A MODEL OF CORRUPTION IN AN INVESTMENT PROJECT

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ABSTRACT: The present paper analyzes the phenomenon of corruption in the context of a Public Works Department (PWD) in a developing country city and examines its tenacity in the face of anticorruption measures. Different behaviour patterns of the supervisor (official) of the PWD have been considered. The interesting result to emerge is that corruption may show a high degree of robustness against marginal attacks and such measures may actually be counterproductive in the different cases considered in this paper.

Keywords: Corruption, investment project, supervisor, contractor, bribe, anticorruption measures.

JEL classification: C71, D72, H54

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1. Introduction:

Wide spread corruption in the agencies entrusted with building and maintaining the infrastructure goes a long way in explaining the poor performance of the developing countries. Although the phenomenon is by no means unheard of in the affluent societies, there is little doubt that the significance of shady transactions as a proportion of GNP is much less compared to that in the developing countries. Although some studies have pointed out the desirability of some corruption on the ground that it enables entrepreneurs to overcome cumbersome regulations, most of the studies conclude that corruption slows down economic development (Gould and Amaro-Reyes 1983, Klitgaard 1991, etc.).

Neither the private nor the public sector of a developing country is free from corruption. But it is much more difficult to detect and check corruption in the public sector because of its huge and flabby structure and its complicated rules of operation. Since the problem is so serious a wide range of measures have been tried to curb corruption, but on the whole these have failed miserably to achieve their purpose.

Following Becker and Stigler (1974), most of the theoretical papers (e.g. Banfield (1975), Rose-Ackerman (1975, 1978) and Klitgaard (1988, 1991) focus on the principal-agent framework of corruption. These models deal with the relationship between the principal, i.e. the top level government and the agent, i.e. an official who takes a bribe from the private individuals interested in some government-produced goods. These studies examine different ways of controlling corruption. Cadot (1987) has analyzed bribery in a model with a hierarchical administration. Basu et al. (1992) have also considered a hierarchical administrative system. The problem of recursion is central to their analysis. They have gone on to analyze some conditions for the control of corruption in the system and these are different from the conventional wisdom. Chaudhuri and Gupta (1996) and Gupta and Chaudhuri (1997) have analyzed corruption in the case of distribution of subsidized formal credit to the small and marginal farmers in backward agriculture and shown the counter-productiveness of the agricultural subsidy policies to combat corruption in the system. In a very different context, but still assuming that the official needs a bribe to make his job, Shleifer and Vishny (1992, 1993) show that increasing the official price leads unambiguously to a reduction in production and has different effects on the bribe depending on the slope of the demand function.

The present paper analyzes the phenomenon of corruption in the context of a Public Works Department in a big developing country city and examines its tenacity in the presence of anticorruption measures. Different behaviour patterns of the supervisor of the PWD have been considered. First, the supervisor behaves like a perfectly discriminating monopolist. By virtue of his power to set an 'all or nothing' offer and the absence of any penalty for failure to give the contract, the supervisor is able to extract the entire surplus pushing the other agent − the contractor down to the latter's normal profit level. We then analyze a Nash bargaining game between the two parties − the supervisor and the contractor. Finally, we consider the case of Stackelberg solution where the supervisor acts as the leader. In all these three cases we analyze the effects of different anticorruption policies on the quality of input used by the contractor and the amount of bribe income of the supervisor. It turns out that the effectiveness of a particular anticorruption measure crucially depends on the assumed behaviour pattern of the supervisor. The interesting result to emerge is that in each of these cases corruption may show a high degree of robustness against marginal attacks and such measures may actually be counterproductive in the three cases considered here.

2. The Model:

A supervisor-cum-official in a PWD has the authority to award a contract of value R* to a contractor for carrying out a particular project during a particular period. It is assumed for the sake of simplicity that there is only one party interested in obtaining the contract. Competition for contract is thus ruled out. We note in defense that in reality competition is usually among a limited number of agents and profits are not driven all the way down to zero. The supervisor (official) has full freedom to withhold the contract during this period.

The specified project with its fixed output Q* needs several inputs in fixed quantities. The crucial assumption on which the whole analysis is built is that the quality of these inputs, indexed by q, can be varied by the contractor within limits. There is a technologically optimum q, denoted q*, corresponding to Q*. Use of inputs of quality q* implies that the job is done right. Q* can also be supported by inferior inputs with q values lower than q*. If a lower value is chosen the quality of the output will suffer but the loss, we assume, cannot be detected without some test. Substitution of inferior material in road building will be a good example of the kind of malpractice we are talking about.[1] Such substitution is profitable from the contractor's point of view because inferior inputs are cheaper. We capture this aspect by making the contractor's cost vary with both output Q and input quality q, namely, C(Q, q) with C_1, $C_2 > 0$. For algebraic convenience we take q to vary continuously. The official is corrupt and willing to pass bad quality material (and thereby risk being punished for shirking his supervisory duty) provided some side payment is forthcoming from the contractor. Once the project is completed, a random check is made by a third party and with probability ρ the actual quality of inputs used will be detected.

[1] The Statesman dated 14th June 1993 reported that large craters in several important streets of Kolkata, including Russel Street, Middleton Street, Sudder Street, Chowringhee Lane, Mirza Ghalib Street had been patched up with stone chips of such inferior quality that they turned to dust within two days of repair.

If q is found to be less than q*, the implication is undesirable for both the agents. The contractor is blacklisted and he is assumed to place a money value of L on this loss of goodwill. The official will have to pay a fine F_1. The probability of detection ρ is also taken to vary inversely with q, signifying that worse the quality of inputs the higher the likelihood that the test will reveal the substandard work. We model this through the function $\rho(q)$, with $\rho' < 0$, $\rho(q^*) = 0$. Both the parties have perfect knowledge of $\rho(.)$.

A shortfall of q from q* only proves that the official has been negligent as a supervisor. It does not automatically imply that he has taken a bribe. There is, however, an additional check by income tax authorities and with probability α they can detect income in excess of the official's regular salary. This probability is taken to vary positively with B, the amount of bribe or black income. In the event of detection, a fine F_2 has to be paid. There is no penalty for offering a bribe. We also note that $B > 0$ implies $q < q^*$ but the converse is not true. In other words, $q = q^*$ implies $B = 0$ but not conversely. The cost-input quality relationship is C(q), suppressing Q*.

2.1 *The Perfectly Discriminating Monopoly Solution*

The expected payoff of the contractor as a function of q can be written as

$$E_2 = R^* - C(q) - \rho(q).L \qquad (1)$$

We assume E_2 to have a unique maximum with respect to q. Define $E_2^* = R^* - C(q^*)$, the normal profit corresponding to honest work. For each q, $(E_2 - E_2^*)$ gives the supply of bribe in the sense of being the maximum payment the contractor is willing to offer for that particular q. It is depicted in figure 1 as the curve BB.

The official's expected payoff can be written as

$$E_1 = B - \rho(q).F_1 - \beta(B).F_2 \qquad (2)$$

Note that we are using the same $\rho(q)$ in defining both E_1 and E_2. This is justified under our assumption that the parties have full information about $\rho(.)$, the probability that the test will be able to identify the true quality of inputs for any chosen q.

From the restrictions $\rho' < 0$, $\beta' > 0$, it follows that E_1 is an increasing function of q, for given B. We assume E_1 to have a unique maximum with respect to B when q is held fixed. Under this assumption the equal-value contours for E_1 are shown in figure 2. The official has full knowledge about BB. The solution is shown in figure 3. The optimum q^0 is less than q* and a positive amount of bribe is being offered and accepted. The gap $(q^* - q^0)$ is a measure of social loss. The supervisor is able to extract the entire surplus and the contractor is left with only his normal profit E_2^*.

Totally differentiating equation (2) we get the slope of the equal-value contours for E_1^* as

$$(dB/dq)\big|_{E1*} = [\rho'(q).F_1 / \{1 - \beta'(B).F_2\}] \quad (3)$$

Owing to our assumption on E_1, $\{1 - \beta'(B).F_2\}$ must be positive and (dB/dq) must be negative. Now from (3), it is easy to show that

$$\left.\begin{aligned} &\partial(dB/dq)/\partial F_1 = [\rho'(q) / \{1 - \beta'(B).F_2\}] < 0; \text{ and,} \\ &\partial(dB/dq)\partial F_2 = [\rho'(q).\beta'(B) / \{1 - \beta'(B).F_2\}^2] < 0 \end{aligned}\right\} \quad (4)$$

So, the algebraic value of the slope of equal-value contours for E_1 decreases as F_1 or F_2 increases. In other words, the equal-value contours for E_1 become steeper at every point on the B–q space. Hence the tangency between the supply curve of bribe, BB, and the equal value curve for E_1, E_1^*, must occur to the southeast of the previous tangency point as F_1 or F_2 increases. In the new equilibrium, B falls and q rises.

On the other hand, as L increases the BB curve shifts downwards. From equation (1), we can show that $\partial(dB/dq)_{BB} / \partial L = -\rho'(q) > 0$. So the algebraic value of the slope increases. In other words, the BB curve becomes flatter at every point as L increases. Hence the tangency between the BB curve and the E_1^* curve must occur to the northwest of the previous equilibrium point. As a consequence, B increases and q decreases in the new equilibrium. So we can write the following proposition.[2]

PROPOSITION 1: In a framework where the PWD supervisor behaves like a perfectly discriminating monopolist, stiffening of penalties on the supervisor (F_1 or F_2) is effective to improve the quality of work and reduce the bribe income of the supervisor, while stiffening of penalty on the contractor is counterproductive.

2.2 *Nash-Bargaining Solution*

In this section of the paper, we make some changes in the functional relationships, which we have used in the previous section. We now assume that

$\rho = \rho(q, B)$ with $\rho_1, \rho_2, \rho_{12} < 0$; $\rho_{22} \geq 0$;and,

$Z = Z(q)$ with $Z' < 0$, $Z'' \geq 0$.

We consider a hierarchical functioning system in the PWD. Z is the fraction of the bribe, B, given to the higher authority by the supervisor to influence them to delay or not to disclose the report of the quality test. Empirically, bribes moving up a hierarchy are well known (see for example, Wade (1988)) and we consider a finite chain case. The lower the quality of inputs used, the larger must be the fraction Z of the bribe required to influence the higher authority. So Z is assumed to be a decreasing function of the inputs quality,

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[2] The proofs are available from the authors on request.

q. It decreases at a non-increasing rate. The probability of detection of use of substandard quality of inputs through the quality check, ρ, is now dependent on the amount of bribe too. ρ decreases at a non-increasing rate as B increases. An increase in B also reduces ρ_1 ($= \partial\rho/\partial q$). So ρ_{12} ($= \partial^2\rho/\partial q\partial B$) is negative too. However, bribing cannot make ρ to be equal to zero since we assume that there is at least one official in the chain who is incorruptible. So the probability of detection of use of substandard inputs through quality test is always positive for any $q < q^*$.

The expected payoffs of the supervisor and the contractor are respectively given by

$$E_1 = B.(1 - Z(q)) - \rho(q, B).F_1 - \beta(B).F_2 \tag{2.1}$$

$$E_2 = R^* - C(q) - \rho(q, B).L \tag{1.1}$$

If the supervisor and the contractor fail to reach an agreement there is no side payment by the contractor to the supervisor and at the same time the contractor cannot use any inputs of quality below q^*. So $E_1^* = 0$ and $E_2^* = R^* - C(q^*)$ in this case.

The first step to reach a Nash bargaining solution is to maximize the joint income of the supervisor and the contractor, which is given by

$$J = R^* - \rho(q, B).(L + F_1) - \beta(B).F_2 - B.Z(q) \tag{5}$$

J(.) is maximized with respect to q and B and the first-order conditions are the following.

$$(\partial J/\partial q) = -[C'(q) + \rho_1(.).(L + F_1) + B.Z'(q)] = 0 \tag{6}$$

and

$$(\partial J/\partial B) = -[\rho_2(.).(L + F_1) + \beta'(B).F_2 + Z(q)] = 0 \tag{7}$$

The second-order condition requires that

$$\Delta = \begin{vmatrix} (\partial^2 J/\partial q^2) & (\partial^2 J/\partial q\partial B) \\ (\partial^2 J/\partial B\partial q) & (\partial^2 J/\partial B^2) \end{vmatrix} \quad \text{must be negative definite.}$$

Here

$$(\partial^2 J/\partial q^2) = -[\underset{(+)}{C''(q)} + \underset{(\geq 0)}{\rho_{11}(.)}.(L + F_1) + B.\underset{(\geq 0)}{Z''(q)}] < 0$$

$$(\partial^2 J/\partial q\partial B) = -[\underset{(-)}{\rho_{12}(.)}.(L + F_1) + \underset{(-)}{Z'(q)}] > 0$$

$$(\partial^2 J/\partial B^2) = -[\underset{(+)}{\rho_{22}(.)}.(L + F_1) - \underset{(\geq 0)}{\beta''(B)}.F_2] < 0$$

We assume that $\Delta > 0$ so that the second-order conditions for maximization of J are satisfied. We also assume that the maximized value of J, $J^* > (E_1^* + E_2^*)$ so that a Nash bargaining solution exists. The next step is to distribute J* between the two players following the solution of a Nash bargaining problem. However, we are not interested in the distribution part of the problem, but like to do some comparative static exercises.

Totally differentiating equations (6) and (7) and solving by Cramer's rule we get the following results.[3]

$$\left.\begin{array}{l}
(dq/dF_1) = (1/\Delta).[\rho_1(.).\{\rho_{22}.(L + F_1) + \beta''(B).F_2\} - \rho_2.\rho_{12}.(L + F_1) - \rho_2.Z'(.)] < 0; \\
\qquad\qquad (+)\quad (-)\quad (+)\qquad\qquad (\geq 0)\qquad\quad (-)\,(-)\qquad\qquad (-)\,(-) \\
 \\
(dq/dF_2) = -\,(1/\Delta).[\rho_{12}.(L + F_1) + Z'(q)].\beta'(B) > 0; \\
\qquad\qquad\quad (+)\ (-)\qquad\qquad\quad (-)\quad (+) \\
(dq/dL) = (1/\Delta).[\rho_1.\{\rho_{22}.(L + F_1) + \beta''(B).F_2\} - \rho_2.\{\rho_{12}.(L + F_1) + Z'(q)\}] < 0; \\
\qquad\qquad (+)\ (-)\ (+)\qquad\qquad\quad (\geq 0)\qquad (-)\ (-)\qquad\qquad (-)
\end{array}\right\} \qquad (8)$$

$$\left.\begin{array}{l}
(dB/dF_1) = (1/\Delta).[\rho_2.\{C''(q) + \rho_{11}.(L + F_1)\} - \rho_1.\{\rho_{12}.(L + F_1) + Z'(q)\}] < 0; \\
\qquad\qquad (+)\ (-)\quad (+)\qquad (+)\qquad\qquad (-)\ (-)\qquad\qquad (-) \\
(dB/dF_2) = [\{\beta'(B)/\Delta\}.\{C''(q) + \rho_{11}.(L + F_1)\}] > 0; \text{ and,} \\
\qquad\qquad\quad (+)\ (+)\quad (+)\qquad (+) \\
(dB/dL) = (1/\Delta).[\rho_2.\{C''(q) + \rho_{11}.(L + F_1)\} - \rho_1.\{\rho_{12}.(L + F_1) + Z'(q)\}] \\
\qquad\qquad (+)\ (-)\qquad\qquad (+)\qquad\qquad (-)\ (-)\qquad\qquad (-)
\end{array}\right\} \qquad (9)$$

These results can be presented in the form of the following proposition.

PROPOSITION 2: In a Nash bargaining framework, stiffening of penalties on the supervisor and/or the contractor in the quality test leads to a fall in the quality of work and also the amount of bribe transaction. On the contrary, stiffening of penalty on the supervisor in the check by the income tax authorities raises the quality of work and the amount of bribe in the new equilibrium.

Hence, an increase in F_1 and/or L leads to a fall in the quality of work and thus is counterproductive. Loss of welfare due to corruption increases in these cases. On the other hand, the effect of an increase in F_2 is to push q towards q*, the social optimum.

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[3] Interested readers may check these results or can obtain the proofs from the authors on request.

2.3 The Stackelberg Solution

We now consider a leadership framework where the supervisor behaves like a Stackelberg leader. The payoff of the contractor is given by the following.

$$E_2 = R^* - C(q) - \rho(q, B).L \qquad (1.1)$$

This is maximized through a choice of q assuming that B is given. The first-order condition of maximization is

$$c'(q) - \rho_1(q, B).L = 0 \qquad (10)$$

Equation (10) is the reaction function of the contractor. It shows how the contractor moves corresponding to different values of B chosen by the supervisor.

Totally differentiating equation (10), it is easy to show that

$$\left.\begin{aligned} (\partial q/\partial B) &= -[\rho_{12}.L / \{C''(q) + \rho_{11}.L\}] > 0; \text{ and,} \\ (\partial q/\partial L) &= -[\rho_1 / \{C''(q) + \rho_{11}.L\}] > 0. \end{aligned}\right\} \qquad (11)$$

So q is an increasing function of both B and L.

The income of the supervisor (over and above his usual salary) is given by

$$E_1 = B.(1 - Z(q)) - \rho(q, B).F_1 - \beta(B).F_2 \qquad (2.1)$$

E_1 is maximized with respect to B and subject to equation (10). The first-order condition of maximization is given by

$$(1 - Z(q)) - B.Z'(q).(\partial q/\partial B) - \rho_1.(\partial q/\partial B).F_1 - \rho_2.F_1 - \beta'(B).F_2 = 0$$

After putting the value of $(\partial q/\partial B)$ this becomes

$$(1 - Z(q)) + [\{B.Z' + \rho_1.F_1\}.\rho_{12}.L / \{C''(q) + \rho_{11}.L\}] - \rho_2.F_1 - \beta'(B).F_2 = 0 \qquad (12)$$

The second-order condition of maximization is

$$\begin{aligned} (\partial^2 E_1/\partial B^2) = -Z'(q).(\partial q/\partial B) + [\ \{ (Z' + B.Z''(q) + \rho_{12}.F_1).\rho_{12}.L \} / \{C''(q) + \rho_{11}.L\}] - \rho_{22}.F_1 \\ - \rho_{12}.(\partial q/\partial B).F_1 - \beta''(B).F_2 < 0 \end{aligned}$$

After putting the value of $(\partial q/\partial B)$ it requires that

$$\begin{aligned} (\partial^2 E_1/\partial B^2) = [\ \{B.Z''(q).\rho_{12}.L + 2.(Z'(q) + \rho_{12}.F_1).\rho_{12}.L\} / \{C''(q) + \rho_{11}.L\}\ ] - \rho_{22}.F_1 - \beta''.F_2 \\ < 0 \text{ (third-order partial derivatives have been ignored)} \end{aligned}$$

We assume that second-order condition of maximization holds.

To derive comparative static results totally differentiating equation (12) one can obtain

$$\begin{aligned} (\partial^2 E_1/\partial B^2).dB = dF_1.[\rho_2 - \{\rho_1.\rho_{12}.L / (C''(q) + \rho_{11}.L)\}] + \beta'(B).dF_2 \\ - [\{(B.Z' + \rho_1.F_1).\rho_{12}.C''(q)] / \{C''(q) + \rho_{11}.L\}^2].dL \end{aligned}$$

So,

$$\left.\begin{aligned}(dB/dF_1) &= [\rho_2 - \rho_1.\rho_{12}.L/(C''(q) + \rho_{11}.L)] / (\partial^2E_1/\partial B^2) > 0\\(dB/dF_2) &= [\beta'(B) / (\partial^2E_1/\partial B^2)] < 0\\(dB/dL) &= -[(B.Z' + \rho_1.F_1).\rho_{12}.C''(q) / (C''(q) + \rho_{11}.L)^2.(\partial^2E_1/\partial B^2)] > 0\end{aligned}\right\} \quad (13)$$

From (11) and (13) it follows that

$$\left.\begin{aligned}(dq/dF_1) &= (\partial q/\partial B).(dB/dF_1) > 0;\\(dq/dF_2) &= (\partial q/\partial B).(dB/dF_2) < 0; \text{ and,}\\(dq/dL) &= (\partial q/\partial L) + (\partial q/\partial B).(dB/dL) > 0.\end{aligned}\right\} \quad (14)$$

These results are summarized in the form of the following proposition.

PROPOSITION 3: In a leadership model where the supervisor acts as the Stackelberg leader, stiffening of penalties on the supervisor or on the contractor in the quality test leads to an improvement in the quality of work. On the contrary, stiffening of penalty on the supervisor in the income tax check leads to a fall in the quality of work.

3. **Summary and Conclusion:**

The following table summarizes the results obtained in this paper:

Effectiveness of the different instruments with respect to q

Framework / Instruments	Perfectly discriminating monopoly case	Nash bargaining solution	Stackelberg solution
F_1	+	—	+
F_2	+	+	—
L	—	—	+

All the paradoxical results may be stated as follows.

1. A stiffening of the penalty on the contractor in the quality test is counterproductive when the supervisor acts as a perfectly discriminating monopolist.
2. Stiffening of penalties on the supervisor and the contractor in the quality test are counterproductive in a Nash bargaining solution.
3. When the supervisor acts as the Stackelberg leader, a stiffening of penalty on the supervisor in the income tax check becomes counterproductive.

So the counter-productiveness of the anticorruption policies crucially depends on the assumed behavior pattern of the supervisor.

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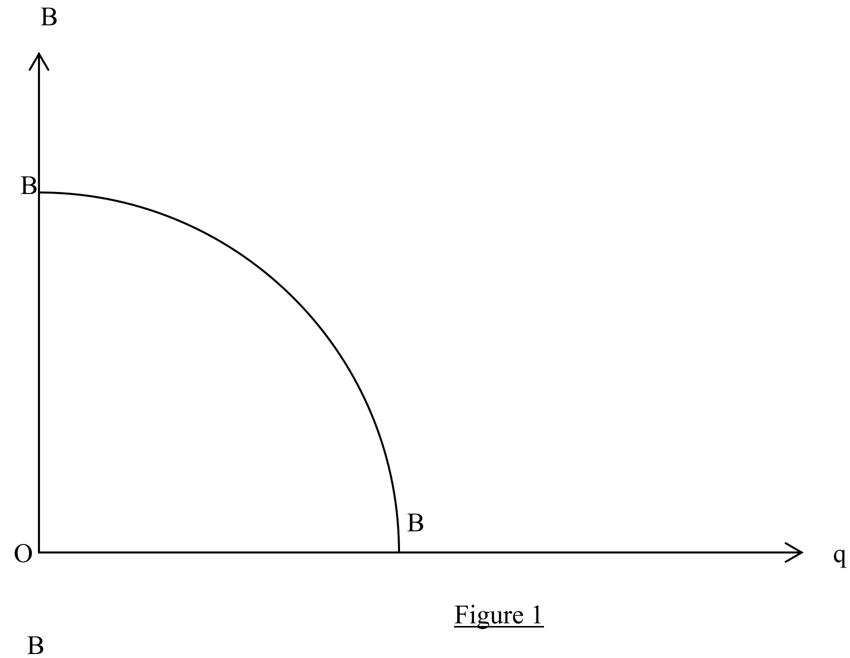

Figure 1

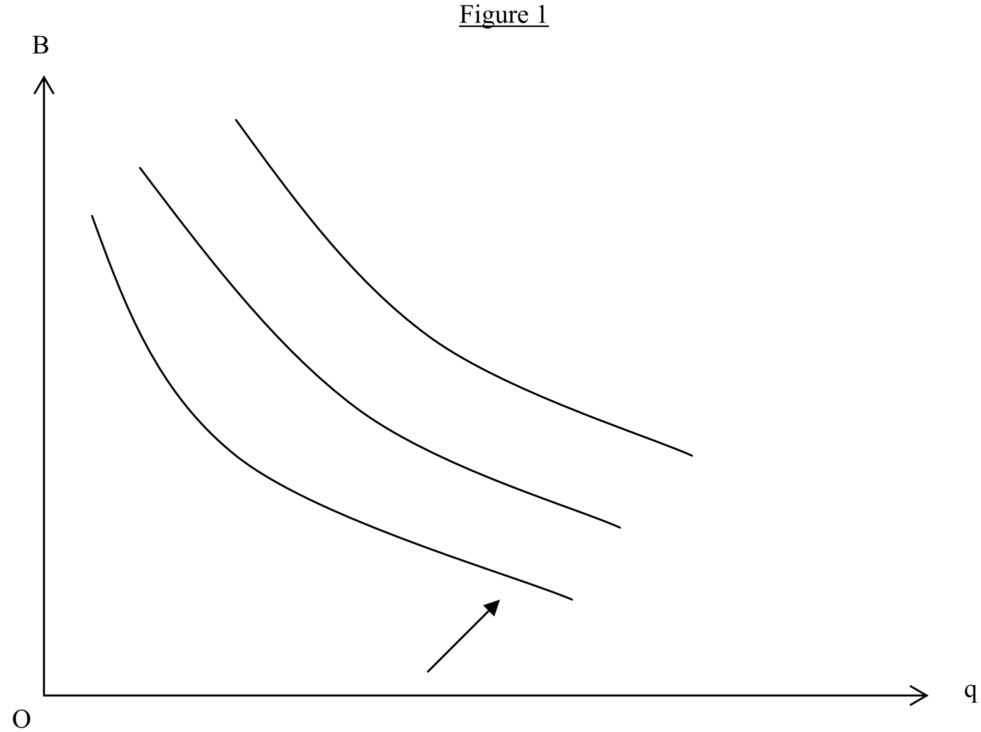

Figure 2

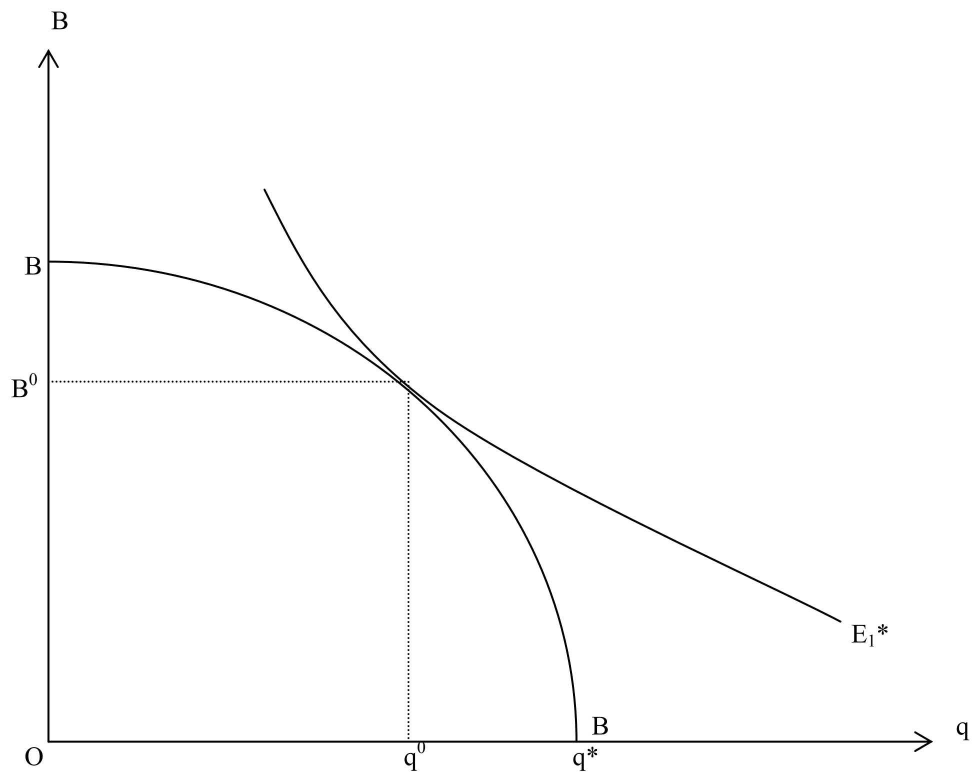

Figure 3