

Bureaucratic Corruption: Efficiency Virtue or Distributive Vice?

Praveen Kulshreshtha

Assistant Professor, Economics Area
Indian Institute of Management
Vastrapur, Ahmedabad 380 015, INDIA

Tel: (91) - (79) – 632 4864

Fax: (91) - (79) – 630 6896

Email: praveen@iimahd.ernet.in

ABSTRACT

Governments frequently allocate resources at low prices and on a first-come-first-served basis because of reasons of equity and a concern for the poor. However, bureaucrats who distribute these resources often take bribes. This paper develops a rigorous model to analyze the distributional, efficiency and public policy implications of bribery in such situations. It is shown that at low prices, the poor would choose to wait while the rich would pay the bribe to obtain the rationed commodity. If the good is in extreme short-supply, the bureaucrat would allocate all units to the rich and the poor would be excluded. Contrary to the assertion made in the corruption literature, bribery may not enhance allocative efficiency.

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"[32] Just as it is not possible not to taste honey or poison placed on the surface of the tongue, even so it is not possible for one dealing with the money of the king not to taste the money in however small a quantity.

[33] Just as fish moving inside water cannot be known when drinking water, even so officers appointed for carrying out works cannot be known when appropriating money.

[34] It is possible to know even the path of birds flying in the sky, but not the ways of officers moving with their intentions concealed."

- Kautiliya, in his 4th century B.C. Indian epic *Arthashastra*. Source: R. P. Kangle (1972), p. 91.

I. INTRODUCTION

Governments across the globe consider equitable development and poverty reduction as valued social objectives, apart from the need to promote economic efficiency and growth. Such distributional goals often compel governments to allocate scarce benefits or resources among their people at subsidized prices using the bureaucratic machinery¹. Unlike the free market system, bureaucratic allocation of resources gives rise to an important social cost, namely the time that individuals have to wait to obtain a benefit, which can be significant, especially when commodities are in great short supply, or when official prices are set well below market-clearing levels. It is therefore not surprising that bureaucratic corruption often arises, in the form of bribe-taking by bureaucrats who allocate

¹ The justification for charging low prices has been examined extensively by Alderman (1987), Barzel (1974), Nichols, Smolensky and Tideman (1971), Polterovich (1993), Sah (1987) and Weitzman (1977).

the benefits (Basu (1993), Debroy et. al. (1994a, 1994b), De Soto (1989), Paul and Gopakumar (2002), Rose-Ackerman (1999))².

Examples of such situations involving bribery abound: Allocation of subsidized credit in Eastern Europe, Lebanon and Russia (De Melo, Ofer and Sandler (1995), Webster (1993), Webster and Charap (1993), Yabrak and Webster (1995)); allocation of subsidized public housing in Hong Kong, Singapore and the United States (Lee (1986), p. 98, Rose-Ackerman (1978), p. 96, Rose-Ackerman (1999), p. 13); allocation of irrigation water and land in India and Pakistan (Murray-Rust and Vander Velde (1994), Rose-Ackerman (1999), p. 13, Vander Velde and Svendsen (1994), Wade (1982, 1984)); allocation of public services in India, such as water supply and sewerage, sanitation, health, school education, street lighting and roads, railway and bus services, issuance of driving licenses and passports, obtaining electricity connections in rural areas, and before liberalization of 1990s- obtaining food at ration shops, ration cards, telephone directories, telephone connections, electricity connections and cooking gas connections (Debroy et. al. (1994a, 1994b), Morris (2002), Paul and Gopakumar (2002)); in business, housing, manufacture and transportation in Peru (De Soto (1989)); and obtaining gasoline at gas stations and seats in restaurants in Russia (Basu (1994)).

² As Rose-Ackerman (1999) points out, bribes tend to equate demand and supply in markets where official prices are set below market-clearing prices.

The presence of bureaucratic corruption in the form of bribery has important distributional, efficiency and public policy implications which have been greatly discussed and debated in the corruption literature, but have not yet been analyzed systematically and comprehensively (see Bardhan (1997), pp. 1336-1337). For instance, it has been observed that if bribery is present, governments may fail to reach the poor by regulating prices below market-clearing levels (see Bardhan, pp. 1336-1337)³. It has also been recognized that in general, bribery can undermine the distributive goals or social objectives of public distribution schemes (see Bardhan, pp. 1335-1337, Rose-Ackerman (1999), p. 13).

However, in a strand of corruption literature beginning with Leff (1964), it has been claimed that when price controls and bureaucratic allocation of commodities result in large waiting times, bribery acts as a “grease” or “speed money” which helps reduce waiting and thereby improves allocative efficiency. The above assertion, commonly referred to as the “efficiency-grease hypothesis” and supported by rigorous models, concludes that only a move towards market-clearing prices or more generally, towards elimination of bureaucratic constraints, will maximize allocative efficiency (Lui (1985) and Rose-Ackerman (1978)).

³ Alternatively, the government can make transfers to the poor enabling them to buy the commodity at the market price. We focus on the welfare effects of low prices (in the presence of bribery) rather than on the relative merits of a low price strategy.

In contrast, another group of social scientists led by Myrdal (1968) have argued that bribery is not exogenous to public distribution systems but is part of systemic attempts by bureaucrats to create wasteful red-tape and delays in order to extract bribes from individuals. Hence, according to this view, bribery can cause waiting times to increase rather than decrease and therefore, bribery can lower allocative efficiency of public allocation schemes. Myrdal's view has been corroborated by a series of recent empirical studies carried out by expert researchers at the World Bank and other international development agencies (for instance, see Kaufmann and Wei (1999), Wei(1999)). However, very few attempts have been made to develop rigorous models which would support Myrdal's view and provide sound justification for the conclusions of various empirical studies on the topic⁴.

In this paper, we develop a rigorous model to analyze and discuss the above issues. Our model demonstrates that although bribery can enhance allocative efficiency in some situations (as predicted by the efficiency grease hypothesis), it would fail to improve allocative efficiency in many situations, especially where the official prices of rationed resources are low. Our analysis also shows that in the presence of bribery, low price policies may not be very effective in enabling governments to reach the poor. At low prices, bribery leads to increased waiting for the poor. Moreover, if the rationed good is in extreme short supply, bribery

⁴ Earlier attempts in this direction have been made by Banerjee (1997), and Shleifer and Vishny (1993)).

can become pervasive and lead to the exclusion of the poor (see also Bardhan, p. 1337). Thus, bribery can completely undermine the government's policy of keeping prices low to reach the poor.

We consider the case where a single bureaucrat distributes a fixed amount of a commodity, whose quantity as well as price is decided upon by the government⁵. However, the bureaucrat can allocate a fraction of the available quantity by charging a bribe in addition to the official price⁶. To obtain the commodity, an individual can either wait, or pay the bribe, in addition to paying the official price of the commodity. In rationing situations, the demand for the commodity is generally greater than its supply. However, as Barzel (1974) has shown, the time an individual is willing to spend waiting also signals his/her willingness to buy the commodity. As explained in the next section, under conditions similar to those that exist in perfectly competitive markets, waiting time can act as a *market-clearing, or equilibrium device* in rationing situations, with a *uniform* waiting

⁵ Many commodities, such as driving licenses, passports and ration cards are not scarce as such and can be supplied to anyone who is qualified and pays the official price. In such cases, scarcity can arise either due to genuine administrative constraints, or delays (red-tape) on part of the bureaucrat (Paul (1995)). In many cases, the commodity is scarce but the bureaucrat can affect the quantity supplied. Although we restrict attention to the case where the commodity's supply is exogenous or fixed by the government, our analysis can be readily extended to incorporate the above cases. For an excellent discussion of the economic impact of bribery in the above cases, see Rose-Ackerman (1999), pp. 13-15.

⁶ This is referred to as a case of *corruption without theft* in the corruption literature, since the bureaucrat keeps the bribe and turns over the official price to the government (See Shleifer and Vishny (1993)). We are therefore assuming that the bureaucrat's services are observable or easily monitored by the government, even though bribe transactions are hidden or secret.

time clearing the market. We show that via bribery, the bureaucrat can indirectly influence the equilibrium waiting time in the rationed good market⁷.

In our model, the disutility of waiting increases with income. Therefore, the poor would be most willing to wait to obtain the commodity while the richest individuals would be most averse to waiting. Hence, if the bureaucrat is corrupt or bribe-taking, the richest individuals will try and obtain the commodity without waiting, by paying the bribe. We show that the lower is the price of the commodity, the greater is the extent of bribery. Therefore, if bribery is present, the government's policy of charging a low price to reach the poor is not as effective as in the absence of bribery. In particular, we show that if the rationed good is in extreme short-supply, then bribery is rampant and the poor are unable to obtain the commodity.

The paper is organized as follows: In Section II, we develop the basic model and define the equilibrium with waiting time in the presence of bribery. In Section III, we analyze the distributional and efficiency implications of bribery in rationing situations. Section VI concludes with a discussion of the public policy implications of our analysis.

⁷ For analytical simplicity, we abstract from the possibility that the bureaucrat can affect waiting time directly, such as by creating red-tape (see Banerjee (1997) for an excellent analysis of red-tape and bribery). This simplification allows us to characterize time as a resource that is dissipated *voluntarily* by individuals. It also helps us focus on the role of waiting time as a market-clearing mechanism in situations where prices of commodities are low and goods are available in limited quantities.

II. THE MODEL

For analytical simplicity, we assume that the population or set of individuals (i) in society is represented by the unit interval $[0, 1]$. Each individual can choose to consume *one* unit of an indivisible commodity, supplied by the government at a price P ⁸. However, the government can supply the commodity to only a fraction s of the population, either due to program design or because of administrative constraints. In general, the demand for the rationed commodity can exceed its supply (*excess demand*). An individual can obtain the commodity by waiting t units, or by paying a bribe b to the bureaucrat, in addition to paying the official price P . Total time available to an individual is normalized to 1 unit.

Individual preferences are defined over consumption of the rationed commodity (x), waiting time (t), and the money income spent on all other goods (m). As suggested above, x takes two values: either 0, or 1. The following 'log-linear' utility function represents individual preferences over x , m and t ⁹:

⁸ In most rationing by waiting situations, only one unit of the commodity is demanded either because of the nature of the commodity (as in Gabszewicz and Thisse (1979) and Atkinson (1995)), or the law requires it to be so. However, individuals may illegally obtain several units of the commodity. According to Debroy et. al (1994b), commercial truck drivers in India tend to obtain about 5 licenses at a point in time. When caught by a traffic inspector for a violation, they can either pay a fine, or turn in their license to be picked up later from the police station. This is where having more than one license is useful. When all five licenses have been turned in, a new set of five licenses is obtained.

⁹ The assumption of identical individual preferences, although restrictive, simplifies our analysis while preserving its insights. Similar utility functions have been frequently employed in economics research (for instance, see Gabszewicz and Thisse (1979)).

$$U(x, m, t) = (V + \beta m)(1-t), x = 1 (V > 0; \beta \geq 1)$$

$$U(x, m, t) = m(1-t), x = 0$$

Note that the utility function is 'log-linear' in terms of the utility from goods and the amount of free time available (1-t). Furthermore, for any given waiting time t, the utility function implies a two-fold effect when an individual chooses to consume the rationed commodity (i.e. when x = 1): Firstly, an individual's utility increases by V, regardless of the income spent on other goods (m). Secondly, an individual's enjoyment of m can also go up, specifically by the factor β . For instance, procuring a driving license enables an individual to drive an automobile, hence increasing his/her travelling freedom and convenience¹⁰. Indeed, without a valid license, purchasing a private automobile is not very useful. Similarly, a person cannot go abroad without a valid passport, even if he/she can afford an overseas trip. Hence, an individual's enjoyment of income spent on other goods (m) can be positively and significantly related to purchase of the rationed good. The factor β captures this '*complementarity*' between the rationed good and other income, or in other words, β represents a potential *positive 'externality'* generated by the rationed good on other income. For expositional convenience, we assume that β is '*greater*' than one¹¹. Finally, observe that for any waiting

¹⁰ This is akin to Amartya Sen's notion that a commodity provides an individual with a *capability* to function in society. See Sen (1983, 1985).

¹¹ For many *essential* commodities such as food and fuel, β is likely to equal one, i.e. there may be no complementarity between the rationed good and remaining income. However, we can readily extend our analysis to such cases.

time t , the individual's utility is lowered by a factor t .

Each individual is endowed with a fixed income y , assumed to be private knowledge of the individual. Therefore, from the viewpoint of the government and the bureaucrat, y is a random variable which, for simplicity, is assumed to follow a uniform distribution in the interval $[0, Y]$, where $Y > 0$. Given these assumptions, the government chooses a price P of the rationed commodity, while the bureaucrat chooses a bribe b . The bribe charged is the same for all individuals, which seems a reasonable assumption given that incomes are private information. An individual can obtain one unit of the rationed commodity either by paying the price P and waiting t units ($0 \leq t \leq 1$), or by paying the bribe b to the bureaucrat, in addition to paying the price P . Lastly, an individual can always exercise the option of not buying the rationed commodity.

For any given price P , bribe b and waiting time t , the utility that an individual derives from either waiting, bribing or not buying the good is illustrated in Figure 1 (on page 15) and in Figure 2 (on page 19), and can be described as:

$U_Q = [V + \beta(y - P)](1 - t)$, if the individual wait and obtains the rationed commodity.

$U_B = V + \beta(y - P - b)$, if the individual obtains the rationed good by paying the bribe.

$U_0 = y$, if the individual does *not* buy the rationed commodity.

Clearly, individuals who would wait and obtain the rationed good would be those for whom U_Q is at least as great as U_O as well as U_B . More precisely, the set of individuals who would wait and obtain the rationed commodity at price P , bribe b and waiting time t (*queuing or waiting set*), can be written as:

$$\mathbf{Q}(t, b, P) = \{i \in [0, 1] \mid y_i \geq P, U_Q \geq U_O, \text{ and } U_Q \geq U_B\}$$

(Note that individuals with incomes less than P are unable to purchase the rationed commodity. In other words, we assume for simplicity that individuals do not have any opportunities to borrow, or lend money.)

Similarly, individuals who would pay the bribe and obtain the rationed good would be those for whom U_B is at least as great as U_O and U_Q . The set of individuals who would pay the bribe to receive the rationed good (*bribing set*) is given by: $\mathbf{B}(t, b, P) = \{i \in [0, 1] \mid y_i \geq (P+b), U_B \geq U_O, \text{ and } U_B \geq U_Q\}$

(Again, note that an individual can obtain the rationed commodity via bribery if and only if he/she can afford to pay bribe b in addition to paying price P .)

Now, let y_{QO} be the level of income at which an individual is indifferent between waiting and not buying the rationed good (i.e. where U_Q equals U_O). Similarly, let y_{BQ} be the income level at which the individual is indifferent between bribing and waiting to obtain the rationed good (i.e. where U_B equals U_Q). Finally, let y_{BO} be the income level at which the individual is indifferent between bribing and not buying the rationed good (i.e. where U_B equals U_O). Thus, y_{QO} represents the

“threshold” level of income above which waiting can arise, y_{BQ} is the threshold income level above which individuals prefer bribing over waiting and y_{BO} is the threshold income level above which bribery can occur. The numerical values of y_{QO} , y_{BQ} and y_{BO} , which can be obtained by equating U_Q and U_O , U_B and U_Q , and U_B and U_O respectively, are given by:

$$y_{QO} = (V - \beta P)(1 - t) / [1 - \beta(1 - t)]; \quad y_{BQ} = P - V/\beta + b/t; \quad y_{BO} = [V - \beta(P + b)] / (1 - \beta)$$

In our analysis, we will focus attention on the subsets of *individual incomes* corresponding to the waiting and bribing sets of the population. These sets of incomes (depicted in Figure 1 and 2) can be easily derived from the definitions of queuing set $Q(t, b, P)$ and bribing set $B(t, b, P)$ and expressed in terms of threshold incomes y_{QO} , y_{BQ} and y_{BO} as:

$$I_Q(t, b, P) = \{ y \in [0, Y] \mid y \geq P, y \leq y_{QO} \text{ and } y \leq y_{BQ} \}, \quad \text{if } t \geq (1 - 1/\beta),$$

$$\{ y \in [0, Y] \mid y \geq P, y \geq y_{QO} \text{ and } y \leq y_{BQ} \}, \quad \text{if } t < (1 - 1/\beta)$$

$$I_B(t, b, P) = \{ y \in [0, Y] \mid y \geq P + b, y \geq y_{BO} \text{ and } y > y_{BQ} \}$$

Lastly, we define the market equilibrium for the rationed commodity by employing Barzel’s notion that under situations of excess demand, waiting can help clear the market. This is because in excess demand situations, individuals who wait longer to obtain the rationed commodity are more likely to receive it than individuals who wait less. Hence, waiting times signal the willingness of individuals to purchase the rationed good. Barzel showed that if there are a large number

of potential buyers and information regarding waiting times is freely available, no single individual can influence the waiting time necessary to obtain the rationed commodity. Hence, under the above conditions, a *uniform* waiting time can clear the market, i.e. there exists a *uniform equilibrium waiting time*, which is analogous to the uniform equilibrium or market-clearing price in a perfectly competitive market.

We extend the above definition of market equilibrium with waiting time to account for bribery. Accordingly, we define the market equilibrium in two stages:

Stage 1: ((P,b)-equilibrium) For any price P and bribe b, (P,b)-equilibrium is the triple (t^*, b, P) , where t^* is the *uniform* waiting time which clears the market at price P and bribe b, i.e. $|Q(t^*, b, P)| + |B(t^*, b, P)| = s$, for given s (equivalently, $|I_{Q(t^*, b, P)}| + |I_{B(t^*, b, P)}| = sY$).

Stage 2: (P-equilibrium) For any price P, P-equilibrium is the triple (t^*, b^*, P) which is a (P,b*)-equilibrium, where b^* is the bribe that *maximizes the bureaucrat's bribe revenue* at price P and t^* is the uniform waiting time that clears the market at bribe b^* and price P¹².

¹² Hence, our equilibrium concept resembles a *subgame perfect equilibrium* in non-cooperative game theory. We also assume that the government does not penalize the bureaucrat for taking a bribe. This assumption is quite realistic in developing economies, where bribery and corruption are rampant at all levels of the bureaucratic hierarchy.

III. ANALYSIS

To analyze the distributional and efficiency implications of bribery in rationing situations, we focus on the allocation of the rationed good when bribery is present. Two important scenarios or cases arise, depending upon the price P that the government charges for the rationed good. Figure 1 illustrates the (P,b) -equilibrium for a given bribe b , where the income segments corresponding to individuals who choose to wait (I_Q) and those who pay the bribe (I_B) are *adjacent*. (This happens when price P is greater than or equal to (V/β) . See Appendix I for computations.) In this case, as Figure 1 shows, individuals at the lower end of the income distribution (specifically, those with incomes less than y_{Q0}) prefer not to purchase the rationed commodity, while the richest individuals (specifically, those with incomes greater than y_{B0}) prefer to pay the bribe (since disutility of waiting increases with income).

Furthermore, note that *the equilibrium waiting time is unaffected by changes in bribe b* when the waiting and bribing income segments are adjacent. This is because in such a (P,b) -equilibrium, the length of the combined waiting and bribing income segments must equal sY , for given s (see definition of (P,b) -equilibrium). Since Y is the upper end of the combined income segments (see Figure 1), and given that the two income segments are adjacent, it follows that y_{Q0} , which is the lower end of the combined income segments, must equal $(1-s)Y$ in equilib

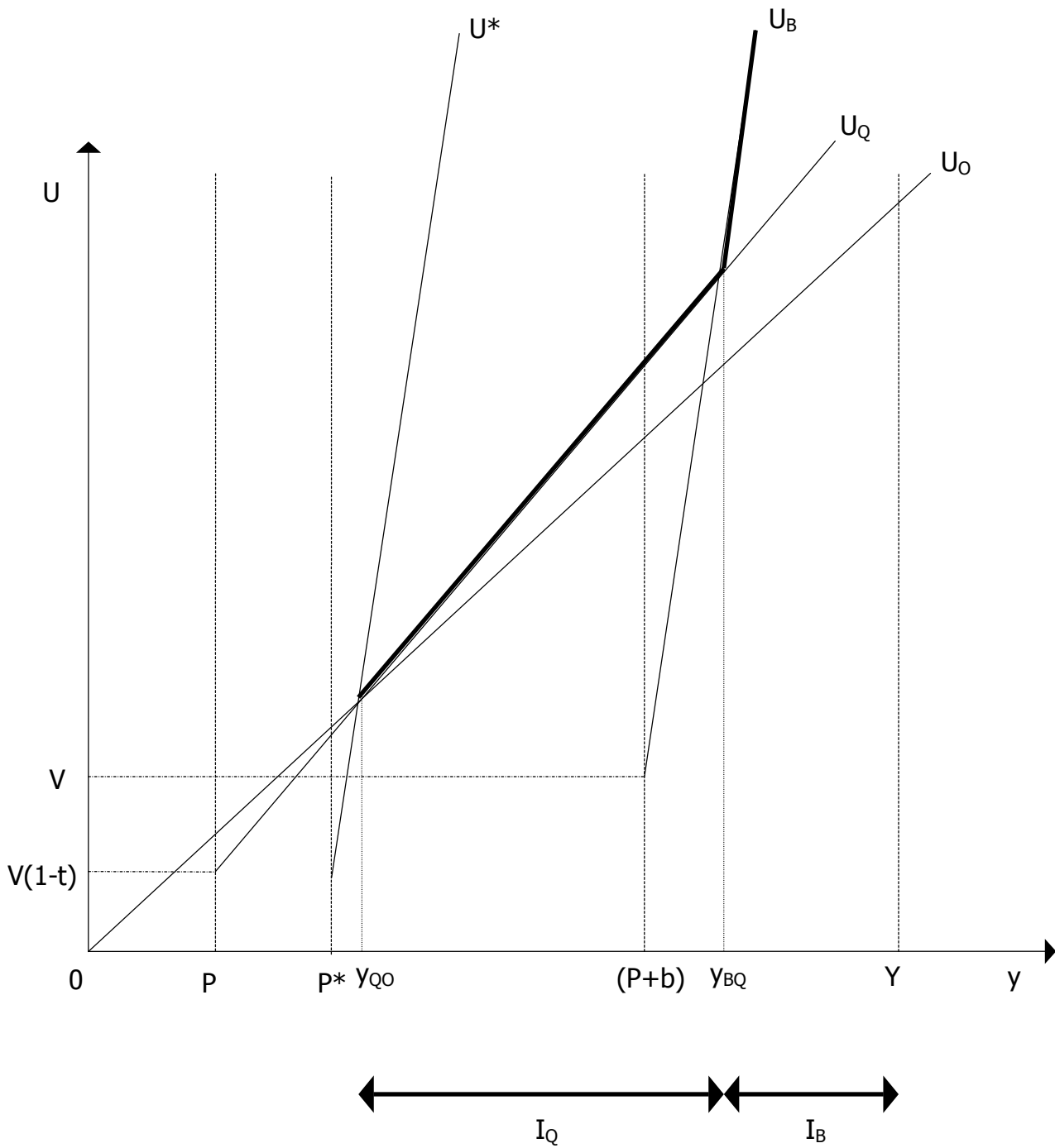


Figure 1: *Adjacent* Waiting and Bribing Income Segments

rium. Hence, the equilibrium waiting time would be completely determined by y_{Q0} . Since by its definition, y_{Q0} does not depend on bribe b , changes in b would not affect y_{Q0} and hence the equilibrium waiting time. However, changes in bribe b can affect y_{BQ} , which is the threshold income level between waiting and bribing. Hence, changes in the bribe level can cause consumers who choose to wait to switch to bribing or vice-versa.

Thus, the equilibrium waiting time does not depend on the bribe when the waiting and bribing income segments are adjacent. Hence, we can conclude that the equilibrium waiting time would be the same, regardless of whether the bureaucrat charges a bribe or not. As a consequence, individuals who would wait to obtain the rationed good both in the presence and absence of bribery (specifically, those with incomes between y_{Q0} and y_{BQ}) are equally well off in both situations, since they face the same waiting time in both situations. However, the richest individuals, who prefer to pay a bribe rather than wait (individuals with incomes exceeding y_{BQ}), are clearly better off if bribery is present because otherwise they would have to obtain the rationed good by waiting, which would yield lower utility (as depicted in Figure 1). In short, bribery makes some individuals (the bribers) better off while leaving other buyers (those who wait) as well off as before. In other words, bribery improves allocative efficiency¹³.

It can also be shown that *the equilibrium waiting time varies inversely with price*

¹³ Also, the *average* waiting time in the market is lower in the presence of bribery than if it were absent. This is because the equilibrium waiting time is identical in both cases but fewer individuals wait to obtain the good when bribery is present.

P of the rationed commodity, at any given bribe b . This is because an increase in price P , at a given bribe b and equilibrium waiting time, would lower the utility of all individuals who purchase the rationed good and therefore, fewer individuals would be willing to buy the rationed commodity, either by waiting or bribing. Hence, the market would fail to clear, with excess supply existing in the market. Therefore, the equilibrium waiting time would fall (analogous to a decrease in equilibrium price in a perfectly competitive market under excess supply conditions). Hence, equilibrium would be restored with a lower waiting time clearing the market. (With similar reasoning, it can be verified that the equilibrium waiting time would increase if there is a decrease in price P .)

In general, it can be shown that the market would clear without any waiting at a sufficiently high price. This is the so-called *market-clearing* price (depicted as P^* in Figure 1), where the equilibrium waiting time would be zero. Clearly, there would be no bribery at this price because with market waiting time being zero, there is no need for individuals to resort to bribing. It is also easy to show that the market-clearing price is *Pareto superior* to all other prices at which the waiting and bribing income segments of the population are adjacent in equilibrium, given bribe b . In other words, the utility of any buyer at the market-clearing price exceeds the utility obtained at any other price P where the waiting and bribing segments are adjacent.

Let us now consider the scenario where the waiting and bribing income segments can be *disjoint*. (This happens when price P is less than (V/β) . See Appendix I for computations.) Figure 2 depicts the (P,b) -equilibrium in this case, for a given bribe b . As illustrated in Figure 2, individuals towards the lower end of the income distribution (specifically, those with incomes between P and y_{Q0}) would prefer to wait and obtain the rationed good, while the relatively rich (those with incomes exceeding y_{B0}) would prefer to pay the bribe.

It is easy to see that in this case, the government can reach the relatively poor individuals in the population by charging a sufficiently low price. In particular, if bribery was absent, the government could reach the poor simply by distributing the rationed commodity free, with a positive waiting time clearing the market, since the poorest individuals (those with incomes less than y_{Q0}) would be willing to wait and obtain the rationed good. However, if bribery is present, the government's policy of reaching the poor is not as simple and effective as above. This is because in any (P,b) -equilibrium where P is less than (V/β) , a fraction of the available quantity is allocated to the relatively rich via bribery, with the remaining units being allocated to the waiting poor. This implies that *the equilibrium waiting time would be higher when bribery is present*, because of lower availability of the rationed good for those who choose to wait (analogous to the increase in equilibrium price in a perfectly competitive market when supply decreases).

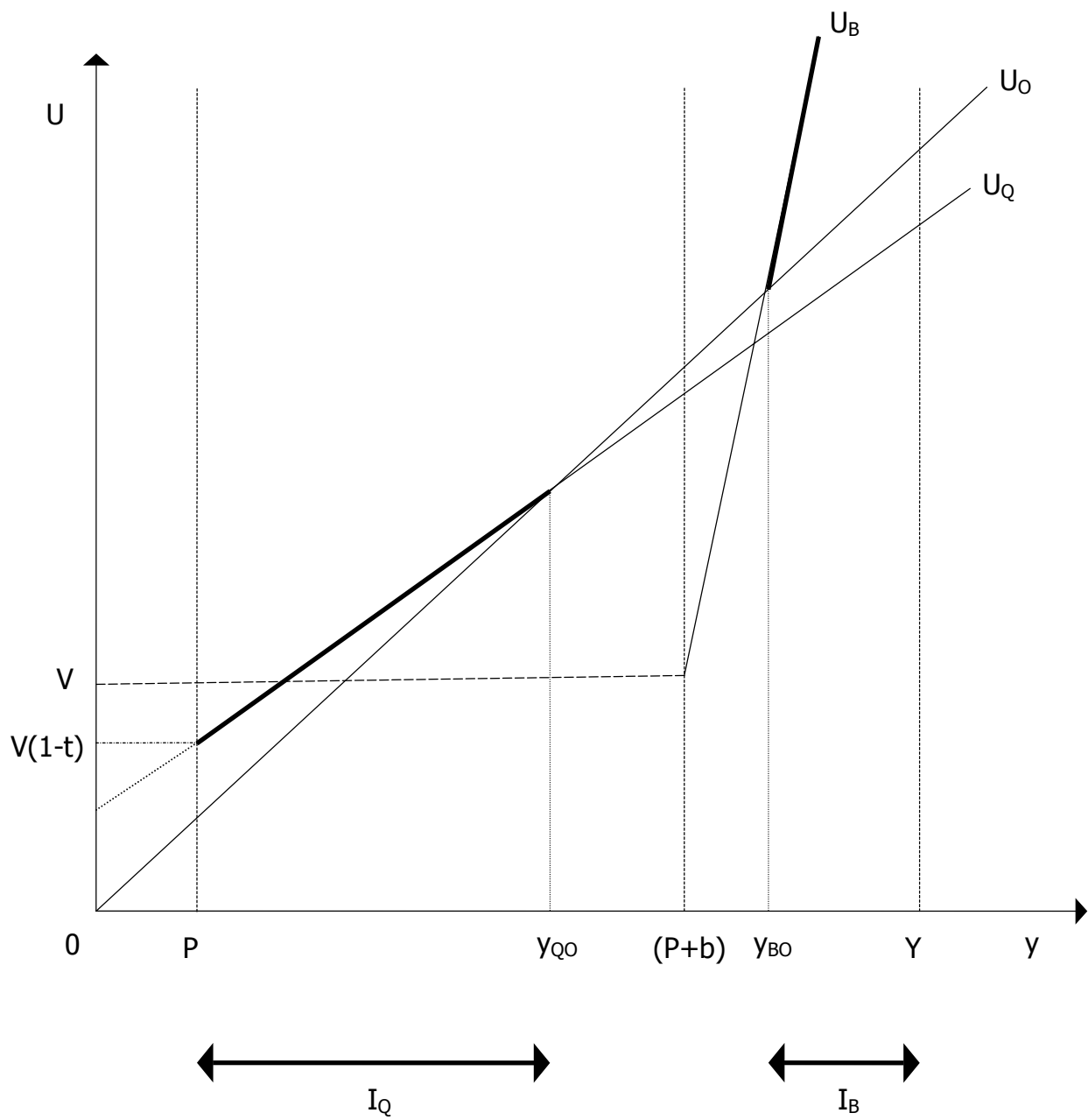


Figure 2: *Disjoint* Waiting and Bribing Income Segments

Thus, bribery would benefit the relatively rich at the expense of the waiting poor, whose utility would be lower because they would need to wait longer to access the rationed commodity. Hence, bribery would *not* improve allocative efficiency in this case¹⁴. It is even possible that the waiting poor are *crowded out* by the rich bribers, i.e. all available quantity supplied is sold to those who pay the bribe. Hence, bribery can be pervasive, in which case the poor would be excluded (This possibility is depicted in Tables 1, 2 and 3 in Appendix II).

IV. CONCLUSION

Our model demonstrates that governments which wish to target commodities at the poorer sections of the society can indeed do so, even in the presence of bribery. The measure of supply of the rationed good plays a crucial role in the government's ability to achieve this goal. When the price of the commodity is low and its supply is small relative to the population size, bribery is rampant and the poor are excluded. Thus bribery can affect the allocation of the rationed commodity and lower the poor's welfare. Governments can mitigate this effect by controlling bribery through strict enforcement of anti-corruption statutes, or by making rationed commodities available in greater quantities.

¹⁴ Stahl and Alexeev (1985) have obtained an analogous result in the context of black markets. They show that although queuing (analogue of waiting) generally produces a socially inefficient outcome, queuing with black markets does not necessarily achieve a Pareto improvement over the outcome under queuing without black markets.

The analysis presented here has some important limiting features. First, the supply of the rationed commodity is assumed to be fixed by the government and cannot be affected by the bureaucrat. In many rationing situations, corrupt bureaucrats can restrict the supply of the commodity below the actually available amount¹⁵. Second, bureaucrats can create elaborate rules and regulations (red-tape) which increase the waiting time of individuals. Such actions may induce a greater fraction of the population to resort to bribery than is predicted by the present model. An analysis of red-tape in rationing situations is likely to yield richer insights than the model presented here.

¹⁵ See Shleifer and Vishny (1992) for a discussion of pervasive shortages caused by bureaucrats in socialist countries.

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APPENDIX I: Computation of (P,b)-equilibrium

Case 1: $P \geq (V/\beta)$ (Refer to Figure 1)

Note that the demand is largest at $t=0$, where $y_{Q0} = (V-\beta P)/(1-\beta) > P$. (P,b)-equilibrium is calculated as follows:

(a) $sY \geq \{Y - (V-\beta P)/(1-\beta)\}$: In this case, $t^* = 0$ since quantity demanded doesn't exceed quantity supplied. Also, $|I_{Q^*}| = \{Y - (V-\beta P)/(1-\beta)\}$ and $|I_{B^*}| = 0$.

(b) $\{Y - (V-\beta P)/(1-\beta)\} > sY > (Y-y_{B0})$: Here, $|I_{(Q^*)}| = (y_{B0}-y_{Q0})$, $|I_{B^*}| = (Y-y_{B0})$ and $|I_{Q^*}| + |I_{B^*}| = sY \Rightarrow (Y-y_{Q0}) = sY \Leftrightarrow y_{Q0} = (1-s)Y$. Also, notice that

$$t^* = 1 - [(1-s)Y/\{V-\beta P+\beta(1-s)Y\}].$$

(c) $sY \leq (Y-y_{B0})$: In this case, $t^* = 1 \Rightarrow |I_{Q^*}| = 0$ and $|I_{B^*}| = (Y-y_{B0}) \geq sY$. Bureaucrat distributes units randomly.

Case 2: $P < (V/\beta)$ (see Figure 2)

Subcase (i): $b \leq (V-P)$. In this case, $y_{B0} \leq (P+b)$. (P,b)-equilibrium is calculated as follows:

(a) $sY \geq (Y-P)$: Here, $t^* = 0$, $|I_{Q^*}| = sY$ and $|I_{B^*}| = 0$.

(b) $(Y-P) > sY > (Y-P-b)$: In this case, $|I_{Q^*}| = (y_{Q0}-P)$, $|I_{B^*}| = Y-P-b$ and

$$t^* = [V + (\beta-2)P + (\beta-1)\{b-(1-s)Y\}] / [V + \beta P + \beta\{b-(1-s)Y\}].$$

(c) $sY \leq (Y-P-b)$: Here, $t^*=1$, $|I_{Q^*}| = 0$ and $|I_{B^*}| = (Y-P-b) \geq sY$. Units are allocated randomly.

Subcase (ii): $b > (V-P)$ In this case, $y_{B0} > (P+b)$. (P,b)-equilibrium is calculated as follows:

(a) $sY \geq (Y-P)$: Here, $t^* = 0$, $|I_{Q^*}| = sY$, $|I_{B^*}| = 0$.

(b) $(Y-P) > sY > (Y - y_{BO})$: In this case, $|I_{Q^*}| = (y_{QO} - P)$, $|I_{B^*}| = Y - y_{BO}$ and $t^* = (1-\beta)[1 - (V-\beta P/\Delta)]$, where $\Delta = [(V - (P+b) + (\beta-1)\{(1-s)Y - P\}]$.

(c) $sY \leq (Y - y_{BO})$: Here, $t^*=1$, $|I_{Q^*}| = 0$ and $|I_{B^*}| = (Y - y_{BO}) \geq sY$. Units are distributed randomly.

Appendix II: Computation of P-equilibrium for P less than V/β

To derive the P-equilibrium, we need to focus attention on the bureaucrat's bribe revenue, which is the product of a bribe b and the size of the bribing set induced by b ($|B|$). Note that the size of the bribing set can take two values: If $y_{BO} \leq (P+b)$, then all individuals who prefer paying the bribe are unable to afford it. Hence, the affordability constraint binds and $|B|$ equals $(Y-P-b)/Y$. However, if $y_{BO} > (P+b)$, affordability constraint does not bind and $|B| = (Y-y_{BO})/Y$. Further, note that $y_{BO} - (P+b) = \{V-\beta(P+b)\}/(1-\beta) - (P+b) = \{b-(V-P)\}/(\beta-1)$. Therefore: $y_{BO} \leq, \text{ or } > (P+b) \Leftrightarrow b \leq, \text{ or } > (V-P)$. Accordingly, the revenue function takes the following two forms:

1. If $b \leq (V-P)$, then the bribe revenue function is given by $R_1(b)$, where

$$\begin{aligned} R_1(b) &= b\{Y-(P+b)\}/Y, \text{ if } b > b_1 = (1-s)Y - P \\ &= bs, \text{ if } b \leq b_1 \end{aligned}$$

2. If $b > (V-P)$, then the bribe revenue function can be written as:

$$\begin{aligned} R_2(b) &= b(Y-y_{BO})/Y, \text{ if } b > b_2 = \{V-\beta P+(\beta-1)(1-s)Y\}/\beta \\ &= bs, \text{ if } b \leq b_2 \end{aligned}$$

It is easily verifiable that for all b , $R_1(b)$ is maximized at $b_1^* = (Y-P)/2$, if $s > s_1^* = (Y-P)/2Y$ and at b_1 , if $s \leq s_1^*$. Similarly, $R_2(b)$ is attained a maximum at $b_2^* = \{(Y-P)/2 + (V-Y)/2\beta\}$, if $s > s_2^* = \{(1/2) + (V-\beta P)/(\beta-1)(2Y)\}$ and at b_2 , if $s \leq s_2^*$. To find the optimal bribe, we need to consider and compare the maximum values of $R_1(b)$ and $R_2(b)$ under the constraints $b \leq (V-P)$ and $b > (V-P)$ respectively. Towards this end, note that $b_1^* \leq (V-P) \Leftrightarrow P \leq (2V-Y)$; $b_1 \leq (V-P) \Leftrightarrow s \geq 1-(V/Y)$; $b_2^* > (V-P) \Leftrightarrow P > P_0 = \{(2V-Y) + (Y-V)/\beta\}$ and $b_2 > (V-P) \Leftrightarrow s < 1-(V/Y)$. Using these relations, we obtain the constrained optima of $R_1(b)$ and $R_2(b)$ as depicted in Tables 4 and 5.

We can now compute the P-equilibrium. To gather the main features of our analysis, we assume that $Y > V$. This leads us to the following three ranges of price P :

Case (i): $P \leq (2V-Y)$ (See Table 1)

Note that $P_0 = \{(2V-Y) + (Y-V)/\beta\} > (2V-Y)$. From Tables 4 and 5, the revenue maximizing bribe varies with quantity supplied s as follows:

(a) $s < 1-(V/Y)$: The only possible optimums are b_2 , with $R_2(b_2) = b_2s$ and $(V-P)$, with $R_1(V-P) = s(V-P)$. However, $b_2 > (V-P) \Rightarrow R_2(b_2) > R_1(V-P)$. Therefore, the optimal bribe is b_2 .

(b) $1-(V/Y) \leq s \leq s_1^*$: The optimal bribe can be either b_1^* , or $(V-P)$, with $R_1(b_1^*) = \{(Y-P)/2\}^2/Y$ and $R_2(V-P) = (V-P)(Y-V)/Y$. However, b_1^* is the optimum, since

$$R_1(b_1^*) > R_2(V-P).$$

(c) $s > s_1^*$: The possible solutions are b_1^* and $(V-P)$, with $R_1(b_1^*) = \{(Y-P)/2\}^2/Y$ and $R_2(V-P) = (V-P)(Y-V)/Y$. However, $R_1(b_1^*) > R_2(V-P)$, which implies that the optimum is b_1^* .

Case (ii): $(2V-Y) < P \leq P_0 = \{(2V-Y) + (Y-V)/\beta\}$ (See Table 2)

(a) $s < 1-(V/Y)$: Analogous to case i(a), b_2 and $(V-P)$ are possible solutions, with $R_2(b_2) = b_2s$ and $R_1(V-P) = s(V-P)$. But, $b_2 > (V-P) \Rightarrow R_2(b_2) > R_1(V-P)$. Therefore, the solution is b_2 .

(b) $s \geq 1-(V/Y)$: The solution is $(V-P)$, with $R_1(V-P) = R_2(V-P) = (V-P)(Y-V)/Y$.

Case (iii): $P > P_0$ (See Table 3)

Note that in this case, $s_2^* \leq 1-(V/Y)$. The optimal bribe is given by:

(a) $s \leq s_2^*$: Possible optima are b_2 and $(V-P)$, with $R_2(b_2) = b_2s$ and $R_1(V-P) = s(V-P)$. But, $b_2 > (V-P) \Rightarrow R_2(b_2) > R_1(V-P)$. Therefore, the optimal bribe is b_2 .

(b) $s_2^* < s \leq 1-(V/Y)$: The optimal bribe is either $(V-P)$, or b_2^* , with $R_1(V-P) = s(V-P)$ and $R_2(b_2^*) = \{(\beta-1)(Y-P)+(V-P)\}^2 / 4\beta(\beta-1)$. But $R_2(b_2^*) > R_1(V-P)$ which implies that the solution is b_2^* .

(c) $s > 1-(V/Y)$: Two possible solutions are $(V-P)$ and b_2^* , with $R_1(V-P) = (V-P)(Y-V)/Y$ and $R_2(b_2^*)$ as in part (b). But $R_2(b_2^*) > R_1(V-P)$, which implies that the solution is b_2^* .

Table 1: $P \leq (2V-Y)$

Measure of available units	Optimal bribe	Size of bribing set (B^*)	Comments
$s < (Y-V)/Y$	$\{V+(\beta-1)(1-s)Y\}/\beta - P$	s	All units sold to bribers
$s \leq (Y-P)/2Y$	$(1-s)Y-P$	s	All units sold to bribers
$s > (Y-P)/2Y$	$(Y-P)/2$	$(Y-P)/2$	Size of bribing set varies <i>inversely</i> with P

Table 2: $(2V-Y) < P \leq P_o = \{(2V-Y)+(Y-V)/\beta\}$

Measure of available units	Optimal bribe	Size of bribing set (B^*)	Comments
$s \leq 1-(V/Y)$	$\{V+(\beta-1)(1-s)Y\}/\beta - P$	s	All units sold to bribers
$s > 1-(V/Y)$	$(V-P)$	$(Y-V)$	Size of bribing set is <i>invariant</i> to P

Table 3: $P > P_0$

Measure of available units	Optimal bribe	Size of bribing set ($ B^* $)	Comments
$s \leq \{(1/2)+(V-\beta P)/(\beta-1)(2Y)\}$	$\{V+(\beta-1)(1-s)Y\}/\beta - P$	s	All units sold to bribers
$s > \{(1/2)+(V-\beta P)/(\beta-1)(2Y)\}$	$\{(Y-P)/2 + (V-Y)/2\beta\}$	$(Y-P)/2$	Size of bribing set varies <i>inversely</i> with P

Table 4: Constrained Maximum of $R_1(b)$

Conditions	Solution	Maximum value of $R_1(b)$
$P \leq (2V-Y), s > s_1^*$	b_1^*	$\{(Y-P)/2\}^2/Y$
$P \leq (2V-Y), 1-(V/Y) \leq s \leq s_1^*$	b_1	$b_1 s = s\{(1-s)Y-P\}$
$P \leq (2V-Y), s < 1-(V/Y)$	$(V-P)$	$s(V-P)$
$P > (2V-Y), s \geq 1-(V/Y)$	$(V-P)$	$(V-P)(Y-V)/Y$
$P > (2V-Y), s < 1-(V/Y)$	$(V-P)$	$s(V-P)$

Table 5: Constrained Maximum of $R_2(b)$

Conditions	Solution	Maximum value of $R_2(b)$
$P \leq P_0, s \geq 1-(V/Y)$	$(V-P)$	$(V-P)(Y-V)/Y$
$P \leq P_0, s < 1-(V/Y)$	b_2	$b_2 s = s\{V-\beta P+(\beta-1)(1-s)Y\}/\beta$
$P > P_0, s > s_2^*$	b_2^*	$\{(\beta-1)(Y-P)+(V-P)\}^2 / 4\beta(\beta-1)$
$P > P_0, s \leq s_2^*$	b_2	$b_2 s$