Process Innovation and the Persistence of Monopoly with Labour-Managed Firms[1]

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December 16, 1998

[1] Acknowledgements. The …rst version of this paper was written while I was at the Institute of Economics, University of Copenhagen. I would like to thank Svend Albæk, Sougata Poddar, Gianpaolo Rossini, Dan Sasaki, Murat Sertel and two anonymous referees for insightful comments and discussion. The responsibility obviously remains with me only.

Abstract

The issue of the persistence of monopoly when at least one labour-managed …rm takes part in an auction for a cost-reducing innovation is tackled in this paper. It is shown that (i) when the incumbent is a pro…t-maximizing …rm while the entrant is a labour-managed …rm, monopoly persists; (ii) when both …rms are labour-managed, monopoly persists only if the technology initially employed by the incumbent is highly ine¢cient as compared to the new one; and, …nally, (iii) when the incumbent is labour-managed while the outsider is a pro…t seeking agent, then entry always occurs and monopoly changes hands.

JEL classi…cation: D92, L13, L20, O31

Keywords: auction, process innovation, persistence of monopoly, e¢ciency e¤ect, labour-managed …rms

1 Introduction

The well-known Schumpeterian hypothesis (Schumpeter, 1942) concerning the superior ability of a monopolist to achieve technological progress as compared to a population of smaller competitors has given rise to a wide debate over the decades, with a large number of in‡uential contributions in favour or against Schumpeter's claim.[1] A subset of this debate is the literature, stemming from the seminal contribution of Gilbert and Newbery (1982) and Reinganum (1983), on the persistence of monopoly when …rms compete for a cost-reducing innovation. All these contributions focus on pro…t maximizing …rms. Gilbert and Newbery (1982) investigate the issue by modelling a situation where a process innovation for an existing product is auctioned to the highest bidder to be selected between an incumbent and a potential entrant, under certainty. Reinganum (1983) introduces uncertainty. Two e¤ects contribute in deciding whether monopoly persists or the entrant acquires the property right on the innovation, so that a duopoly regime takes place. The …rst is the so-called "e¢ciency e¤ect", relying on the comparison between the pro…t incentives for the two …rms to bid for the innovation. This e¤ect works in favour of the incumbent, since a monopolist operating at the lowest average cost available on the basis of the new technology is surely better o¤ than two duopolists when these operate with the same technology, and, a fortiori, when one of them operates with an inferior technology. The second e¤ect is the so-called "replacement e¤ect", taking into account the fact that the entrant starts from scratch while the monopolist can at best replace herself. This works in favour of the entrant, in that the incumbent may in some circumstances "rest on her laurels". The contribution of Gilbert and Newbery (1982) features only the …rst e¤ect, so that they conclude in favour of the persistence of monopoly. On the basis of the interaction of both e¤ects, Reinganum (1983) claims that both persistence and the arising of a duopoly regime are plausible outcomes of the auction, the latter being the case if the replacement e¤ect is large enough to outweigh the e¢ciency e¤ect. Variations and extensions have been provided later on by Harris and Vickers (1985); Leininger (1991); Lippman and Mamer (1992); Krishna (1993); and Yi (1995), inter alia. Each of these contributions o¤ers some new insights as to the way the auction as well as the bidding process can be modelled, and

[1] See, inter alia, Arrow (1962), Dasgupta and Stiglitz (1980), and the exhaustive surveys by Gilbert (1989) and Reinganum (1989).

highlights the role of factors such as the evolution of strategic interaction over time, the presence of budget constraints, the availability of productive capacity over time or the degree of sunkness characterizing the R&D e¤orts in determining the outcome of the auction and, consequently, market structure.

The persistence result obtained by Gilbert and Newbery (1982) relies on the fact that, when only strict pro…t maximizing behaviour is accounted for, a monopolist gains larger pro…ts than the whole industry would do under oligopoly, if all …rms avail of the same technology. Hence, the same must hold, a fortiori, in the case where the monopolist operates with the most ef-…cient technology around. As a consequence, an auction where the patent on a cost-reducing innovation is o¤ered to the highest bidder is bound to assign it to the monopolist. How about situations where at least one …rm is not aiming at pro…t maximization? This is the case when labour-managed …rms are involved, their aim being the maximization of value added per worker. Three alternative settings can be envisaged, where (i) both the incumbent and the potential entrant are labour-managed …rms; (ii) the incumbent is an entrepreneurial …rm, while the entrant is employee-controlled; and, …nally, (iii) the incumbent is a labour managed-…rm, while the entrant is entrepreneurial.

The existing view on labour-managed …rms is twofold. On the one hand, if partnership and labour force do not coincide, the maximization of value added is obtained through the adjustment of variables that include the size of labour force itself. This yields the well known "perverse" behaviour of labour-managed …rms in response to a price increase in the output market (see, inter alia, Vanek, 1970; Meade, 1972; Ireland, 1987; Cremer and Cremer, 1992; Delbono and Rossini, 1992; Stewart, 1991 and 1992; Lambertini, 1996; Lambertini and Rossini, 1998). On the other, an enterprise whose workers are the residual claimants over …rm's income, i.e., where they coincide with partners by statute, is not subject to this "perversion" in that the size of the partnership/labour force is not among the variables being adjusted to maximize value added. Instead, membership is decided upon through a voting mechanism (Sertel, 1982, 1987). By now it is widely recognised that most of the workers' enterprises we can observe …t into the latter picture.[2]

Here, I focus on a setting where a labor-managed …rm's membership is a¤ected by the process of value added maximization. The analysis carried

[2] A well known instance is AVIS Car Rental. The same holds for many law …rms and consulting …rms.

out in the remainder of the paper stresses that since a direct measure of success is the profit level, profit-maximizing behaviour is neatly prevailing in terms of its ability to achieve technical progress and entry, if the latter is a direct consequence of the former. This points to a dynamic inefficiency of labour-managed units, adding up to their well-known static inefficiency, with the caveat that considering workers' enterprises where members are also residual claimants over firm's income would certainly mitigate if not completely eliminate both inefficiencies.

The remainder of the paper is organized as follows. Section 2 introduces the basic settings and briefly describes the monopoly equilibria, together with the setting where a profit-maximizing incumbent faces an entry threat by a labour-managed outsider. The case of competition between labour-managed firms is dealt with in section 3. Section 4 describes the situation where a labour-managed incumbent and a profit-seeking entrant compete for the innovation. Section 5 contains an overall assessment of results. Finally, section 6 provides concluding remarks.

2 The setup

At the outset, the market is being served by a monopolist producing a single good, whose inverse demand function is

$$p = a - x; \tag{1}$$

where p is the price and x is the output level. Technology requires labour only, according to the production function $x = \sqrt{L}$, so that the marginal product of labour is decreasing, and $L = \tau x^2$; where $\tau = 1/\sigma^2$: In order to operate, each firm must pay a fixed entry fee k, so that, if she is a profit-seeking agent, her objective function is

$$\pi^M_{pm}(\tau) = px - \tau x^2 - k; \tag{2}$$

where superscript M and subscript pm jointly identify a profit-maximizing monopolist. The labour wage rate is normalized to one. Simple algebra suffices to establish that the optimal output is $x^M_{pm} = a/2(1 + \tau)$ and the equilibrium profit amounts to $\pi^M_{pm}(\tau) = (a^2 - 4k - 4k\tau)/4(1 + \tau)$:

If instead the firm is a labour-managed one, she aims at setting the output (or fixing the price) so as to maximize value added per worker, i.e.,

$$V_{lm}^{M}(\bar{c}) = \frac{px - k}{\bar{c}x^2}; \tag{3}$$

this being achieved at $x_{lm}^{M} = 2k=a$. Subscript lm stands for labour-managed. In equilibrium, the value added per worker amounts to $V_{lm}^{M}(\bar{c}) = (a^2 - 4k)=4\bar{c}k$, while …rm's pro…ts are $¼_{lm}^{M} = k(a^2 - 4k - 4\bar{c}k)=a^2$, implying the overall constraint $\bar{c} < (a^2 - 4k)=4k$: It can then be easily established that $¼_{pm}^{M} > ¼_{lm}^{M}$ in the admissible range of parameters.

Assume a cost-reducing innovation obtained by an independent laboratory, such that the good can be produced at unit cost $\underline{c} \in [0;\bar{c})$, becomes available. In the present model, such innovation can be interpreted as enhancing labour productivity through an increase in °: A patent of in…nite duration over the new technology is auctioned to the highest bidder between the incumbent and a potential entrant. If the outsider acquires the property rights over the innovation, a duopoly arises, with the following market demand function:

$$p = a - x^{I} - x^{E}; \tag{4}$$

where superscripts I and E identify the incumbent and the entrant, respectively. If entry occurs, simultaneous Cournot competition takes place. It can be easily shown that, notwithstanding the maximand of a labour-managed …rm is value added per worker, the measure of her ability to bid for an innovation is still represented by pro…t. Consider what follows. De…ne as $V_{lm}^{j} = (px_{lm}^{j} - k)=(cx_{lm}^{i}); j = E; I; M; c \in \{\underline{c};\bar{c}\}$; the value added per worker when the labour-managed …rm is, alternatively, the outside bidder, the incumbent, or the monopolist. According to the generic worker's participation constraint, the individual value added must be higher than the wage available as an outside option. As a consequence, the maximum amount of resources any member could be asked to forgo without exiting the …rm is $V_{lm}^{j} - 1$, given that the wage is normalized to one. In the aggregate, this yields $L(V_{lm}^{j} - 1) = px_{lm}^{j} - k - L = ¼_{lm}^{j}$: Hence, in order to establish whether the market remains monopolistic or instead is bound to become a duopoly, one has to evaluate the e¢ciency e¤ect, as measured by the following inequality:

$$¼^{M}(\underline{c}) \gtrless \text{ or } < ¼^{I}(\bar{c}) + ¼^{E}(\underline{c}): \tag{5}$$

If $¼^{M}(\underline{c}) \geq ¼^{I}(\bar{c}) + ¼^{E}(\underline{c})$, as is the case when both …rms maximize pro…ts (Gilbert and Newbery, 1982), the incumbent operating with the new tech-

nology is able to make at least as high a bid as the outside competitor, and monopoly persists. A priori, this is not necessarily the case if at least one …rm is labour-managed. However, the situation in which the incumbent is a pro…t-maximizing agent while the entrant is labour-managed leads to a straightforward result and can be quickly dealt with. Since ceteris paribus a pro…t-maximizing …rm gains higher pro…ts than a labour-managed counterpart, then it is immediate to verify that

$$¼^{M}_{pm}(\underline{c}) \; , \; ¼^{I}_{pm}(\overline{c}) + ¼^{E}_{pm}(\underline{c}) > ¼^{I}_{pm}(\overline{c}) + ¼^{E}_{Im}(\underline{c}); \tag{6}$$

so that monopoly persists, due to the fact that competition between an employee-controlled …rm and a pro…t-seeking one entails lower overall industry pro…ts as compared to the case where all agents aim at pro…t maximization, and consequently the e¢ciency e¤ect favours the incumbent even more than in the case described by Gilbert and Newbery (1982).[3] Hence, we have the following

Proposition 1 If a patent of in…nite duration on a cost-reducing innovation is o¤ered to the highest bidder to be chosen between a pro…t-maximizing incumbent and a labour-managed outsider, the former always wins and monopoly persists.

3 Bidding for the innovation in a labour-managed market

When both the incumbent and the (potential) entrant are labour-managed …rms, in order to ascertain what the outcome of the auction is going to be, one has to evaluate whether

$$¼^{M}_{Im}(\underline{c}) \; , \; \text{or} \; < ¼^{I}_{Im}(\overline{c}) + ¼^{E}_{Im}(\underline{c}); \tag{7}$$

where $¼^{M}_{Im} = k(a^2 ¡ 4k ¡ 4\underline{c}k)=a^2$: The following result obtains:

[3] As shown in Okuguchi (1993) and Lambertini (1996), if …rms were able to determine the timing of moves in an extended game (Hamilton and Slutsky, 1990), the pro…t-maximizing …rm would take the lead, while the labour-managed …rm would follow. This would strenghten the result even further.

Proposition 2 If a patent of in…nite duration on a cost-reducing innovation is o¤ered to the highest bidder to be chosen between two labour-managed …rms, monopoly persists if and only if the cost initially borne by the incumbent is higher than a critical threshold $\bar{c}^{\alpha}$:

Proof. See the appendix.

If the technology initially employed by the incumbent is characterized by a su¢ciently high marginal cost, the e¢ciency e¤ect favours the incumbent, in that the gain o¤ered by the innovation is so large that it leads to the persistence of monopoly. This can be given the following interpretation. When a …rm maximizes pro…t, she restricts output under monopoly, while she would increase (respectively, restrict) her output when faced with a large (respectively, small) …rm under Cournot competition, due to the presence of strategic substitutability in the quantity space, as described by the decreasing reaction function characterizing a Cournot pro…t-seeker.[4] If the incumbent is a labour-managed …rm, given the nature of her objective function and the consequent positive slope of her reaction function in duopoly, she aims at restricting production no matter what the degree of competition is. Though, under monopoly she restricts the output more than under duopoly, since in the latter case the increasing reaction function pulls her in the opposite direction, so that we end up observing that each labour-managed oligopolist produces more than she would if she stood alone in the market place. Hence, when it comes to her ability to compete for an innovation, she will pre-empt the outsider if and only if the parameter a¤ecting the old marginal cost is su¢ciently high to bring about a signi…cant loss. If this is the case, the pro…t she would get in case of entry is low enough to drive the persistence result. Otherwise, the tendency to lower output irrespectively of the environment, is bound to condemn the incumbent to loose the auction and accomodate entry.

[4] The concept of strategic substitutability/complementarity has been introduced by Bulow, Geanakoplos and Klemperer (1985). For the comparative statics characterizing oligopoly with pro…t-maximizing agents, see also Singh and Vives (1984) and Dixit (1986), inter alia.

4 Bidding for the innovation when the outsider is entrepreneurial

I shall now turn my attention to the case where the entrant is strictly aiming at pro…t maximization, while the incumbent is a labour-managed …rm. The outcome of the auction for a cost-reducing innovation is summarized by

Proposition 3 If a patent of in…nite duration on a cost-reducing innovation is o¤ered to the highest bidder to be chosen between a labour-managed incumbent and a pro…t-maximizing entrant, the latter wins and replaces the former as a monopolist.

Proof. See the appendix.

The above result is less straightforward than that observed in the reversed situation where the incumbent is a pro…t-seeker and the outsider is a labour-managed …rm. However, it lends itself to an interpretation on the very same grounds. Under Cournot competition and perfect certainty, a …rm's ability to bid for an innovation is directly measured by her pro…ts which, in turn, are proportional to her output level. Since a pro…t-maximizing …rm is, by de…nition, bigger than a labour-managed one, then the latter cannot prevent entry by the former, all the more if one observes that ultimately their respective bids depends on their respective pro…ts should each of them stand alone in the market with the new technology. As a last remark, it is worth observing that the switch from a labour-managed to a pro…t-maximizing monopoly is also socially welcome, both because of the obvious increase in output and because that output is produced at a lower cost.

5 Discussion

As a general appraisal, it can be observed that, since bidding for an innovation is proportional to the output level, the labour-managed …rm will exhibit a poorer performance than her pro…t-seeking counterpart when it comes to both output and technological progress. This is still another argument pointing at the by now well known issue of labour-managed …rms' ine¢ciency or "perversion", making the labour-managed …rm a lesser competitor to a pro…t-maximizing …rm, than a unit of the same nature would prove to be.

This has been highlighted by the existing literature under several respects (see Ireland, 1987; Delbono and Rossini, 1992; Okuguchi, 1993; Lambertini, 1996; Lambertini and Rossini, 1998), one being particularly worth mentioning, namely, the di¤erent reaction of a pro…t-maximizing …rm to the threat of entry. Horowitz (1991) and Stewart (1991) stress that a labour-managed unit is somewhat a lesser evil to a pro…t-maximizing enterprise than the latter is to the former, and this entails that a pro…t-maximizing …rm would always prefer to coexist with a relatively less aggressive labour-maximizing counterpart than with a rival of her kind. This seems to imply that a pro…t-seeking …rm would be more willing to accomodate (respectively, …ght) entry by a labour-managed (pro…t-seeking) …rm, rather than by a pro…t-seeking (labour-managed) unit. This statement solely relies upon the di¤erent decrease in pro…ts experienced by a pro…t-maximizing incumbent in the two settings, because, as it is usually the case in entry models, technology is available to all …rms and the property rights on it cannot be strategically used to prevent entry. This, on the contrary, is the case in innovation races and the measure of the e¢ciency e¤ect proves that it is easier for a pro…t-maximizing incumbent to acquire the innovation when the outside competitor is a relatively unaggressive labour-managed bidder. Mutatis mutandis, a similar argument applies when roles are reversed, producing as a result a pro…t-maximizing monopoly. Finally, if both bidders are labour-managed, the result of the auction depends on the ex ante level of marginal cost, in that the incumbent is in a position to achieve technological progress if she is su¢ciently ine¢cient so as not to be tempted to "sleep on her laurels".

Two caveats are in order. First, the above results are the outcome of a speci…c model and their validity under more general assumptions on demand and cost structure remains to be investigated. This holds, in particular, for propositions 2 and 3. Second, turning the labour-managed …rm into a workers' enterprise makes her able to …t the established norm according to which short-run size and output must be increasing in market price (Sertel, 1982, 1987). This suggests that the dynamic ine¢ciency of labour-managed …rms taking part in innovation races might well disappear if their members were the claimants over the income ‡ows generated by the innovation. Analogous considerations are likely to hold when the problem of separation between ownership and control is considered (Stewart, 1992). Hence, the labour-managed …rm depicted by the early theoretical approach appears to be an unviable economic institution. This is con…rmed by casual observation, and is all the more relevant on the policy front, when it comes to the problem

of privatisation in industries previously served by monopoly franchised public enterprises. This is the case, e.g., of postal service in many countries in Europe. Under this respect, the present paper suggests that, since labour continues to be a strong residual claimant in many of these public enterprises, both before and after privatisation, they may tend to behave like the labour-managed …rms modeled in this paper. To the extent they do, their competitors might …nd it easier to appropriate the bene…ts of technological innovation. The consequences could be the more harmful the more such innovations are labour-replacing, i.e., capital intensive.

6 Conclusions

The issue whether labour-managed …rms can challenge pro…t-maximizing …rms in the …eld of technical progress has been tackled in a model of Cournot competition under certainty. It emerges that entrepreneurial …rms do have a drastically superior ability in achieving cost-reducing innovation. In the light of the foregoing analysis, the threat of entry by labour-managed …rms appears indeed weak, at least when facing a pro…t-seeking incumbent. When instead the incumbent is of the same kind, the outsider acquires the rights on the innovation, and consequently enters, if the cost initially borne by the incumbent is low enough. In such a case, the gain the incumbent would enjoy by winning represents an insu¢cient incentive to pre-empt. Thus, it appears that the internal organization of …rms heavily a¤ects their ability to innovate. Finally, the persistence of monopoly, changing hands from a labour-managed to a pro…t-seeking one, in itself does not necessarily imply a (static) ine¢ciency, provided the innovation goes along with an increase in the output level.

Although derived under speci…c assumptions, these results, adding to the well known short-run ine¢ciency of the labour-managed …rm, produce some relevant policy implications and points to the need of a comprehensive reassessment of the employee-controlled …rm in Sertel's vein.

Appendix

Proof of Proposition 2. I proceed in two steps. First, I show that there exists an acceptable range of cost parameters where post-entry pro…ts are positive for both …rms. Second, I evaluate (7) within that range.

Step I. The objective functions, when the outside competitor wins the auction, are $V^I(\bar{c}) = (px^I - k)/[(x^I)^2\bar{c}]$ and $V^E(\underline{c}) = (px^E - k)/[(x^E)^2\underline{c}]$: The …rst order conditions for individual value-added maximization yield $x^I = x^E = (a - \sqrt{a^2 - 8k})/2$; provided $k < a^2/8$: Moreover, $x^I = x^E > x^M_{Im}$ over the acceptable range of parameters, due to the increasing best reply function characterizing labour-managed …rms (see Okuguchi, 1993). Substituting and simplifying, I obtain:

$$\pi^I_{Im} = \frac{[2a + \bar{c}(a - \sqrt{a^2 - 8k})](a - \sqrt{a^2 - 8k}) + 12k}{4}; \qquad (a1)$$

$$\pi^E_{Im} = \frac{[2a + \underline{c}(a - \sqrt{a^2 - 8k})](a - \sqrt{a^2 - 8k}) + 12k}{4}; \qquad (a2)$$

whose positivity entails the following constraint:

$$0 \cdot \underline{c} < \bar{c} < \mathbf{e} = \frac{2a(\sqrt{a^2 - 8k} - a) + 12k}{(a - \sqrt{a^2 - 8k})^2}; \qquad (a3)$$

which is tighter than the constraint concerning monopoly pro…ts.

Step II. I now evaluate the sign of $\pi^M_{Im}(\underline{c}) - \pi^I_{Im}(\bar{c}) - \pi^E_{Im}(\underline{c})$; simplifying to:

$$\frac{4a^2(a^2 - 6k) + (a + \bar{c} + \underline{c})(a - \sqrt{a^2 - 8k})^2 + 4k(a^2 - 4k - 4\underline{c}k)}{4a^2}; \qquad (a4)$$

which is linear in the cost parameters, and can be solved to obtain the unique critical threshold for $\bar{c}$. The root of the polynomial in (a4) is

$$\bar{c}^{\alpha} = \frac{2[a^3(2 + \underline{c})(\sqrt{a^2 - 8k} - a) + 2a^2k(5 + \underline{c}) + 8k^2(1 + \underline{c})]}{a^2(a - \sqrt{a^2 - 8k})^2}; \qquad (a5)$$

with sign $[\pi^M_{Im}(\underline{c}) - \pi^I_{Im}(\bar{c}) - \pi^E_{Im}(\underline{c})] = \text{sign}\,[\bar{c} - \bar{c}^{\alpha}]$: If $\mathbf{e} > \bar{c}^{\alpha}$, there exists an interval of parameters where $\pi^M_{Im}(\underline{c}) - \pi^I_{Im}(\bar{c}) - \pi^E_{Im}(\underline{c})$ can have both signs, otherwise it is always positive and monopoly persists in the admissible range. It can be veri…ed that

$$\partial \bar{c}^{\alpha} / \partial \underline{c} > \underline{c}^{\alpha} = \frac{4k(2+a^2) - a^3\sqrt{a^2-8k}(1-a)}{a^3\sqrt{a^2-8k}(a-1) - 4k(a^2+2k)}. \qquad \text{(a6)}$$

In turn, it must be $\partial > \underline{c}^{\alpha}$, which holds if $k > \hat{k} = (6 - a^2 + a\sqrt{a^2-3})/9$; where $\hat{k}$ is increasing and concave in a, with $\lim_{a \to 1} \hat{k} = 1/2$; $\hat{k} < a^2/8$ 8 $a > 0$: ■

Proof of Proposition 3. It suffices to verify that the incumbent's post-entry profits are negative in the admissible range of cost parameters. The objective functions are, respectively, $V_{Im}^{I} = (px_{Im}^{I} - k)/[\bar{c}(x_{Im}^{I})^2]$ and $\pi_{pm}^{E} = px_{pm}^{E} - \underline{c}(x_{pm}^{E})^2 - k$: Optimal output levels in duopoly are

$$x_{Im}^{I} = \frac{-a(1+2\underline{c}) + \sqrt{a^2(4\underline{c}^2+4\underline{c}+1) + 16k(1+\underline{c})}}{2}; \qquad \text{(a7)}$$

$$x_{pm}^{E} = \frac{a(3-2\underline{c}) - \sqrt{a^2(4\underline{c}^2+4\underline{c}+1) + 16k(1+\underline{c})}}{4(1+\underline{c})}. \qquad \text{(a8)}$$

Substituting and simplifying one obtains:

$$\pi_{Im}^{I} = \frac{\{(1+2\underline{c})[a(3+2\underline{c}) - \Phi] - 2\bar{c}(1+\underline{c})[\Phi - a(1+2\underline{c})]\}[\Phi - a(1+2\underline{c})]}{8(1+\underline{c})} - k; \qquad \text{(a9)}$$

$$\pi_{pm}^{E} = \frac{a[a(4\underline{c}^2+4\underline{c}+1) - (3+2\underline{c})\Phi]}{8(1+\underline{c})}; \qquad \text{(a10)}$$

where $\Phi = \sqrt{a^2(4\underline{c}^2+4\underline{c}+1) + 16k(1+\underline{c})}$: If the incumbent wins the auction, her profits are $\pi_{Im}^{M} = k(a^2 - 4k - 4\underline{c}k)/a^2$; so that $\underline{c} < (a^2-4k)/4k$: For the profit in (a9) to be positive, the following must hold:

$$\bar{c} < \bar{c}^{0} = \frac{(1+2\underline{c})[a(3+2\underline{c}) - \Phi][\Phi - a(1+2\underline{c})] - 8k(1+\underline{c})}{2(1+\underline{c})[\Phi - a(1+2\underline{c})]^2}. \qquad \text{(a11)}$$

In turn, though, it must be that $\bar{c}^{0} > \underline{c}$: Simple calculations show that this is never the case in the acceptable range of parameters. This, in combination with the inequality $\pi_{Im}^{M} < \pi_{pm}^{M}$; establishes the proposition. ■

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