FINANCING A NATIONALIZED MONOPOLY: COASE´S VERSUS HOTELLING-LERNER´S SOLUTION*

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ABSTRACT

Coase (1946) rejected the superiority of Hotelling-Lerner solution upon average-cost pricing in face to finance a nationalized monopoly due to taxes being distortionary. In this paper, we show that this conjecture is not generally true. According to the utilitarian criterion, we find a distortionary Hotelling-Lerner tax policy which improves upon the average cost pricing.

Key words: Distortionary taxation, Lump-sum taxation, Optimal taxation, Price-average cost equilibrium, Second-best.

RESUMEN

Coase (1946) rechazó la superioridad de la solución de Hotelling-Lerner sobre el equilibrio precio-coste medio debido a la distorsión causada por los impuestos. En este trabajo se muestra que esta congetura no es cierta en general. Encontrando que, de acuerdo con el criterio utilitarista, es posible una política fiscal Hotelling-Lerner distorsionante que mejora el equilibrio precio-coste medio.

Palabras clave: Imposición distorsionante, Impuestos de capitación, equilibrio precio-coste medio, Optimo subsidiario.

1. INTRODUCTION

The solution of Hotelling (1938) and Lerner (1946) to the problem of the optimal policy for a nationalized monopoly, against average cost pricing, consists of equalizing market price to marginal cost and financing the losses derived from economies of scale by non-distortionary (lump-sum) taxation. Coase (1946) puts forward three objections against this solution: first, marginal cost pricing does not necessarily guarantee efficiency; second, the Hotelling-Lerner solution could alter income distribution; and third, the non-distortionary character of taxes actually was a theoretical abstraction and taxes were, in general, distortionary. Coase suggested average cost pricing as a better alternative for the case in which two part tariffs are unfeasible.[1] In his own words: *"the claim which is made for the Hotelling-Lerner solution as inevitably superior to average cost pricing must therefore be rejected"* (Coase, 1946, p. 181).

The present paper compares both solutions for the case of a single-output monopoly focusing on the third objection. For these purposes I will consider the usual version of average cost pricing (the so-called Coase's solution) and a distortionary version of the Hotelling-Lerner solution, where the planner equates the price of the monopolized good to its marginal cost while losses arising from economies of scale are financed by proportional taxes or

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[1] Two part tariffs were claimed to be efficient by Coase; Vohra (1990) demonstrates that Coase's conjecture does not generally hold.

subsidies on the remaining private goods. As we will see the formulation used will allow us to characterize average cost pricing as a particular outcome of the class of distortionary Hotelling-Lerner policy. This will let us compare both policies within the same framework, obtaining that, in general, average cost pricing is not second-best optimum. Then there will be a distortionary Hotelling-Lerner tax policy, in particular the second-best tax policy, which improves according to the utilitarian criterion, average cost pricing against Coase's statement.

2. MODEL AND RESULTS

Let us consider an economy with three goods[2]; leisure, denoted by x, which is the *numeraire*, the good offered by the nationalized monopoly, denoted by y, and a private good, denoted by z, produced under perfect competition. We make the following assumptions:

A1: There are n consumers. The ith consumer is endowed with a strictly positive initial quantity of *numeraire* w_i. Let $l_i = w_i - x_i$ be the amount of labor supplied by consumer i. $(x_i,y_i,z_i) \in \mathbb{R}^3_+$ represents his consumption

[2] This is adopted for the sake of simplicity, similar results can be reached with more than three goods. Otherwise, if there are only two goods, there would be one tax policy equivalent to average-cost pricing, i.e., both solutions would be the same.

vector. The preferences of the ith consumer are represented by a utility function $u_i:\mathbb{R}^3_+ \longrightarrow \mathbb{R}$, which is assumed to be strictly concave and increasing. Demand correspondences of private goods $x_i(\bullet)$ and $z_i(\bullet)$ will be assumed as strictly positive in their arguments[3].

A2: There are r perfectly competitive firms producing good z. We denote by s_j the output of jth firm and by $C_j(s_j)$ its cost function. We will assume constant returns, and consequently the profits of the firm j are zero. Denoting by q the equilibrium price (i.e. the marginal cost), market equilibrium requires that:

$$\sum_{j=1}^{r} \hat{s}_j = \sum_{i=1}^{n} z_i. \qquad (1)$$

A3: The cost function of the nationalized monopoly is given by:

$$C(y) = \begin{cases} k + c\,y & \text{if } y > 0 \\ 0 & \text{if } y = 0 \end{cases}, \qquad (2)$$

[3] This is because if one of the private goods was not demanded for some price, the model would become one with two commodities, then both solutions would be the same (see the previous footnote).

where c and k are constants satisfying $c > 0$, $0 < k < \sum_{i=1}^{n} w_i$; and $y = \sum_{i=1}^{n} y_i$. Denoting by T the tax revenue of the public sector, the budgetary equilibrium is given by:

$$T + p\,y = C(y)\ , \tag{3}$$

where p is the price set by the public sector for the consumption of y. Notice that for T = 0, (3) is just the price-average cost restriction. The feasibility condition in the labor market is:

$$\sum_{i=1}^{n} l_i = C(y) + \sum_{j=1}^{r} C_j(s_j)\ . \tag{4}$$

The following lemma states that the budgetary equilibrium for the public sector (3) implies equilibrium in the labor market (4), and *vice-versa.*

Lemma 1. *The budget of the public sector is balanced if and only if feasibility condition for the numeraire good holds.*

The proof is an immediate consequence of Walras law. This result allows us to use equation (3) instead of (4), which will be useful in following calculations.

We will now specify the functional form of T. We assume that taxes are proportional and anonymous. Let us denote by $t_1 \in [-1,1]$ the tax (subsidy) rate on income and by $t_2 \in [-1,1]$, the ad valorem tax (subsidy) rate on good z.

An *economic policy* is a triple $\{p, t_1, t_2\} \in \mathbb{R}_+ \times [-1,1]^2$ satisfying:

$$p\,y + t_1 \sum_{i=1}^{n} (w_i - x_i) + t_2\, q \sum_{i=1}^{n} z_i = k + cy\ . \tag{5}$$

This allows us to define the following policies:

(a) $\{\bar{C},0,0\}$ *as Coase's solution or the price-average cost policy (PAC policy), where* $\bar{C} = C(y)/y$.

(b) $\{c,t_1,t_2\}$ *as distortionary Hotelling-Lerner solution (DHL tax policy) where c is the marginal cost for producing good y and:*

$$t_1 \sum_{i=1}^{n} (w_i - x_i) + t_2\, q \sum_{i=1}^{n} z_i - k = 0\ . \tag{6}$$

Notice that Lemma 1 implies that (5) and (6) are equivalent to the labor market feasibility condition. We now define our two equilibrium concepts.

Definition 1. *Price-Average Cost Equilibrium (PACE)*

The allocation $\{ (x_i^m, y_i^m, z_i^m) \}_{i=1}^{n}$ *is a PACE if, given the PAC policy, it satisfies (1) and (4), and* $\forall\ i = 1, 2,\dots, n$ (x_i^m, y_i^m, z_i^m) *solves the program:*

$$\begin{cases} Max\ u_i(x_i, y_i, z_i) \\ s.t\quad w_i \geq x_i + \bar{C}_m\, y_i + q\, z_i \end{cases}\ , \tag{7}$$

where $\bar{C}_m = C(y^m)/y^m$.

Definition 2. *Tax Equilibrium (TAXE)*

The allocation $\{ (x_i^t, y_i^t, z_i^t) \}_{i=1}^{n}$ *is a TAXE if, given the DHL tax policy, it satisfies (1) and (4), and* $\forall$ *i = 1, 2,...,n* (x_i^t, y_i^t, z_i^t) *solves the program:*

$$\begin{cases} \text{Max} \ u_i(x_i, y_i, z_i) \\ \text{s.t} \quad (1-t_1)(w_i - x_i) \geq c\, y_i + (1+t_2) q\, z_i \end{cases} \quad (8)$$

The next Lemma shows that there are taxes such that TAXE equals PACE.

Lemma 2. *The DHL tax policy {c, t,-t} with t =* $1 - c/\bar{C}_m$ *generates a TAXE which equates the PACE.*

Proof: Plugging the DHL tax policy {c, t, -t}, with $t = 1 - c/\bar{C}_m$, into the consumers' budget constraint of (8) and comparing with (7). ∎

We denote the above DHL tax policy as DHL-PAC equivalent policy. This result leads us to obtain average cost pricing as a particular outcome of the class of DHL tax policy, allowing comparisons among other tax policies. Notice that in the DHL-PAC equivalent policy t is a measure of the returns of scale of the monopolized good; this occurs because t is proportional to the scale elasticity ($\varepsilon = \bar{C}/c$).

We now define a second-best tax policy through the concept of optimal taxation of Atkinson and Stiglitz (1972). First we will assume that the Social Welfare Function (SWF) is utilitarian. Given the set of feasible policies, the

social planner chooses those values of the fiscal instruments that maximize the SWF. Let $V_i(t_1,t_2)$ denote the indirect utility function of the ith consumer. Then, we have the following:

Definition 3. *Second-Best DHL Tax Policy (SBTP).*

The DHL tax policy $\{c, \hat{t}_1, \hat{t}_2\}$ *is a SBTP if it solves the following problem:*

$$\begin{cases} \text{Max} \ \sum_{i=1}^{n} V_i(t_1,t_2) \\ \text{s.t.} \quad t_1 \sum_{i=1}^{n} l_i + t_2\, q \sum_{i=1}^{n} z_i \geq k \end{cases} \quad (9)$$

calling μ the Lagrange multiplier of (9) and λ_i the ith consumer's marginal utility of income, we find that:

$$\partial V_i/\partial t_1 = -\lambda_i l_i \ , \quad \partial V_i/\partial t_2 = -\lambda_i q\, z_i \ . \quad (10)$$

The first order conditions of (9), by the interiority conditions assumed in A1, can be written as:

$$\sum_{i=1}^{n} \frac{(\mu-\lambda_i)}{\mu} l_i = t_1 \sum_{i=1}^{n} \frac{\partial x_i}{\partial t_1} - t_2\, q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_1} \quad (11)$$

$$\sum_{i=1}^{n} \frac{(\mu-\lambda_i)}{\mu} q z_i = t_1 \sum_{i=1}^{n} \frac{\partial x_i}{\partial t_2} - t_2 q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_2} , \tag{12}$$

Equations (11) and (12) define the second-best DHL tax policy $\{c, \hat{t}_1, \hat{t}_2\}$. According to Dierker (1991) and because of A1, A2, and A3, second-order conditions are fulfilled.

Proposition 1. *If at the SBTP* $y_i > 0$ *for some consumer i, then PACE is not a SBTP.*

Proof: Assume that PACE is generated by the SBTP. Thus, by Lemma 2, the DHL PAC-equivalent tax policy $\{c, t, -t\}$ with $t = 1 - c/\bar{C}_m$ maximizes (9). This implies that this policy must satisfy equations (11) and (12). Denoting by $\{(y_i^*, x_i^*, z_i^*)\}_{i=1}^{n}$, with $l_i^* = w_i - x_i^*$ and $y_i^* > 0$ for some i, the PACE is given by:

$$\sum_{i=1}^{n} \frac{(\mu-\lambda_i)}{\mu} l_i^* = t\left[\sum_{i=1}^{n} \frac{\partial x_i}{\partial t_1}(t,-t) + q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_1}(t,-t) \right] \tag{13}$$

$$\sum_{i=1}^{n} \frac{(\mu-\lambda_i)}{\mu} q z_i^* = t\left[\sum_{i=1}^{n} \frac{\partial x_i}{\partial t_2}(t,-t) + q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_2}(t,-t) \right] , \tag{14}$$

subtracting (14) from (13)

$$\sum_{i=1}^{n} \frac{(\mu-\lambda_i)}{\mu} (l_i^* - q z_i^*) = t\, \Gamma , \tag{15}$$

$$\text{where } \Gamma = \sum_{i=1}^{n} \left[\frac{\partial x_i}{\partial t_1}(t,-t) + q \frac{\partial z_i}{\partial t_1}(t,-t) - \frac{\partial x_i}{\partial t_2}(t,-t) - q \frac{\partial z_i}{\partial t_2}(t,-t) \right].$$

However, under PACE $l_i^* = \bar{C}_m y_i^* + q z_i^*$, (15) can be written as:

$$C(y^*) - \bar{C}_m \sum_{i=1}^{n} \beta_i y_i^* = t\, \Gamma \tag{16}$$

with $\beta_i = \lambda_i/\mu > 0$; $i = 1,2,\dots,n$.

Denoting by ϑ the surplus of the public budget from (6) we have that:

$$\frac{\partial \vartheta}{\partial t_1} = \sum_{i=1}^{n} l_i - t_1 \sum_{i=1}^{n} \frac{\partial x_i}{\partial t_1} + t_2 q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_1} = 0 \tag{17}$$

$$\frac{\partial \vartheta}{\partial t_2} = \sum_{i=1}^{n} q z_i - t_1 \sum_{i=1}^{n} \frac{\partial x_i}{\partial t_2} + t_2 q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_2} = 0 , \tag{18}$$

plugging the PAC-equivalent policy $\{c,t,-t\}$ with $t = 1 - c/\bar{C}_m$ (and its allocation) into (17) and (18), we find that:

$$\sum_{i=1}^{n} l_i^* = t \left[\sum_{i=1}^{n} \frac{\partial x_i}{\partial t_1}(t,-t) + q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_1}(t,-t) \right] \tag{19}$$

$$\sum_{i=1}^{n} q z_i^* = t \left[\sum_{i=1}^{n} \frac{\partial x_i}{\partial t_2}(t,-t) + q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_2}(t,-t) \right] , \tag{20}$$

subtracting (20) from (19) and simplifying,

$$C(y^*) = t\,\Gamma \; . \tag{21}$$

Finally, from (21) and (16) we obtain that:

$$\sum_{i=1}^{n} \beta_i y_i^* = 0 \; ,$$

which holds if and only if $y_i^* = 0 \; \forall \; i = 1,2,\ldots,n$. Contradiction.■

Proposition 2. *If at the SBTP* $y_i > 0$ *for some consumer i, there is at least one DHL tax policy which improves upon average cost pricing.*

Proof: As a consequence of proposition 1 price-average cost equilibrium is not a second-best, therefore it is possible to choose a distortionary Hotelling-Lerner solution, in particular the second best tax policy, which improves upon average cost pricing.■

3. CONCLUSION

Even supporting Coase's criticism about the distortionary character of the taxes proposed by Hotelling and Lerner, the paper shows that it is possible to choose a (distortionary) tax scheme which improves average-cost pricing policy for the case of a single-output monopoly. The particular way in which Hotelling-Lerner's policy was defined (DHL tax policy) allows us to find Coase's solution as a particular outcome of the class of the DHL tax policy. This feature leads us to compare average cost-pricing with other fiscal policies. Concluding that, in general, the above policy differs from the second best tax policy.

APPENDIX

A.1. Lemma 1

The budget of the public sector is balanced if and only if feasibility condition for the numeraire good holds.

Proof: Denoting by $\vartheta_{ij} \in [0,1]$ the participation of consumer i in the profits of firm j, where $\sum_{i=1}^{n} \vartheta_{ij} = 1 \ \forall \ j = 1,2,...r$, and by T_i the taxes paid by consumer i with $T = \sum_{i=1}^{n} T_i$, the budget balance of i implies that:

$$\sum_{j=1}^{r} \vartheta_{ij} \Pi_j + w_i = T_i + x_i + p\, y_i + q\, z_i \qquad (A.1)$$

adding over consumers:

$$\sum_{j=1}^{r} \Pi_j + \sum_{i=1}^{n} w_i = T + \sum_{i=1}^{n} x_i + p\, y + q \sum_{i=1}^{n} z_i \qquad (A.2)$$

Profits are given by:

$$\sum_{j=1}^{r} \Pi_j = q \sum_{j=1}^{r} z_j - \sum_{j=1}^{r} C(z_j) \qquad (A.3)$$

plugging in (L.2) we have:

$$\sum_{i=1}^{n} w_i - \sum_{i=1}^{n} x_i - \sum_{j=1}^{r} C(z_j) = T + p\, y \qquad (A.4)$$

Therefore if the market of the *numeraire* good is in equilibrium, the left hand side of (A.4) is equal to C(y) and (3) is holds. On the other hand, if (3) occurs, from the right hand side of (A.4), we obtain the feasibility condition (4).■

A. 2. Derivation of the second-best tax policy (SBTP); formulas 10, 11, and 12.

The Lagrangian associated with (9) is

$$\mathcal{L}(t_1,t_2) = \sum_{i=1}^{n} V_i(t_1,t_2) + \mu \left\{ t_1 \sum_{i=1}^{n} l_i + t_2\, q \sum_{i=1}^{n} z_i - k \right\} \qquad (A.5)$$

whose first order conditions are:

$$\sum_{i=1}^{n} \frac{\partial V_i}{\partial t_1} + \mu \left[\sum_{i=1}^{n} l_i - t_1 \sum_{i=1}^{n} \frac{\partial x_i}{\partial t_1} + t_2\, q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_1} \right] = 0 \qquad (A.6)$$

$$\sum_{i=1}^{n} \frac{\partial V_i}{\partial t_2} + \mu \left[q \sum_{i=1}^{n} z_i - t_1 \sum_{i=1}^{n} \frac{\partial x_i}{\partial t_2} + t_2 q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_2} \right] = 0 \qquad \text{(A.7)}$$

Let us consider the individual maximization problem under the DHL tax policy, given by (8):

$$\begin{cases} \text{Max} \quad u_i(x_i, y_i, z_i) \\ \text{s.a} \quad (1-t_1)(w_i - x_i) \geq c\, y_i + (1+t_2) q\, z_i \\ \qquad \text{with } (t_1, t_2) \in [-1,1]^2 \end{cases} \qquad \text{(A.8)}$$

Denoting with λ_i the multiplier of Lagrange associated with (A.8), the first order conditions are given by:

$$\partial u_i / \partial x_i = \lambda_i \, (1 - t_1) \qquad \text{(A.9)}$$

$$\partial u_i / \partial y_i = \lambda_i \, c \qquad \text{(A.10)}$$

$$\partial u_i / \partial z_i = \lambda_i \, (1 + t_2) \qquad \text{(A.11)}$$

differentiating the budget constraint (A.8) with respect to t_1 and t_2,

$$- l_i = (1 - t_1) \frac{\partial x_i}{\partial t_1} + c \frac{\partial y_i}{\partial t_1} + (1 + t_2)\, q \frac{\partial z_i}{\partial t_1} \qquad \text{(A.12)}$$

$$- q\, z_i = (1 - t_1) \frac{\partial x_i}{\partial t_2} + c \frac{\partial y_i}{\partial t_2} + (1 + t_2)\, q \frac{\partial z_i}{\partial t_2} \qquad \text{(A.13)}$$

Otherwise, the indirect utility function is defined as follows:

$$V_i(t_1, t_2) = u_i[x_i(t_1,t_2),\, y_i(t_1,t_2),\, z_i(t_1,t_2)] \qquad \text{(A.14)}$$

Differentiating with respect to t_j, j = 1,2 we get that:

$$\frac{\partial V_i}{\partial t_j} = \frac{\partial u_i}{\partial x_i} \frac{\partial x_i}{\partial t_j} + \frac{\partial u_i}{\partial y_i} \frac{\partial y_i}{\partial t_j} + \frac{\partial u_i}{\partial z_i} \frac{\partial z_i}{\partial t_j}, \quad j = 1,2. \qquad \text{(A.15)}$$

Taking (A.9), (A.10) and (A.11) into account,

$$\frac{\partial V_i}{\partial t_j} = \lambda_i \left[(1 - t_1) \frac{\partial x_i}{\partial t_j} + c \frac{\partial y_i}{\partial t_j} + (1 + t_2)\, q \frac{\partial z_i}{\partial t_j} \right], \quad j = 1,2. \qquad \text{(A.16)}$$

using (A.12) and (A.13)

$$\partial V_i / \partial t_1 = - \lambda_i l_i \qquad \partial V_i / \partial t_2 = - \lambda_i q\, z_i \qquad \text{(A.17)}$$

Therefore (10) is proved. Finally, substituting (A.17) in (A.6) and (A.7) and operating, we obtain the conditions:

$$\sum_{i=1}^{n} \frac{(\mu - \lambda_i)}{\mu} l_i = t_1 \sum_{i=1}^{n} \frac{\partial x_i}{\partial t_1} - t_2 q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_1} \qquad (11)$$

$$\sum_{i=1}^{n} \frac{(\mu - \lambda_i)}{\mu} q\, z_i = t_1 \sum_{i=1}^{n} \frac{\partial x_i}{\partial t_2} - t_2 q \sum_{i=1}^{n} \frac{\partial z_i}{\partial t_2} \qquad (12)$$

which characterize the SBTP.■

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