It follows that the overall effect of λ on employment under strong unionism is ambiguous. However, it is certainly negative if $\hat{n}_{\lambda} < 0$.

As far as capital is concerned, this is affected directly (a) and indirectly ($b\overline{n}_{\lambda}^{i}$) by competition.

The direct effect a is positive (negative) when $\overline{R}_{q\lambda}$ >0 (<0)[17]. In fact, a rise (fall) in marginal revenue is matched by the firm with a rise (fall) in output (the cost function is as

[17] The denominator of a is always negative.

such unaffected by competition). And this is obtained through an expansion (contraction) of capital stock[18].

The indirect effect $b\bar{n}_{\lambda}^{i}$ occurs through the impact of λ on $\bar{n}$. In fact, as $\bar{n}$ changes, $\bar{k}$ may have to change as well in order to keep marginal revenue equal to marginal cost. The sign of this indirect effect is in general ambiguous. A larger $\bar{n}$ diminishes both marginal revenue (unless $\bar{R}_{qq} = 0$), which induces the management to lower output via a reduction in capital stock, and marginal cost (unless $\bar{q}_{kn} = 0$), which, on the contrary, favours an increase in output, that is, in capital. These two opposite effects are captured in *b* respectively by $\bar{R}_{qq}\bar{q}_{n}$ and $r\frac{\bar{q}_{kn}}{\bar{q}_{k}^{2}}$. Since the denominator of *b* is always negative, *b* is positive when the marginal revenue effect is larger, in absolute value, than the marginal cost effect; and it is negative otherwise. Thus, if, e.g., *b* is positive, the impact of an increase in employment on capital is negative. In fact, a rise in employment leads to a fall in marginal revenue, which is larger than the fall in marginal cost. *Ceteris paribus,* this induces the management to lower capital in order to reduce output and thereby re-establish the equivalence between marginal revenue and marginal cost. For similar reasons, $\bar{k}_{\lambda}^{i}$ is increasing in $\bar{n}_{\lambda}^{i}$ when *b* is negative.

In summary, both *a* and *b* may be either positive or negative, so that the overall impact of competition on capital is ambiguous.

Finally, $\bar{x}_{\lambda}^{i}$ is simply the weighted sum of the changes in employment and capital and it may therefore be itself positive as well as negative.

[18] See section 2.4.1 for a similar argument for the non-unionism case.

2.4.2.1 The impact of competition: strong vs. weak unionism

Let us now compare weak and strong unionism. By definition, the change in employment under weak unionism is never larger than under strong unionism (see (2.1)). Thus

$$\bar{n}_{\lambda}^{SU} \geq \bar{n}_{\lambda}^{WU}$$

where the equality sign holds only for $\bar{n}_{\lambda}^{SU} \leq 0$. As already noted in section 2.2, if $\bar{n}_{\lambda}^{WU} = \bar{n}_{\lambda}^{SU}$, the impact of competition under strong unionism and under weak unionism is the same for capital and output as well. So

$$\bar{n}_{\lambda}^{WU} = \bar{n}_{\lambda}^{SU} \quad \Rightarrow \quad \bar{k}_{\lambda}^{WU} = \bar{k}_{\lambda}^{SU} \quad \text{and} \quad \bar{x}_{\lambda}^{WU} = \bar{x}_{\lambda}^{SU}$$

In other words, weak unionism differs from strong unionism only as long as $\bar{n}$ is a positive function of competition under the latter. Otherwise, they are the same.

As to capital stock we have

$$b < 0 \quad \Rightarrow \quad \bar{k}_{\lambda}^{SU} \geq \bar{k}_{\lambda}^{WU}$$

$$b > 0 \quad \Rightarrow \quad \bar{k}_{\lambda}^{SU} \leq \bar{k}_{\lambda}^{WU}$$

So, depending on the sign of b[19], the change in capital might be larger under strong unionism or under weak unionism, with equality signs holding only for $\bar{n}_{\lambda}^{SU} \leq 0$. Moreover, the sign of (2.10) can be different under the two unionisms.

Finally, the impact of competition on output is certainly larger under strong unionism when strong and weak unionism diverge, i.e. when $\bar{n}_{\lambda}^{SU} > 0$, so that $\bar{n}_{\lambda}^{WU} = 0$. To see this, just insert (2.10) into (2.11) and note that the resulting expression is increasing in $\bar{n}_{\lambda}^{i}$. Thus

$$\bar{x}_{\lambda}^{SU} \geq \bar{x}_{\lambda}^{WU}$$

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[19] The determinants of the sign of *b* have been discussed in the previous section.

2.4.3 The impact of competition: non-unionism vs. unionism

From the comparison between non-unionism and unionism we can note the following:

(a) under both settings each variable (employment, capital, and output) may be positively or negatively affected by competition; if competition has a positive or negative impact depends on the values of the derivative of marginal revenue with respect to competition and, for the unionism case, on the values of $\bar{\phi}_\lambda$ and $\bar{\phi}$ as well;

(b) under unionism inputs and outputs can to some extent move in different directions. It is therefore possible that employment falls, while capital stock and output increase. This is not possible under non-unionism, as employment, capital stock, and output all move in the same direction when competition increases. So, a positive impact of competition on marginal revenue, which would raise inputs and output under non-unionism, might not be sufficient to ensure a rise in inputs and output under unionism. In fact, the reduction in $\bar{\phi}$ may offset the positive impact stemming from $\bar{R}_{q\lambda}$ and $\hat{R}_{q\lambda}$ being positive;

(c) under non-unionism, a positive derivative of marginal revenue with respect to competition is a necessary and sufficient condition for inputs and output to rise; under unionism, this condition is neither necessary nor sufficient for capital and output to rise, while it is necessary but not sufficient for employment to increase under strong unionism (see equation (2.9));

(d) the relative change in employment is, in general, smaller under unionism than under non-unionism. To see this just rewrite (2.9) as follows

$$\frac{\bar{n}_\lambda^{SU}}{\bar{n}} = \frac{\hat{n}_\lambda \bar{\phi}}{\bar{\phi}\hat{n}} + \frac{\hat{n}\bar{\phi}_\lambda}{\bar{\phi}\hat{n}} = \frac{\hat{n}_\lambda}{\hat{n}} + \frac{\bar{\phi}_\lambda}{\bar{\phi}} \leq \frac{\hat{n}_\lambda}{\hat{n}}$$

with equality sign holding only for $\bar{\phi}_\lambda = 0$.

Finally, note that (a), (b), (c), and (d) all apply to both strong and weak unionism with the only exception of employment under weak unionism as this is not allowed to increase by assumption.

2.5 The impact of competition on firm efficiency

This section derives the conditions for competition to have a positive impact on firm efficiency (x-efficiency).

We will only consider x-efficiency under unionism as we know from section 2.3 that the firm is perfectly efficient under non-unionism whatever the level of product market competition (that is, $\hat{\sigma} = 1$ for all λ's). On the contrary, always from section 2.3, we know that under unionism the firm is employing too many workers (too little capital) from a cost minimising point of view, i.e. $\bar{\sigma} < 1$. So, for competition to have a positive impact on firm efficiency, $\bar{\sigma}$ has to be positively correlated to λ.

2.5.1 X-efficiency under unionism

It can be shown that under unionism, x-efficiency arises as long as the following condition holds (see Appendix A4)

$$(2.12) \qquad a - \left(\frac{d\bar{k}}{d\bar{n}} + b \right) \bar{n}^{i}_{\lambda} > 0 \qquad \qquad i = WU,\ SU$$

where

$$\frac{d\bar{k}}{d\bar{n}} = \frac{\bar{q}_{nk}\bar{q}_{n} - \bar{q}_{nn}\bar{q}_{k}}{\bar{q}_{nk}\bar{q}_{k} - \bar{q}_{kk}\bar{q}_{n}} \geq 0$$

and *a* and *b* are as in section 2.4.2. *a* measures the impact on $\bar{\sigma}$ of the change in $\bar{k}$ while $\frac{d\bar{k}}{d\bar{n}} + b$ reflects the impact on $\bar{\sigma}$ of the change in $\bar{n}$. If the inequality in (2.12) is reversed, more competition leads to more firm inefficiency.

Due to concavity of the production function, $\frac{d\bar{k}}{d\bar{n}} + b$ is always positive. It follows that firm efficiency is more likely to increase under weak unionism than under strong unionism.

In fact

$$a-\left(\frac{d\overline{k}}{d\overline{n}}+b\right)\overline{n}_{\lambda}^{WU} \geq a-\left(\frac{d\overline{k}}{d\overline{n}}+b\right)\overline{n}_{\lambda}^{SU}$$

with equality sign holding only for $\overline{n}_{\lambda}^{SU} \leq 0$. The reason why x-efficiency is more likely to arise under weak unionism is quite obvious. From the point of view of cost minimisation, at the time λ increases, employment is too large. Hence, the fact that it can not increase under weak unionism can only have a positive impact on firm efficiency. Using the firm efficiency measure we can therefore write

$$\overline{\sigma}_{\lambda}^{WU} \geq \overline{\sigma}_{\lambda}^{SU}$$

with equality sign holding only for $\overline{n}_{\lambda}^{SU} \leq 0$. We shall now analyse under which conditions (2.12) is met. We first discuss (2.12) under the hypothesis that marginal revenue is increasing in competition for any value of output, i.e. we assume that under non-unionism an increase in competition always raises firm's employment, capital, and production. Then we relax this assumption by allowing the derivative of marginal revenue with respect to λ to be negative.

X-efficiency when marginal revenue is increasing in λ

We start by assuming that competition has always a positive effect on firm's employment, capital, and production under non-unionism. This is equivalent to set $\overline{R}_{q\lambda}$ and $\hat{R}_{q\lambda}$ larger than zero[20]. In this case a turns out to be positive. This means that, under weak unionism, $\overline{R}_{q\lambda} > 0$ is a sufficient condition for $\overline{\sigma}$ to be increasing in competition. This follows straightforwardly from the non-positivity of $\overline{n}_{\lambda}^{WU}$ and the positivity of $\frac{d\overline{k}}{d\overline{n}}+b$. So, if competition has in general a positive impact on output under non-unionism, then x-

[20] We implicitly assume that there is a level of λ for which under non-unionism the amount $\overline{x}$ is produced.

efficiency certainly arises under weak unionism. By contrast, under strong unionism, a>0 may not be sufficient to ensure more firm efficiency as λ rises. In fact, if $\bar{\phi}_\lambda$ is not too small ($\bar{\phi}_\lambda$ is non-positive by Assumption 3), $\bar{n}$ will rise (see equation (2.9)) affecting $\bar{\sigma}$ negatively. In this case, the overall impact of competition on $\bar{\sigma}$ turns out to be ambiguous, i.e. firm efficiency may either increase or decrease (or stay constant) in response to a rise in λ.

Firm efficiency is on the contrary certainly increasing in competition under strong unionism as well if $\bar{\phi}_\lambda$ is small enough to cause a reduction in $\bar{n}$. In this case, $\bar{n}_\lambda^{SU} < 0$, so that $\bar{n}_\lambda^{WU} = \bar{n}_\lambda^{SU}$, and weak and strong unionism deliver the same outcome.

X-efficiency when marginal revenue may decrease in λ

If we allow $\bar{R}_{q\lambda}$ and $\hat{R}_{q\lambda}$ to be negative and/or to have different signs, the impact of an increase in competition will in general be ambiguous under both unionisms. If $\bar{R}_{q\lambda}$ is positive (and $\hat{R}_{q\lambda}$ is negative) (2.12) is unambiguously met as a is positive and $\bar{n}_\lambda^i$ is negative (in this case weak and strong unionism coincide). As a result, firm efficiency improves with competition. The opposite holds if $\bar{R}_{q\lambda}$ is negative (so that a is negative), $\hat{R}_{q\lambda}$ is positive and $\bar{\phi}_\lambda$ is not too small (so that $\bar{n}_\lambda^{SU}$ is positive). In this case, however, weak and strong unionism diverge, in that firm efficiency falls more under the latter than under the former. Finally, if $\bar{R}_{q\lambda}$ and $\hat{R}_{q\lambda}$ are both negative, weak and strong unionism coincide and firm efficiency may either increase or decrease (or stay constant) in response to a rise in λ.

Before giving an example, we summarise the findings on x-efficiency in the following proposition

PROPOSITION 2.2 *Under unionism, firm efficiency can either increase or decrease in product market competition; x-efficiency is more likely to arise under weak unionism than* *under strong unionism; if under non-unionism firm's production is increasing with competition, x-efficiency certainly arises under weak unionism; under non-unionism firm efficiency is not affected by competition.*

Proof: the proof trivially follows from previous observations. ◎

2.6 An example

In this section we discuss a special case. We specify the functional forms of demand and production by taking two of the most widely used functions in economic analysis, namely the constant elasticity of demand function and the Cobb-Douglas production function. So

$$D = p^{-\frac{1}{1-\lambda}} \qquad\qquad x = \frac{n^{\alpha} k^{\beta}}{\alpha^{\alpha} \beta^{\beta}}$$

where D is demand, p is firm's output price, β and α are positive parameters, with $\alpha+\beta\leq 1$, and $\lambda \in (0,1)$. We shall take the demand elasticity $1/(1-\lambda)$ as a measure of competition. The more elastic the demand, the more competitive the market. For simplicity we set $w=r=1$ and assume that at the time the technological shock occurs the firm is perfectly efficient and profit maximising. Then

$$\sigma(n',k') = \frac{\alpha'}{\beta}\frac{k'}{n'} = 1$$

where α' is the initial value of α and k' and n' are given by

$$k' = \beta\lambda^{\frac{1}{1-(\alpha'+\beta)\lambda}} \qquad\qquad n' = \alpha'\lambda^{\frac{1}{1-(\alpha'+\beta)\lambda}}$$

Assume that α falls and takes the value $\alpha'' < \alpha'$. Then the management would like to increase capital stock. As far as labour is concerned, both cases may arise, i.e. the optimal level of employment after a decrease in α might be lower as well as higher than the initial one. Following Assumption 1 we shall consider only the former case, i.e. we shall assume that after a decrease in α the profit maximising level of employment gets lower. The equilibrium values for all relevant variables are under the two different cases (unionism and non-unionism) the following ones (see Appendix A5)

(2.13) $$\hat{n} = \alpha'' \lambda^{\frac{1}{1-s\lambda}} < \bar{n} = \bar{\phi}\alpha'' \lambda^{\frac{1}{1-s\lambda}}$$

(2.14) $$\hat{k} = \beta\lambda^{\frac{1}{1-s\lambda}} < \bar{k} = \bar{\phi}^{\frac{\alpha''\lambda}{1-\beta\lambda}} \beta\lambda^{\frac{1}{1-s\lambda}}$$

(2.15) $$\hat{x} = \lambda^{\frac{s}{1-s\lambda}} < \bar{x} = \bar{\phi}^{\frac{\alpha''}{1-\beta\lambda}} \lambda^{\frac{s}{1-s\lambda}}$$

(2.16) $$\hat{\sigma} = 1 > \bar{\sigma} = \frac{1}{\bar{\phi}^{t}}$$

where

$$s = \alpha'' + \beta \qquad t = \frac{1-s\lambda}{1-\beta\lambda}$$

So, in equilibrium, since $\bar{\phi}$ is bigger than 1, employment, capital, and production are larger under unionism. Specifically, the larger is $\bar{\phi}$, the higher are employment, capital stock, and production. As far as firm efficiency is concerned, this is clearly higher under non-unionism. Let us now turn to the impact of competition on the equilibrium.

Employment, capital, and output are all increasing in competition under non-unionism, while firm efficiency is unaffected. Formally

(2.17) $$\frac{\hat{n}_\lambda}{\hat{n}} = \frac{\hat{k}_\lambda}{\hat{k}} = m > 0$$

(2.18) $$\frac{\hat{x}_\lambda}{\hat{x}} = sm > 0$$

(2.19) $$\frac{\hat{\sigma}_\lambda}{\hat{\sigma}} = 0$$

where

$$m = \frac{1}{1-s\lambda}\left[\frac{1}{\lambda} + \frac{s}{1-s\lambda}\log\lambda\right] > 0$$

In the case of unionism firm efficiency may be affected by competition. In particular, since $\overline{\sigma}$ is smaller than 1, x-efficiency arises under strong unionism if $\overline{\sigma}_{\lambda}^{SU} > 0$, and under weak unionism if $\overline{\sigma}_{\lambda}^{WU} > 0$. We shall first express the impact of λ on the different variables as a function of the change in employment, as this is what differentiates weak from strong unionism. Thus

(2.20) $$\frac{\overline{k}_{\lambda}^{i}}{\overline{k}} = \frac{1}{1-\beta\lambda}\left[h + \alpha''\lambda\frac{\overline{n}_{\lambda}^{i}}{\overline{n}}\right] \le \frac{\overline{k}_{\lambda}^{SU}}{\overline{k}} \qquad i=WU,\ SU$$

(2.21) $$\frac{\overline{x}_{\lambda}^{i}}{\overline{x}} = \frac{1}{1-\beta\lambda}\left[\beta h + \alpha''\frac{\overline{n}_{\lambda}^{i}}{\overline{n}}\right] \le \frac{\overline{x}_{\lambda}^{SU}}{\overline{x}} \qquad i=WU,\ SU$$

(2.22) $$\frac{\overline{\sigma}_{\lambda}^{i}}{\overline{\sigma}} = \frac{1}{1-\beta\lambda}\left[h - (1-s\lambda)\frac{\overline{n}_{\lambda}^{i}}{\overline{n}}\right] \ge \frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}} \qquad i=WU,\ SU$$

(2.23) $$\frac{\overline{n}_{\lambda}^{SU}}{\overline{n}} = m + \frac{\overline{\phi}_{\lambda}}{\overline{\phi}} \le \frac{\hat{n}_{\lambda}}{\hat{n}}$$

(2.1) $$\overline{n}_{\lambda}^{WU} = \begin{cases} \overline{n}_{\lambda}^{SU} & \text{if} \quad \overline{n}_{\lambda}^{SU} < 0 \\ 0 & \text{otherwise} \end{cases}$$

where

$$h = \frac{1}{\lambda} + \frac{\alpha''}{1-s\lambda}\left[\left(\frac{\beta}{\alpha''} + \frac{1}{1-s\lambda}\right)\log\lambda + \log\overline{\phi}\right] > 0$$

and $\overline{\phi}_{\lambda}$ is non-positive by Assumption 3.

The above equations state that (a) since $\overline{n}_{\lambda}^{i}$ may be negative as well as positive (equations (2.1) and (2.23)), under unionism the impact of an increase in competition can be positive as well as negative for capital and output (equations (2.20) and (2.21)); (b) $\overline{\sigma}_{\lambda}^{WU}$ is positive, i.e. an increase in competition always raises firm efficiency under weak unionism (x-efficiency) (equations (2.1) and (2.22)); (c) the relative change in employment is smaller under unionism than under non-unionism (equations (2.17) and (2.23)); (d) the impact of competition on capital and output is larger under strong unionism than under weak unionism when the two settings deliver different outcomes, that is when $\overline{n}_{\lambda}^{SU} > 0$, so that $\overline{n}_{\lambda}^{WU} = 0$ (equations (2.20) and (2.21)). In this case, though, the change in firm efficiency is smaller under strong unionism (equation (2.22)).

The fact that the impact of competition on output is larger under strong unionism and the one on firm efficiency is larger under weak unionism is consistent with the findings of sections 2.4.2.1 and 2.5.1. Under strong unionism, equations (2.20) to (2.22) can be rewritten in an explicit way, so that we can check whether x-efficiency arises under strong unionism as well. Insertion of (2.23) in (2.20) to (2.22) yields the following expressions[21]

$$\text{(2.20')} \qquad \frac{\overline{k}_{\lambda}^{SU}}{\overline{k}} = m + \frac{\alpha''}{1-\beta\lambda}\left[\lambda\frac{\overline{\phi}_{\lambda}}{\overline{\phi}} + \frac{1}{1-\beta\lambda}\log\overline{\phi}\right] \qquad i=WU,\ SU$$

$$\text{(2.21')} \qquad \frac{\overline{x}_{\lambda}^{SU}}{\overline{x}} = sm + \frac{\alpha''}{1-\beta\lambda}\left[\frac{\overline{\phi}_{\lambda}}{\overline{\phi}} + \frac{\beta}{1-\beta\lambda}\log\overline{\phi}\right] \qquad i=WU,\ SU$$

$$\text{(2.22')} \qquad \frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}} = \frac{1}{1-\beta\lambda}\left[\frac{\alpha''}{1-\beta\lambda}\log\overline{\phi} - (1-s\lambda)\frac{\overline{\phi}_{\lambda}}{\overline{\phi}}\right] > 0 \qquad i=WU,\ SU$$

Having written the relative changes in explicit form, we can see that the sign of (2.20'), (2.21'), and (2.23) is determined by the interaction of two different components: the first one is represented by the first term on the RHS and is equal to the corresponding relative change under non-unionism; the second one is reflected by the second term on the RHS and stems from $\overline{\phi}$ being larger than 1 and non-increasing in competition. The first component

[21] Note that these are the same under weak unionism when $\overline{n}_{\lambda}^{SU} \leq 0$; if $\overline{n}_{\lambda}^{SU} > 0$, instead, the corresponding expressions under weak unionism are equations (2.20) to (2.22) with i=WU and $\overline{n}_{\lambda}^{WU}$ set equal to zero.

is positive for all variables, while the second one is negative for employment, and either positive or negative for capital and output. As a consequence, capital and output may increase as employment falls. If $\bar{\phi}_{\lambda}$ is equal to zero, the relative changes of employment, capital, and output are all positive and larger than or equal to those under non-unionism.

The only equation to be certainly positive is the one relative to firm efficiency (equation (2.22')). This means that $\bar{\sigma}$ is positively correlated to competition under strong unionism too. And this holds even if $\bar{\phi}_{\lambda}=0$. Hence, more competition implies more firm efficiency under both weak and strong unionism. We summarise the results of this section in the following propositions.

PROPOSITION 2.3 *Unionism leads in comparison to non-unionism to*

(a) higher employment, capital stock, and production;

(b) lower firm efficiency, whereby under non-unionism the firm is perfectly efficient.

Proof: *(a)* follows from (2.13) to (2.15); *(b)* stems from (2.16).◎

PROPOSITION 2.4 *The impact of an increase in competition can be different under unionism and non-unionism. In particular*

(a) employment, capital stock and production all increase under non-unionism, while each of these variables can either increase or decrease (or stay constant) under unionism (in particular, competition may lower employment and raise output);

(b) under non-unionism firm efficiency is unaffected by competition, while it is increasing with competition (x-efficiency) under unionism;

(c) the change in firm efficiency is never smaller under weak unionism than under strong unionism;

(d) the relative impact of competition on employment is larger under non-unionism than under unionism.

Proof: *(a)* follows from (2.1), (2.17), (2.18), (2.20), (2.21), and (2.23); *(b)* stems from (2.19), (2.22), and (2.22'); *(c)* is derived from (2.1) and (2.22); *(d)* is obtained from (2.17) and (2.23).◎

2.7 Conclusion

In this chapter it was shown that when the firm union affects directly employment, the firm is not efficient. That is, the profit maximising capital/employment combination is sub-optimal, in the sense that unit costs of production are not minimised. As a consequence, output is larger and possibly nearer its socially optimal value than under non-unionism.

Due to the inefficiency in production, an increase in product market competition might have a qualitatively different impact on employment and output. In particular, the former might decrease and the latter expand (through a rise in capital) as competition increases. By contrast, under non-unionism, the derivatives with respect to competition of employment, capital, and output are either all positive or all negative.

Further, the conditions under which firm efficiency improves with competition (x-efficiency) have been derived. Unless the union can force the management to employ new workers, if competition raises firm's output when the firm is perfectly efficient, it does increase firm efficiency when the firm is producing in an inefficient way. In other words, competition is always increasing firm efficiency under weak unionism and the hypothesis that, under non-unionism, firm's output is positively correlated to competition.

In general, x-efficiency is more likely to be observed under weak unionism than under strong unionism. Moreover, it was shown that x-efficiency arises always when the demand function is of constant elasticity type and the production function is Cobb-Douglas.

In the next chapter the model is extended to check whether the results so far obtained hold through when instead of a single firm a whole sector of the economy is considered. Moreover, the way the unions choose $\bar{\phi}$ is made explicit and a formal justification for Assumption 2 and Assumption 3 is given.

CHAPTER 3

Imperfect competition and firm efficiency: the industry case

3.1 Introduction

In this chapter we extend the analysis of Chapter 2 to a whole industry (or sector) of the economy. The main difference is that now each firm is faced with a demand schedule that depends on the prices of all firms operating in the same market and on the amount of nominal income spent by the consumers on their goods. We shall see that this has consequences mainly for the equilibrium level of capital.

The analysis is conducted at a lower level of generality than in Chapter 2. In particular, for all firms we use the same Cobb-Douglas production function as in Chapter 2, section 2.6 and the CES demand function introduced in Chapter 1, section 1.2.2. Hence, any comparison between the firm and the industry case will not concern the general model of sections 2.3 to 2.5 of Chapter 2, but the one specified in section 2.6.

Moreover, we make explicit the decision process of the union with respect to the determination of $\bar{\phi}$, thereby giving a formal justification for Assumption 2 and Assumption 3. Specifically, the conditions implied by these two assumptions become the result of the maximisation of the union expected utility function.

Finally, a numerical example is presented.

3.2 The model

We now extend the approach of the previous chapter to the analysis of a whole sector, called S, of the economy. Each firm in this sector is denoted by a subscript j where $j \in [0,1]$. Products are differentiated so that firms have a certain degree of monopolistic power. The demand side is modelled as in Chapter 1, section 1.2.2. So, preferences of the representative consumer over goods from S are expressed by a symmetric CES utility function, such that each firm faces a downsloping demand curve given by

$$c_j = \left(\frac{p_j}{P}\right)^{-\frac{1}{1-\lambda}}\left(\frac{I}{P}\right) \qquad \forall j \in [0,1]$$

where p_j is the price of the good produced by firm j; $1/(1-\lambda)$ denotes the constant price elasticity of demand corresponding to the elasticity of substitution between any two goods produced in S with $\lambda \in (0,1)$. As λ approaches one, the industry approaches perfect competition. As λ tends to 1, in fact, all goods in S become perfect substitutes. P is the consumer price index of the goods produced in S and is a function of p_j (see Chapter 1, section 1.2.2). Finally, I is nominal income spent on goods from S.

The production function is the same used in section 2.6 of the previous chapter and is identical for all firms. So

$$x_j = \frac{n_j^{\alpha} k_j^{\beta}}{\alpha^{\alpha}\beta^{\beta}} \qquad \forall j \in [0,1]$$

where x_j is the level of output of firm j; k_j and n_j are, respectively, the amount of capital and labour employed by firm j; α and β are positive parameters, with $\alpha+\beta\leq 1$. Firms take the unit cost of capital, r, the unit cost of labour, w, the price index P, and income I as exogenous and set their optimal demand for labour and capital by maximising profit. As in the firm case, we set $w=r=1$ and assume that at the time the technological shock occurs firms are perfectly efficient and profit maximising. Then

$$\sigma(n'_j, k'_j) = \frac{\alpha'}{\beta}\frac{k'_j}{n'_j} = 1 \qquad \forall j \in [0,1]$$

where α', n'_j, and k'_j are the initial values of α, n_j, and k_j. Specifically, employment and capital are given by (see Appendix B)

(3.1) $$n'_j = \alpha' \lambda I \qquad \forall j \in [0,1]$$

(3.2) $$k'_j = \beta \lambda I \qquad \forall j \in [0,1]$$

whereby the above expressions were obtained exploiting the symmetry of the model that implies $p_j = P$ for all j. Both employment and capital are negatively affected by imperfect competition (λ<1). $\alpha' I$ and βI are the levels of employment and capital when firms act as price-takers.

At this point we introduce a further assumption. When $\alpha+\beta<1$, that is, when there are decreasing returns to scale, price taking behaviour leads to a positive profit. This may cause confusion as price taking is used to denote perfect competition. But if firms make positive profit, price taking cannot correspond to perfect competition as the latter is associated with zero profit. So, to obtain the perfect competition case we could not simply assume price taking firms, but we would have to consider entry as well. In order to avoid this complication and to establish a formal equivalence between price taking behaviour and perfect competition without entry of new firms we make the following assumption

ASSUMPTION 4 *define* π(1) *as the amount of profit that firms make when they act as price takers. Then,* π(1) *is the minimum amount of profit at which firms are willing to produce.*

Basically, Assumption 4 makes price taking equivalent to perfect competition. In fact, no outside firm wants to enter the market when firms are price taking because the firms already in the industry are not enjoying any rent, i.e., they are not making any profit above

$\pi(1)$. This allows us to avoid a formal analysis of entry and to establish an equivalence between price taking behaviour and perfect competition[22].

Having cleared this matter, we assume again that at some point α falls and takes the value $\alpha'' < \alpha'$ and that profit maximising labour demand decreases. Hence, the management aims at reducing employment. As in the previous chapter, we shall analyse and compare the case in which the management is free to choose the level of employment (non-unionism), and the case in which the enterprise union is involved in the determination of employment (weak and strong unionism). Before comparing the outcomes under these different settings, we extend the approach of Chapter 2 by making explicit the way the unions determine their optimal level of labour demand.

3.3 The market selection hypothesis and unions utility

This section deals with the problem of determining labour demand under unionism. The aim is to give a formal justification for Assumption 2 ($\bar{n} > \hat{n}$). Assumption 3 ($\bar{\phi}_\lambda \leq 0$) will be discussed in section 3.5.2. These two assumptions are particularly important as they play a non-marginal role in determining the results of the previous chapter.

To determine the way unions choose employment we resort to the market selection hypothesis, according to which, in a competitive environment, a firm that does not maximise profits will eventually be driven out of the market. This argument is mainly associated with the work by Friedman [1953]. As he puts it,

> … - unless the behavior of businessmen in some way or other approximated behavior consistent with the maximization of returns, it seems unlikely that they would remain in business for long. Let the apparent immediate determinant of business behavior be anything at all – habitual reaction, random chance, or whatnot. Whenever this determinant happens to lead to behavior consistent with rational and informed maximization of returns, the business will prosper and acquire resources with which to expand; whenever it does not, the business will tend to lose resources and can be kept in existence only by the addition of resources

[22] Alternatively, we could have introduced fixed costs of production equal to $\pi(1)$.

> from outside. The process of "natural selection" thus helps to validate the [maximization of returns] hypothesis-or, rather, given natural selection, acceptance of the hypothesis can be based largely on the judgement that it summarizes appropriately the conditions for survival (FRIEDMAN [1953], p. 22).

Thus, the content of the selection hypothesis is that profit maximising firms are (more likely to be) the survivors. This hypothesis provides therefore a justification for the use of profit maximisation in modelling firm behaviour.

Despite its intuitive appealing, the market selection hypothesis has not been without its critics. Some authors have, in fact, expressed doubts about its validity and developed alternative models, in which firms are allowed to behave in a way inconsistent with profit maximisation.

So Nelson and Winter [1982] adopt an evolutionary approach, in which firms simply follow some given decision rules and update them over time. These decision rules need not be fully consistent with profit maximisation, although the most profitable firms are still expected to drive the less profitable ones out of business. Blume and Easley [1992] develop a model in which individuals make risky investments using different rules; they show that utility maximisation is not necessarily the rule most likely to succeed. More clear-cut is the result obtained by Dutta and Radner [1999]. They find that only firms that do not maximise profits survive in the long run[23].

Despite these criticisms, we adopt the market selection hypothesis in our effort to provide a reasonable way in which unions determine firms' labour demand. In particular, we assume that, if firms are not profit maximising, those among them that are closer to profit maximisation have better chances to survive for any given degree of product market competition. And, if competition increases, the survival chances of the firms that are closer to profit maximisation rise, while those of the other firms diminish.

These assumptions are somehow implicit in the market selection argument and already Alchian [1950] pointed out that success or survival only requires relative superiority[24]. In the context of the x-efficiency literature, the market selection hypothesis has been used by

[23] For a critical discussion of the profit maximisation hypothesis, see Winter [1987].
[24] "Even in a world of stupid men there would still be profits" (Alchian [1950], p. 213).

Schmidt [1997]. In his model, managerial effort increases in competition because more competition implies a higher probability of bankruptcy[25]. Although based on the same idea, our approach is different and can be described as follows.

We define $\hat{n}_j^D$ as firm *j* labour demand under non-unionism[26], $\overline{n}_j^D$ as firm *j* labour demand under unionism, and $\overline{\phi}_j$ as the ratio between the two, that is

$$\overline{\phi}_j \equiv \frac{\overline{n}_j^D}{\hat{n}_j^D} \qquad \forall j \in [0,1]$$

$\overline{\phi}_j$ corresponds to the variable $\overline{\phi}$ introduced in Chapter 2, section 2.4.2. Given $\hat{n}_j^D$, determining firm *j* labour demand under unionism is equivalent to determining $\overline{\phi}_j$. Hence, we can conduct the analysis in terms of the variable $\overline{\phi}_j$, instead of using $\overline{n}_j^D$.

We assume that in each period a fraction 1-ε ($\varepsilon \in$ [0,1]) of the firms in sector *S* goes bankrupt in the wake of some exogenous adverse shocks. However, for each firm leaving the market there is a new one entering it so that the number of firms in sector *S* can be viewed as constant[27]. This means that each firm should have a likelihood of survival equal to ε in each period. However, following the arguments above, the probability of going bankrupt for a given firm increases if the firm is not profit maximising, when all other firms are. A measure of how close is firm *j* to profit maximisation is given by the difference in absolute value between $\overline{\phi}_j$ and 1, as $\overline{\phi}_j = 1$ corresponds to profit maximisation. Thus, the larger $\left|\overline{\phi}_j - 1\right|$, the further away is firm *j* from profit maximisation. Denoting by $\overline{\phi}_{-j}$ the $\overline{\phi}$ chosen by all unions other than union *j*, it follows that the probability of survival of firm *j* is less than ε if $\left|\overline{\phi}_j - 1\right| > \left|\overline{\phi}_{-j} - 1\right|$ and it is larger than ε if $\left|\overline{\phi}_j - 1\right| < \left|\overline{\phi}_{-j} - 1\right|$. If $\left|\overline{\phi}_j - 1\right| = \left|\overline{\phi}_{-j} - 1\right|$, the probability of survival of each firm is exactly equal to ε. Given this, we assume that $\overline{\phi}_j$

[25] See Chapter 1, section 1.3 as well.

[26] $\hat{n}_j^D$ corresponds to *(III)* in Appendix B.

[27] Constancy of the number of firms in the market is not necessary but it simplifies the exposition.

is the outcome of a maximisation process. Specifically, union *j* is assumed to maximise the following expected utility function

$$E[U(\phi_j)] = \varepsilon\Psi(\phi_j, \phi_{-j}, \lambda)U(\phi_j) \qquad \forall j \in [0,1] \tag{3.3}$$

where $U(.)\equiv U$ is the utility function of union *j*, $\varepsilon\Psi(.)$, which is bound between 0 and 1, is the probability of survival of firm *j*, and the utility when the firm goes bankrupt has been set equal to zero. These functions are the same for all unions. (3.3) is continuous, everywhere twice differentiable, and concave in ϕ_j. As to *U*, we assume $U_{\phi_j}>0$, i.e. the utility of union *j* is increasing in ϕ_j. Union *j* chooses ϕ_j to maximise (3.3) taking ϕ_{-j} as given. $\Psi(.)\equiv\Psi$ has the following features

$$(i)\Psi_{\phi_j} \leq 0 \qquad \forall \phi_j > 1 \qquad \forall j \in [0,1]$$

$$(ii)\Psi_{\phi_j} \geq 0 \qquad \forall \phi_j < 1 \qquad \forall j \in [0,1]$$

$$(iii)\Psi_{\phi_{-j}} \geq 0 \qquad \forall \phi_{-j} \geq 1 \qquad \forall j \in [0,1]$$

$$(iv)\Psi(v, v, \lambda) = 1 \qquad \forall \lambda \in (0,1)$$

(*i*) and (*ii*) state that the probability of survival of firm *j* is in general higher the closer is ϕ_j to unity. It follows that union *j* will never choose a demand for labour lower than the profit maximising one since it would definitely be better off by setting $\bar{n}_j^D = \hat{n}_j^D$. Hence, the optimal ϕ_j, $\bar{\phi}_j$, and, by extension, the optimal ϕ_{-j}, $\bar{\phi}_{-j}$, are never smaller than 1. This means that, if we ignore the solution $\bar{\phi}_j = 1$, maximisation of (3.3) leads to the result implied by Assumption 2.

This fact is taken into account in (*iii*) that is defined only for $\phi_{-j} \geq 1$. In particular, (*iii*) states that the further other firms are from profit maximisation, the higher the probability of survival of firm *j*. This assumption explains why an increase in ϕ_j may have no impact on

Ψ (equality signs in (*i*) and (*ii*)). In fact, if ϕ_{-j} is very large and ϕ_j is close to unity, a small change in the latter may not make any difference. In this case, we can imagine Ψ as being flat and equal to $1/\varepsilon$ for some interval around $\phi_j = 1$. Conversely, if ϕ_{-j} is close to unity and ϕ_j is very large, Ψ is equal (or close) to zero. In this case, a small change in ϕ_j may have no impact on Ψ at all. A similar argument applies to the equality sign in (*iii*). (*iv*) says that when $\phi_j = v$ for all *j*'s, then all firms survive with a probability of ε.

As we know that $\bar{\phi}_j$ is larger than unity for all *j*'s, we make the following assumptions, that are contingent on ϕ_{-j} and ϕ_j being equal to or larger than 1

$$(v)\Psi_\lambda < 0 \qquad \forall \phi_j > \phi_{-j},\ \forall \phi_{-j} \geq 1 \qquad \forall j \in [0,1]$$

$$(vi)\Psi_\lambda > 0 \qquad \forall \phi_j < \phi_{-j},\ \forall \phi_j \geq 1 \qquad \forall j \in [0,1]$$

(*v*) and (*vi*) state that the probability of survival of firm *j* is positively (negatively) affected by competition if firm *j* is closer to (further away from) profit maximisation than the other firms are.

Due to the symmetry of the model, in equilibrium maximisation of (3.3) with respect to ϕ_j gives a value $\bar{\phi}_j$, which is the same for all *j*'s. Moreover, from (*ii*) follows that $\bar{\phi}_j$ is in general larger than 1. So, $\bar{\phi}_j = \bar{\phi}_{-j} = \bar{\phi} \geq 1 \ \ \forall j \in [0,1]$. Obviously $\bar{\phi}$ must be always small enough to guarantee a level of profit above the minimum required for production, which is given by $\pi(1)$ (see Assumption 4). It follows that $\bar{\phi}$ is equal to 1 when firms are price taking, i.e., under perfect competition unionism and non-unionism yield the same outcome. In fact, if $\bar{\phi}$ were larger than 1, profit would fall below $\pi(1)$. This feature will prove to be quite important in the discussion on x-efficiency in section 3.5.2. Finally, note that the results of this section are all independent of Assumption 1.

3.4 Industry equilibrium under non-unionism and under unionism

In this section we compare the two equilibria that arise when the management is free to hire and fire without the agreement of the union (non-unionism) and when the firm union sets firm labour demand (unionism). The equilibrium under unionism is determined through the imposition of the restriction implied by Assumption 1, i.e. firm labour demand is lower than current employment. This restriction allows us to treat strong and weak unionism together as they deliver the same equilibrium. On the contrary, Assumption 2 ($\overline{\phi} > 1$), no longer holds, in the sense that now $\overline{\phi}$ is determined as in section 3.3, so that it is either equal to or larger than 1. The equilibria under non-unionism and under unionism are given by (see Appendix B)

(3.4) $$\hat{n} = \alpha'' \lambda I \leq \overline{n} = \overline{\phi}^{t} \alpha'' \lambda I$$

(3.5) $$\hat{k} = \beta \lambda I = \overline{k}$$

(3.6) $$\hat{x} = (\lambda I)^{s} \leq \overline{x} = \overline{\phi}^{t\alpha''} (\lambda I)^{s}$$

(3.7) $$\hat{\sigma} = 1 \geq \overline{\sigma} = \frac{1}{\overline{\phi}^{t}}$$

As usual the superscripts '^' and '¯' denote respectively the equilibrium values under non-unionism and under unionism. Strict inequalities hold for $\overline{\phi}$ >1, while for $\overline{\phi}$ =1 the two equilibria are the same. Under perfect competition, the levels of employment, capital, output, and efficiency are the same under the two settings as price taking implies $\overline{\phi}$ =1.

As long as non-unionism and unionism deliver different outcomes, i.e. as long as λ<1 and $\overline{\phi}$ >1, the following remarks hold.

The equilibrium level of employment is higher when the unions determine firms' labour demand than under non-unionism (equation (3.4)). So, the presence of the unions has a beneficial effect in terms of employment.

Capital stock is the same under the two settings (equation (3.5)). As a consequence, the ratio capital/labour is smaller when the unions choose employment. Since under non-unionism this ratio corresponds to the optimal one, when the unions affect the level of employment firms are inefficient (see (3.7)). This result is due to the fact that firms, although forced to keep a larger number of workers, have no incentive to expand capital stock to obtain the cost minimising ratio between labour and capital. Doing this would, in fact, lower profits. In particular, demand for capital turns out to be independent of labour demand (see Appendix B) and the final outcome is overmanning. Note that the expression for firm efficiency is identical to the one derived in the firm case (see (3.7) and (2.16)).

As to output (equation (3.6)), due to the presence of a larger workforce, production is higher under unionism then under non-unionism. The union forces therefore the firm to produce more than it wants to do, thereby possibly enhancing social efficiency[28].

We summarise the findings of this section in the following proposition.

PROPOSITION 3.1 *If* $\bar{\phi} > 1$, *unionism leads in comparison to the non-unionism case to*

(a) higher employment and production;

(b) lower firm efficiency, whereby under non-unionism firms are perfectly efficient;

(c) equal capital stock.

If $\bar{\phi} = 1$, *unionism delivers the same outcome as non-unionism.*

Proof: *(a)* follows from (3.4) and (3.6); *(b)* stems from (3.7); *(c)* is derived from (3.5).◎

Thus the main difference between the firm case and the industry case is given by capital stock. This is larger under unionism in the firm case, while there is no difference between non-unionism and unionism in the industry case. This follows from equilibrium capital stock being independent of employment. More importantly, though, none of the results of this section hinges on Assumption 2, that, by contrast, was necessary to determine the firm case outcomes. In fact, now the implicit condition of Assumption 2, i.e. $\bar{\phi} > 1$, is the result of the maximisation of the union objective function.

[28] See Chapter 2, section 2.3.

Notably, the larger is $\bar{\phi}$, the higher are employment and production, in both the industry and firm case (see (3.4) and (3.6), and (2.13) and (2.15)). In particular, $\bar{\phi}$ has only a positive effect on employment and production (and capital, in the firm case).

3.5 The impact of competition

In this section the impact of an increase in competition on the equilibrium is discussed. As in the previous chapter, we distinguish between strong unionism and weak unionism. However, we no longer assume that $\bar{\phi}$ is non-increasing in λ. That is, we relax Assumption 3.

3.5.1 The impact of competition under non-unionism

When the management is free to adjust labour without the consent of the union, the impact of an increase in competition is straightforward: employment, production, and capital stock increase, and firm efficiency is unaffected, i.e. whatever the level of competition firms are always producing in a perfectly efficient way. Formally

(3.8) $$\frac{\hat{n}_\lambda}{\hat{n}} = \frac{\hat{k}_\lambda}{\hat{k}} = \frac{1}{\lambda} > 0$$

(3.9) $$\frac{\hat{x}_\lambda}{\hat{x}} = \frac{s}{\lambda} > 0$$

(3.10) $$\frac{\hat{\sigma}_\lambda}{\hat{\sigma}} = 0$$

3.5.2 The impact of competition under unionism

We now analyse the impact of competition under weak and strong unionism. Since $\bar{\sigma}$ is smaller than 1, x-efficiency arises under strong unionism if $\bar{\sigma}_{\lambda}^{SU} > 0$, and under weak unionism if $\bar{\sigma}_{\lambda}^{WU} > 0$. We shall first express the impact of λ on the different variables as a function of the change in employment, as this is what differentiates weak from strong unionism. Thus

(3.11) $$\frac{\bar{k}_{\lambda}^{i}}{\bar{k}} = \frac{\hat{k}_{\lambda}}{\hat{k}} = \frac{1}{\lambda} > 0 \qquad i=WU, SU$$

(3.12) $$\frac{\bar{x}_{\lambda}^{i}}{\bar{x}} = \frac{\beta}{\lambda} + \alpha'' \frac{\bar{n}_{\lambda}^{i}}{\bar{n}} \le \frac{\bar{x}_{\lambda}^{SU}}{\bar{x}} \qquad i=WU, SU$$

(3.13) $$\frac{\bar{\sigma}_{\lambda}^{i}}{\bar{\sigma}} = \frac{1}{\lambda} - \frac{\bar{n}_{\lambda}^{i}}{\bar{n}} \ge \frac{\bar{\sigma}_{\lambda}^{SU}}{\bar{\sigma}} \qquad i=WU, SU$$

(2.1) $$\bar{n}_{\lambda}^{WU} = \begin{cases} \bar{n}_{\lambda}^{SU} & \text{if } \bar{n}_{\lambda}^{SU} < 0 \\ 0 & \text{otherwise} \end{cases}$$

The above equations state that (a) the relative change in capital is positive and equal under unionism (weak and strong) and non-unionism (equation (3.11)); moreover, given (3.5), the absolute change is the same as well; (b) $\bar{\sigma}_{\lambda}^{WU}$ is positive, i.e. an increase in competition always raises firm efficiency under weak unionism (x-efficiency) (equations (2.1) and (3.13)); (c) the impact of competition on output is larger under strong unionism than under weak unionism when the two settings deliver different outcomes, that is when $\bar{n}_{\lambda}^{SU} > 0$, so that $\bar{n}_{\lambda}^{WU} = 0$ (equation (3.12)). In this case, though, the change in firm efficiency is smaller under strong unionism (equation (3.13)).

Remark (a) stems from capital being independent of employment, and therefore of $\bar{\phi}$, which is the variable that differentiates unionism from non-unionism. Remark (b) derives from the increase in capital. At the time competition increases, firms are employing too many workers for the amount of capital in use, i.e. the ratio capital/labour is too small. Since labour can not increase under weak unionism by assumption and capital expands as λ rises, the ratio of capital to labour increases, so that firm efficiency improves. Concerning remark (c), output rises more under strong unionism because, when employment increases under strong unionism, it remains constant under weak unionism, and capital rises by the same extent under both weak and strong unionism. For the same reason the change in firm efficiency is smaller under strong unionism.

To see whether x-efficiency arises under strong unionism too (that is, if $\bar{\sigma}_{\lambda}^{SU}$ is positive) and, more generally, how changes in firm efficiency are related to changes in output and employment, we give an expression for $\bar{n}_{\lambda}^{SU}$ as a function of $\bar{\sigma}_{\lambda}^{SU}$ (equation (3.14)) and insert it into (3.12) and (3.13). Thus

(3.14) $$\frac{\bar{n}_{\lambda}^{SU}}{\bar{n}} = \frac{1}{\lambda} - \frac{\bar{\sigma}_{\lambda}^{SU}}{\bar{\sigma}}$$

(3.12') $$\frac{\bar{x}_{\lambda}^{SU}}{\bar{x}} = \frac{s}{\lambda} - \alpha'' \frac{\bar{\sigma}_{\lambda}^{SU}}{\bar{\sigma}}$$

(3.13') $$\frac{\bar{\sigma}_{\lambda}^{SU}}{\bar{\sigma}} = \frac{1}{1-\beta\lambda}\left[\frac{\alpha''}{1-\beta\lambda}\log\bar{\phi} - (1-s\lambda)\frac{\bar{\phi}_{\lambda}}{\bar{\phi}}\right]$$

Equations (3.14) and (3.12') show that the impact of competition on employment and output under strong unionism[29] can be decomposed into two effects: a direct effect, represented by the first term on the RHS, that is positive and equal to the impact of competition under non-unionism (see (3.8) and (3.9)); and an indirect effect, represented by the second term on the RHS, that is negatively correlated to the change in firm efficiency. The indirect effect is proper of unionism as, under non-unionism, firms are perfectly efficient for every λ.

[29] On the relationship between (3.12') and (3.13') and the corresponding expressions under weak unionism see note 21 in Chapter 2, section 2.6.

Since we have relaxed Assumption 3 ($\bar{\phi}_\lambda \leq 0$), firm efficiency may be increasing as well as decreasing in competition. In fact, the sign of (3.13') is ambiguous. However, Assumption 3 would be a sufficient (though not necessary) condition for firm efficiency to increase in λ. In fact, since $\bar{\phi}$ is never smaller than 1, if $\bar{\phi}_\lambda \leq 0$, (3.13') is certainly positive. This is the same result obtained in the single firm case, which is not surprising as the expressions for firm efficiency are the same (see (3.7) and (2.16)) so that the corresponding derivatives have to be the same as well (see (3.13') and (2.22')). In general, though, the process through which unions choose $\bar{\phi}$ (described in section 3.3) does not ensure as such a non-positive impact of competition on $\bar{\phi}$. Nevertheless, there are some values of λ for which $\bar{\phi}_\lambda$ is non-positive and x-efficiency arises. To see this, consider that from the discussion of section 3.3 we have

$$\bar{\phi} \geq 1 \qquad \forall \lambda \in (0,1)$$

and $$\bar{\phi} \to 1 \qquad \text{for } \lambda \to 1$$

If we ignore the particular case in which $\bar{\phi}$ is constantly equal to 1 for all λ's[30], these two expressions imply that for some levels of competition $\bar{\phi}$ is larger than 1 and that there must be some λ's for which $\bar{\phi}_\lambda$ is strictly negative, as $\bar{\phi}$ tends to 1 as λ approaches 1. Those λ's for which $\bar{\phi}_\lambda$ is strictly negative give rise to x-efficiency[31]. So, we can conclude that there are some values of λ for which firm efficiency is increasing in competition under strong unionism as well.

This result extends to all λ's when the cross-derivative of Ψ, $\bar{\Psi}_{\phi_j\lambda} \equiv \Psi_{\phi_j\lambda}(\bar{\phi},\bar{\phi},\lambda)$, is non-positive. To see this, note that, using the first order condition for a maximum of (3.3), we can write the condition $\bar{\phi}_\lambda \leq 0$ as follows

(3.15) $$\Psi_{\phi_j\lambda}(\bar{\phi},\bar{\phi},\lambda)U(\bar{\phi}) + \Psi_\lambda(\bar{\phi},\bar{\phi},\lambda)U_{\phi_j}(\bar{\phi}) \leq 0$$

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[30] In this case, unionism simply collapses to the non-unionism case.

(3.15) is the same as Assumption 3 under the hypothesis that $\bar{\phi}$ is determined as in section 3.3. Since the second term in (3.15) is negative by (*v*) from section 3.3, if $\overline{\Psi}_{\phi_j\lambda}$ is non-positive, (3.15) is satisfied. In this case, $\bar{\phi}_\lambda$ is non-positive, (3.13') is positive and efficiency increases with competition.

Thus, the sign of $\overline{\Psi}_{\phi_j\lambda}$ plays a crucial role. If it is negative, competition raises efficiency; if it is positive and sufficiently large[32], competition lowers efficiency. However, it seems reasonable to believe it to be negative. In fact, $\overline{\Psi}_{\phi_j\lambda}$ measures the impact of competition on the size of the fall in firm *j*'s probability of survival due to a fall in firm *j*'s efficiency. In other words, if firm *j* becomes less efficient (a rise in ϕ_j), its probability of survival decreases. This decrease is measured by $\overline{\Psi}_{\phi_j} \equiv \Psi_{\phi_j}\left(\bar{\phi}, \bar{\phi}, \lambda\right)$. If $\overline{\Psi}_{\phi_j\lambda}$ is negative, it means that $\overline{\Psi}_{\phi_j}$ becomes larger in absolute value as competition rises. That is, the more competitive is the market, the sharper is the fall in firm *j*'s probability of survival stemming from a rise in ϕ_j. This assumption seems quite plausible, so that we in general expect $\overline{\Psi}_{\phi_j\lambda}$ to be negative and (3.15) to be met for any value of λ.

The intuition behind this result is easily explained. When the product market is highly competitive the union is willing to accept the level of employment desired by the management because this guarantees the long run survival of the firm. However, as the product market becomes less and less competitive the survival chances of an inefficient firm increase leaving more room for the union to enlarge employment. Put differently, the union shares the monopolistic profit in terms of employment. As competition increases the existence of a pie to share becomes uncertain. So, the union is more willing to give up part of its gain in order to be sure that there will be some gain at all[33].

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[31] X-efficiency arises for $\bar{\phi}_\lambda$=0 as well and even for $\bar{\phi}_\lambda$>0, provided that $\bar{\phi}_\lambda$ is not too large.

[32] By sufficiently large, we mean that $\overline{\Psi}_{\phi_j\lambda}$ must be large enough to make the LHS of (3.15) positive and large enough to cause (3.13') to become negative (the size of $\bar{\phi}_\lambda$ is positively correlated to the size of the LHS of (3.15)).

[33] Moreover, the pie, i.e. the monopolistic rent, gets smaller as competition increases.

Concerning the impact of competition on employment and output under strong unionism, we discuss (3.14) and (3.12') only for the case in which (3.15) is satisfied, i.e. under x-efficiency. The consequence for output and employment of x-efficiency is that their relative changes are lower than under non-unionism and possibly negative. This result extends to weak unionism (see equations (3.12) and (2.1)). Formally

$$\frac{\bar{\sigma}_\lambda^{SU}}{\bar{\sigma}} > 0 \quad \Rightarrow \quad \frac{\bar{x}_\lambda^i}{\bar{x}} < \frac{\hat{x}_\lambda}{\hat{x}} \quad \text{and} \quad \frac{\bar{n}_\lambda^i}{\bar{n}} < \frac{\hat{n}_\lambda}{\hat{n}} \qquad i=WU, SU$$

The reason is that the improvement in firm efficiency is due to a reduction in $\bar{\phi}^t$, which means less demand for labour and, therefore, less output. The negative impact of the firm efficiency improvement is full for employment and weighted by the labour productivity parameter α for output. This implies that employment and output may move in different directions. In particular, there is a range of values of the change in firm efficiency for which employment decreases and output increases. Formally, we have

$$\frac{\bar{\sigma}_\lambda^{SU}}{\bar{\sigma}} < \frac{1}{\lambda} \quad \Rightarrow \quad \bar{n}_\lambda^{SU} > 0,\ \bar{n}_\lambda^{WU} = 0,\ \bar{x}_\lambda^i > 0 \qquad i=WU, SU$$

$$\frac{1}{\lambda} < \frac{\bar{\sigma}_\lambda^i}{\bar{\sigma}} < \frac{s/\alpha''}{\lambda} \quad \Rightarrow \quad \bar{n}_\lambda^i < 0 \ \text{ and } \ \bar{x}_\lambda^i > 0 \qquad i=WU, SU$$

$$\frac{\bar{\sigma}_\lambda^i}{\bar{\sigma}} > \frac{s/\alpha''}{\lambda} \quad \Rightarrow \quad \bar{n}_\lambda^i < 0 \ \text{ and } \ \bar{x}_\lambda^i < 0 \qquad i=WU, SU$$

We summarise the main results of the last two sections in the following proposition.

PROPOSITION 3.2 *The impact of an increase in competition can be different depending on whether firms can freely adjust labour. In particular*

(a) employment and production increase under non-unionism, while they can either increase or decrease (or stay constant) under unionism (in particular, competition may lower employment and raise output); capital stock increases by the same extent in all cases;

(b) under non-unionism firm efficiency is unaffected by competition; by contrast, firm efficiency is increasing with competition (x-efficiency) under weak unionism for every value of λ and it is increasing under strong unionism for at least some values of λ;

(c) the change in firm efficiency is never smaller under weak unionism than under strong unionism;

(d) if firm efficiency increases in λ, the relative impact of competition on employment and output is larger under non-unionism than under unionism.

Proof: *(a)* follows from (2.1), (3.8), (3.9), (3.11), (3.12), (3.14), and (3.12'); *(b)* stems from (2.1), (3.10), (3.13), (3.13'), and Assumption 4; *(c)* is derived from (2.1) and (3.13); *(d)* is obtained from (2.1), (3.8), (3.9), (3.12), (3.14), and (3.12').©

All results about the impact of competition are pretty similar to those derived in the firm case (see Proposition 2.4). With respect to the unionism results, the main difference lies in the assumptions behind them. In the firm case, the impact of competition under unionism was derived by assuming $\bar{\phi}_\lambda \leq 0$ (Assumption 3). By contrast, in this section we have made no restrictions on the sign of $\bar{\phi}_\lambda$ and shown that, in general, Assumption 3 can be recovered from maximisation of the union objective function.

Independently of the differences in the underlying assumptions, the firm and industry case differ also with respect to the behaviour of capital stock. In the industry case, the impact of competition on capital is positive and the same under all settings (non-unionism, weak and strong unionism); in the firm case, the impact of λ on capital varies according to the different settings (see Chapter 2, section 2.6). The reason is that equilibrium capital is independent of employment in the industry case, while it is positively correlated to labour in the firm case.

Concerning the fact that competition has a larger impact on firm efficiency under weak unionism than under strong unionism (point *(c)*), the reason for this is the same that was behind the corresponding result in the firm case. That is, at the time the increase in λ occurs, firms are inefficient because they have too many employees for the amount of capital in use. Hence, constraining the workforce to be not expanding, as it is the case under weak unionism, can only have a positive effect on firm efficiency.

We now give a numerical example to illustrate the results of this chapter.

3.6 A numerical example

In this last section of Chapter 3 before the conclusion we provide a numerical example. Let us assume that union *j*'s utility function takes on the following form

$$U(\phi_j) = \phi_j - 1 \qquad \forall j \in [0,1]$$

while Ψ is given by

$$\Psi = Exp[-\delta(\phi_j - \phi_{-j})] \qquad \forall j \in [0,1]$$

if $Exp[-\delta(\phi_j - \phi_{-j})] \leq 1/\varepsilon$ and is equal to $1/\varepsilon$ otherwise. ϕ_j and ϕ_{-j} are both constrained to be larger than (or equal to) unity. Given (*v*) and (*vi*) from section 3.3, δ has to be a positive function of product market competition. We choose the following function for δ

$$\delta = 15\frac{\lambda^6}{1-\lambda^2}$$

Assume further that the initial level of α, α', is equal to 0.5, the new value after the shock, α'', is 0.3, the productivity parameter of capital, β, is equal to 0.5, and income spent on goods from *S*, *I*, is equal to 1. We consider both settings, unionism and non-unionism, and both strong and weak unionism. Figures 1a and 1b depict employment, production, and firm efficiency as a function of λ for strong unionism, while figures 2a and 2b are the corresponding graphs under weak unionism. In all figures the dotted lines refer to the non-unionism case, while the full lines refer to unionism. Figures 1a and 2a show the employment schedules while 1b and 2b the production and efficiency ones. Under strong unionism, we consider only values of λ larger than 0.6 because, when λ is lower, Assumption 1 is violated as the optimal level of employment under unionism ($\overline{n}$) results larger than current employment (n')[34].

Figure 1a shows that under strong unionism the level of employment is larger than under non-unionism and that there are values of λ for which increases in competition leads to lower employment. In particular, under strong unionism the level of employment reaches a minimum for $\lambda=\lambda_M$.

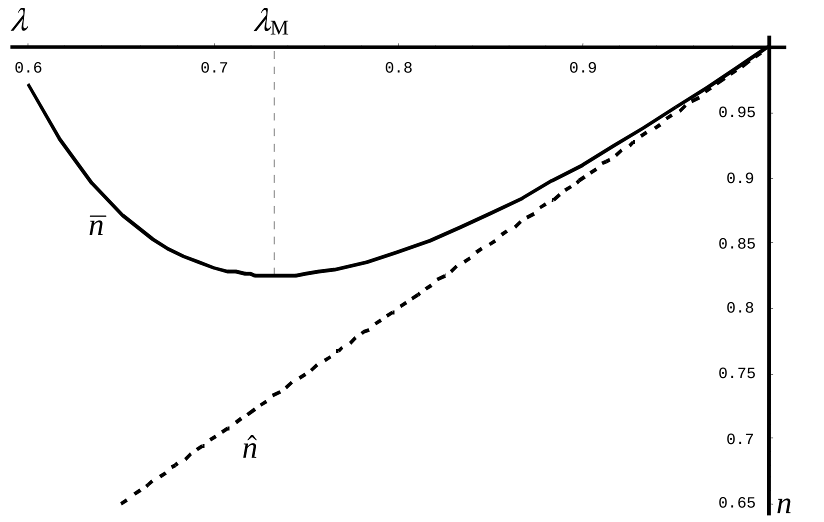
Figure 1b shows that firm efficiency under strong unionism ($\overline{\sigma}$) is always increasing in λ. As to output, the corresponding schedule for the non-unionism case ($\hat{x}$) lies always below the output curve under unionism ($\overline{x}$). Both schedules are everywhere increasing in competition. This implies that under unionism output and employment diverges for $0.6<\lambda<\lambda_M$. In this range the increase in capital stock offsets the decrease in labour input causing production to further increase.

[34] For an analysis of the case $\overline{n} > n'$, see Pompermaier [2000].

Figure 1 - Efficiency, employment, and production as a function of λ strong unionism and non-unionism

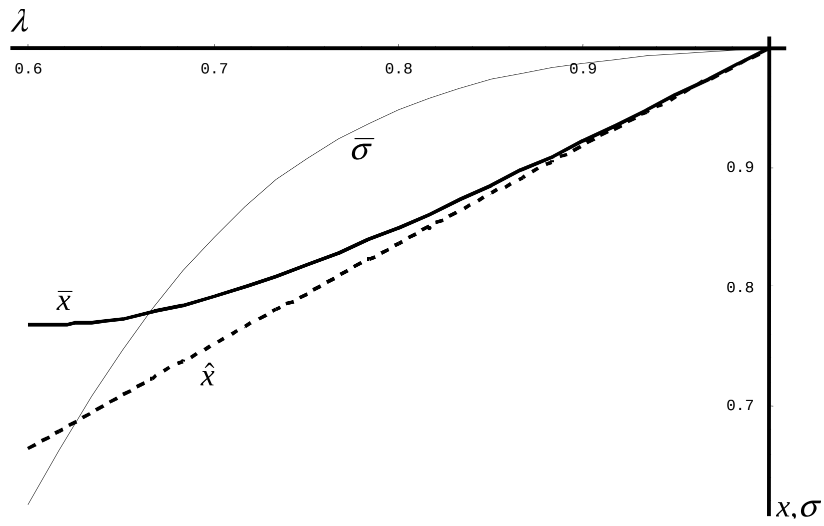
(α''=0.3, α'=0.5, β=0.5; I=1; n and x normalised to 1 for $\lambda \to 1$)

1a)



$\bar{n}$ =employment under strong unionism; $\hat{n}$ =employment under non-unionism

1b)

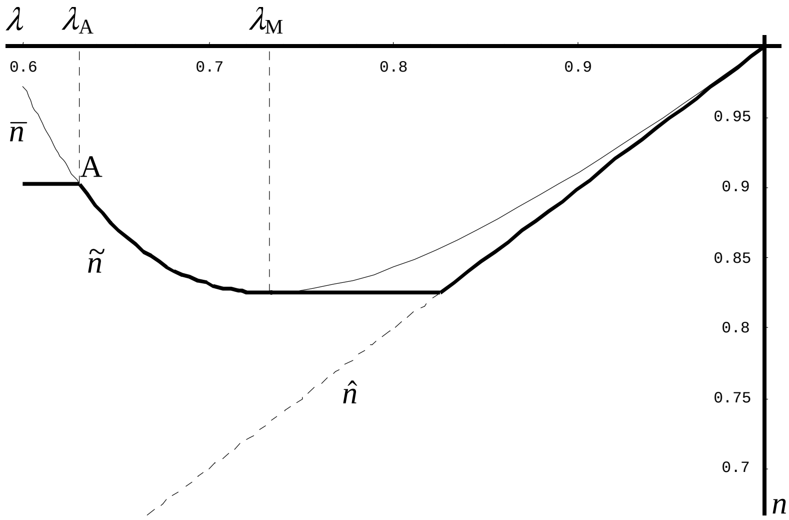


$\hat{x}$ =production under non-unionism; $\bar{x}$ =production under strong unionism;
$\bar{\sigma}$ =efficiency under strong unionism

Figure 2 - Efficiency, employment, and production as a function of λ weak unionism

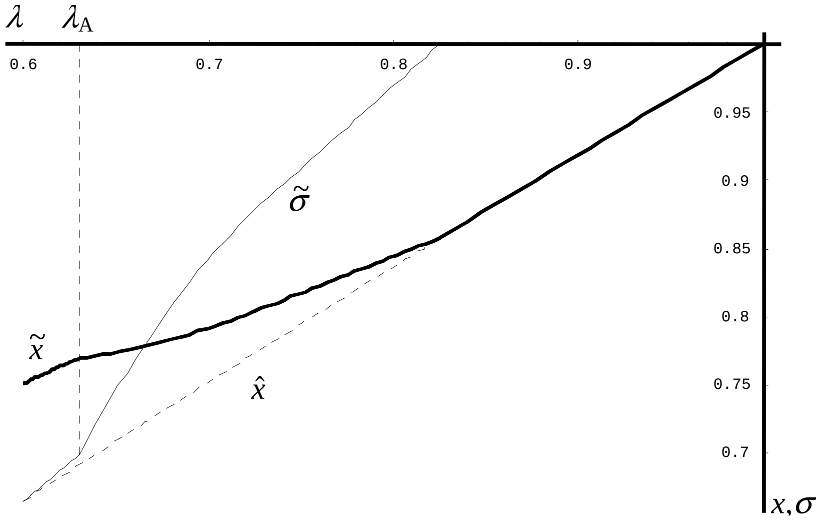
(α''=0.3, α'=0.5, β=0.5; I=1; n and x normalised to 1 for $\lambda \rightarrow 1$)

2a)



$\hat{n}$ =employment under non-unionism; $\bar{n}$ =employment under strong unionism; $\tilde{n}$ = employment under weak unionism

2b)



$\hat{x}$ =production under non-unionism; $\tilde{x}$ =production under weak unionism; $\tilde{\sigma}$ =efficiency under weak unionism

Figures 2a and 2b refer to weak unionism. We start from a given equilibrium, A in Figure 2a, and draw the different schedules for changes in λ. By assumption, employment is not allowed to rise above its current level under weak unionism as long as it lies above the corresponding non-unionism level. For this reason, if λ falls, so that $\lambda<\lambda_A$, $\tilde{n}$, which is used to denote employment under weak unionism, remains constant and below its corresponding strong unionism level $\bar{n}$. By contrast, if λ increases, $\tilde{n}$ and $\bar{n}$ coincide. This follows from the fact that $\bar{n}_\lambda^{SU} < 0$ so that, by assumption, $\bar{n}_\lambda^{WU} = \bar{n}_\lambda^{SU}$ (see (2.1)). However, once λ_M is reached, $\bar{n}$ starts rising again, i.e. $\bar{n}_\lambda^{SU}$ becomes positive. In this case $\bar{n}_\lambda^{WU}$ is equal to zero, so that $\tilde{n}$ is constant for $\lambda_M<\lambda<0.83$ and lies below $\bar{n}$. For $\lambda=0.83$, $\tilde{n} = \hat{n}$, i.e. employment under weak unionism is equal to employment under non-unionism. As a consequence, $\tilde{n}$ starts rising again after $\lambda=0.83$ as weak unionism simply collapses to the non-unionism case. Thus, above $\lambda=0.83$ there is no difference between weak unionism and non-unionism[35].

As far as firm efficiency and production are concerned (Figure 2b), they are both increasing in competition. For $\lambda<0.83$ weak unionism output ($\tilde{x}$) is consistently higher than non-unionism output. However, once this threshold value is reached, weak unionism coincides with non-unionism, so that, for $0.83<\lambda\leq 1$, $\tilde{x}$ is equal to $\hat{x}$, and $\tilde{\sigma}$ (=firm efficiency under weak unionism) is constantly equal to 1.

3.7 Conclusion

In this chapter the approach used in the firm case was extended to the analysis of a whole sector of the economy. The results obtained confirm essentially those of Chapter 2. However, they were derived in a different way. In fact, we relaxed Assumption 2 and Assumption 3, that were crucial in determining the outcomes of the previous chapter, and introduced a union expected utility function, whose features reflect the market selection

[35] Basically, for $\lambda>0.83$, (2.2) from Chapter 2, section 2.2 with $\tilde{n}$ instead of $\bar{n}$ on the right hand side, no

hypothesis. In general, maximisation of the union objective function leads to employment being larger under unionism, as in Assumption 2, and to $\bar{\phi}$ being decreasing in λ, as in Assumption 3.

As far as the actual equilibrium outcomes are concerned, employment and production are larger under unionism than under non-unionism. As in the firm case, unionism leads to firm inefficiency while when the management is allowed to fire at will firms are perfectly efficient. The behaviour of capital stock is different. In the firm case, capital stock is smaller under non-unionism, while it turns out to be equal under the two settings in the industry case.

The impact of an increase in competition on the equilibrium is quite similar to that obtained in the previous chapter. Thus, under non-unionism, more competition means more employment and production, and no impact on firm efficiency. Under unionism, competition has generally a positive impact on firm efficiency (x-efficiency), while it has an ambiguous effect on employment and production. In particular, as in the firm case, the latter may expand and the former fall as competition increases.

A slight difference between the firm and the industry case arises with respect to capital stock: under unionism, capital is certainly increasing with competition in the industry case, while it might be decreasing when only a single firm is taken into consideration.

The differences between the firm and the industry case with respect to capital stem from the fact that equilibrium capital stock is independent of employment in the industry case, while, in the firm case, equilibrium capital is a positive function of labour.

In the next chapter we analyse a last extension of the model, in that we apply the approach followed so far within a general equilibrium framework. In particular, we assume sector *S* to be the only sector producing consumption goods in the economy and we model labour and capital supply. These extensions will allow us a proper welfare analysis.

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longer holds.

CHAPTER 4

Imperfect competition and firm efficiency: the general equilibrium case

4.1 Introduction

In this chapter we present a general equilibrium model of imperfect competition with x-efficiency. The model is an extension of the one used to analyse the industry case. In particular, we make the following changes: (a) we add a labour supply function; (b) we assume that *S* is the only industry of the economy producing consumer goods; (c) we add a sector producing the capital good. These changes imply that, unlike in the firm and industry cases, factor prices are endogenous. Moreover, having a labour supply, formally derived from the households' utility function, allows us to conduct a proper welfare analysis. Households' utility functions, and therefore households' demand for goods and labour supply, are the same as in Chapter 1, section 1.2.2. The production function of the firms producing the consumers' goods is the same used in the previous chapter, i.e. a Cobb-Douglas with constant or decreasing returns to scale. As to the capital good sector, this is modelled in the simplest way: we assume constant returns to scale and perfect competition, so that price equals marginal cost. Concerning the behaviour of the unions, the framework developed in the previous chapter applies (see Chapter 3, section 3.3).

These extensions will lead to conclusions somewhat different from the ones of the industry and firm cases, in particular with respect to the level of output. In fact, this may be lower under unionism: a result in sharp contrast with the industry case as well as with the firm case, even by taking into account the general approach to the latter (see Chapter 2, section 2.3).

Moreover, the effects of an increase in competition under unionism will turn out to be not as clear cut as those predicted by the literature on imperfect competition and stated in Proposition 1.1.

4.2 The model

In this section we outline the basic building blocks of the model, the firms, the households and markets in which they interact.

Households

Preferences of households are modelled as in Chapter 1, section 1.2.2. In summary, there is a continuum of households $i \in [0,1]$ whose utility function looks as follows

$$U(c_{ij}, l_i) = \left(\int_{j=0}^{1} c_{ij}^{\lambda} dj \right)^{\frac{1}{\lambda}} - \frac{\gamma}{\gamma+1} l_i^{\frac{\gamma+1}{\gamma}} \qquad \forall i \in [0,1]$$

The first term is the utility of consumption while the second term is the disutility of labour (l_i). Aggregate demand for any good m, $m \in [0,1]$, and labour supply are

$$c_m = \left(\frac{p_m}{P} \right)^{-\frac{1}{1-\lambda}} \frac{I}{P}$$

$$l = \left(\frac{w}{P} \right)^{\gamma}$$

The parameter γ represents the wage elasticity of labour supply while I is total nominal income[36].

Firms

There are two sectors: a capital good sector and a consumption good sector. The latter is characterised by monopolistic competition while the former by perfect competition. As to monopolistic firms, their production function is the same as in the previous two chapters. So

$$x_j = \frac{n_j^{\alpha} k_j^{\beta}}{\alpha^{\alpha} \beta^{\beta}} \qquad \forall j \in [0,1]$$

where x_j is the level of output of firm j; k_j and n_j are, respectively, the amount of capital and of labour employed by firm j and $\alpha>0$ and $\beta>0$ are the technology parameters with $\alpha+\beta\leq 1$. Again, all firms take nominal wage w, cost of capital r, price index P, and nominal income I as exogenous and set their optimal factors' demand by maximising profit.

In the sector producing the capital good the only production input is labour. Returns to scale are constant and production is normalised to be equal to employment. So

$$k = n^k$$

where n^k denotes the amount of labour employed in the capital sector. One representative firm produces and sells the capital good to the monopolistic firms. Since perfect competition is assumed, capital is sold at its marginal cost, i.e.

$$r = w$$

with r the price of capital. As a convention, we shall use k to refer to both the amount of physical capital and the employment level in the capital sector.

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[36] The demand function is the same as in Chapter 3. However, there sector S was interpreted as just one industry out of many making up the economy and I as the amount of nominal income spent on goods from S.

4.3 General equilibrium

In this section we derive the equilibrium under non-unionism and unionism. In the former case, the management of each monopolistic firm is free to choose the level of employment; in the latter, enterprise unions determine firms' labour demand. The restriction under unionism concerns only the firms in the monopolistic sector. In the capital good sector the management is free to choose the desired level of employment or, equivalently, the capital sector is not unionised. Unlike in the industry and firm cases, we do not describe the pre-technological shock equilibrium. This can be however easily derived by substituting α' for α'' in the non-unionism equilibrium.

4.3.1 General equilibrium under non-unionism

In this section we derive the symmetric equilibrium under non-unionism, i.e. under the assumption that the management of the monopolistic firms can freely choose input amounts. The equilibrium total employment is given by (see Appendix B)

$$\hat{L} = s\left(\frac{\lambda^{\gamma}}{s}\right)^{\frac{1}{1+(1-s)\gamma}} \tag{4.1}$$

Employment is distributed between the two sectors in the following way

$$\hat{n} = \alpha''\left(\frac{\lambda^{\gamma}}{s}\right)^{\frac{1}{1+(1-s)\gamma}} \tag{4.2}$$

$$\hat{k} = \beta\left(\frac{\lambda^{\gamma}}{s}\right)^{\frac{1}{1+(1-s)\gamma}}$$

Here we look at an economy in which there is just one industry producing consumption goods and I is total income, that is all spent on goods from this only industry.

and total consumption/output is given by

$$\hat{C} = \left(\frac{\lambda^{\gamma}}{s} \right)^{\frac{s}{1+(1-s)\gamma}}$$

As a measure of welfare we take the utility function, that in equilibrium is equal to

$$\hat{U} = \left(\frac{\lambda^{\gamma}}{s} \right)^{\frac{s}{1+(1-s)\gamma}} \left(1 - \frac{\gamma}{\gamma+1} \lambda s \right)$$

Finally, firm efficiency in the monopolistic sector equals

(4.3) $$\hat{\sigma} = \frac{\alpha''}{\beta} \frac{\hat{k}}{\hat{n}} = 1$$

i.e., firms are perfectly efficient under non-unionism. Since in the capital sector labour is the only factor of production, no issue of productive efficiency arises for firms producing the capital good.

4.3.2 General equilibrium under unionism

In this section the equilibrium under unionism is derived. Assumption 1 is maintained so that both weak and strong unionism deliver the same equilibrium. Assumption 4 is also retained, so that price taking corresponds to perfect competition.

Labour demand of monopolistic firm *j* under unionism is obtained in the same way as in the industry case (see Chapter 3, section 3.3). The equilibrium total employment is then given by (see Appendix B)

(4.4) $$\overline{L} = z \left[\frac{\lambda^{\gamma} \overline{\phi}^{\, t\alpha''\gamma}}{z} \right]^{\frac{1}{1+(1-s)\gamma}}$$

where

$$z = \alpha''\bar{\phi}^{t} + \beta$$

and *t* is the same as in the previous chapters, i.e.

$$t = \frac{1 - s\lambda}{1 - \beta\lambda}$$

Employment is distributed between the two sectors in the following way

(4.5) $$\bar{n} = \alpha''\bar{\phi}^{t}\left[\frac{\lambda^{\gamma}\bar{\phi}^{t\alpha''\gamma}}{z}\right]^{\frac{1}{1+(1-s)\gamma}}$$

(4.6) $$\bar{k} = \beta\left[\frac{\lambda^{\gamma}\bar{\phi}^{t\alpha''\gamma}}{z}\right]^{\frac{1}{1+(1-s)\gamma}}$$

Total consumption/output is

(4.7) $$\bar{C} = \bar{\phi}^{t\alpha''}\left[\frac{\lambda^{\gamma}\bar{\phi}^{t\alpha''\gamma}}{z}\right]^{\frac{s}{1+(1-s)\gamma}}$$

and welfare equals to

(4.8) $$\bar{U} = \bar{\phi}^{t\alpha''}\left[\frac{\lambda^{\gamma}\bar{\phi}^{t\alpha''\gamma}}{z}\right]^{\frac{s}{1+(1-s)\gamma}}\left[1 - \frac{\gamma}{\gamma+1}\lambda z\right]$$

Firm efficiency in the monopolistic sector equals

(4.9) $$\bar{\sigma} = \frac{\alpha''}{\beta}\frac{\bar{k}}{\bar{n}} = \frac{1}{\bar{\phi}^{t}} \leq 1$$

i.e., the level of firm inefficiency under unionism is the same as in the firm and industry cases[37] (see equations (2.16) and (3.7)). This means again that firms are employing too many workers (too little capital) from a cost minimising point of view.

It is worth noting that the share of employment in the consumption good sector is increasing in $\bar{\phi}$. So, the larger $\bar{\phi}$ the larger the share of total employment allocated to the monopolistic firms. This means that $\bar{\phi}$ can be used as a measure of employment misallocation. That is, $\bar{\phi}$ has now a new dimension: beside being, as in the firm and industry cases, a demand variable and a measure of firm inefficiency, it is a measure of the extent to which total employment is misallocated between the capital and the monopolistic sector. Given this, we can interpret the equilibrium equations under unionism as the result of the interaction of three effects of $\bar{\phi}$: a *demand*, a *supply*, and an *allocation* effect. They can be described as follows:

the *demand* effect accounts for the larger demand for labour in the monopolistic sector; it is expressed by the $\bar{\phi}$ before the squared brackets in equations (4.4), (4.5), and (4.7). Ignoring welfare, its impact on the equilibrium is positive;

the *supply* effect accounts for the labour supply response to the demand effect; it is given by the $\bar{\phi}$ inside the squared brackets in equations (4.4) to (4.7) and is increasing in the elasticity of labour supply, γ. If γ=0, the supply effect disappears. Ignoring welfare, its impact on the equilibrium is positive;

the *allocation* effect reflects the misallocation of labour between the monopolistic and the capital sector; it is expressed by the $\bar{\phi}$ in the z inside the squared brackets of equations (4.4) to (4.7). Ignoring welfare, its impact on the equilibrium is negative.

Notably, there is no demand effect in the capital equation (see (4.6)). This is a consequence of the fact that, in equilibrium, capital stock does not directly depend on monopolistic sector employment[38].

[37] As in the previous chapter, when we refer to the firm case we mean the one of Chapter 2, section 2.6. However, some of the conclusions apply to the more general framework of Chapter 2, sections 2.3 to 2.5, as well.

[38] This result was already noted in the industry case. However, in general equilibrium, $\bar{k}$ does indirectly depend on $\bar{n}$ via the supply and allocation effects.

All three effects are present in the welfare equation as well, though they are not properly distinguishable. Moreover, the way they impact on it is ambiguous. In fact, welfare is a positive function of consumption and negatively correlated to total employment. Thus, as demand and supply effects raise consumption and total employment, their overall impact on welfare turns out to be ambiguous. The same goes for the allocation effect.

The presence of negative and positive effects of $\overline{\phi}$ raises the question whether capital, employment and output are higher or lower under non-unionism or under unionism. In fact, the negative allocation effect may offset the positive demand and supply ones for some, if not all, parameter values, causing some equilibrium levels to be lower under unionism than under non-unionism. We discuss this issue in the next section.

4.3.3 General equilibrium: non-unionism vs. unionism

We now compare the equilibrium derived under non-unionism with that obtained under unionism. We do this under the assumption that the economy is not perfectly competitive (λ<1) and that $\overline{\phi}$ is larger than 1.

It is easy to see that total employment and monopolistic sector employment are in general larger under unionism while firm efficiency is lower. Specifically

$$\overline{L} \geq \hat{L} \qquad \overline{n} > \hat{n} \qquad \overline{\sigma} < \hat{\sigma} = 1 \qquad \forall \lambda < 1,\ \forall \overline{\phi} > 1$$

The firm efficiency result does not need particular comments as the expressions for $\overline{\sigma}$ and $\hat{\sigma}$ are identical to those obtained in the firm and industry cases.

Concerning total employment, if γ>0, $\overline{\phi}$'s demand effect is larger than its allocation effect and, as a consequence, $\overline{L}$ is strictly larger than $\hat{L}$. However, if γ=0, i.e. if labour supply is completely inelastic, the demand effect exactly offsets the allocation one, while the supply effect is zero. As a result, total employment turns out to be the same under unionism as under non-unionism ($\overline{L} = \hat{L}$).

Similar remarks hold for monopolistic sector employment. In this case, though, even for γ=0, the demand effect of $\bar{\phi}$ is larger than its allocation one, so that monopolistic sector employment is always larger under unionism.

As for capital, output, and welfare, they are larger under unionism when the following conditions are met

$$(4.10) \qquad \bar{\phi}^{t\alpha''\gamma} > \frac{z}{s} \qquad \Leftrightarrow \qquad \bar{k} > \hat{k}$$

$$(4.11) \qquad \bar{\phi}^{\frac{t\alpha''(\gamma+1)}{s}} > \frac{z}{s} \qquad \Leftrightarrow \qquad \bar{C} > \hat{C}$$

$$(4.12) \qquad \bar{\phi}^{\frac{t\alpha''(\gamma+1)}{s}} > \frac{z}{s}\left[\frac{\gamma+1-\gamma\lambda s}{\gamma+1-\gamma\lambda z}\right]^{\frac{1+(1-s)\gamma}{s}} \qquad \Leftrightarrow \qquad \bar{U} > \hat{U}$$

The LHS of (4.10) represents $\bar{\phi}$'s supply effect while the RHS is its allocation effect (there is no demand effect in the capital equilibrium equation (4.6)). So, for capital to be larger under unionism, we need the supply effect to be larger than the allocation one, i.e. we need a sufficiently large γ.

By contrast, output may be larger under unionism even when the supply effect is smaller than the allocation one. This follows from the fact that consumption benefits from the demand effect. So, while the RHS of (4.11) still expresses the allocation effect, the LHS embodies the supply as well as the demand effect. Note that $\bar{k} > \hat{k}$ implies $\bar{C} > \hat{C}$, while $\bar{C} > \hat{C}$ does not imply $\bar{k} > \hat{k}$, i.e. if capital stock is larger under unionism then consumption is larger too, while a larger output does not imply a larger capital stock. The intuition behind this result is quite straightforward. Since monopolistic sector employment is larger under unionism ($\bar{n} > \hat{n}$), if capital is larger as well, output has to be larger itself. However, if capital is smaller under unionism, output may still be higher because of the higher labour input.

As far as welfare is concerned, the interpretation of (4.12) is not easy as welfare is a positive function of consumption but negatively correlated to total employment. Note, however, that the term in squared brackets is larger than 1. This means that if (4.12) is met, then (4.11) is satisfied too. In other words, if welfare is larger under unionism, then consumption must be larger too. By contrast, more consumption under unionism does not necessarily lead to higher welfare. That is, $\overline{U} > \hat{U}$ implies $\overline{C} > \hat{C}$, while $\overline{C} > \hat{C}$ does not imply $\overline{U} > \hat{U}$. The intuition behind this result is again straightforward. Since households in general work more under unionism ($\overline{L} \geq \hat{L}$) then they must consume more to be better off than under non-unionism. However, if $\overline{C}$ lies only slightly above $\hat{C}$, the gain in welfare from higher consumption may be offset by the loss due to higher employment so that welfare may be higher under non-unionism. Thus, since employment is larger under unionism, a higher level of consumption is a necessary but not sufficient condition for higher welfare. By contrast, if $\overline{C} < \hat{C}$, welfare is certainly lower under unionism, since households work more and consume less.

The divergence between consumption and aggregate employment is due to the allocation effect. In fact, under non-unionism employees are better allocated between the consumption and the capital sector. As a consequence, output might be larger under non-unionism although total employment is lower. In this respect, the crucial parameter turns out to be γ, the wage elasticity. When γ is small (large) output is larger under non-unionism (unionism). The reason is that a small γ implies a rigid labour supply so that the difference between $\overline{L}$ and $\hat{L}$ has to be small. In this case, under non-unionism, the positive impact on output stemming from the fact that $\hat{L}$ is optimally allocated offsets the negative one due to $\hat{L}$ being slightly smaller than $\overline{L}$. As a result consumption under non-unionism turns out to be larger than under unionism. In the extreme case of a completely inelastic labour supply (γ=0), total employment is always equal to 1, i.e. $\overline{L} = \hat{L} = 1$, and $\hat{C} > \overline{C}$, since the only difference between non-unionism and unionism concerns the allocation of labour between the capital and the consumption good sectors.

By contrast, when γ is large, the difference between $\overline{L}$ and $\hat{L}$ is large too. In this case, output is higher under unionism, as the higher level of employment compensates for its bad allocation across sectors.

Notably, a large value of γ, though it guarantees higher output, does not lead necessarily to higher welfare under unionism. This means that there is an asymmetry with respect to the elasticity of labour supply: when γ is small enough to cause output under non-unionism to exceed that under unionism, welfare is certainly larger under non-unionism; however, a large γ, such that consumption is higher under unionism ($\overline{C} > \hat{C}$), does not imply a higher level of welfare under unionism.

Finally, note that, while $\overline{\sigma}$ is a negative function of $\overline{\phi}$, $\overline{L}$ is positively correlated to it. This means that the more inefficient firms are, the higher is aggregate employment. We summarise the main results of this section in the following proposition

PROPOSITION 4.1 *If* $\overline{\phi} > 1$, *unionism leads in comparison to the non-unionism case to*

a) higher monopolistic sector employment;

b) higher total employment unless γ=0 *in which case total employment is constantly equal to* 1*;*

c) lower (higher) consumption and capital sector employment when labour supply is rigid (elastic);

d) lower welfare when labour supply is rigid;

e) lower firm efficiency, whereby under non-unionism firms are perfectly efficient.

If $\overline{\phi}$ *=1, unionism delivers the same outcome as non-unionism.*

Proof: *(a)* follows from (4.2) and (4.5); *(b)* stems from (4.1) and (4.4); *(c)* is derived from (4.10) and (4.11); *(d)* is obtained from (4.12); *(e)* follows from (4.3) and (4.9).◎

The simultaneous presence of negative and positive effects of $\overline{\phi}$ constitutes the main difference between the general equilibrium case and the firm and industry cases discussed in the previous two chapters. There we found that there is no negative impact of $\overline{\phi}$ but only a positive one. Thus, employment, capital, and output were all increasing in (or unaffected by) $\overline{\phi}$, so that the equilibrium values were never smaller under unionism than under non-unionism. By contrast, in a general equilibrium framework, a negative effect of $\overline{\phi}$ emerges.

In fact, $\overline{\phi}$ has a distorsive impact on the allocation of labour between the capital and the consumption sector. As a consequence, output and capital may be lower under unionism. Specifically, this is the case when γ is small. If γ is large, no major difference arises between the general equilibrium case and the industry and firm cases. Note that all empirical studies suggest an elasticity of labour supply of around 0.1-0.2[39]. This means that we shall view the rigid labour supply case as the more realistic one.

The results summarised in Proposition 4.1 are not completely new. In particular, the positive impact of unionism on employment and possibly production is a result already obtained in a general equilibrium framework by Dixon and Santoni [1995], who develop a model in which there are enterprise unions that bargain sequentially over wages and employment as in Manning [1987]. In equilibrium, higher union power over wages leads to lower output/employment while higher union power over employment yields higher output/employment. However, since capital enters additively the production function, no issue of optimal input combination arises in their framework.

A Cobb-Douglas function is instead used by Layard and Nickell [1990]. They show that if firms and unions bargain over wages and employment, employment will be the same as if they bargain over wages only. However, although they assume imperfect competition in the product market as we did, labour and capital are fixed in their model, so that their results are not directly comparable to ours[40].

4.4 The impact of competition

In this section the impact of an increase in competition under non-unionism and under unionism is discussed. As in the previous chapters, we take into consideration and analyse separately weak and strong unionism.

[39] See Blundell and Macurdy [1999] and Blundell *et al*. [1998].
[40] See also Chapter 1, section 1.2.1.

4.4.1 The impact of competition under non-unionism

We look first at the impact of competition under non-unionism. Taking the derivatives with respect to λ of the equilibrium equations (see section 4.3.1) yields

$$(4.13)\qquad \frac{\hat{L}_\lambda}{\hat{L}} = \frac{\hat{n}_\lambda}{\hat{n}} = \frac{\hat{k}_\lambda}{\hat{k}} = \frac{1}{1+(1-s)\gamma}\left(\frac{\gamma}{\lambda}\right) \geq 0$$

$$(4.14)\qquad \frac{\hat{C}_\lambda}{\hat{C}} = \frac{s}{1+(1-s)\gamma}\left(\frac{\gamma}{\lambda}\right) \geq 0$$

$$(4.15)\qquad \frac{\hat{U}_\lambda}{\hat{C}} = \frac{s}{1+(1-s)\gamma}\left[\frac{\gamma}{\lambda}(1-\lambda)\right] \geq 0$$

$$(4.16)\qquad \frac{\hat{\sigma}_\lambda}{\hat{\sigma}} = 0$$

Equation (4.16) states that competition has no impact on firm efficiency. In particular, firms are perfectly efficient whatever the level of product market competition (see equation (4.3)).

Equations (4.13) to (4.15) imply that the impact of competition on employment, output, and welfare varies according to the elasticity of labour supply, γ.

Specifically, if $\gamma>0$, (4.13) to (4.15) are all positive. This means that monopolistic sector employment, capital sector employment, production and welfare all increase as competition augments. Thus, in this case, the equilibrium is negatively affected by imperfect competition in the product market, i.e. by λ being smaller than 1.

By contrast, if $\gamma=0$, i.e. if labour supply is completely inelastic, competition has no impact on the equilibrium. The reason is that imperfect competition in the product market affects the equilibrium through the labour supply. Specifically, since prices are higher under imperfect competition, real wages are lower and so labour supply is lower. However, if labour supply is completely rigid, it does not depend on real wages any longer and, so, imperfect competition has no effect on the equilibrium.

These results mirror those obtained in Chapter 1, section 1.2.2 and summarised in Proposition 1.1.

4.4.2 The impact of competition under unionism

In this section we consider unionism, both weak and strong. As in the industry and firm cases, x-efficiency arises under strong unionism if $\overline{\sigma}_{\lambda}^{SU} > 0$, and under weak unionism if $\overline{\sigma}_{\lambda}^{WU} > 0$. We shall first express the impact of λ on the different variables as a function of the change in monopolistic sector employment, as this is what differentiates weak from strong unionism. Thus, the impact of competition is given by

(4.17) $$\frac{\overline{L}_{\lambda}^{i}}{\overline{L}} = \frac{\beta}{\beta+\gamma(1-\beta)z}\left[\frac{\gamma}{\lambda}+\alpha''\gamma\left(1+\frac{1-\beta}{\beta}\overline{\phi}^{t}\right)\frac{\overline{n}_{\lambda}^{i}}{\overline{n}}\right] \leq \frac{\overline{L}_{\lambda}^{SU}}{\overline{L}}$$ i=WU, SU

(4.18) $$\frac{\overline{k}_{\lambda}^{i}}{\overline{k}} = \frac{z}{\beta+\gamma(1-\beta)z}\left[\frac{\gamma}{\lambda}+\alpha''\left(\gamma-\frac{\overline{\phi}^{t}}{z}\right)\frac{\overline{n}_{\lambda}^{i}}{\overline{n}}\right]$$ i=WU, SU

(4.19) $$\frac{\overline{C}_{\lambda}^{i}}{\overline{C}} = \frac{\beta z}{\beta+\gamma(1-\beta)z}\left[\frac{\gamma}{\lambda}+\alpha''\left(\frac{\gamma}{\beta}-\frac{\overline{\phi}^{t}-1}{z}\right)\frac{\overline{n}_{\lambda}^{i}}{\overline{n}}\right]$$ i=WU, SU

(4.20) $$\frac{\overline{U}_{\lambda}^{i}}{\overline{C}} = \frac{\beta z}{\beta+\gamma(1-\beta)z}\left\{\frac{\gamma}{\lambda}(1-\lambda)+ \right. \\ \left. +\alpha''\left[\gamma(1-\lambda)+\gamma(1-\lambda\overline{\phi}^{t})\left(\frac{1-\beta}{\beta}\right)-\frac{\overline{\phi}^{t}-1}{z}\right]\frac{\overline{n}_{\lambda}^{i}}{\overline{n}}\right\}$$ i=WU, SU

(4.21) $$\frac{\overline{\sigma}_{\lambda}^{i}}{\overline{\sigma}} = \frac{z}{\beta+\gamma(1-\beta)z}\left\{\frac{\gamma}{\lambda}-[1+(1-s)\gamma]\frac{\overline{n}_{\lambda}^{i}}{\overline{n}}\right\} \geq \frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}}$$ i=WU, SU

(2.1) $$\overline{n}_{\lambda}^{WU} = \begin{cases} \overline{n}_{\lambda}^{SU} & \text{if} \quad \overline{n}_{\lambda}^{SU} < 0 \\ 0 & \text{otherwise} \end{cases}$$

Since $\bar{n}_\lambda^{SU}$ may be negative as well as positive (see (4.22) below), the sign of all equations is ambiguous, with the exception of (4.21) for the weak unionism case; in fact $\bar{\sigma}_\lambda^{WU}$ is certainly positive, which implies that an increase in competition always raises firm efficiency under weak unionism (x-efficiency). When strong and weak unionism deliver different outcomes, that is when $\bar{n}_\lambda^{SU} > 0$, so that $\bar{n}_\lambda^{WU} = 0$, the change in total employment is larger under strong unionism (equation (4.17)). In this case, though, the change in firm efficiency is smaller under strong unionism (equation (4.21)).

Moreover, the changes in capital and output are more likely to be larger under strong unionism (weak unionism) when γ is large (small) (equations (4.18) and (4.19)). The reason is that, when γ is large, increases in monopolistic sector employment occur mainly through an expansion of total employment, which has a positive impact on capital and output. On the contrary, when γ is small, increases in monopolistic sector employment occur largely at the expense of a reduction in capital sector employment, which has a negative effect on output (and welfare too).

To see whether x-efficiency arises under strong unionism too (that is, if $\bar{\sigma}_\lambda^{SU}$ is positive) and, more generally, how changes in firm efficiency are related to changes in output and employment, we give an expression for $\bar{n}_\lambda^{SU}$ as a function of $\bar{\sigma}_\lambda^{SU}$ and insert it into (4.17) to (4.21). Thus[41]

$$(4.22)\qquad \frac{\bar{n}_\lambda^{SU}}{\bar{n}} = \frac{\hat{n}_\lambda}{\hat{n}} + \frac{\alpha''}{1+(1-s)\gamma}\left[\frac{1}{\alpha''+\beta\bar{\sigma}} - \gamma\right]\frac{\bar{\sigma}_\lambda^{SU}}{\bar{\sigma}} - \frac{\bar{\sigma}_\lambda^{SU}}{\bar{\sigma}}$$

$$(4.17')\qquad \frac{\bar{L}_\lambda^{SU}}{\bar{L}} = \frac{\hat{L}_\lambda}{\hat{L}} + \frac{\alpha''}{1+(1-s)\gamma}\left[\frac{1}{\alpha''+\beta\bar{\sigma}} - \gamma\right]\frac{\bar{\sigma}_\lambda^{SU}}{\bar{\sigma}} - \frac{\alpha''}{\alpha''+\beta\bar{\sigma}}\frac{\bar{\sigma}_\lambda^{SU}}{\bar{\sigma}}$$

$$(4.18')\qquad \frac{\bar{k}_\lambda^{SU}}{\bar{k}} = \frac{\hat{k}_\lambda}{\hat{k}} + \frac{\alpha''}{1+(1-s)\gamma}\left[\frac{1}{\alpha''+\beta\bar{\sigma}} - \gamma\right]\frac{\bar{\sigma}_\lambda^{SU}}{\bar{\sigma}}$$

[41] On the relationship between (4.17') to (4.21') and the corresponding expressions under weak unionism see note 21 in Chapter 2, section 2.6.

(4.19') $$\frac{\overline{C}_{\lambda}^{SU}}{\overline{C}}=\frac{\hat{C}_{\lambda}}{\hat{C}}+\frac{s\alpha''}{1+(1-s)\gamma}\left[\frac{1}{\alpha''+\beta\overline{\sigma}}-\gamma\right]\frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}}-\alpha''\frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}}$$

(4.20') $$\frac{\overline{U}_{\lambda}^{SU}}{\overline{C}}=\frac{\hat{U}_{\lambda}}{\hat{C}}-\alpha''\lambda\left(\frac{1}{\overline{\sigma}}-1\right)\frac{\hat{L}_{\lambda}}{\hat{L}}+$$
$$+\frac{\alpha''(s-\lambda z)}{1+(1-s)\gamma}\left[\frac{1}{\alpha''+\beta\overline{\sigma}}-\gamma\right]\frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}}-\alpha''\left(1-\frac{\lambda}{\overline{\sigma}}\right)\frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}}$$

(4.21') $$\frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}}=\frac{1}{1-\beta\lambda}\left[\frac{\alpha''}{1-\beta\lambda}\log\overline{\phi}-(1-s\lambda)\frac{\overline{\phi}_{\lambda}}{\overline{\phi}}\right]$$

(4.21') states that the impact of competition on firm efficiency is again the same as in the firm and industry cases (see (2.22') and (3.13')). This is not surprising as the corresponding equilibrium values are the same too (see (2.16), (3.7), and (4.9)).

As to the other variables, we discuss the impact of competition on them under the assumption that firm efficiency is increasing in λ[42]. As in the industry case, we can identify a direct and an indirect effect of λ. The former accounts for changes stemming directly from the increase in λ, while the latter accounts for changes induced by the variation in firm efficiency brought about by the rise in competition ($\overline{\sigma}_{\lambda}^{SU}$). We examine them in turn.

Direct effect

The direct effect is given by the first term on the RHS of (4.22), (4.17'), (4.18'), and (4.19') and by the first two terms on the RHS of (4.20'). In all but one cases, it equals the impact of competition under non-unionism and is therefore never negative (see (4.13) and (4.14)). The only exception is given by the welfare function (equation (4.20')). In this case, the direct effect is smaller than under non-unionism and possibly negative as a consequence of the initial misallocation of labour. In particular, the larger the initial misallocation, i.e. the smaller $\overline{\sigma}$, the smaller the direct effect on welfare. We now turn to the indirect effect.

[42] For a discussion see Chapter 3, section 3.5.2.

Indirect effect

The indirect effect is given by all terms containing the change in firm efficiency ($\bar{\sigma}_{\lambda}^{SU}$) and is proper of unionism as under non-unionism firms are perfectly efficient for any λ. It is made up of the same three different components that were discussed in sections 4.3.2 and 4.3.3, i.e. the allocation, demand, and supply effects. This is not surprising as in sections 4.3.2 and 4.3.3 the impact of $\bar{\phi}$ on the equilibrium was at issue, while here we analyse the impact of a change in firm efficiency, i.e. of a change in $\bar{\phi}^{t}$. However, since firm efficiency is negatively correlated to $\bar{\phi}$, the signs of the single effects are reversed. So, while $\bar{\phi}$'s demand and supply effects are positive, those of $\bar{\sigma}_{\lambda}^{SU}$ are negative; while the allocation effect of $\bar{\phi}$ is negative, that of $\bar{\sigma}_{\lambda}^{SU}$ is positive. Specifically, the allocation, demand, and supply effects of an improvement in firm efficiency ($\bar{\sigma}_{\lambda}^{SU} > 0$) can be described as follows:

the allocation effect is positive for aggregate and sectoral employment and for consumption and is expressed by the term $\frac{1}{\alpha'' + \beta\bar{\sigma}}$ in (4.17') to (4.20') and in (4.22); the allocation effect is decreasing in $\bar{\sigma}$ [43];

the demand effect impacts negatively on total employment, monopolistic sector employment, and consumption and corresponds to the last term in equations (4.17'), (4.19'), (4.20'), and (4.22);

the supply effect is negative for aggregate and sectoral employment and for consumption and is reflected by the γ in the squared brackets in (4.17') to (4.20') and in (4.22). The absolute value of the supply effect is increasing in γ.

It is easy to see that the allocation effect is never large enough to compensate for the demand effect for monopolistic sector employment (equation (4.22)). In other words, an improvement in firm efficiency has always a negative impact on $\bar{n}$.

[43] This means that the higher is the level of initial firm inefficiency, the larger is the positive impact of an improvement in firm efficiency on employment and output. In other words, there are decreasing marginal gains from a rise in firm efficiency.

Concerning total employment (equation (4.17')), an improvement in firm efficiency has in general a negative impact on it. The only case in which aggregate employment is unaffected by $\bar{\sigma}_{\lambda}^{SU}$ is when γ=0. This is consistent with the fact that, if labour supply is completely rigid, $\bar{L}$ is always equal to 1.

The overall effect of the improvement in efficiency/allocation of labour[44] on capital and consumption too (equations (4.18') and (4.19')) depends on γ. In fact, the larger is the elasticity of labour supply, the more likely it is that the indirect effect of competition is negative for capital and output. In particular, we have

(4.23) $\gamma < \dfrac{s}{\alpha'' + \beta\bar{\sigma}} - 1 \quad \Rightarrow$ ind. eff. positive for C and k

$\dfrac{s}{\alpha'' + \beta\bar{\sigma}} - 1 < \gamma < \dfrac{1}{\alpha'' + \beta\bar{\sigma}} \quad \Rightarrow$ ind. eff. negative for C and positive for k

$\gamma > \dfrac{1}{\alpha'' + \beta\bar{\sigma}} \quad \Rightarrow$ ind. eff. negative for C and k

where ‘ind. eff.’ stands for ‘indirect effect’.

Notably, the indirect effect is never positive for output and negative for capital. The reason is that no demand effect is present in the capital sector, while supply and allocation effects are the same for both variables.

The analysis of the response of welfare to an increase in firm efficiency (equation (4.20')) is a little different. The impact of the different effects related to the improvement in firm efficiency is in fact ambiguous. This is a consequence of welfare being a positive function of consumption and a negative one of labour. Thus, e.g., the allocation effect is positive for both labour and consumption, but since an increase in the former reduces welfare, we can not a priori say whether the allocation effect impacts positively or negatively on welfare. A similar reasoning holds for the demand and supply effects. Anyway, if the initial misallocation is not too large relative to the level of competition, the

[44] An improvement in firm efficiency corresponds to a better overall allocation of labour in the economy.

sign of the different effects of $\overline{\sigma}_{\lambda}^{SU}$ will be the same for welfare as for all other variables. By not too large, we mean that *z*, which is an increasing function of $\overline{\phi}^{t}$, must be smaller than s/λ and $\overline{\sigma}$ must be larger than λ.

The overall impact of competition

The simultaneous presence of direct and indirect effects of various signs does not allow to determine whether the different variables are in general raised or decreased by competition. The ambiguity of the impact of competition stems from the fact that an increase in competition leading to x-efficiency entails two opposite effects. On the one hand, more competition means better labour allocation and lower prices and therefore higher production and employment. On the other hand, more competition means more firm efficiency, which means less demand for labour in the monopolistic sector with a negative spillover effect on the capital sector via the elasticity of labour supply. Depending on which effect is larger output and (total and sectoral) employment will either increase or decrease, with an ambiguous effect on welfare.

Despite the indeterminacy of the overall effect of competition, a few points can still be made.

Firstly, the relative increase in total and monopolistic sector employment is in general larger under non-unionism than under unionism. This follows from the indirect effect of competition being generally negative for these two variables. Formally

$$\frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}} > 0 \qquad \Rightarrow \qquad \frac{\overline{n}_{\lambda}^{i}}{\overline{n}} < \frac{\hat{n}_{\lambda}}{\hat{n}} \quad \text{and} \quad \frac{\overline{L}_{\lambda}^{i}}{\overline{L}} \leq \frac{\hat{L}_{\lambda}}{\hat{L}} \qquad\qquad i=WU,\, SU$$

where the equality sign in the last inequality refers to the case $\gamma=0$.

Secondly, if the increase in firm efficiency is sufficiently large and labour supply is rigid, output and welfare rise with competition while aggregate and monopolistic sector employment fall.

A sufficiently large increase in firm efficiency is needed for employment to be negatively affected by competition. In particular, provided that $\gamma>0$[45], aggregate employment is lowered by competition when the following condition is met

$$(4.24) \qquad \frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}} > \frac{\alpha''+\beta\overline{\sigma}}{\lambda\alpha''(1-\beta+\beta\overline{\sigma})} \equiv y_{\overline{L}} \qquad \Leftrightarrow \qquad \overline{L}_{\lambda}^{i} < 0 \qquad i=WU, SU$$

Similarly, monopolistic sector employment decreases with competition when the following condition is satisfied

$$(4.25) \qquad \frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}} > \frac{1}{\lambda(1-\beta)} \equiv y_{\overline{n}} \qquad \Rightarrow \qquad \overline{n}_{\lambda}^{i} < 0 \qquad i=WU, SU$$

The difference between (4.24) and (4.25) is that the former is a sufficient and necessary condition, while the latter is sufficient but not necessary. That is, if $\frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}} < y_{\overline{L}}$, competition raises aggregate employment, while if $\frac{\overline{\sigma}_{\lambda}^{SU}}{\overline{\sigma}} < y_{\overline{n}}$ monopolistic sector employment may still be decreasing in competition[46].

A second remark about (4.24) and (4.25) is that the former implies the latter. In fact, $y_{\overline{L}} \geq y_{\overline{n}}$. Thus, if aggregate employment is lowered by competition, so is monopolistic sector employment. While if the latter falls with competition, total employment may still be raised by it.

A rigid labour supply is, instead, a sufficient (though not necessary) condition for capital and output to be increasing in competition. In fact, when γ is small, the indirect effect of competition is positive (see (4.23)). Given that its direct effect is never negative (see (4.13) and (4.14)), we can conclude that, when labour supply is rigid, competition raises capital and output.

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[45] When $\gamma=0$ total employment is constantly equal to 1, whatever the degree of competition.
[46] Whether it is or not depends on the elasticity of labour supply. If γ is large, competition raises monopolistic sector employment, while if it is small $\overline{n}$ is still a negative function of λ.

So, if the improvement in firm efficiency is large enough to satisfy (4.24) and γ is small enough to satisfy (4.23), competition raises capital and output and lowers aggregate and monopolistic sector employment. In this case, welfare is positively affected by competition. In fact, welfare corresponds roughly to the difference between consumption and total employment; and the former increases in λ, while the latter falls. Thus, the model links jobless rises in output to increases in competition without having to resort to technological progress.

The intuition behind this result is as follows. When γ is small, aggregate employment is scarcely sensitive to changes in demand for labour. Hence, the improvement in firm efficiency, which is a consequence of a reduction in labour demand coming from the monopolistic firms, has only a limited negative impact on total employment. In fact, its effect boils down mainly to a reallocation of labour from the monopolistic sector to the capital sector, which implies a better allocation of labour and, hence, higher output and higher welfare.

Before giving a numerical example of all three settings (non-unionism, weak and strong unionism) we summarise the main results of the last two sections in the following proposition.

PROPOSITION 4.2 *In a general equilibrium setting, the impact of an increase in competition can be different depending on whether firms can freely adjust labour. In particular*

(a) total and sectoral employment, consumption, and welfare increase under non-unionism (unless γ=0 *in which case they are all constant), while they can either increase or decrease (or stay constant) under unionism (in particular, competition may lower aggregate and monopolistic sector employment and raise output and welfare);*

(b) under non-unionism firm efficiency is unaffected by competition; by contrast, firm efficiency is increasing in λ *(x-efficiency) under weak unionism for every value of* λ *and it is increasing under strong unionism for at least some values of* λ*;*

(c) the change in firm efficiency is never smaller under weak unionism than under strong unionism;

(d) if firm efficiency increases in λ, the relative impact of competition on monopolistic sector employment is larger under non-unionism than under unionism;

(e) if firm efficiency increases in λ, the relative impact of competition on total employment is larger under non-unionism than under unionism unless γ=0, in which case total employment is always equal to 1.

Proof: *(a)* follows from (2.1), (4.13) to (4.15), (4.22) and from (4.17) to (4.20); *(b)* stems from (4.16), (4.21), (4.21'), and Assumption 4; *(c)* is derived from (2.1) and (4.21); *(d)* is obtained from (2.1) and (4.22); *(e)* follows from (2.1), (4.17), and (4.17').◎

The results summarised in Proposition 4.2 are similar to those obtained in the firm and industry cases (see Proposition 2.4 and Proposition 3.2). The only major difference concerns capital. Under unionism, capital is always increasing with competition in the industry case, while it may be decreasing in general equilibrium as well as in the firm case[47].

4.5 A numerical example

As in the previous chapter, we provide now a numerical example. The parameters' values are the same as in the industry case. So, we still assume that the new level of α is equal to 0.3 while the productivity parameter of capital, β, is equal to 0.5. Income is now endogenous. Further, we maintain the same kind of utility and probability functions. Thus, union *j*'s utility function is

$$U(\phi_j) = \phi_j - 1 \qquad \forall j \in [0,1]$$

and Ψ is given by

[47] Note, however, that capital is increasing with competition in general equilibrium too for a wide range of parameter values.

$$\Psi = Exp\left[-\delta\left(\phi_j - \phi_{-j}\right)\right] \qquad \forall j \in [0,1]$$

if $Exp\left[-\delta\left(\phi_j - \phi_{-j}\right)\right] \leq 1/\varepsilon$ and is equal to $1/\varepsilon$ otherwise. ϕ_j and ϕ_{-j} are both constrained to be larger than (or equal to) unity. However, we define δ in a different way with respect to the industry case[48]. In particular we set

$$\delta = \frac{\lambda}{1-\lambda}$$

which implies the following optimal ϕ

$$\bar{\phi} = \frac{1}{\lambda}$$

We consider two different labour supplies, a rigid and an elastic one, and we still distinguish between weak and strong unionism. However, the distinction between the two unionisms is limited to the elastic labour supply case as, when the labour supply is rigid, the impact of competition on the monopolistic sector employment is always negative, which implies that strong unionism and weak unionism are the same (see Chapter 2, section 2.2). Note that, since $\bar{\phi}_\lambda$<0, efficiency is increasing in λ under both weak and strong unionism.

Figures 3a and 3b depict monopolistic sector employment for different levels of product market competition when the labour supply is rigid (3a) and elastic (3b). As expected (see section 4.3.3) under unionism employment in the monopolistic sector is always larger than under non-unionism. This is a consequence of $\bar{\phi}$'s allocation effect being smaller than its demand and supply effects. However, under unionism, the impact of competition varies according to the elasticity of labour supply. When labour supply is rigid employment in the monopolistic sector is monotonic decreasing in competition while it is monotonic increasing when labour supply is elastic. This implies that, when labour supply is rigid

[48] The reason for changing δ is mainly optical: if we had maintained the same δ used in the industry case, the difference between some variables under unionism and under non-unionism would have been too small for a proper graphical representation.

(elastic), employment in the monopolistic sector lies above (below) the λ=1 level. Moreover, Figures 3a and 3b imply that $\overline{n}_{\lambda}^{SU}$ is negative for γ=0.1 and positive for γ=5. It follows that there is no difference between strong and weak unionism when labour supply is rigid, while the two unionisms diverge when labour supply is elastic.

Figures 4a and 4b refer to capital sector employment. This is larger under unionism (non-unionism) when labour supply is elastic (rigid). So, as expected, a large γ is needed to compensate for the negative allocation effect $\overline{\phi}$ (see section 4.3.3). Put differently, when γ is small, total labour supply is pretty constant. So, since unionism leads to more employment in the monopolistic sector, it must lead to less employment in the capital sector. This needs not to be true when labour supply is elastic. In this case, the higher level of employment in the monopolistic sector is mainly the result of increased labour supply and not only of a reallocation of labour from the capital sector.

Figures 5a and 5b show total employment. This is always larger under unionism for both elasticities, as the sum of $\overline{\phi}$'s demand and supply effects is always larger than its allocation effect.

Figures 6a and 6b depict consumption/output. When γ is large (Figure 6b) output is always larger under unionism. This means that, though badly allocated, households produce more under unionism. In other words, γ is large enough to yield a $\overline{\phi}$'s supply effect that, together with the demand one, is larger than the allocation effect, whatever the level of competition. Less clear-cut is the case in which $\overline{\phi}$'s supply effect is small. In fact, when γ is small (Figure 6a), output is larger (smaller) under non-unionism for small (large) values of λ. This means that, when competition is low, the negative allocation effect offsets the positive demand and supply effects: i.e., under non-unionism there are less households employed but, since they are optimally allocated between the two sectors, output is larger. As competition increases, though, the misallocation effect becomes small enough to be compensated by the demand and supply effects. As a result, output becomes larger under unionism. Note that Figures 3a and 6a imply that, under unionism, more competition means more production and less employment in the monopolistic sector if labour supply is rigid.

Figures 7a and 7b refer to welfare. When γ is large (small) welfare is larger under unionism (non-unionism). Thus, when labour supply is elastic, the utility gain from higher consumption offsets the utility loss from larger total employment. As a result the welfare schedule under unionism lies above the non-unionism one. The opposite holds when labour supply is rigid. Part of this result could be inferred from the consumption and total employment graphs (Figures 5a and 6a). In fact, for small values of λ and rigid labour supply, households consume more and work less under non-unionism, which implies that they are better off under non-unionism than under unionism.

Figures 8a to 8e refer to weak unionism. As we said, when labour supply is rigid there is no difference between weak and strong unionism, as employment in the monopolistic sector is monotonic decreasing in λ under strong unionism. Hence, Figures 8a to 8e depict the elastic labour supply case. As in the previous chapter, we start from a given equilibrium, A, corresponding to λ=0.6, and draw the different schedules for changes in λ.

By assumption, employment in the monopolistic sector is not allowed to rise under weak unionism as long as it lies above the corresponding non-unionism level. For this reason, for $\lambda_A<\lambda<0.76$, $\tilde{n}$, which denotes employment in the monopolistic sector under weak unionism, is constantly equal to its initial value and is therefore smaller than $\bar{n}$, the corresponding level of employment under strong unionism (see Figure 8a). Capital sector employment, total employment, consumption, and welfare all increase less under weak unionism in response to a rise in competition than under strong unionism (Figures 8b to 8e). This means that $\bar{n}_{\lambda}^{i}$ in equations (4.17) to (4.20) has always a positive impact so that when $\bar{n}_{\lambda}^{SU} > \bar{n}_{\lambda}^{WU}$, capital, output, and welfare all increase more under strong than under weak unionism.

As λ increases, the weak unionism schedules converge toward the non-unionism ones, until they reach them at λ=0.76. For higher levels of competition weak unionism coincides with non-unionism as the level of employment in the monopolistic sector under non-unionism exceeds the initial one. By contrast, if we consider reductions in λ starting from λ_A, weak unionism coincides with strong unionism because under strong unionism the optimal level of employment in the monopolistic sector falls as competition decreases. And, when employment in the monopolistic sector decreases under strong unionism, there is no difference between the two unionisms. So, for $\lambda<\lambda_A$, $\tilde{n}=\bar{n}$, and, accordingly, $\tilde{k}=\bar{k}$, $\tilde{L}=\bar{L}$, $\tilde{U}=\bar{U}$, and $\tilde{C}=\bar{C}$, where the variables denoted by the superscript '˜' refer to weak unionism and those denoted by '¯' refer to strong unionism. Conversely, when $\lambda>0.76$, weak unionism coincide with non-unionism. Thus, for $\lambda>0.76$, $\tilde{n}=\hat{n}$, and, accordingly, $\tilde{k}=\hat{k}$, $\tilde{L}=\hat{L}$, $\tilde{U}=\hat{U}$, and $\tilde{C}=\hat{C}$.

Notably, nearly all variables are increasing in competition under both unionism and non-unionism and with both elastic and rigid labour supply. The only exception is given by monopolistic sector employment that is decreasing in λ when labour supply is rigid. This means that for $\bar{n}$ the positive direct effect of competition is smaller than the negative indirect one when $\gamma=0.1$.

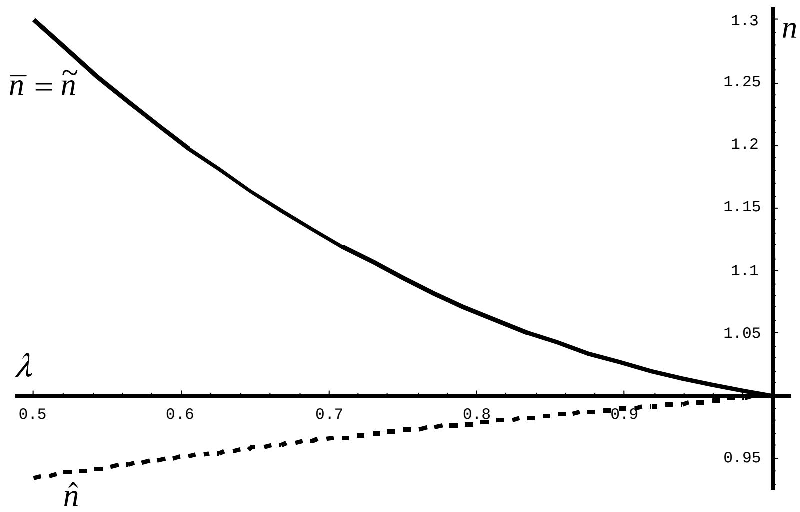
Concerning non-unionism, the sign of the impact of competition does not depend on the chosen parameter values since, as long as $\gamma>0$, competition has always a positive effect on all real variables for any parameter value. By contrast, different parameter values and/or a different probability of survival function may substantially affect the unionism outcomes. Specifically, some variables may become decreasing in competition and possibly follow a non-monotonic path.

Finally, Figures 9a and 9b show firm efficiency under strong ($\bar{\sigma}$) and weak ($\tilde{\sigma}$) unionism. As expected, both $\bar{\sigma}$ and $\tilde{\sigma}$ are increasing in competition (x-efficiency) for both $\gamma=0.1$ and $\gamma=5$. Specifically, since the change in firm efficiency does not depend on γ under strong unionism (see (4.21')), $\bar{\sigma}$ follows the same pattern in both figures. By contrast, the change in firm efficiency is a function of γ when this diverges from strong unionism (see (4.21)). So, since the two unionisms diverge only under elastic labour supply, the path of $\tilde{\sigma}$ coincides with that of $\bar{\sigma}$ when $\gamma=0.1$, while it is to a certain extent different when $\gamma=5$. In the latter case (Figure 9b), starting from the initial equilibrium A, we note that firm efficiency follows the same path under both unionisms if λ falls, while it increases more under weak unionism than under strong unionism when λ rises. Once λ has reached 0.76, firms under weak unionism become perfectly efficient as weak unionism collapses to non-unionism. The pattern of $\tilde{\sigma}$ in Figure 9b reflects that of the schedules of Figures 8a to 8e.

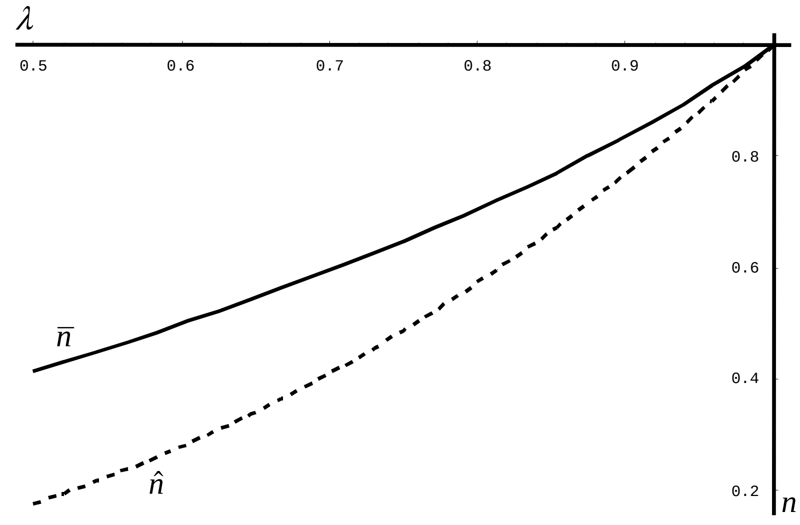
Figure 3 – Monopolistic sector employment as a function of λ with rigid (γ=0.1) and elastic (γ=5) labour supplies

(α''=0.3, β=0.5; *n* normalised to 1 for $\lambda\to$1)

3a) rigid labour supply



3b) elastic labour supply



$\bar{n}$ =monopolistic sector employment under strong unionism

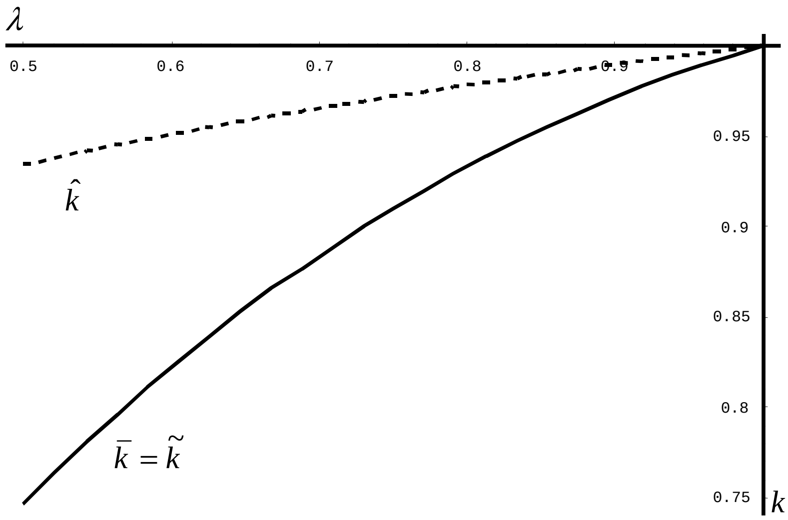
$\tilde{n}$ = monopolistic sector employment under weak unionism

$\hat{n}$ = monopolistic sector employment under non-unionism

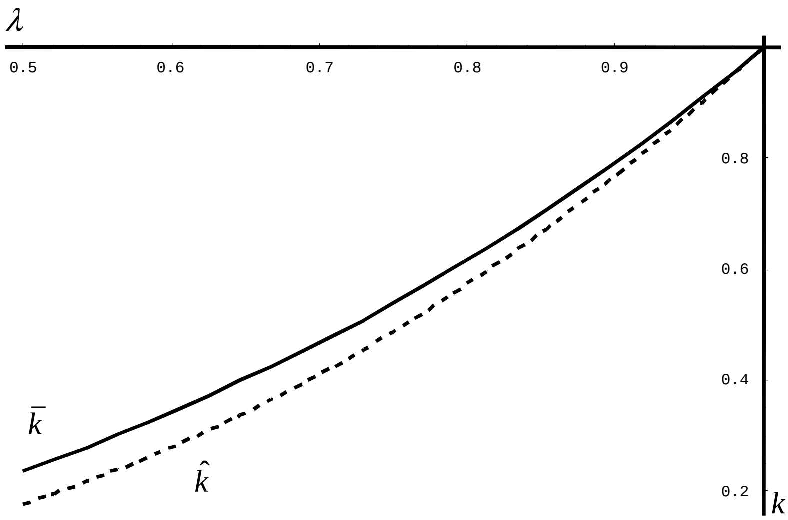
Figure 4 – Capital sector employment as a function of λ with rigid (γ=0.1) and elastic (γ=5) labour supplies

(α''=0.3, β=0.5; k normalised to 1 for $\lambda \to 1$)

4a) rigid labour supply



4b) elastic labour supply

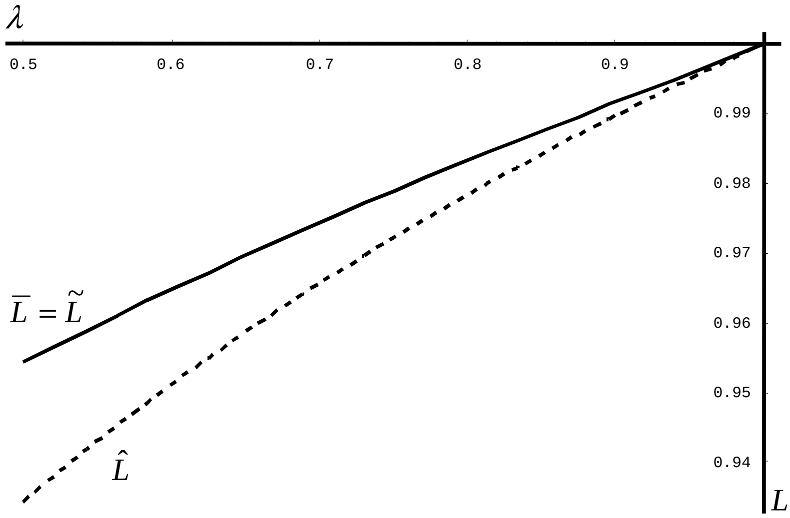


$\bar{k}$ = capital under strong unionism; $\tilde{k}$ = capital under weak unionism; $\hat{k}$ = capital under non-unionism

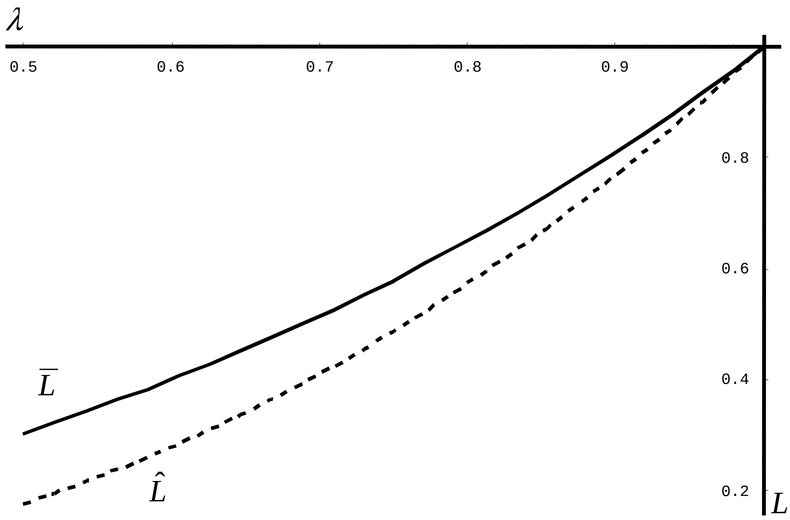
Figure 5 – Total employment as a function of λ with rigid (γ=0.1) and elastic (γ=5) labour supplies

(α''=0.3, β=0.5; L normalised to 1 for $\lambda \to 1$)

5a) rigid labour supply



5b) elastic labour supply

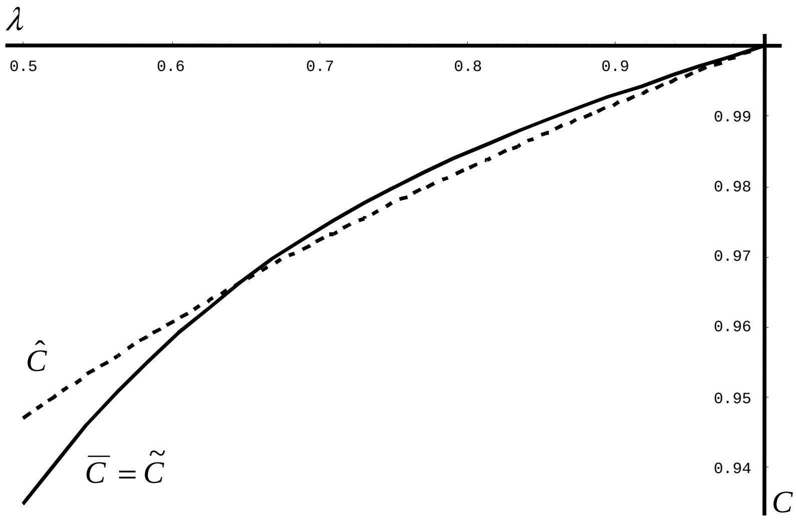


$\overline{L}$ = total employment under strong unionism; $\tilde{L}$ = total employment under weak unionism; $\hat{L}$ = total employment under non-unionism

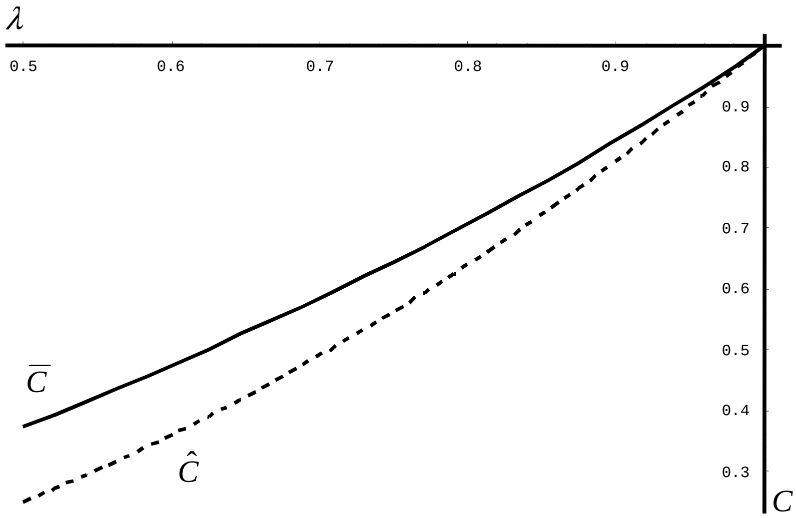
Figure 6 – Consumption as a function of λ with rigid (γ=0.1) and elastic (γ=5) labour supplies

(α''=0.3, β=0.5; C normalised to 1 for $\lambda \to 1$)

6a) rigid labour supply



6b) elastic labour supply

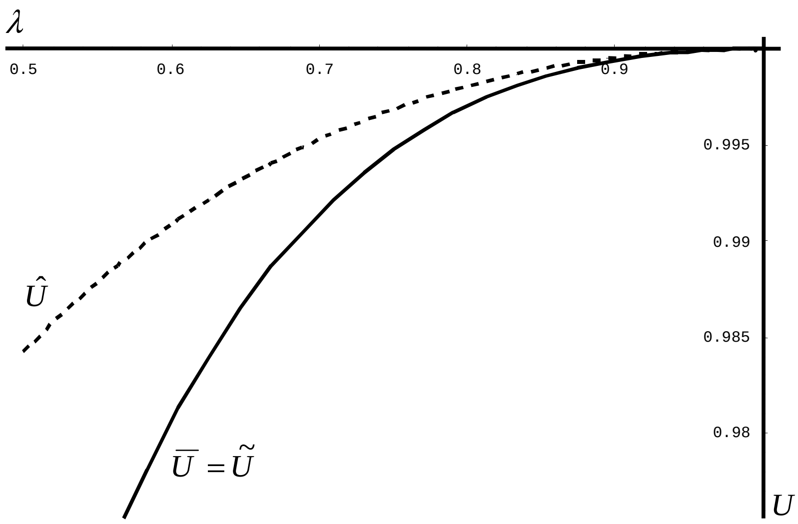


$\overline{C}$ = consumption under strong unionism; $\tilde{C}$ = consumption under weak unionism; $\hat{C}$ = consumption under non-unionism

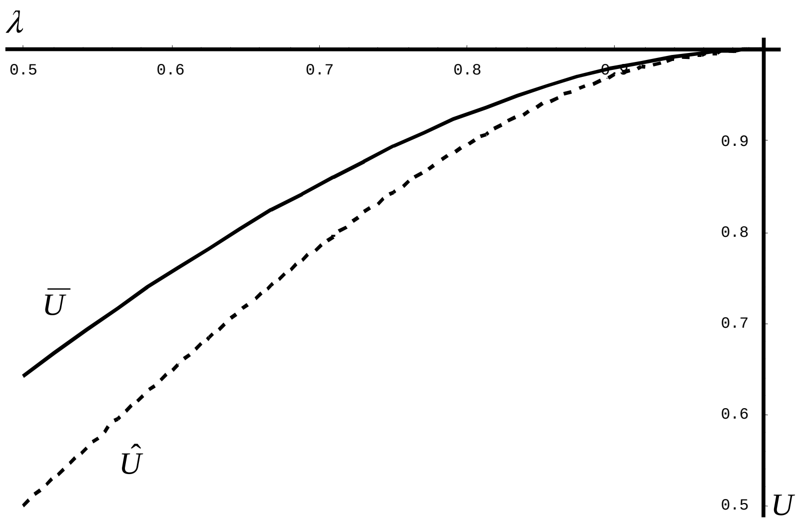
Figure 7 – Welfare as a function of λ with rigid (γ=0.1) and elastic (γ=5) labour supplies

(α''=0.3, β=0.5; U normalised to 1 for $\lambda \to 1$)

7a) rigid labour supply



7b) elastic labour supply

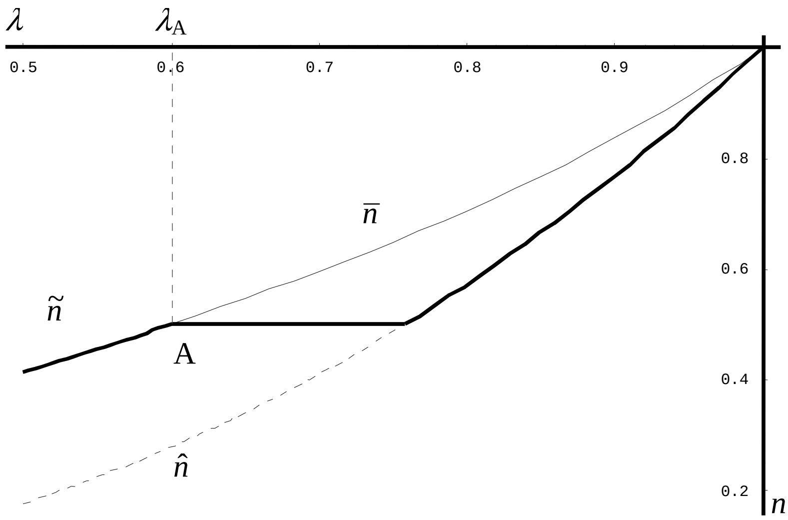


$\overline{U}$ = welfare under strong unionism; $\tilde{U}$ = welfare under weak unionism;
$\hat{U}$ = welfare under non-unionism

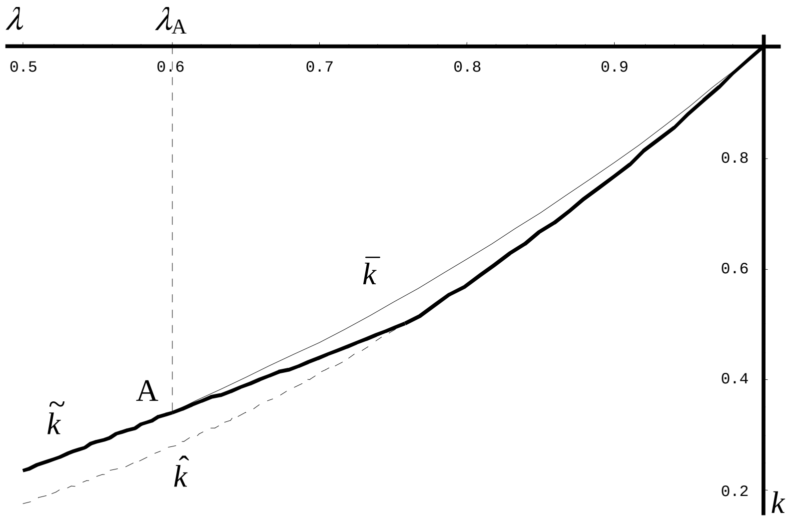
Figure 8 - Employment, consumption, and welfare as a function of λ when the labour supply is elastic (γ=5): weak unionism

(α''=0.3, β=0.5; *n*, *k*, *L*, *C*, and *U* normalised to 1 for $\lambda \rightarrow 1$)

8a) monopolistic sector employment

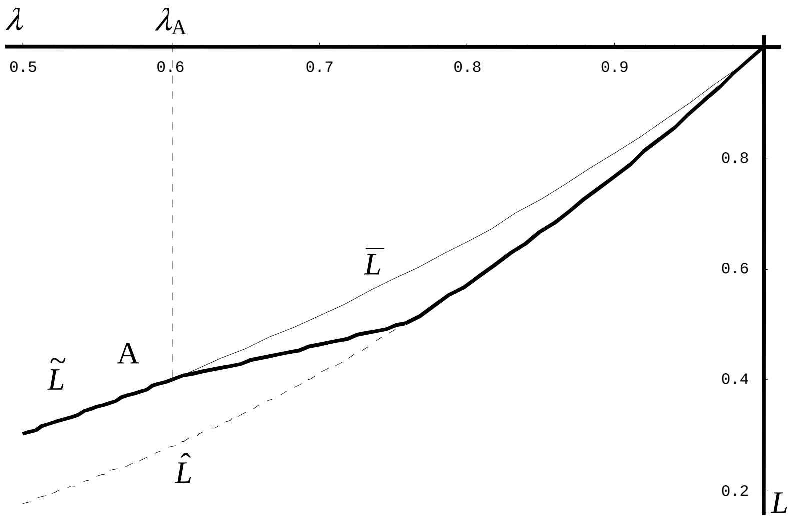


8b) capital sector employment

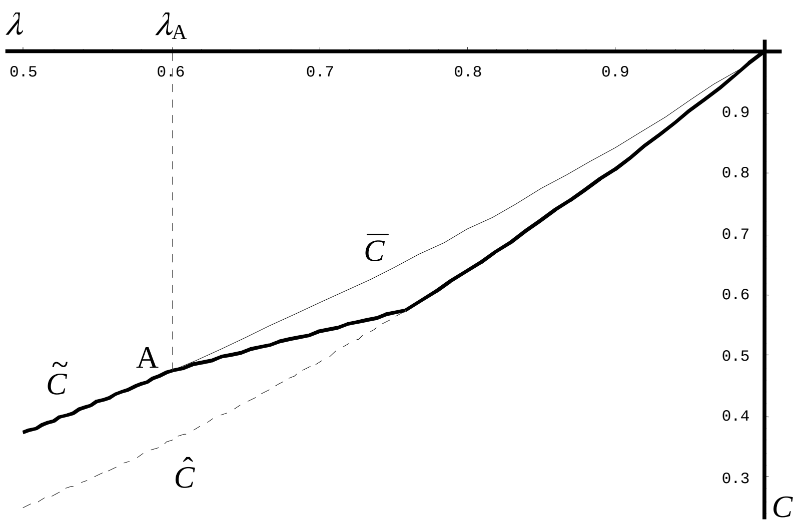


$\bar{n}$, $\tilde{n}$, and $\hat{n}$ as in Figure 3; $\bar{k}$, $\tilde{k}$, and $\hat{k}$ as in Figure 4

8c) total employment

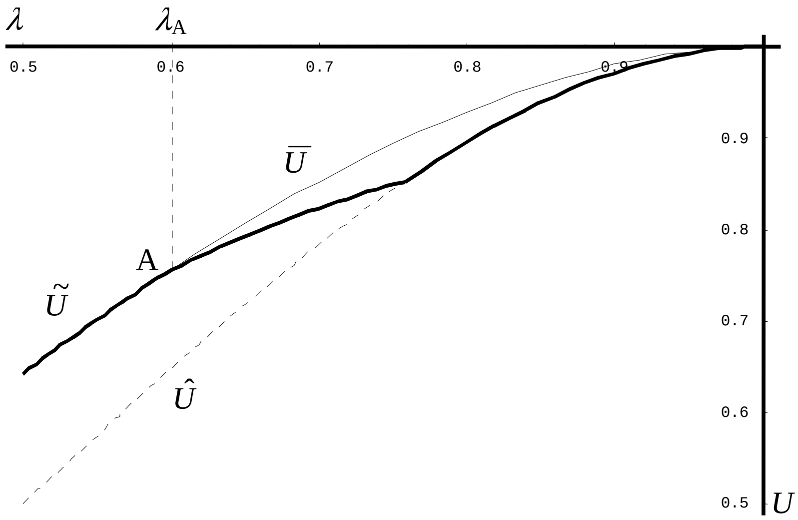


8d) consumption



$\bar{L}$, $\tilde{L}$, and $\hat{L}$ as in Figure 5; $\bar{C}$, $\tilde{C}$, and $\hat{C}$ as in Figure 6

8e) welfare

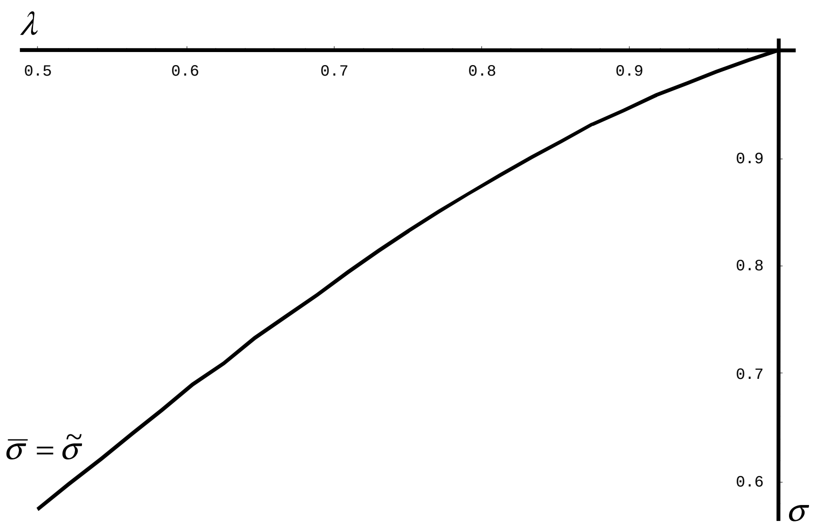


$\overline{U}$, $\tilde{U}$, and $\hat{U}$ as in Figure 7

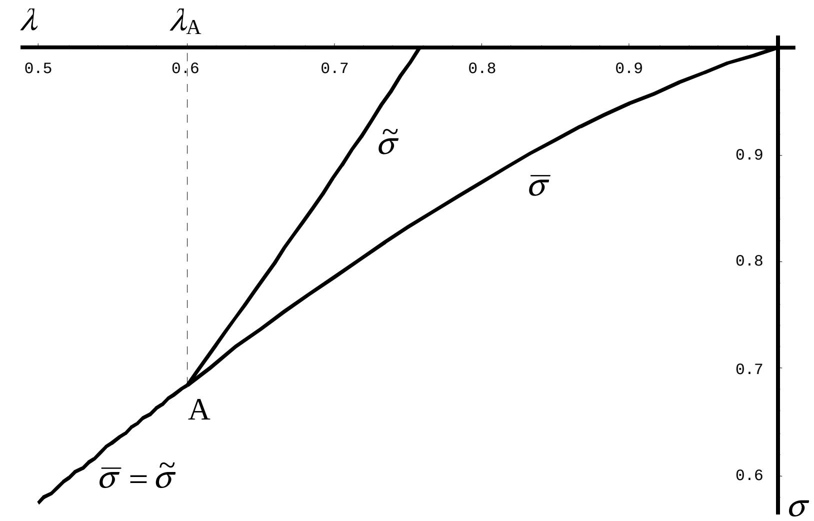
Figure 9 – Firm efficiency as a function of λ with rigid (γ=0.1) and elastic (γ=5) labour supplies

(α''=0.3, β=0.5)

9a) rigid labour supply



9b) elastic labour supply



$\bar{\sigma}$ =firm efficiency under strong unionism; $\tilde{\sigma}$ =firm efficiency under weak unionism

4.6 Firm, industry, and general equilibrium case: a comparison

We now compare the conclusions we drew for each of the three cases we have examined so far, that is the firm, the industry, and the general equilibrium case[49]. As far as the equilibrium is concerned, the following remarks can be made:

(a) in all cases employment (total and monopolistic sector employment for the general equilibrium case) is larger under unionism;

(b) in the firm case, capital is larger under unionism; in the industry case, it is equal under unionism and non-unionism; in general equilibrium, it is larger under unionism (non-unionism) when the elasticity of labour supply is large (small);

(c) output is larger under unionism than under non-unionism in the firm and industry cases; in general equilibrium, it is larger under unionism (non-unionism) when the elasticity of labour supply is large (small);

(d) in all cases, firms are perfectly efficient under non-unionism and inefficient under unionism; the level of firm inefficiency under unionism is the same in all three cases.

The above remarks hold only as long as unionism delivers a different equilibrium from non-unionism, i.e. when $\bar{\phi} > 1$. Remark (a) holds for total employment only if $\gamma > 0$.

As to the impact of competition on the equilibrium, we have:

(e) in all cases the relative change in employment (total and monopolistic sector employment for the general equilibrium case) is larger under non-unionism than under unionism;

(f) in the firm case, the change in capital under strong unionism is never smaller than under weak unionism, while it might be larger or smaller than under non-unionism; in the industry case, the relative and absolute change in capital is the same for non-unionism, weak and strong unionism; in general equilibrium, changes in capital under the different settings can not be unambiguously ordered;

[49] By firm case we mean, as usual, the one of Chapter 2, section 2.6.

(g) under weak unionism, the impact of competition on output is never larger than under strong unionism in the firm and industry cases; in the industry case, the relative impact of competition on output is larger under non-unionism than under unionism, while in the firm case it might be larger under unionism; in general equilibrium, changes in output under the different settings can not be unambiguously ordered;

(h) in all cases, under weak unionism the impact of competition on firm efficiency is always positive and never smaller than under strong unionism; moreover, under the latter, the change in firm efficiency is always the same and positive for at least some values of λ; under non-unionism firm efficiency is independent of the level of competition.

Remarks (e), (f), and (g) refer to the x-efficiency case, i.e. to $\overline{\sigma}_{\lambda}^{SU} > 0$. Remark (e) holds for total employment only if $\gamma>0$. Most of the above observations are summarised in Table 1.

TABLE 1

EQUILIBRIUM

($\bar{\phi} > 1$)

	Firm	Industry	General Equilibrium
Employment	SU = WU > NU	SU = WU > NU	SU = WU > NU*
Capital	SU = WU > NU	SU = WU = NU	SU = WU ? NU
Output	SU = WU > NU	SU = WU > NU	SU = WU ? NU
Welfare	-	-	SU = WU ? NU
Firm efficiency	NU=1> $\bar{\phi}^{-t}$ = SU = WU		

IMPACT OF COMPETITION

($\bar{\sigma}_{\lambda}^{SU} > 0$)

	Firm	Industry	General Equilibrium
Employment	NU > SU ≥ WU	NU > SU ≥ WU	NU > SU ≥ WU**
Capital	NU ? SU ≥ WU	NU = SU = WU	NU ? SU ? WU
Output	NU ? SU ≥ WU	NU > SU ≥ WU	NU ? SU ? WU
Welfare	-	-	NU ? SU ? WU
Firm efficiency	WU ≥ SU > NU = 0		

NOTE –NU = non-unionism; WU = weak unionism; SU = strong unionism; Employment = total as well as monopolistic sector employment in general equilibrium; 'NU > SU' always refers to relative changes; impact of competition on firm efficiency is always the same for strong unionism and always positive under weak unionism whatever the sign of $\bar{\sigma}_{\lambda}^{SU}$; *NU=SU=WU=1 for total employment when γ=0; **NU=SU=WU=0 for total employment when γ=0.

4.7 Conclusion

In this last chapter before the final remarks, a last extension of the approach introduced in Chapter 2 has been undertaken. In particular, the general equilibrium implications of unionism and non-unionism have been analysed. The main result of the previous chapters, i.e. the x-efficiency one, has been confirmed. Like in the firm and industry cases, employment in the monopolistic firms is larger under unionism. This result extends to aggregate employment, which equally turns out to be generally larger under unionism.

The main divergence between the results of the previous chapters and those of the present one concerns output: this may be larger (as in the firm and industry cases) or smaller under unionism. In this respect the crucial parameter is the elasticity of labour supply: if it is large, output is larger under unionism; if it is small, output is larger under non-unionism. The same applies to capital.

Moreover, the general equilibrium framework has allowed us to assess the welfare implications of unionism and non-unionism. Since welfare corresponds roughly to the difference between consumption and employment, it is smaller under unionism when γ is small. And a small γ is what all empirical studies suggest.

Concerning the impact of competition, this is as usual unambiguous under non-unionism: sectoral and aggregate employment, consumption, and welfare all increase in competition. Under unionism, we register the same ambiguity encountered in the previous chapters: all variables may increase as well as decrease with product market competition.

As far as firm efficiency is concerned, this is certainly increasing in competition under weak unionism and at least for some λ's under strong unionism. We can therefore conclude that, whatever level of aggregation (firm, industry, whole economy) we choose, the x-efficiency result retains its validity all through the analysis.

CONCLUSIONS

In this work we presented a new approach to x-efficiency and applied it at different levels of aggregation. The approach is based on the idea that firms face constraints when taking decisions about input amounts. That is, the management can not costlessly adjust inputs in response to changes in external conditions. The consequence is that the actual input combination is suboptimal and firms show unit costs of production that are higher than those that the available technology and current factor prices would allow to obtain.

In our model there are two inputs, capital and labour, and only the latter can not be frictionless adjusted by the management. That is, the management can increase or lower capital without incurring any cost, but it can not do the same with labour. This is not freely adjustable because firm workers are organised in a firm union that, to various degrees, has the power to set the level of employment within the firm. The outcome is that the size of the workforce diverges from the one consistent with profit maximisation. In particular, since the union is supposed to prefer more to less employment, the level of employment within the firm lies above the one desired by the management.

Once the union has set employment, the management chooses capital stock. In doing that, it must decide between either minimising unit costs of production or maximising profit. These two objectives are usually not conflicting with each other. Quite to the contrary, profit maximisation normally implies cost minimisation (but not vice-versa). However, this does not hold when one input, in our case labour, is set at a level higher then the profit maximising one. In this case, setting capital so that unit costs of production are minimised, is not profit maximising. In particular, output would be too large. Since the objective of a firm is profit maximisation and not cost minimisation (the latter is just a by-product of the former under normal conditions), the management chooses capital to maximise profit and disregards cost minimisation. The result is that for the level of output produced, the firm is employing too little capital and too much labour. In other words, increasing capital and reducing labour so as to keep total output unchanged would decrease total (and unit) costs of production. This result is a general one as it applies always when there are constant or decreasing returns to scale and constant or decreasing marginal revenue. So, all we need to obtain firm inefficiency, i.e. unit costs of production higher than those that current prices and the available technology would allow to attain, are frictions in the firm's ability to adjust one or more inputs.

In this context, an increase in competition may have a positive or negative impact on firm efficiency depending on the type of assumptions we make about revenue and cost functions.

By analysing a single firm, we showed that, if marginal revenue is increasing in competition and the union can only prevent job cuts but not force the management to hire new workers, an increase in competition always raises firm efficiency (x-efficiency).

The reason is that an increase in competition raises the profit maximising output level and induces therefore the management to expand capital. As a consequence, the capital to labour ratio, that was too small from a cost minimising point of view, increases, getting thereby closer to its cost minimising value.

In the context of Cobb-Douglas production functions and CES utility functions and independently of the level of aggregation (firm, industry, whole economy), x-efficiency always arises when employment is not allowed to increase.

Provided that certain conditions are met, this result extends to the case in which the unions can force the management to expand employment. These conditions require assuming that an increase in competition reduces the survival probability of relative inefficient firms (market selection hypothesis). If the reduction in the probability of survival associated with a rise in competition gets larger as the firm becomes more inefficient, then x-efficiency arises at any level of competition even if the unions have the unconstrained right to set employment.

The intuition behind this result is simple. An increase in competition reduces the probability of survival of an inefficient firm and induces thereby the unions to be more ‘conservative’. That is, unions respond to an increase in competition by giving up employment: the reward for acting like that is higher firm efficiency and, hence, a higher probability of survival.

Whatever assumption we make about how unions set employment, there would be anyway some level of competition at which x-efficiency arises. To see this consider that firm inefficiency is caused by unions sharing monopolistic rent in terms of employment. As the market in which the firm operates becomes more competitive, the rent diminishes until it disappears under perfect competition. This means that under perfect competition the firm must be perfectly efficient, as there is no rent to capture. So, as long as the firm is inefficient under imperfect competition, there must be some levels of competition at which firm efficiency rises so that the firm reaches perfect efficiency under perfect competition.

Although our main focus was on firm efficiency, we discussed also the consequences for employment, output, and welfare of allowing unions to determine firm labour demand.

We found that, whatever the level of aggregation, employment in the unionised firm(s) lies above the non-unionism level, i.e. above the level that is attained when firm labour demand is set by the management. In general equilibrium, this result extends to aggregate employment as long as labour supply is not completely rigid. If this is the case, then total employment is equal to unity for every degree of product market competition and independently of the presence of the unions.

Unions have a positive impact on employment because they do not bargain over wages. These, in fact, are assumed to adjust until the labour market is cleared. So, what the unions do is simply to increase demand for labour for any given level of real wage. This, in an otherwise perfectly competitive labour market, leads naturally to higher equilibrium employment (unless labour supply is completely rigid).

However, larger employment does not necessarily imply larger output. In particular, if labour supply is rigid, larger employment in the unionised sector is mainly obtained at the cost of lower employment in the capital sector and only marginally through an increase in aggregate employment. As a consequence, under unionism output may actually lie below the non-unionism level. The reason is that, under non-unionism, labour is perfectly allocated across sectors so that the economy is producing the maximum amount of output for the given level of aggregate employment. By contrast, under unionism, labour is to a certain degree misallocated across sectors. It follows that total output is not as high as it could be. Since the difference in total employment between non-unionism and unionism is small when labour supply is rigid, the better allocation of labour under the former offsets the slight difference in aggregate employment causing output to be larger under non-unionism than under unionism. Conversely, if labour supply is elastic, total employment will be much larger under unionism and output will lie above its non-unionism level, as the difference in aggregate employment will be big enough to compensate for its bad allocation.

The possibility of a smaller output under unionism is confined to the general equilibrium case. In fact, when we discussed the firm or the industry case, we found that output was invariably higher under unionism. The reason was that factor prices were exogenous and fixed. Thus, somehow, we were assuming infinitely elastic factor supplies so that the increase in demand for labour in the unionised firm(s) had no negative impact on capital. Specifically, the rise in demand for labour had no impact at all on capital in the industry case and a positive one in the firm case as the optimal demand for capital was a positive function of employment. It is therefore no surprise that the general equilibrium case delivers the same outcome as the firm and industry cases when labour supply is elastic.

Finally, welfare may be larger under either setting, unionism or non-unionism. Again the crucial parameter is the elasticity of labour supply. Is this small, then welfare is certainly larger under non-unionism; is the elasticity large, then welfare may be larger under unionism. So, in the case of welfare, we notice an asymmetry that did not emerge in the discussion on output. Specifically, a rigid labour supply leads necessarily to higher welfare and output under non-unionism, while an elastic labour supply, though it leads to higher output under unionism, does not ensure that welfare too is higher when unions set employment. This discrepancy between welfare and output is due to the fact that the former is negatively affected by labour while the latter is not. Roughly speaking, welfare corresponds to the difference between output and total employment. Since the latter is always larger under unionism, if labour supply is inelastic, welfare is higher under non-unionism because households consume more and work less. However, if labour supply is elastic, households do actually consume more under unionism. But they have to work more as well, so that we can not a priori determine whether welfare is larger under unionism or under non-unionism. Notably, all empirical studies suggest that labour supply is rigid, so that we may draw the conclusion that unionism increases employment but reduces output and welfare.

A last point concerns the impact of competition on employment, output, and welfare.

Under non-unionism there are no ambiguities: employment, consumption, and welfare all increase in competition. The reason is that competition lowers the mark-up of prices over wages; as a consequence real wages increase and labour supply expands causing employment, output, and welfare to rise.

The same mechanism is at work under unionism. In this case, though, there is the added impact of the improvement in firm efficiency, that an increase in competition brings about. This added effect makes the overall impact of competition under unionism ambiguous. In fact, an increase in firm efficiency has mostly a negative impact on the equilibrium. The reason is that the improvement in firm efficiency is obtained by reducing demand for labour in the unionised firm(s). This has only negative effects in the firm and industry cases, while it has also a positive impact in general equilibrium. In the latter case, in fact, a reduction in demand for labour of the unionised firms leads to a better allocation of labour across sectors. This positive allocation effect is not large enough to make the overall impact of an increase in firm efficiency positive for aggregate and monopolistic sector employment. However, it may be sufficiently large to ensure that output is raised by an increase in firm efficiency. Whether this is the case or not depends on the elasticity of labour supply. If labour supply is rigid, then an improvement in firm efficiency has a positive impact on output. And the overall impact of competition on output becomes unambiguously positive.

These arguments highlight one important feature of the model: output and employment may move in different directions. That is, an increase in competition that expands output does not necessarily imply higher employment. Quite to the contrary, if labour supply is rigid, the model predicts rising output and falling employment. This represents a sharp departure from the conclusions of the current models of imperfect competition. These models can not in fact yield such a result because they assume perfect firm efficiency at every level of competition. Hence, as output rises so does employment. Our model, instead, predicts that as competition increases, labour is reallocated so that it becomes more productive and, since demand for consumption goods does not increase sufficiently, employment falls.

The model can be extended in different ways.

One first obvious extension would be to assume that within each firm management and union bargain over employment. This modification would not affect any of the results. In fact, the equilibrium employment under unionism would turn out to be equal to $\kappa\overline{n} + (1-\kappa)\hat{n}$, where $\kappa \in (0,1)$ represents the bargaining power of the union, and $\hat{n}$ and $\overline{n}$ are, respectively, the management's and the union's preferred level of employment. So, employment under unionism would still be larger than $\hat{n}$. And this is a sufficient condition for all results of our analysis to retain their validity.

A slightly different case is the one in which management and union bargain not only over employment but also over wages. In this case, firms would still be inefficient under unionism. The reason is that the inefficiency stems from employment being too large for the given level of wage. How the latter is determined, by the market or through a bargaining process, is irrelevant. Thus, as long as the unions directly affect employment, firms are bound to be inefficient.

The x-efficiency result would probably hold true as well. If union and management bargain over both wage and employment, the bargained wage will be higher than under a perfectly competitive labour market and employment will be larger than it would be if profits were to be maximised at the bargained wage. So, in response to an increase in competition, we would expect the unions to give up either some wage or some employment or some of both. Whatever the union decides to do, firm efficiency will improve. If it gives up employment, we are back in our framework. If it decides to give up only wage, firm efficiency still improves. In fact, firms are inefficient because the technical rate of substitution between labour and capital lies below the corresponding price ratio. Since a ceteris paribus fall in the wage rate reduces this ratio, a lower wage is a sufficient condition for firm efficiency to increase.

The only result that would certainly be affected by allowing the unions to bargain over wages is the employment outcome. In our model, unless labour supply is completely rigid, employment is larger under unionism in the monopolistic sector as well as in the whole economy. By contrast, if unions bargain over wages as well as over employment, the latter may turn out to be larger under non-unionism. In fact, as shown by Dixon and Santoni [1995], higher union power over wages leads to lower employment, while higher union power over employment yields higher employment. Still, the impact of competition remains ambiguous, unless unions react to an increase in competition by giving up only wage. In this case, competition has certainly a positive impact on the equilibrium, since bargained wages are consistently higher than market wages.

Note that, if unions bargain only over wages and not over employment, no firm efficiency issue arises. In fact, given the bargained wage, the management would simply choose labour and capital so as to minimise costs.

Other extensions are thinkable. One may want to allow for international trade and possibly link the degree of competition in the monopolistic sector to the degree of openness of the economy. Another modification could consist in changing the input that is subject to adjustment frictions. Thus, one can take the non-unionism case, under which the management sets both labour and capital, and assume that capital is not costlessly adjustable. In this case, the costs of adjusting capital may prevent the management from adopting the optimal labour to capital ratio. Again, as competition increases, the probability of liquidation of the firm rises reducing the flow of future expected profits. As a consequence, the firm may find it profitable to incur the capital adjustment costs in order to raise the probability of survival and, hence, expected returns.

There are certainly other extensions that the reader can think of while lacking a better pastime. Such extensions may possibly lead to conclusions completely different from those of this work. We doubt it, although we can not exclude it, as, after all, it is economics.

Appendix A

In this appendix we follow the usual convention according to which, given two variables y and x, $\frac{dy}{dx}$ *denotes the total derivative of y with respect to x and* y_x *the partial derivative of y with respect to x.*

A1 Production under non-unionism and under unionism

We show that production is larger under unionism by proving that marginal cost for every given level of output $g < q\left(\bar{n}, \tilde{k}\right)$ *is higher under non-unionism.*
Let us denote by k^* *and* n^* *the solution to the firm cost minimisation problem for* $g < q\left(\bar{n}, \tilde{k}\right)$*. So*

(I) $$\frac{q_n^*}{q_k^*} \equiv \frac{q_n(n^*, k^*)}{q_k(n^*, k^*)} = \frac{w}{r}$$

(II) $$q(n^*, k^*) = g$$

Under non-unionism the cost function is therefore

$$C^{NU}(g) = wn^* + rk^*$$

and marginal cost is

$$\frac{dC^{NU}(g)}{dg} = r\frac{dk^*}{dg} + w\frac{dn^*}{dg} = \left(r + w\frac{dn^*}{dk^*}\right)\frac{dk^*}{dg} = r\left(1 + \frac{w}{r}\frac{dn^*}{dk^*}\right)\frac{dk^*}{dg} = r\left(1 + \frac{q_n^*}{q_k^*}\frac{dn^*}{dk^*}\right)\frac{dk^*}{dg}$$

where $\frac{dn^*}{dk^*}$ *is derived from total differentiation of (I) and is therefore given by*

(III) $$\frac{dn^*}{dk^*} = \frac{q_{nk}^* q_k^* - q_{kk}^* q_n^*}{q_{nk}^* q_n^* - q_{nn}^* q_k^*} > 0$$

Under unionism total cost for the same amount of output g is given by

$$C^U(g) = w\bar{n} + rk^U(\bar{n}, g)$$

where $k^U(\bar{n}, g)$ *is implicitly given by* $q(\bar{n}, k^U) = g$ *. Since* $g < q(\bar{n}, \tilde{k})$, $k^U < \tilde{k}$ *.*
Marginal cost in this case is

$$\frac{dC^U(g)}{dg} = r\frac{dk^U}{dg} = \frac{r}{q_k(\bar{n}, k^U)}$$

Using (I) and (II) we can write

$$\frac{dg}{dk^*} = q_k^* + q_n^* \frac{dn^*}{dk^*} > 0$$

So that

$$\frac{dC^{NU}(g)}{dg} > \frac{dC^U(g)}{dg} \quad \Leftrightarrow \quad \left(\frac{q_k(\bar{n}, k^U)}{q_k(n^*, k^*)} - 1\right)\frac{dg}{dk^*} > 0 \quad \Leftrightarrow \quad q_k(\bar{n}, k^U) > q_k(n^*, k^*)$$

The last condition $q_k(\bar{n}, k^U) > q_k(n^*, k^*)$ *is always met. To see this consider that* $q(\bar{n}, k^U) = q(n^*, k^*)$*. This implies either (a)* $k^* \leq k^U < \tilde{k}$ *and* $n^* \geq \bar{n}$ *or (b)* $k^* > k^U$ *and* $n^* < \bar{n}$*. (a) is not possible. In fact,* $\frac{dn^*}{dk^*} > 0$ *and, by the very definition of* $\tilde{k}$ *(see p. 38)**, if* $k^* = \tilde{k}$, $n^* = \bar{n}$*. So, if* $n^* \geq \bar{n}$*, then* $k^* \geq \tilde{k}$*, which contradicts* $k^* \leq k^U < \tilde{k}$*. So (b) must be true. Since* $q_{kk} < 0$ *and* $q_{kn} \geq 0$*, it is straightforward that* $q_k(\bar{n}, k^U) > q_k(n^*, k^*)$*. Hence, the marginal cost schedule under non-unionism lies above the one under unionism for all* $g < q(\bar{n}, \tilde{k})$*. And, hence, also for* $\bar{x} = q(\bar{n}, \bar{k})$*. Since, by assumption, marginal cost is not decreasing in output under both unionism and non-unionism and marginal revenue is either constant or decreasing, it follows that* $\hat{x} < \bar{x}$ *.*

<u>A2 The impact of competition on employment and capital stock under non-unionism</u>

To obtain the derivative of $\hat{n}$ *with respect to* λ*, we use the profit maximisation condition (2.3), which is*

$$R_q\left[q(\hat{n}, \hat{k}), \lambda\right] - C_q\left[q(\hat{n}, \hat{k})\right] = R_q[\hat{q}, \lambda] - C_q[\hat{q}] = \hat{R}_q - \hat{C}_q = 0$$

$\hat{n}$ *and* $\hat{k}$ *also satisfy cost minimisation. So*

(IV) $$\frac{\hat{q}_n}{\hat{q}_k} \equiv \frac{q_n(\hat{n},\hat{k})}{q_k(\hat{n},\hat{k})} = \frac{w}{r}$$

Total differentiation of (IV) yields

$$\frac{d\hat{k}}{d\hat{n}} = \frac{\hat{q}_{nk}\hat{q}_n - \hat{q}_{nn}\hat{q}_k}{\hat{q}_{nk}\hat{q}_k - \hat{q}_{kk}\hat{q}_n}$$

Total differentiation of the profit maximisation condition gives

$$\hat{R}_{q\lambda}d\lambda + \left(\hat{R}_{qq}\hat{q}_n - \hat{C}_{qq}\hat{q}_n + \hat{R}_{qq}\hat{q}_k\frac{d\hat{k}}{d\hat{n}} - \hat{C}_{qq}\hat{q}_k\frac{d\hat{k}}{d\hat{n}}\right)d\hat{n} = 0$$

$$\frac{d\hat{n}}{d\lambda} = \frac{\hat{R}_{q\lambda}}{\left(\hat{C}_{qq} - \hat{R}_{qq}\right)\left(\hat{q}_n + \hat{q}_k\frac{d\hat{k}}{d\hat{n}}\right)}$$

which is equal to (2.6) (in (2.6) $\hat{n}_\lambda$ denotes a total derivative (see p. 37)). The same procedure can be used to derive (2.7).

<u>*A3 The impact of competition on employment and capital stock under unionism*</u>

Derivation of (2.9) is straightforward

$$\bar{n} = \phi\hat{n} \qquad \Rightarrow \qquad \frac{d\bar{n}^{SU}}{d\lambda} = \frac{d\hat{n}}{d\lambda}\phi + \hat{n}\phi_\lambda = \frac{\hat{R}_{q\lambda}}{\left(\hat{C}_{qq} - \hat{R}_{qq}\right)\left(\hat{q}_n + \hat{q}_k\frac{d\hat{k}}{d\hat{n}}\right)}\phi + \hat{n}\phi_\lambda$$

which is equal to (2.9) (in (2.9) $\bar{n}_\lambda^{SU}$ denotes a total derivative).

(2.10) can be obtained from total differentiation of (2.5). The latter is equal to

$$R_q\left(q(\bar{n},\bar{k}),\lambda\right) - \frac{r}{q_k(\bar{n},\bar{k})} = R_q\left(\bar{q},\lambda\right) - \frac{r}{\bar{q}_k} = \bar{R}_q - \frac{r}{\bar{q}_k} = 0$$

and total differentiation yields

$$\left[\bar{R}_{q\lambda} + \bar{R}_{qq}\bar{q}_n\frac{d\bar{n}^i}{d\lambda} + r\frac{\bar{q}_{kn}}{\bar{q}_k^2}\frac{d\bar{n}^i}{d\lambda}\right]d\lambda + \left[\bar{R}_{qq}\bar{q}_k + r\frac{\bar{q}_{kk}}{\bar{q}_k^2}\right]d\bar{k}^i = 0$$

(V) $$\frac{d\bar{k}^i}{d\lambda} = -\frac{\bar{R}_{q\lambda}}{\bar{R}_{qq}\bar{q}_k + r\frac{\bar{q}_{kk}}{\bar{q}_k^2}} - \left(\frac{\bar{R}_{qq}\bar{q}_n + r\frac{\bar{q}_{kn}}{\bar{q}_k^2}}{\bar{R}_{qq}\bar{q}_k + r\frac{\bar{q}_{kk}}{\bar{q}_k^2}}\right)\frac{d\bar{n}^i}{d\lambda}$$

which is equal to (2.10) (in (2.10) $\bar{k}_\lambda^i$ and $\bar{n}_\lambda^i$ denote total derivatives).

A4 The impact of competition on firm efficiency under unionism

By definition we have

$$\sigma(\bar{n}(\lambda),\bar{k}(\lambda)) \equiv \frac{q_n(\bar{n}(\lambda),\bar{k}(\lambda))}{q_k(\bar{n}(\lambda),\bar{k}(\lambda))}\frac{r}{w} \equiv \frac{\bar{q}_n}{\bar{q}_k}\frac{r}{w}$$

Taking the derivative of $\sigma(\bar{n}(\lambda),\bar{k}(\lambda))$ with respect to λ and ignoring the factor price ratio (w and r are both positive constants) yields

$$\frac{d\bar{\sigma}^i}{d\lambda} = \frac{\left(\bar{q}_{nn}\frac{d\bar{n}^i}{d\lambda} + \bar{q}_{nk}\frac{d\bar{k}^i}{d\lambda}\right)\bar{q}_k - \left(\bar{q}_{kn}\frac{d\bar{n}^i}{d\lambda} + \bar{q}_{kk}\frac{d\bar{k}^i}{d\lambda}\right)\bar{q}_n}{\bar{q}_k^2}$$

$$\frac{d\bar{\sigma}^i}{d\lambda} = \frac{(\bar{q}_{nn}\bar{q}_k - \bar{q}_{kn}\bar{q}_n)\frac{d\bar{n}^i}{d\lambda} + (\bar{q}_{nk}\bar{q}_k - \bar{q}_{kk}\bar{q}_n)\frac{d\bar{k}^i}{d\lambda}}{\bar{q}_k^2}$$

$$\frac{\bar{q}_k^2}{\bar{q}_{nk}\bar{q}_k - \bar{q}_{kk}\bar{q}_n}\frac{d\bar{\sigma}^i}{d\lambda} = -\left(\frac{\bar{q}_{kn}\bar{q}_n - \bar{q}_{nn}\bar{q}_k}{\bar{q}_{nk}\bar{q}_k - \bar{q}_{kk}\bar{q}_n}\right)\left(\frac{d\bar{n}^i}{d\lambda}\right) + \frac{d\bar{k}^i}{d\lambda}$$

$$y\frac{d\bar{\sigma}^i}{d\lambda} = -\left(\frac{d\bar{k}}{d\bar{n}}\right)\left(\frac{d\bar{n}^i}{d\lambda}\right) + \frac{d\bar{k}^i}{d\lambda}$$

Insertion of (V) gives condition (2.12) (y is always positive and in (2.12) $\bar{n}_\lambda^i$ denotes a total derivative).

A5 Capital stock and employment with constant elasticity of demand and Cobb-Douglas production function

Nominal profit is given by

$$\pi = px - rk - wn$$

since

$$x = D = p^{-\frac{1}{1-\lambda}}$$

we can rewrite nominal profit as follows

$$\pi = x^{\lambda} - rk - wn \qquad \textit{where} \quad x = \frac{n^{\alpha''} k^{\beta}}{\alpha''^{\alpha''} \beta^{\beta}}$$

First order conditions for profit maximisation are

$$\text{(*)} \qquad \frac{d\pi}{dk} = 0 \qquad \Rightarrow \qquad \lambda x^{\lambda-1} x_k = 1 \qquad \Rightarrow \qquad k^{1-\beta\lambda} = \frac{\lambda\beta}{\alpha^{\alpha''\lambda} \beta^{\beta\lambda}} n^{\alpha''\lambda}$$

$$\frac{d\pi}{dn} = 0 \qquad \Rightarrow \qquad \lambda x^{\lambda-1} x_n = 1$$

where both w and r have been set equal to unity. Taking the ratio between the two first order conditions gives

$$k = \frac{\beta}{\alpha''} n$$

Insertion of this ratio in (*) and rearranging yields

$$\hat{n} = \alpha'' \lambda^{\frac{1}{1-s\lambda}} \qquad \textit{and} \qquad \hat{k} = \beta \lambda^{\frac{1}{1-s\lambda}}$$

If, on the contrary, we assume labour to be determined by the union we have

$$\bar{n} = \bar{\phi} \alpha'' \lambda^{\frac{1}{1-s\lambda}}$$

Insertion of $\bar{n}$ *into (*) yields*

$$\bar{k} = \hat{k} \bar{\phi}^{\frac{\alpha''\lambda}{1-\beta\lambda}} = \beta \bar{\phi}^{\frac{\alpha''\lambda}{1-\beta\lambda}} \lambda^{\frac{1}{1-s\lambda}}$$

Appendix B

Appendix B describes how to derive the equilibrium equations of Chapter 4 under unionism. To obtain those of Chapter 3 simply follow the same procedure while considering income, I, always as exogenous. To simplify notation, superscripts have been dropped. To derive the corresponding values under non-unionism, set ϕ=1.
Equilibrium in the monopolistic sector requires

$$x_j = \frac{n_j^{\alpha} k_j^{\beta}}{\alpha^{\alpha}\beta^{\beta}} = \left(\frac{p_j}{P}\right)^{-\frac{1}{1-\lambda}} \frac{I}{P} = c_j \qquad \forall j \in [0,1]$$

that can be rewritten as follows

(I) $$p_j = \frac{n_j^{\alpha(\lambda-1)} k_j^{\beta(\lambda-1)}}{\alpha^{\alpha(\lambda-1)}\beta^{\beta(\lambda-1)}} \frac{P^{\lambda}}{I^{\lambda-1}} \qquad \forall j \in [0,1]$$

Profit is given by

$$\pi_j = p_j x_j - rk_j - wn_j = \left[\frac{n_j^{\alpha(\lambda-1)} k_j^{\beta(\lambda-1)}}{\alpha^{\alpha(\lambda-1)}\beta^{\beta(\lambda-1)}} \frac{P^{\lambda}}{I^{\lambda-1}}\right] \frac{n_j^{\alpha} k_j^{\beta}}{\alpha^{\alpha}\beta^{\beta}} - wk_j - wn_j \quad \Rightarrow$$

$$\pi_j = \frac{n_j^{\alpha\lambda} k_j^{\beta\lambda}}{\alpha^{\alpha\lambda}\beta^{\beta\lambda}} \frac{P^{\lambda}}{I^{\lambda-1}} - wk_j - wn_j \qquad \forall j \in [0,1]$$

First order conditions for profit maximisation are

(II) $$\frac{\partial \pi}{\partial k} = 0 \qquad \Rightarrow \qquad \beta\lambda k^{\beta\lambda-1} \frac{n^{\alpha\lambda}}{\alpha^{\alpha\lambda}\beta^{\beta\lambda}} \frac{P^{\lambda}}{I^{\lambda-1}} = w$$

$$\frac{\partial \pi}{\partial n} = 0 \qquad \Rightarrow \qquad \alpha\lambda n^{\alpha\lambda-1} \frac{k^{\beta\lambda}}{\alpha^{\alpha\lambda}\beta^{\beta\lambda}} \frac{P^{\lambda}}{I^{\lambda-1}} = w$$

where the subscript j was dropped since all firms are identical. Taking the ratio between the two first order conditions and rearranging gives

$$k = \frac{\beta}{\alpha} n$$

Insertion of this ratio in (II) yields

$$\beta\lambda\left(\frac{\beta}{\alpha}n\right)^{\beta\lambda-1}\frac{n^{\alpha\lambda}}{\alpha^{\alpha\lambda}\beta^{\beta\lambda}}\frac{P^{\lambda}}{I^{\lambda-1}}=w \qquad \Rightarrow \qquad n^{1-s\lambda}=\alpha^{1-s\lambda}\lambda P^{\lambda}I^{1-\lambda}w^{-1} \qquad \Rightarrow$$

(III) $$n=\alpha\left(\frac{\lambda}{w}\right)^{\frac{1}{1-s\lambda}}P^{\frac{\lambda}{1-s\lambda}}I^{\frac{1-\lambda}{1-s\lambda}}$$

where $s\equiv\alpha+\beta$*. Under unionism we have*

(IV) $$n=\phi\alpha\left(\frac{\lambda}{w}\right)^{\frac{1}{1-s\lambda}}P^{\frac{\lambda}{1-s\lambda}}I^{\frac{1-\lambda}{1-s\lambda}}$$

Insertion of (IV) into (II) yields

$$\left[\beta\lambda k^{\beta\lambda-1}\frac{1}{\alpha^{\alpha\lambda}\beta^{\beta\lambda}}\frac{P^{\lambda}}{I^{\lambda-1}}\right]\left(\phi\alpha\left(\frac{\lambda}{w}\right)^{\frac{1}{1-s\lambda}}P^{\frac{\lambda}{1-s\lambda}}I^{\frac{1-\lambda}{1-s\lambda}}\right)^{\alpha\lambda}=w \qquad \Rightarrow$$

$$\left[\frac{\beta^{1-\beta\lambda}k^{\beta\lambda-1}}{\alpha^{\alpha\lambda}}P^{\lambda+\frac{\alpha\lambda^{2}}{1-s\lambda}}I^{1-\lambda+\left(\frac{1-\lambda}{1-s\lambda}\right)\alpha\lambda}\alpha^{\alpha\lambda}\phi^{\alpha\lambda}\left(\frac{\lambda}{w}\right)^{\frac{\alpha\lambda}{1-s\lambda}+1}\right]=1 \qquad \Rightarrow$$

$$k^{1-\beta\lambda}=\beta^{1-\beta\lambda}P^{\frac{\lambda}{1-s\lambda}(1-\beta\lambda)}I^{\frac{1-\lambda}{1-s\lambda}(1-\beta\lambda)}\phi^{\alpha\lambda}\lambda^{\frac{1-\beta\lambda}{1-s\lambda}}w^{-\frac{1-\beta\lambda}{1-s\lambda}} \qquad \Rightarrow$$

(V) $$k=\beta P^{\frac{\lambda}{1-s\lambda}}I^{\frac{1-\lambda}{1-s\lambda}}\left(\frac{\lambda}{w}\right)^{\frac{1}{1-s\lambda}}\phi^{\frac{\alpha\lambda}{1-\beta\lambda}}$$

The ratio between (V) and (IV) is given by

(VI) $$\frac{k}{n}=\frac{\beta}{\alpha}\phi^{\frac{s\lambda-1}{1-\beta\lambda}}$$

Since in equilibrium $n_j=n$, $k_j=k$, *and* $p_j=P \quad \forall j\in[0,1]$ *we can insert k from (VI) in (I) and write*

$$P=\left(\frac{n^{s}}{\alpha^{s}}\phi^{\frac{\beta(s\lambda-1)}{1-\beta\lambda}}\right)^{\lambda-1}\frac{P^{\lambda}}{I^{\lambda-1}}$$

Plugging (IV) in this last expression gives

$$P=\left[\frac{\phi^{s(\lambda-1)}\alpha^{s(\lambda-1)}P^{\frac{s(\lambda-1)\lambda}{1-s\lambda}}I^{\frac{s(\lambda-1)(1-\lambda)}{1-s\lambda}}}{\alpha^{s(\lambda-1)}}\left(\frac{\lambda}{w}\right)^{\frac{s(\lambda-1)}{1-s\lambda}}\right]\phi^{\frac{\beta(1-s\lambda)(1-\lambda)}{1-\beta\lambda}}\frac{P^{\lambda}}{I^{\lambda-1}}\qquad\Rightarrow$$

$$P^{1-\lambda-\frac{s(\lambda-1)\lambda}{1-s\lambda}}=\left(\frac{\lambda}{w}\right)^{\frac{s(\lambda-1)}{1-s\lambda}}\phi^{\frac{\beta(1-s\lambda)(1-\lambda)}{1-\beta\lambda}+s(\lambda-1)}I^{\frac{s(\lambda-1)(1-\lambda)}{1-s\lambda}+1-\lambda}\qquad\Rightarrow$$

$$P^{\frac{1-\lambda}{1-s\lambda}}=\left(\frac{\lambda}{w}\right)^{-\frac{s(1-\lambda)}{1-s\lambda}}\phi^{-\frac{\alpha(1-\lambda)}{1-\beta\lambda}}I^{\frac{(1-s)(1-\lambda)}{1-s\lambda}}\qquad\Rightarrow$$

$$P=\left(\frac{\lambda}{w}\right)^{-s}I^{1-s}\phi^{-\frac{\alpha(1-s\lambda)}{1-\beta\lambda}}=\left(\frac{\lambda}{w}\right)^{-s}I^{1-s}\phi^{-t\alpha}$$

Substituting now P back into (IV) we obtain n

$$n=\phi\alpha\left(\frac{\lambda}{w}\right)^{\frac{1}{1-s\lambda}}I^{\frac{1-\lambda}{1-s\lambda}}\left[\left(\frac{\lambda}{w}\right)^{-\frac{s\lambda}{1-s\lambda}}I^{\frac{(1-s)\lambda}{1-s\lambda}}\phi^{-\frac{\alpha\lambda}{(1-s\lambda)(1-\beta\lambda)}}\right]\qquad\Rightarrow$$

$$n=\alpha\phi^{1-\frac{\alpha\lambda}{(1-s\lambda)(1-\beta\lambda)}}\left(\frac{\lambda}{w}\right)^{\frac{1}{1-s\lambda}-\frac{s\lambda}{1-s\lambda}}I^{\frac{1-\lambda}{1-s\lambda}+\frac{(1-s)\lambda}{1-s\lambda}}\qquad\Rightarrow$$

$$n=\alpha\phi^{\frac{1-s\lambda}{1-\beta\lambda}}\left(\frac{\lambda}{w}\right)I=\alpha\phi^{t}\left(\frac{\lambda}{w}\right)I$$

using (VI) we get k

$$k=\frac{\beta}{\alpha}\phi^{\frac{s\lambda-1}{1-\beta\lambda}}n=\frac{\beta}{\alpha}\phi^{\frac{s\lambda-1}{1-\beta\lambda}}\left[\alpha\phi^{-\frac{s\lambda-1}{1-\beta\lambda}}\left(\frac{\lambda}{w}\right)I\right]=\beta\left(\frac{\lambda}{w}\right)I$$

i.e., capital does not depend directly on employment. To get an expression for nominal income, I, we use the labour market clearing condition

$$n+k=I\left(\frac{\lambda}{w}\right)\left(\alpha\phi^{t}+\beta\right)=w^{\gamma}\left(\frac{\lambda}{w}\right)^{s\gamma}I^{(s-1)\gamma}\phi^{\frac{\alpha(1-s\lambda)}{1-\beta\lambda}\gamma}=l\qquad\Rightarrow$$

$$I^{1+(1-s)\gamma}=w^{1+(1-s)\gamma}\lambda^{s\gamma-1}\phi^{t\alpha\gamma}\left(\alpha\phi^{t}+\beta\right)^{-1}\qquad\Rightarrow$$

$$I=w\left[\lambda^{s\gamma-1}\phi^{t\alpha\gamma}\left(\alpha\phi^{t}+\beta\right)^{-1}\right]^{\frac{1}{1+(1-s)\gamma}}=w\left[\frac{\lambda^{s\gamma-1}\phi^{t\alpha\gamma}}{z}\right]^{\frac{1}{g}}$$

where $g \equiv 1+(1-s)\gamma$ *and* $z \equiv \alpha\phi^t + \beta$. *So, we can now derive k and n in real terms*

$$k = \frac{\beta\lambda I}{w} = \frac{\beta\lambda}{w} w \left[\frac{\lambda^{s\gamma-1}\phi^{t\alpha\gamma}}{z}\right]^{\frac{1}{g}} = \beta\left[\frac{\lambda^{\gamma}\phi^{t\alpha\gamma}}{z}\right]^{\frac{1}{g}}$$

$$n = \phi^t \frac{\alpha\lambda I}{w} = \phi^t \frac{\alpha\lambda}{w} w \left[\frac{\lambda^{s\gamma-1}\phi^{t\alpha\gamma}}{z}\right]^{\frac{1}{g}} = \alpha\phi^t\left[\frac{\lambda^{\gamma}\phi^{t\alpha\gamma}}{z}\right]^{\frac{1}{g}}$$

These last two expressions can be used to obtain total employment, consumption, and welfare

$$l = k + n = (\beta + \alpha\phi^t)\left[\frac{\lambda^{\gamma}\phi^{t\alpha\gamma}}{z}\right]^{\frac{1}{g}} = z\left[\frac{\lambda^{\gamma}\phi^{t\alpha\gamma}}{z}\right]^{\frac{1}{g}}$$

$$C = \frac{n^{\alpha}k^{\beta}}{\alpha^{\alpha}\beta^{\beta}} = \phi^{t\alpha}\left[\frac{\lambda^{\gamma}\phi^{t\alpha\gamma}}{z}\right]^{\frac{\alpha}{g}}\left[\frac{\lambda^{\gamma}\phi^{t\alpha\gamma}}{z}\right]^{\frac{\beta}{g}} = \phi^{t\alpha}\left[\frac{\lambda^{\gamma}\phi^{t\alpha\gamma}}{z}\right]^{\frac{s}{g}}$$

$$U = C - \frac{\gamma}{\gamma+1} l^{\frac{\gamma+1}{\gamma}} = C\left[1 - \frac{\gamma}{\gamma+1}\lambda z\right] = \phi^{t\alpha}\left[\frac{\lambda^{\gamma}\phi^{t\alpha\gamma}}{z}\right]^{\frac{s}{g}}\left[1 - \frac{\gamma}{\gamma+1}\lambda z\right]$$

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