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On monopolistic competition and optimal product diversity: workers' rents also matter*

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Abstract

In the Dixit-Stiglitz model of monopolistic competition, entry of firms is socially too small. Other authors have shown that excess entry is also a possibility with other preferences for diversity. We show that workers' rents also contribute to explain excess entry through a general equilibrium mechanism. Larger wages indeed raises the aggregate earnings and firms sales and profits, which entices too many firms to enter. We discuss the possibility of over-provision of varieties by comparing the equilibrium to unconstrained and constrained social optima and to other regulatory framework where wages are not controlled.

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1 Introduction

Do firms offer too many varieties under monopolistic competition? Early contributions in economic literature have adopted an industrial organization approach based on partial equilibrium frameworks. For instance, Chamberlin (1950) considers the case of firms selling perfect substitutes and concludes that firms set production to the left of the point of their minimum average cost so that too many firms enter. Spence (1976) more formally analyzes the case of imperfect substitutes and suggests that monopolistic competition is likely to yield excess-provision of product varieties in environment with high own price elasticities and low cross elasticities. In their influential paper based on CES preferences, Dixit and Stiglitz' (1977) reach opposite result of under-provision of product variety: firms set production levels larger than the (unconstrained) social optimum and entry is below its social optimum.

Many economists have attempted to challenge Dixit and Stiglitz' (1977) result with one of the two following approaches. In the first approach, researchers reconsidered the firms' behaviors in the monopolistic competition. In particular, d'Aspremont *et al.* (1989), Yang and Heijdra (1993) and d'Aspremont *et al.* (1996) assume that firms have non zero masses and use their ability to alter price indices and incomes in order to increase their own profits. Such models give evidence of a 'Ford' effect, in reference to Henry Ford who firstly exploited the positive causality between wages and product demand. In such models, firms' strategic behavior may yield excess entry, which reverses the Dixit and Stiglitz' result (1977). In the second approach, researchers have analyzed the possibility of over-provision of product varieties under different assumptions about consumer preferences. For instance, Benassy (1996) and Vives (1999, p.172) have extended Dixit and Stiglitz' preferences to show that entry can be too large or too small according to the balance between consumers' preferences for variety and for individual consumption of each single variety. Anderson *et al.* (1995) have challenged the representative consumer approach to show that excess entry occurs in a model where the consumers' taste heterogeneity is explicitly assumed. Finally many economists use spatial models to discuss consumer heterogeneity in the context of horizontal differentiation. Salop (1979) already noted the existence of excess entry under linear 'transport' cost (linear preferences). Matsumura and Okamura (2006a) showed that this property extends to much broader classes of 'transport' cost functions (non linear preferences). Matsumura and Okamura (2006b) present examples of under-provision in spatial models. Hence, either over-provision or under-provision of product varieties can be expected.

In this paper we start from a model where perfectly competitive labor markets yield under-provision of varieties and show that introducing bargaining power of the unions changes the results drastically. This approach is based on a general equilibrium features of *imperfect labor market models.* The model includes a sector with constant returns to scale and a unionized, manufacturing sector with increasing returns to scale, allowing workers of the latter sector to capture a rent. We show that workers' rents also contribute to explain excess entry through a general equilibrium mechanism. Larger wages indeed raise the aggregate earnings and firms sales and profits, which creates a Ford effect that is similar to the one discussed in d'Aspremont *et al.* (1996) but that is triggered by another mechanism. Yet, as those authors show, this effect entices too many firms to enter. We therefore show that the Dixit and Stiglitz' (1977) prediction can be reversed with too many varieties offered by the market. This effect is likely to be effective in developed economies where the increasing returns to scale sector is non negligible and where workers are able to extract rents.

Our analysis shows that large enough union bargaining power implies that firms provide too many product varieties. This result applies when the equilibrium is compared to unconstrained social optimum where prices, wages and entry are controlled by a planner or to a constrained social optimum where only prices and wages are controlled and where firms must break even. We also show that the result holds under more likely forms of government interventions where the government has no control on wages. As a consequence, our result offers a new mechanism explaining over-provision of product variety compared to the mechanisms set out in the existing literature. It provides a general equilibrium answer to a question that has often been discussed in the partial equilibrium framework of industrial economics. We furthermore claim that our result extends to economies with other forms of wage rigidities in the monopolistically competitive sector. Indeed, the present mechanism is only based on the fact that manufacturing workers are able to push up prices and to extract rents over the competitive wage.

The paper is organized as it follows. Section 2 presents the model and the market equilibrium. Section 3 discusses the conditions under which over-provision of product varieties takes place with respect to social optimum and several regulatory benchmarks.

2 The model

As in Picard and Toulemonde (2006), we consider a general equilibrium model with a homogenous good produced under constant returns to scale and with a bundle of differentiated goods produced under increasing returns to scale. Both sectors transform one unit of labor into one unit of output. No rent is available in the constant returns to scale sector. Thus, workers in that sector are paid at their marginal productivity. We define the price of this homogenous good as the numéraire so that the wage is equal to one in that sector.

The firms that produce the differentiated goods have some market power which creates a rent that can be seized by their workers who organize themselves in trade unions. In that sector, unions can bargain wages that are larger than 1, which makes this industry attractive for all workers. However, firms' production in that industry is not large enough to hire all workers at the union wage, and unions prevent wages to fall. Hence, the labor market is dual with a low wage sector that produces goods under constant returns to scale and with a high-wage sector that produces goods under increasing returns to scale.

In the wage game, the wage setting is decentralized with an independent, utilitarian union per firm. The union and the firm bargain first over wages. Then the firm chooses employment given wages (the firm has the right to manage). The firms that produce under increasing returns to scale also face a fixed cost f which is paid in terms of the numéraire good.

We now define consumers preferences which determine the demand for each good and the demand for labor by each firm. Then we define unions preferences and we solve the wage bargaining game. Once all variables are determined at the firm level, we move to the analysis at the aggregate level, which allows us to check whether there is too much or too little entry of firms and thus whether there is over- or under-supply of varieties.

Preferences We consider m individuals who share the same preferences:

$$U = c_o^{1-\mu} * \left(\int_0^n c(i)^{1-1/\sigma} di \right)^{\mu \frac{\sigma}{\sigma - 1}} \tag{1}$$

where c_o is the consumption of the numéraire and where $c(i)$ is the consumption of a differentiated variety $i \in [0, n]$. Consumers spend a share $1 - \mu$ of their income on the numéraire and a share μ on the differentiated goods. The elasticity of substitution among differentiated varieties is constant and equal to $\sigma > 1$. Accordingly, consumers' demand for the differentiated variety i is given by

$$c(i) = \left(\frac{p(i)}{P}\right)^{-\sigma} \frac{\mu E}{P} \text{ where } P \equiv \left(\int_0^n p(i)^{1-\sigma} di\right)^{\frac{1}{1-\sigma}} \tag{2}$$

The earnings of the m consumers are denoted by E; $p(i)$ is the price of the differentiated variety i, and P is the price index of the differentiated varieties.

Firms behavior Firm i chooses the price $p(i)$ that maximizes its profits,

$$\pi(i) \equiv p(i)\, c(i) - w(i)\, l(i) - f$$

where $w(i)$ is the wage bargained with the union in firm i and $l(i) = c(i)$ is the demand for labor. Under monopolistic competition, each firm takes the index P and the expenditures E as given. Because the product demand is iso-elastic, firm i sets its price as a markup over the marginal costs: $p(i) = w(i)\,\sigma/(\sigma-1)$ so that profits are $\pi(i) = w(i)\, l(i)/(\sigma-1) - f$. Because workers have unit productivity, the demand for labor is iso-elastic and found by plugging the value of $p(i)$ in (2)

$$l(i) = c(i) = \left(\frac{w(i)}{P}\frac{\sigma}{\sigma-1}\right)^{-\sigma} \frac{\mu E}{P} \tag{3}$$

Unions Unions are utilitarian. Each union i maximizes the sum of utility that its workers derive from the wages offered by the firm. With the Cobb-Douglas-CES utility specification, the utility of a worker is his real wage, $w(i)/P_G$ where $P_G \equiv P^{\mu}\mu^{-\mu}(1-\mu)^{\mu-1}$ denotes the price index of both types of goods. Hence, union utility levels are equal to $V(i) = w(i)l(i)/P_G$.

Nash bargaining We consider the Nash solution for the wage bargaining. Accordingly, wages maximize the following product

$$N \equiv \left[V(i) - \overline{V}\right]^{\phi} \left[\pi(i) - \bar{\pi}\right]^{1-\phi}$$

where ϕ is the union bargaining power, $\overline{V}$ and $\bar{\pi}$ are the fall-back utilities and profits. In case of persistent disagreement with the firm, workers are employed in the constant returns to scale sector and earn a unit wage; their utility is equal to $1/P_G$. Hence, the union contribution to the Nash product is $(w(i)-1)\, l(i)/P_G$.

In case of persistent disagreement with the union, we assume that the firm still incurs the fixed cost ($\bar{\pi}(i) = -f$). This is also what is implicitly assumed in many models of wage bargaining in which the fixed cost is set equal to zero (see e.g. the seminal paper by McDonald and Solow, 1981). The firm's contribution to the Nash product is therefore $\pi(i) - \bar{\pi} = w\,(i)\,l\,(i)\,/\,(\sigma - 1)$.

In a Nash bargaining, $w(i)$ maximizes the Nash product. Under monopolistic competition, there is a large number of firms and unions that consider the price index P, and the earnings E as constants. The maximization gives

$$w(i) = w = 1 + \frac{\phi}{\sigma - 1} \tag{4}$$

for all firms i. Thus the wage is a fixed mark-up over the wage in the constant returns to scale sector and it is independent of the number of firms. The wage increases with the union bargaining power and it decreases with the demand elasticity.

Equilibrium number of firms We now determine the equilibrium number of firms. Under free entry, firms enter until their profits fall to zero. This requires that the sale of each firm is equal to $c = f\,(\sigma - 1)\,/w$. From (3), we note that c depends upon total real earnings, E/P. Since all varieties are sold at the same price, the price index is $P = n^{1/(1-\sigma)}p = n^{1/(1-\sigma)}w\sigma/\,(\sigma - 1)$. Earnings E are made of wages of the nc unionized workers and the $m - nc$ non unionized workers: $E = (m - nc) + ncw$. Using this definition and (3), we find

$$c = \frac{1}{n}\frac{\mu}{w}\frac{\sigma - 1}{\sigma}E \quad \text{and} \quad E = \frac{m\sigma w}{w\sigma - \mu\,(\sigma - 1)\,(w - 1)} \tag{5}$$

In the standard model, unions do not bargain over wages: $w = 1$. Then, total earnings are simply equal to m, the number of workers who earn a unit wage. Also, the value of sales of a firm, $pc = \sigma c/\,(\sigma - 1)$, is then equal to total earnings spent on differentiated varieties, μE, divided by the number of competing firms, n.

There are three channels through which wages and unions affect profits. First, larger wages increase the marginal costs, which reduces the production of each firm. Second, larger wages increase the markup ($p - w = w/\,(\sigma - 1)$). In the Cobb-Douglas-CES setting, at a given expenditure level, these two effects cancel out to leave profits unchanged.[1]

[1] The value of sales of a firm, $pc = \sigma wc/\,(\sigma - 1)$, is equal to total earnings spent on differentiated varieties, μE, divided by the number of competing firms, n. Hence, profits $(p - w)c - f = \mu E/\,(\sigma n) - f$ are independent of w.

Third, larger wages raises the aggregate earnings, E, which raises the sales of each firm and increases their profits. It is thus expected that larger wages will attract more firms to the industry, through a general equilibrium effect.

Indeed, profits fall to zero if and only if $\mu E/(\sigma n) = f$, which, using the above values of earnings E and wages, w, is equivalent to

$$n_E \equiv \frac{\mu m}{f} \frac{\sigma - 1 + \phi}{(\sigma - 1 + \phi)\,\sigma - \mu\phi\,(\sigma - 1)} \quad \text{and} \quad c_E \equiv f \frac{(\sigma - 1)^2}{\sigma - 1 + \phi}$$

In the standard model in which unions are powerless, $\phi = 0$ and $n_E = \mu m/\sigma f$. It is readily checked that *the equilibrium mass of firms, n_E, increases with the union bargaining power, ϕ.*

Operating profits $(p - w)\,c_E$ must cover fixed costs f. Therefore they are constant and independent of the union bargaining power. Combining this fact to the result that the markup $p - w$ increases with the union bargaining power, one readily infers that the production of each firm, c_E, decreases with the union bargaining power. To sum up, *an increase in union bargaining power increases the mass of firms and decreases the production of each firm.*

The natural next question is whether the economy operates with too much or too little entry and whether the production of each firm is too large or too small.

3 Entry: too much or too little?

To check whether there is too much or too little entry, we must compare n_E with an "optimal" mass of firms. The optimal mass of firms may be defined in different ways. *(i)* We start with an optimal mass of firms defined as the (unconstrained) social optimum where a planner is able to choose the values of c_o, $c(i)$ and n that maximize utility (1) under the resource constraint. In this social optimal allocation, firms' operating profits are not constrained to cover the fixed costs. *(ii)* As a second way to define the optimal mass of firms, we constrain firms to cover their fixed costs with their operating profits. However, the planner can choose the wage and the price of each good. We then discuss two other regulatory benchmarks in which the planner has control over entry or product prices but has no control on wages, which are negotiated between unions and firms. We distinguish between *(iii)* behavioral regulation where the planner controls prices but not entry and *(iv)* structural regulation where he/she controls entry but not prices. We compare those four benchmark cases with the equilibrium outcome.

3.1 Unconstrained social optimum

In the unconstrained social optimum (denoted by the subscript $_U$), the planner controls product and labor prices and entry and he/she is allowed to use lump sum transfers to compensate money loosing firms. By symmetry, consumers have the same consumption levels q$c(i) \equiv c$. The manufacturing sector require nc manufacturing workers and the sector also buys nf units of the traditional good produced by nf non-manufacturing workers. The traditional sector also produces c_o for the final consumption of the traditional good, which requires the hiring of c_o non-manufacturing workers. So, full employment of labor resources implies that $m = n(c + f) + c_o$. Maximizing individuals' utility (1) with respect to c_o, c and n under this resource constraint yields the unconstrained social optimal levels of consumption and varieties:

$$n_U \equiv m \frac{\mu}{f} \frac{1}{\sigma - 1 + \mu} \quad \text{and} \quad c_U \equiv f\,(\sigma - 1)$$

We first compare the consumption levels. One can check that if unions have no bargaining power ($\phi = 0$), equilibrium consumption levels coincide with the first best ($c_E = c_U$) as in Dixit and Stiglitz (1977). Yet, an increase in union bargaining power raises the markup, which promotes entry until operating profits cover the fixed costs. At the equilibrium, there are more firms, each of them producing less. Hence, $c_E < c_U$: each firm produces less at the equilibrium than under the unconstrained social optimum.

Second, we compare the mass of firms. It is readily checked that if unions do not have bargaining power ($\phi = 0$), then the number of varieties is smaller at the equilibrium than in the unconstrained social optimum ($n_E < n_U$). This is the Dixit and Stiglitz's (1977) result according to which the equilibrium implies too few varieties: consumers have a preference for variety but firms cannot enter profitably because their operating profits are too small to cover their fixed costs. By contrast, an increase in union bargaining power raises n_E and leaves n_U unchanged. For large union power, it is possible that the equilibrium generates too many varieties.[2] Operating profits are large and entice

[2] We can check that $n_E > n_U \iff \phi\,(\mu\sigma - 1) > (1 - \mu)\,(\sigma - 1)$. The inequality holds only if the increasing returns sector is sufficiently large and generates sufficiently large rents (i.e., if μ is large and σ

excessive entry which results in over-provision of varieties. This effect is strengthened when the unionized sector is large; that is, when the share of manufacturing industry (μ) is large.

Hence, one can show that there exists a threshold $\phi_E > 0$ such that $n_U > n_E$ iff $\phi < \phi_E$.[3] *For small enough values of bargaining power, the equilibrium induces a too small number of varieties compared to the unconstrained social optimum.* Therefore, there exists *under-provision of varieties for small union bargaining power* and *there may exist over-provision of varieties otherwise.*

The solid curve in Figure 1 displays the values of (μ, σ) such that $n_E = n_U$ under monopoly unions ($\phi = 1$) and the dotted curve under symmetric bargaining power ($\phi = 1/2$). The sets of parameters (μ, σ) implying over-provision of varieties ($n_E > n_U$) lie on the right hand of each curve.

INSERT FIGURE 1 HERE

Many econometric studies report elasticities of substitution σ between 2 and 7 and shares μ of the increasing return to scale sector between 0.8 and 0.9.[4] Hence, in practice, over-provision of varieties is not unlikely to occur in unionized economies.

3.2 Constrained social optimum

In the constrained social optimum (denoted by the subscript $_C$), the planner is not allowed to transfer money to firms. It therefore chooses wages and product prices in a way that prevents firms to make losses. The planner sets the wage to the opportunity cost of labor, that is $w = 1$, which prevents the labor market to be dual. Expenditures are equal to m because all workers earn the same unit wage.

At the break-even point, firms must set the price $p = 1 + f/c$. At the same time, the value of production is equal to the earnings spent on manufactured goods $npc = \mu m$. The consumption on each variety can readily be computed from the last two relationships as $c = \mu m/n - f$. The consumption of the homogeneous good is equal to $c_0 =$

is small so that $\mu\sigma > 1$).

[3] Note that if $\phi_E > 1$, then there is always under-provision of varieties.

[4] See e.g. Head and Mayer (2004), Combes and Overman (2004).

$(1-\mu) E = (1-\mu) m$ and the indirect utility (1) is proportional to $c^{\mu} n^{\mu\sigma/(\sigma-1)}$. The number of varieties that maximizes this expression is given by

$$n_C \equiv \frac{\mu m}{\sigma f}$$

so that

$$c_C \equiv (\sigma - 1) f$$

which corresponds to the expression found in Dixit and Stiglitz (1977). As in Dixit and Stiglitz, the number of varieties and the production of each firm under the second best precisely corresponds to the market equilibrium when unions do not have bargaining power. However, we have shown that an increase in the union bargaining power raises the equilibrium number of firms and decreases their production level. Therefore, it is always the case that *unions with some bargaining power contribute to an over-provision of varieties.* The number of varieties and the consumption levels in the constrained and unconstrained social optima and in the equilibrium are depicted in Figure 2.

INSERT FIGURE 2 HERE

Of course, in most cases, governments are not able to control the wages in the labor market. They are just able to regulate product prices or entry so that wages are the result of bargaining between firms and workers. The following setting describes the regulatory situation where the planner controls product prices but not wages and entry. The next one characterizes the case where the planner controls entry but not wages and prices.

3.3 Behavioral regulation

Under behavioral regulation (denoted by the subscript $_B$), a regulator controls only product prices but not wages. However, transfers to the firms are not allowed so that firms are required to break even.

By symmetry the regulator sets the same price p_B for all manufacturing firms. At this price the demand for a variety is equal to $c = c_B \equiv \mu E (p_B)^{-\sigma} P^{\sigma-1}$. The firm's contribution to the Nash product in the wage bargaining is therefore $(p_B - w) c_B$, whereas the union contribution to the Nash product is $(w-1) c_B$. The bargained wage is now

$$w = 1 + \phi (p_B - 1)$$

Unionized workers thus get a rent $\phi(p_B - 1)$ that increases with union bargaining power ϕ and with the price p_B imposed by the regulator.

At the aggregate level, expenditures are equal to $E_B = nc_B(w-1)+m = nc_B\phi(p_B-1)+m$ and the price index is $P_B = n^{-1/(\sigma-1)}p_B$. Using these last two expressions, the consumption becomes

$$c_B = \frac{\mu m}{n(p_B(1-\mu\phi)+\mu\phi)}$$

Firms must break even so that $(p_B - w)c_B = f$. Using this relationship, the break-even price, output and expenditure levels are given by

$$p_B = 1 + \frac{fn}{\mu m(1-\phi) - fn(1-\mu\phi)}, \; c_B = \frac{\mu m}{n} - f\frac{1-\mu\phi}{1-\phi} \text{ and } E_B = m + \frac{\phi}{1-\phi}nf \quad (6)$$

The price increases with the number of varieties n because breaking even becomes more difficult when firms face more competitors. At the same time consumption decreases. Nevertheless, the expenditure level increases with the bargaining power and the number of varieties.[5]

The planner sets the price p_B that maximizes the utility (1) subject to conditions (6). Since p_B is a strictly increasing function of n, this is equivalent to find the optimal number of firms n that maximizes the utility (1), which is proportional to $n^{\mu/(\sigma-1)}p_B^{-\mu}E_B$, where E_B and p_B are functions of n. From this expression we observe three effects. First, a rise in the number of varieties improves utility because of individuals' preference for variety. Second, because it increases the break-even prices, it increases the cost of living and decreases welfare. Finally, because higher product prices partly accrue to workers, they also increase their income and expenditure. We show in Appendix A that if unions do not have bargaining power ($\phi = 0$), the number of varieties and the output are equal to the constrained social optimum ($n_B = n_C$ and $c_B = c_C$). Furthermore we show that the number of firms decreases with the union power (n_B decreases with ϕ). This is because after the bargaining process, the firm collects only a small share of its operational profit. To allow this firms to break even, the government is obliged to set a large price and reduce competition dramatically. Finally, numerical simulations reveal that c_B increases in ϕ. The government increases output in response to stronger union power in order to allow the firm to cover the fixed cost of operation. Those results are depicted in Figure 2.

[5] Note that one can show that p_B and c_B are always positive for all $\phi \in (0,1)$ at the behavioral regulation optimal number of varieties $n = n_B$ (computed below).

3.4 Structural regulation

Under structural regulation (denoted by the subscript $_S$), the regulator controls entry but not product and labor prices. The regulator is allowed to sell each market i to investors or entrepreneurs through the collection of a franchise fee or to subsidize entry through a subsidy. The fee or the subsidy are transfers from or to the firms' owners and has no effect on total earnings in the economy.

Prices and wages are set by firms and workers as it is the case in the competitive equilibrium. Therefore, wages are given by expression (4) and prices are simple mark-ups over those wages. The total earnings respectively include the incomes of workers hired in unionized and non-unionized firms and, the profits (i.e. the value of either the franchise fee or the entry subsidy): $E = wnc+ (m-nc)+ n\left[wc/(\sigma-1)-f\right]$. Total manufacturing consumption is equal to the total expenditure on manufacturing goods: $ncp = \mu E$. Solving for those two equalities gives the total earnings $E = (m-nf)\left[1-\mu+\mu\left(\sigma-1\right)/\left(\sigma w\right)\right]^{-1}$. The indirect utility is proportional to $En^{\frac{\mu}{\sigma-1}}$. Inserting the expenditure function and maximizing the resulting expression with respect to n yields

$$n_S = m\frac{\mu}{f}\frac{1}{\sigma-1+\mu} = n_U \quad \text{and} \quad c_S = \frac{(\sigma-1)^3 f}{(\sigma-1)(\sigma-\mu)+\phi\sigma(1-\mu)} < c_U$$

Hence, compared to the unconstrained social optimal, structural regulation yields the same number of varieties but a smaller consumption level.

We may readily compare structural regulation with the equilibrium. One can show that $n_S > n_E$ and $c_S < c_E$ iff $\phi < \phi_E$ where $\phi_E > 0$ is the same threshold as in the comparison with the unconstrained social optimum. *For small enough values of bargaining power, the equilibrium induces a too small number of varieties compared to the structural regulation.* Indeed, the planner entices firms to enter with subsidies and raises competition. Since prices are unchanged, the consumption of each variety drops. Those results are depicted in Figure 2.

4 Conclusion

We show that economies with sufficiently powerful unions are likely to provide too many varieties compared to the constrained and unconstrained social optima and to plausible regulatory settings. Excess entry may indeed be the result of workers' rents and macroeconomic feedbacks in unionized economies. This result applies broadly to economies with wage rigidities and it suggests as in Vives (1999, p.176) that the Dixit-Stiglitz CES model has a singular flavor. Excess entry may indeed be the most likely situation in monopolistically competitive industries.

Appendix A

Under behavioral regulation, the planner maximizes $n^{\mu/(\sigma-1)} p_B^{-\mu} E_B$ where

$$p_B = 1 + \frac{fn}{\mu m(1-\phi) - fn(1-\mu\phi)} \text{ and } E_B = m + \frac{\phi}{1-\phi} nf$$

The first order condition is given by $Z(n) = 0$ where

$$Z(n) \equiv \phi f^2 (\mu + \sigma - 1)(1 - \mu\phi) n^2 + mf\mu (1-\phi)(\sigma - \phi(\sigma - 1 + 2\mu)) n - \mu^2 m^2 (1-\phi)^2$$

It is readily checked from this expression that $Z(n_C) = 0$ at $\phi = 0$. If unions do not have bargaining power ($\phi = 0$), the number of varieties and the output are thus equal to the constrained social optimum ($n_B = n_C$ and $c_B = c_C$).

Note that $Z(n)$ is a quadratic and convex function and has one positive root n_B. Therefore, n_B is a unique maximum. This also implies that $Z(n)$ is an increasing function at $n = n_B$. Since $dZ/dn > 0$ at n_B we naturally get that n_B decreases in ϕ if and only if

$$dZ/d\phi > 0 \iff X(n) \equiv (2\mu m(1-\phi) - (1-2\mu\phi) fn)(\mu m - f(\mu + \sigma - 1) n) > 0$$

This function $X(n)$ is a quadratic function accepting the two following roots:

$$n_1 = \frac{\mu m}{f} \frac{1}{\sigma + \mu - 1}, \; n_2 = 2\frac{\mu m}{f} \frac{1-\phi}{1-2\mu\phi}$$

Note that

$$Z(n_1) = \mu^2 m^2 (1-\mu) / (\sigma + \mu - 1) > 0$$
$$Z(n_2) = \mu^2 m^2 (1-\phi)^2 (2(\sigma - 1)(\phi(1-\mu) + (1-\mu\phi)) + 1) / (1-2\mu\phi)^2 > 0$$

We consider the cases where one or two roots of $X(n) = 0$ are positive. First, if $1 - 2\mu\phi < 0$, only one root is positive (n_1) and $X(n)$ is positive for all $n \in (0, n_1)$. Moreover, because $Z(n_1) > 0$, we get that $n_B < n_1$. Therefore, $X(n_B) > 0$, which proves that $dZ/d\phi > 0$ and that n_B decreases in ϕ.

Second, if $1 - 2\mu\phi \geq 0$, both roots are positive and $X(n)$ is positive for all $n \in (0, \min(n_1, n_2))$. Because $Z(n_1) > 0$ and $Z(n_2) > 0$, we have that $n_B < \min(n_1, n_2)$. Hence, $X(n_B) > 0$, which proves that $dZ/d\phi > 0$ and that n_B decreases in ϕ.

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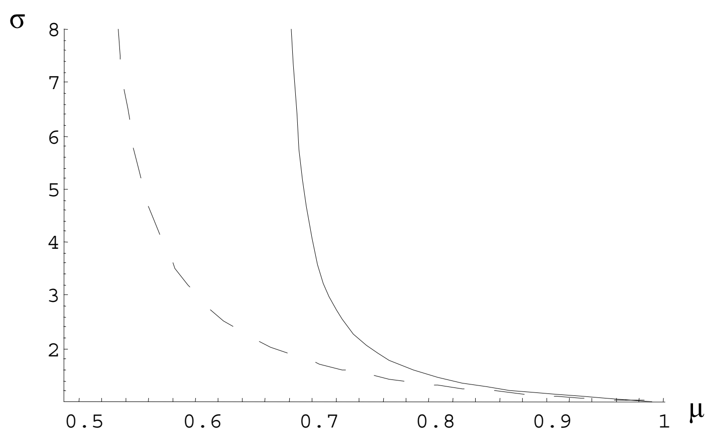

Figure 1: Over-provision of varieties in unionised economies.

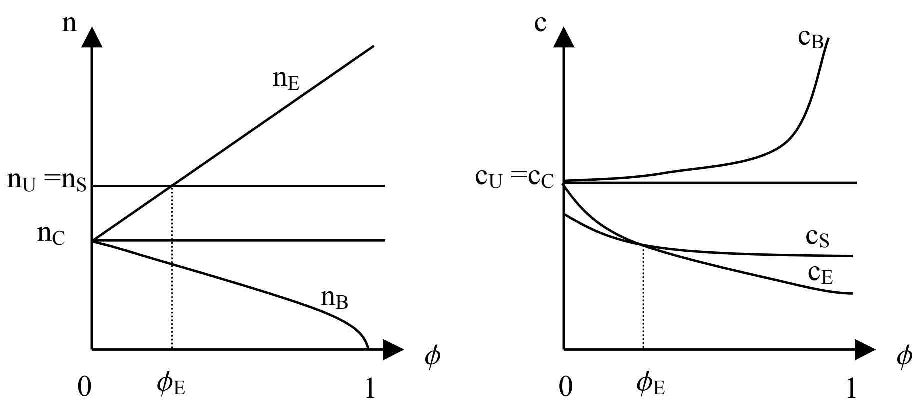

Figure 2: Comparison of the number and quantity of varieties in unionised economies.