***Production Competition in Electricity Sector: Social Welfare vs. Managerial Incentives in Partially Regulated Duopoly.***

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ABSTRACT

*Authors study production competition between two electricity producers, where one agent is subjected to a nationalization decision and the other private producer chooses managerial incentive to counterpart governmental actions. The government wants to maximize a modified form of social welfare and chooses partial nationalization, which still has serious impact on the rival private producer. We find out, that by offering managerial incentives the private producer recovers its lost profit and induces even less nationalization. Also, such equilibrium might have same level of the social welfare as compared to one without incentives.*

Keywords*: mixed duopoly, profit maximization, social welfare.*

## I. Introduction.

Certain state regulated companies and mixed ownership in economy are quite spread across different countries. While profit considerations led to privatization of many state-owned companies in transition economies, state presence has been frequently observed in energy sectors all over the world (check Barth *et al.* (2001) for evidence on EU countries, Sherif *et al.* (2003) for transition economies and Shirai (2002) for China and India.). And if the market is regulated then any entrance of private competitor, regardless if it is foreign or national stays under control of the government. At the same time, entry of private and foreign participators is typically

subject to state control. There is also widespread evidence of managerial incentive schemes in the corporate world (Jensen *et al*. (2004)). We will study a market where partially public electricity producer competes against a private company. We allow the state owned producer to define the level of privatization and private producer is allowed to set managerial incentives (which are normally reflected in salary bonus which depends on sales volume). Such studies might be helpful to model energy reforms.

We assume that the government is interested in maximization of the social welfare, but has a certain level of profit orientation. This profit orientation forces governmental firm to act as a private one. On the other hand, the private producer answer on the competition from pre public firms is to offer the competitiveness of the public one by offering revenue-linked incentives based on the sales volume to managers. The combination of managerial incentives and profit orientation will cause even greater privatization of the public company. As a consequence, a particular type of mixed duopoly emerges in which privatization is always partial and the private company always departs from (pure) profit maximization. More interestingly, in this mixed duopoly the government's profit orientation determines a certain level of industry profit, and the private producer's managerial incentives scheme forces a transfer of profit from the public producer to the private one leaving the social welfare unchanged.

This pure redistributive role of managerial incentives is possible only in a mixed duopoly. We also observe that the combination of partial nationalization and managerial incentive improves social welfare from the level of pure duopoly (involving only private agents) without managerial incentive.

While there is a vast literature on competition starting from the works of Monti (1972) and Klein (1971), non-profit-maximizing motives in economy have been gaining more and more attention nowadays.

There are many papers that have studied mixed duopoly, but only few deal with partial privatization (such as Fershtman, 1990; Matsumura, 1998), but there is a large literature on managerial incentives (see Vickers (1985), Fershtman and Judd (1987) and Sklivas (1987) etc). Bringing these two paradigms together,

We integrate these two literatures with the objective of simultaneously determining optimal privatization and managerial incentives.

The paper is organized as follows. Section I sets out the basic model and Section II discusses optimal privatization and managerial incentives.

The concluding section discusses policy implications.

Mixed ownership in economy is a common feature across different countries. While profit considerations led to privatization of many state-owned companies in transition economies, state presence has been frequently observed in energy sectors all over the world. See Barth *et al.* (2001) for evidence on EU countries, Sherif *et al.* (2003) for transition economies and Shirai (2002) for China and India. Even in the Anglo-Saxon economies, the recent credit crisis of 2007 subsequently led to nationalization of many banks and financial institutions. At the same time, entry of private and foreign participators is typically subject to state control. There is also widespread evidence of managerial incentive schemes in the corporate world (Jensen *et al.* (2004)). We will study such interactions between a partially public electricity producer and a private producer by allowing the former to choose the degree of public ownership and the latter managerial incentive prior to engaging in contract or price competition. Examining such interactions will also be helpful to model different reforms in energy sectors.

We assume that the government is obliged to maximize social welfare, but is also somewhat profit oriented. This profit orientation forces the government to privatize the public producer to some extent. The presence of a competitor makes the government internalize some of the strategic effects that state ownership, howsoever partial, might have on the other producer's profit. On its part, the private producer can counter the competitiveness of the public one by offering revenue-linked incentives to its manager. The combination of managerial incentives and profit orientation will cause even greater privatization of the public company. As a consequence, a particular type of mixed duopoly emerges in which privatization is always partial and the private company always departs from (pure) profit maximization. More interestingly, in this mixed duopoly the government's profit orientation determines a certain level of industry profit, and the private producer's managerial incentives scheme forces a transfer of profit from the public producer to the private one leaving the social welfare unchanged.

This pure redistributive role of managerial incentives is possible only in a mixed duopoly. We also observe that the combination of partial nationalization and managerial incentive improves social welfare from the level of pure duopoly (involving only private agents) without managerial incentive.

Then we consider the case of electricity price competition with contract differentiation where we show that the private company will offer profit linked incentives to its manager in equilibrium. The reason for incentives to be profit-linked is that the electricity price appears on the cost side of the private producer's balance sheet and different prices in different contracts are strategic complements. Therefore, by linking reward to profit the managers are essentially induced to increase contract prices, which will be reciprocated by the other competitor as well (due to strategic

complementarities). This is consistent with the price competition result of Fershtman and Judd (1987).

As for privatization, the result depends on the degree of private and public sector differentiation. If two markets are fairly apart then the government does not worry about the adverse effects of nationalization on the private agent (because such effects would be minimal) and maximizes social welfare through full nationalization. On the other hand, if the two contract types are close substitutes then the government cares about the adverse effects spilling over to the second market, and tends to increase the public agent's prices by undertaking partial privatization. Here, due to market differentiation it is difficult to ascertain whether the managerial incentives are merely redistributive as they were under contract competition. Nevertheless, here too managerial incentives are proving to be an effective means of countering the effects of nationalization.

While there is a vast literature on financial sphere competition starting from the works of Monti (1972) and Klein (1971), non-profit-maximizing motives in economy have been gaining more and more attention nowadays.

There are many papers that have studied mixed duopoly, but partial privatization concerns only a few (such as Fershtman, 1990; Matsumura, 1998). Even fewer papers have studied mixed duopoly in the electricity context

But there is a large literature on managerial incentives (see Vickers (1985), Fershtman and Judd (1987) and Sklivas (1987) etc).

We integrate these two literatures with the objective of simultaneously determining optimal privatization and managerial incentives.

The paper is organized as follows. Section II sets out the basic model and Section III discusses optimal privatization and managerial incentives.

The concluding section (IV) discusses policy implications.

## II. The Model.

We consider a two-stage game between a partially public and a fully private electricity producer. In the first stage, the government decides on the share of public ownership in the partially public firm, while the private producer decides on incentives. In the second stage the two producers engage in competition of the offered contracts: when electricity prices are regulated, as in many developing economies, producers tend to compete more in production. Profits are subsequently realized. We solve the game by backward induction, i.e., we first derive the equilibrium demand for the electricity (stage 2) and then the equilibrium ownership and managerial incentives of the public producer and private one, respectively (stage 1).

The public producer is indexed as **s** (state owned), and the private one indexed as **p** (private). Consumers have to pay electricity price $p$ :

$$p = s(D_s + D_p), s > 0 \quad (1)$$

Here $D_p$ and $D_s$ are the electricity volume produced by the private and the private agents, respectively, while *s* denotes the slope of the demand curve. On the revenue side, both producers face a constant rate of return *R* on each unit of electricity sold. Fixed *R* can be justified by assuming that technology levels and market access rules are fairly equal to both companies.

The public company is jointly owned by the government and private investors, and the choice of the volume of production is made by joint decision. If the private investors had full ownership, it would have maximized $\pi_1 = (R - r) D_s$ by choosing $D_s$ as

$$D_s = \frac{R - sD_p}{2s} \quad (2)$$

Denote this hypothetical reaction function as $RF_s^1$.

On the other hand, if the company was under full state ownership, the government would maximize social welfare W, which is defined as the sum of customer surplus (*S*) and profit ($\pi$) and is given by

$$S = pD - \int_0^D stdt = pD - sD^2/2 = sD^2/2 \quad (3)$$

$$W = S + \sum_{i=1}^{2} \pi_i \quad (4)$$

From (3) and (4) we obtain

$$S = (R - \frac{s}{2} D)D \text{ , where } D = D_s + D_p \quad (5)$$

Then, the government maximizes W by choosing $D_s$ as

$$D_s = \frac{R - sD_p}{s} \quad (6)$$

which would have been its reaction function. We denote it as $RF_s^2$. However, there must be a balance between the profit maximizing objective of the private agent and the social welfare objective of the government representative. This can be modeled in a number of ways. (See Kalashnikov et. al 2008) We take the approach suggested by Fershtman (1990) in which the public firm's production choice is given by a weighted reaction function, where weights are applied on the two extreme reaction functions – fully public (6) and fully private (2) – and the weights directly correspond to their respective shares of ownership. Thus, the reaction function of the public firm is

$$RF_s = \alpha RF_s^2 + (1-\alpha) RF_s^1 \quad (7)$$

where $\alpha \in [0, 1]$ is the degree of public ownership. Thus (6) can be rewritten as

$$D_s = \frac{(1+\alpha)(R - sD_p)}{2s} \quad (8)$$

As described by formulae (7) it permits for the government to determine the desired level of the profit for the electricity industry, still keeping in mind the social responsibility. Governments and regulators are known to be concerned about firm and industry performance especially in the electricity sector as it is vital to whole economy performance. A variety of measures are employed by governments to ensure that electricity sector is stable and still possibly profitable. While our model is deterministic and cannot allow for potential losses and even bankruptcy, we introduce the concern of government for industry profits by modifying its objective function. Thus, the government chooses $\alpha$ to maximize a modified social welfare function which places a higher weight on profit. The modified social welfare function (MW) is presented by

$$MW = S + \beta(\pi_1 + \pi_2) \quad (9)$$

Using (3) we can rewrite (9) as

$$MW = W + (\beta - 1)(\pi_1 + \pi_2) \quad (10)$$

We represent the $\beta$ coefficient as following: if $\beta = 1$ we have extremely social welfare oriented government, which is less realistic scenario in energy sector. Still, it may happen in such areas as medical care and so on, but barely in the area of electricity production; then if $\beta > 1$, the government has a certain interests in making profit. Thus, the profit part appears in the objective function for the state owned firm.

The private producer, though technologically identical to its public counterpart, may hire a manager and offer him/her incentives to boost its profit. Following the strategic delegation literature (see Vickers, 1985; Fershtman and Judd, 1987; Sklivas, 1987), we assume a linear incentive scheme which may reward (or penalize) the manager for generating revenue beyond the standard profit maximizing level. Now, the private firm CEO is interested in choosing $D_p$ in a way that maximizes

$$E_M = (1-\phi)\pi_2 + \phi D_p R \quad (11)$$

Depending on the owner's preference $\phi$ can take a wide range of values. The standard case of profit maximization is given by $\phi = 0$. If $\phi > 0$, then private firm managers are interested in sale volumes more than in making profit. At last, if $\phi < 0$ implies that the manager will be encouraged to pursue profit more than sales.

The manager maximizes the above objective function and his/her choice of $D_p$ gives the private producer's demand function (we will call it $RF_p$)

$$D_p = \frac{R-(1-\phi)sD_s}{2s(1-\phi)} \tag{12}$$

The reaction curves of the two producers are given by (8) and (12) and are presented in Figure 1.

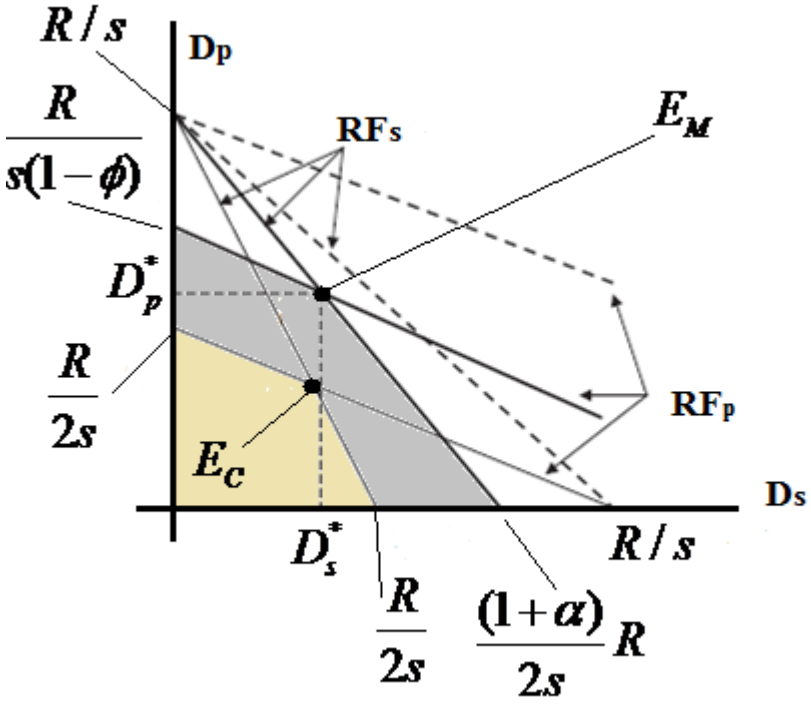


Figure 1. Reaction curves for public and private producers.

Two thick curves, denoted as $RF_S$ and $RF_P$, are drawn with the assumption that $\alpha \in (0, 1)$ and $\phi \in (0, 1/2)$. The downward slopes indicate that the production volumes are strategic substitutes. If the private agent chooses zero production, the public agent will choose its monopoly production as $(1+\alpha)R/2s$, and similarly, if the public producer chooses zero production the private one's manager will choose $D_p = R/2s(1-\phi)$. Conversely, if the private producer chooses $D_p = R/s$, the public one will simply close down, and similarly, the public one's choice of $D0 = R/b(1-\rho)$ will force the private producer to close down. Thus, the monopoly and entry deterring levels of demand can be defined in the usual way as quantity setting firms' outputs are defined. The equilibrium

demands are given by point $E_M(D_s^*, D_p^*)$ which we obtain as

$$D_s^* = R(1+\alpha)(1-2\phi) \Big/ s(3-\alpha)(1-\phi) \tag{13}$$

$$D_p^* = R\big(1-\alpha+\phi(1+\alpha)\big) \Big/ s(1-\phi)(3-\alpha) \tag{14}$$

It is clear that we must have $\phi$ <0.5 for $D_s$ to be positive. If indeed it were the case that $\phi \geq 0.5$, the public producer would be forced to close down, and the private one would produce $D_p = R/s$; however, its profit will fall to zero, which also suggests that the private producer will never set $\phi > 0.5$. This extreme situation is described by the two dashed reaction curves. On the other extreme, if $\alpha = 0$ and both producers were profit-maximizers (i.e., $\phi = 0$) we would have a pure duopoly. Both reaction curves would shift inward and we have the Cournot production volumes as $D_p = D_S = \frac{R}{3s}$. This is given by point $E_C$ at the intersection of two thinner reaction curves. Since point $E_M$ lies north-east of $E_C$, it is clear that the ***mixed duopoly generates much greater individual and aggregate production volumes*** than the private duopoly. As can be seen from (13) and (14), managerial incentive of the private producer and privatization of the public producer will both favor the private company and hurt the public one in terms of their production. Formally,

$$\frac{\partial D_S}{\partial \phi} < 0, \frac{\partial D_S}{\partial \alpha} > 0, \frac{\partial D_P}{\partial \phi} > 0, \frac{\partial D_P}{\partial \alpha} < 0 \qquad \text{if} \qquad \phi < 0.5 \tag{15}$$

Finally, if the private producer had set $\phi < 0$, its output would fall against any given $\alpha$ because its reaction function would shift inward starting from the situation of profit maximization. Consequently, its production would fall below the pure duopoly level. However, such a scenario is never profitable for the private producer. Therefore, we will not consider $\phi < 0$. Henceforth, our attention will be restricted to $\phi \in [0, 0.5]$ under production competition.

## III. Optimal Privatization and Managerial Incentives.

We now move to the first stage of the game and analyze the strategic interactions in terms of managerial incentives and privatization. For this we need to derive the private

producer's profit and the government's modified social welfare from the second stage equilibrium. From (13) and (14) we get

$$\pi_1 = \frac{R^2(1-\alpha^2)(1-2\phi)^2}{s(1-\phi)^2(3-\alpha)^2} \tag{16}$$

$$MW = \frac{R^2[2-\phi(1+\alpha)][2-\phi(1+\alpha)+\beta(1-\alpha)(1-2\phi)]}{s(1-\phi)^2(3-\alpha)^2} \tag{17}$$

$$\pi_2 = \frac{R^2(1-\alpha)(1-2\phi)[(1-\alpha)+\phi(1+\alpha)]}{s(1-\phi)^2(3-\alpha)^2} \tag{18}$$

It is very important to note is that both for $\pi_{1,2} > 0$ $\alpha < 1$. Without some privatization two companies cannot operate. Further, in the pure duopoly case, i.e., when $\alpha, \phi = 0$, each company earns $\pi_{1,2} = \frac{R*R}{9s}$.

The government and the private producer determine their respective choice variables, i.e., $\phi$ and $\alpha$ at same time. The private producer's owner chooses $\rho$ by maximizing (18) as follows:

$$\phi(\alpha) = \frac{1+\alpha}{5+\alpha} \tag{19}$$

This is the private agent's 'incentive reaction function', which is upward sloping in $\alpha$ (see Figure 2). Starting from a situation of complete nationalization, as the public producer starts privatization process ($\alpha$ goes down); in that case $D_S$ falls, $D_P$ rises (assuming $\phi < 0.5$) and the private investor starts to turning down sales incentives. Alternatively stated, in a situation of pure duopoly, the private agent can enjoy its highest profit by setting $\phi$ = 0.20. Now if the government executes its power using public producer, the private agent will experience a loss in profit. To make up for the lost profit, it will then raise its revenue incentive above 0.20. Thus, the greater is $\alpha$, the greater is $\phi$. The managerial incentive is a strategic complement to nationalization, or a strategic substitute to privatization (which is measured by $1 - \alpha$). Starting from a situation of complete nationalization, as the public producer reduces $\alpha$ $D_S$ falls, $D_P$ rises (assuming $\phi < 0.5$), and the private producer reduces its aggressiveness by cutting down on its sales incentives. (or incentives to increase production). To solve for the public producer's response, we maximize MW with respect to $\alpha$. These yields

$$\alpha = \frac{2-\beta-\phi(1+\beta)}{\beta-\phi(3\beta-1)} \tag{20}$$

Here is important to mention some points.

First, if $\beta = 1$, optimal $\theta$ is 1 regardless of $\rho$. Second, given $\phi < 1/2$ and $\beta > 1$, government's choice of privatization is partial. That is, $\alpha \in (0, 1)$. Third, when $\phi = 0$, the resulting privatization is still partial, $0 < \alpha < 1$. This is because the government is now concerned about profit and driving consumer surplus to its maximum by setting $\alpha = 1$ inflicts losses for both producers.

Fourth, from the government's point of view nationalization (privatization) and managerial incentives are strategic substitutes as $\alpha(\phi) < 0$. This is exactly opposite of the perspective the private producer has. This is where mixed duopoly is crucially different from pure duopoly. As the government is not only concerned about private agent's profit, but also values the industry profit relatively more than consumer surplus, it internalizes some of the negative effects on profit that would follow from aggressive production by both companies. So when the private producer is expected to increase its production incentives (thus inducing greater aggression by its manager in the second stage), the public company divests its ownership to reduce the public producer's aggression, in order to contain the overall level of production. Thus, the government accommodates the private agent's aggression through privatization.

We derive the Nash equilibrium from the intersection of the two reaction functions, i.e., the nationalization reaction function of the public company and the incentive reaction function of the private company. Equilibrium $\alpha$ and $\phi$ are given as follows:

$$\alpha^* = \frac{3-2\beta}{2\beta-1} \tag{21}$$

$$\phi^* = \frac{1}{4\beta-1} \tag{22}$$

The solution is graphically shown in Figure 2. In order to ensure an interior solution we need to assume that the vertical intercept of the nationalization reaction function is greater than that of the incentive reaction function. This gives an upward limit on $\beta$, i.e., $\beta < 3/2$. Beyond this level of $\beta$, the government becomes too profit oriented and hence would prefer to fully privatize the public agent. Therefore, for $\beta \in (1, 3/2)$, (22)-( 23) give the equilibrium solution of $\alpha$ and $\phi$.

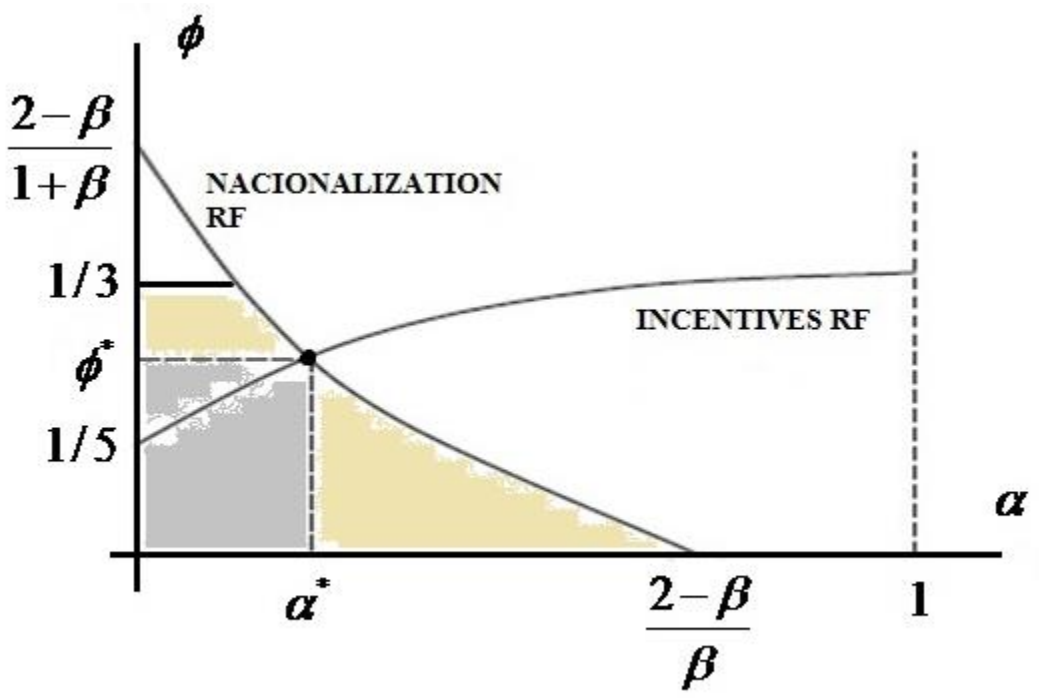


Figure 2. Privatization and managerial incentives.

Let us consider two different situations.

First, if there were no private producers at all, what would be the optimal privatization? This can be determined by considering that if $D_P = 0$ and $D_S = {(1+\alpha)R}/{2s}$ would be optimal yielding $MW = \left(R^2/8s\right)(1+\alpha)[1+\alpha+2\beta(1-\alpha)]$ and maximizing it one gets an optimal $\alpha^* = {1}/{2\beta-1}$. This optimal privatization depends only on $\beta$ coefficient. If $\beta$=1 then $\alpha^* = 1$, so that divestment in monopoly case is optimal only if there is certain profit concern.

Second, if the government has no additional concern for profit (i.e., if $\beta$ = 1) its reaction curve would be vertical at $\alpha$ = 1 and the only Nash equilibrium is then $\phi$ = 1/3 and $\alpha$ = 1. At $\phi$ = 1/3 we can see from Figure 1 that both $D_P, D_S > 0$. Thus, both producers have positive production volumes, and making no profit. Such situation does not allow for industry to develop extra capacities, imply research and development strategies etc and thus will lead to the bankruptcy of the whole industry.

Still, by using sales-oriented managerial incentives the private firm can prevent the exit from the industry, even earning only zero profit. So the managerial incentive can be seen as a survival strategy of private firm in the face of complete nationalization. In this environment, therefore, the government can make the mixed duopoly solvent by having some additional concern for profit. From the second stage equilibrium demand is as given in (13)-(14) we derive the total production as

$$D = \frac{R[2-\phi(1+\alpha)]}{s(1-\phi)(3-\alpha)} \tag{23}$$

If we plug in the values of $\phi$ and $\alpha$ from the formulas (21) and (22) we get the equilibrium value

$$D^* = \frac{R\beta}{b(2\beta-1)} \tag{24}$$

Now it is possible to describe the above discussion as:

***Theorem:*** *A) If the government is profit oriented (i.e., $\beta$ > 1), the Nash equilibrium is characterized by the public producer being partially privatized and the private producer offering managerial incentives. Compared to the 'no managerial incentives' case, privatization degree is larger.*

*B) Social welfare in a mixed duopoly with equilibrium privatization and managerial incentives is higher than that in a private duopoly without managerial incentives; but it is the same as that in a mixed duopoly without managerial incentives. Thus in a mixed duopoly, managerial incentives become merely redistributive having no efficiency effect.*

## IV. Conclusions.

We have studied special cases of partial privatization of the state owned firm and an optimal strategy for the private producer, presented as incentives to increase the sales volumes. It is shown, that if the government is interested in profit making then it will order partial privatization of the energy industry; as the response, the private electricity producer will offer sale volume incentive to it managers, in order to increase competition. It is also shown that the level of privatization is higher when private producer does not offer sale volume incentives. Due to that, we conclude that partial privatization and revenue incentives are the preferable option for the customer. It is important to mention, that in our model the level of the profit orientation of the state agent is the most important factor to determine the total industry profit; on the other hand, the managerial incentives are responsible for profit distribution between companies. Moreover, profit orientation and managerial incentives appear to be playing two distinct roles. Profit orientation determines the industry profit and managerial incentives determine its distribution between two producers. This merely redistributive role of managerial incentive seems to be possible only in a mixed duopoly. Thus, for a

government which still has certain profit orientation it is advisable to make partial privatization facing strong competitor from the abroad. Vice versa, in case of private agent, in order to lower possible grade of nationalization it is advisable to offer sales volume incentives to it managers.

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**APPENDIX:**

*Proof of the Theorem:*

$D^*$ with the aggregate demand in two cases: (1) pure duopoly without managerial incentives, and (2) mixed duopoly without managerial incentives.

(1) In the first case, total demand is $D = 2R/3s$ which is obtained by substituting $\phi = \alpha = 0$ in (10). Since $\beta > 1$, $D^* > 2R/3s$. That is, social welfare is higher in the mixed duopoly compared with the case of a private duopoly without managerial incentives.

(2) In the second case, we derive the aggregate supply by substituting $\alpha = (2-\beta)/\beta$ (which is the optimal value of $\alpha$ when $\phi = 0$) in (10). These yields $D = \frac{R\beta}{s(2\beta-1)}$ which is exactly the same as (24).

Therefore, social welfare in the mixed duopoly with managerial incentives is same as that in a mixed duopoly without managerial incentives. Since $D$ is the same in both situations, consumer surplus is the same and therefore the industry profit is unchanged. But we know from (16)-(18) that the public producer's profit will fall with an increase in $\phi$. Thus, the managerial incentive is playing a merely redistributive role with no effect on efficiency, which is entirely determined by the government's profit orientation.

In a pure duopoly managerial incentives (offered by two private producers) lead to mutual over-production, and this generates higher social welfare but lowers industry profit. In a mixed duopoly with partial privatization the level of privatization depends on the profit orientation level. In an extreme, when the government is not profit oriented at all (e.g. $\beta = 1$) then the industry profit will be zero. Managerial incentives of the private producer will still be able to induce a redistribution of total demand but there will be no profit to redistribute. In case of $\beta > 1$ the optimal privatization level in the absence of managerial incentive will give industry profit $\pi = R^2\beta(\beta-1)/s(2\beta-1)$.

If now the private producer offers managerial incentives, the government will further nationalize the state owned agent, so that the industry profit and social welfare remain the same, but the private agent's profit rises at the expense of the public one's and this redistribution of profit happens due to the re-distribution of the production volumes.

**End of the proof.**