

# I

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## *Introduction: The property rights model*

In the slave societies of the American South and of the West Indies, slaves persistently – albeit rarely – bought their contracts from their owners in order to redeem themselves from slavery. In these societies, as in others, the law afforded owners nearly absolute rights over their slaves and granted the slaves themselves no legal rights; consequently slaves were not legally entitled to own the property necessary for self-purchase. There was no legal barrier or authority to stand in the way of owners' owning both slave *and* freedom money. Nevertheless, self-purchase whereby slaves acquired property rights to their own labor did occur.

Because transacting is costly, as an economic matter property rights are never fully delineated. In the case of slaves, even though they were legally their owners' property, owners had to spend resources to induce their slaves to produce, and even then slaves seldom produced to their ultimate capacity. Thus slave ownership itself was never absolute, despite the slaves' lack of legal protection. Owners were able to enhance the value of their property through *granting* slaves some ownership rights in exchange for services the owners valued even more. Hence slaves were owners too, and could on occasion buy their freedom. As elaborated upon in Chapter 6, the study of property rights and of the costs of transacting can yield an explanation of why slaves were able to buy their freedom; such explanations may be tested against the facts. The property rights model I develop in this book can provide explanations of an array of such arrangements, which standard economic theory cannot successfully address, from identifying the reasons behind the choice between wage and piece-rate contracts to pinpointing the conditions under which charity is more efficient than profit-seeking behavior.

In the remainder of this chapter I shall define "property rights" and sketch the framework to be used in this book. In Chapter 2 the examination of the gasoline shortage in the 1970s illustrates the usefulness and importance of the property rights framework and familiarizes the reader

with its mechanics. Chapters 3 and 4 present the property rights model and its main organizational implications. Chapters 5 through 9 expand the model and apply it to various problems including rights formation, slavery, and resource allocation in non-market settings, and Chapter 10 recapitulates.

THE INHERENT DIFFICULTY OF  
DELINEATING RIGHTS FULLY

Property rights of individuals over assets consist of the rights, or the powers, to consume, obtain income from, and alienate these assets. Obtaining income from and alienating assets require exchange; exchange is the mutual ceding of rights. Legal rights, as a rule, enhance economic rights, but the former are neither necessary nor sufficient for the existence of the latter. The rights people have over assets (including themselves and other people) are not constant; they are a function of their own direct efforts at protection, of other people's capture attempts, and of government protection. The last condition is effected primarily through the police and the courts.<sup>1</sup> Squatters' rights to the land they occupy are less secure than those of legal owners not because they lack deeds but because less police protection is expected for such holdings. As defined here, property rights are not absolute and can be changed by individuals' actions; such a definition, then, is useful in the analysis of resource allocation. Economists' past failure to exploit the property rights notion in the analysis of behavior probably stems from their tendency to consider rights as absolute.

The concept of property rights is closely related to that of transaction costs. I define transaction costs as the costs associated with the transfer, capture, and protection of rights. If it is assumed that for any asset each of these costs is rising and that both the full protection and the full transfer of rights are prohibitively costly, then it follows that rights are never complete, because people will never find it worthwhile to gain the entire potential of "their" assets. In order that the rights to an asset be complete, or be perfectly delineated, both its owner and other individuals potentially interested in the asset must possess full knowledge of all its valued properties. With full knowledge, the transfer of rights to an asset can be readily effected. Conversely, when rights are perfectly delineated, product information must be costless to obtain, and the (relevant) costs of transacting must then be zero.

<sup>1</sup>The distinction sometimes made between property rights and human rights is spurious. Human rights are simply part of people's property rights. Human rights may be difficult to protect or to exchange, but so are rights to many other assets. See Alchian and Allen (1977, p. 114).

When transaction costs are positive, rights to assets cannot be perfectly delineated. The attributes of such assets are not fully known to prospective owners and are often not known to the current owner either. The transfer of assets entails costs resulting from both parties' attempts to determine what the valued attributes of these assets are and from the attempt by each to capture those attributes that, because of the prohibitive costs, remain poorly delineated.<sup>2</sup> Exchanges that otherwise would be attractive may be forsaken because of such exchange costs.

An illustration of the costliness of exchanging rights and their effect on resource allocation stems from the draft of college football players by the National Football League (NFL). Drafting is the acquisition by one team of the exclusive negotiation rights for the services of a player, inclusive of the right to transfer to any NFL team. Every year, the twenty-eight NFL teams select eligible college players in a predetermined sequence. It would seem that the team with the right to, say, the twentieth selection would select the player among those not yet drafted who is most valuable to any of the teams. Given the diversity of both players and teams, the probability that the team with the right to the twentieth selection will also be the one placing its highest value on any of the remaining players is the same as any other team's, that is, one in twenty-eight. Were the costs of exchange among teams low, the probability of that player's being traded would then be twenty-seven in twenty-eight. The observed trading frequency of newly drafted players, however, is much lower than a low transaction cost model predicts. This cost of transacting, at least, does seem to be considerable.

What underlies this costliness of transacting? What are the factors that prevent people from realizing the full value of their assets? Commodities have many attributes whose levels vary from one specimen of a commodity to another. The measurement of these levels is too costly to be comprehensive or entirely accurate. How difficult it is to obtain full information in the face of variability fundamentally determines how difficult it is to delineate rights. Because it is costly to measure commodities fully, the potential of wealth capture is present in every exchange. The opportunity for wealth capture is equivalent to finding property in the public domain; in every exchange, then, some wealth spills over into the public domain, and individuals spend resources to capture it. Whereas people always expect to gain from exchange, they also always spend resources on capture. Individuals maximize their (expected) net gains, the gains from exchange as conventionally perceived net of the cost of effecting exchange.

The sale of cherries illustrates the phenomenon of wealth capture. Obvious problems of information present themselves when cherries are

<sup>2</sup>Similar considerations, not elaborated on here, apply to the protection of assets.

exchanged. Customers must spend resources in order to determine whether a store's cherries are worth buying and in order to determine which particular cherries to buy. Store owners who allow customers to pick and choose cannot easily prevent them from eating cherries after they have already decided whether or not to buy them, nor can they prevent customers' careless handling of cherries. Indeed, the process of picking and choosing itself allows wealth capture in the form of excess choosing.<sup>3</sup> Some of the cherries' attributes, then, are placed in the public domain. The high cost of information results in transaction costs: costs that would not arise were the owner and the consumer of cherries the same person. If information about the cherries were costless, their initial owner would not have to relinquish any rights; and pilfering, damage, and excess choosing would be avoided. In reality, such public domain problems are unavoidable; people can take steps, however, to reduce the associated losses.

#### DIVIDED OWNERSHIP OF COMMODITIES

Net gains from exchange can often be increased if the original owners of commodities transfer only subsets of the commodities' attributes and retain the rest. Exchange that takes this form results in divided property rights for single commodities: Two or more individuals may own distinct attributes of the same commodity. As elaborated in Chapters 4 and 7, restrictions on the owners' behavior may be imposed in order to enhance the separation of their individual rights. Incomplete separation makes attributes common property, relinquishing them to the public domain; if they are in the public domain, resources are spent on their capture.

Not only is ownership of commodities often divided; ownership of organizations may be divided as well.<sup>4</sup> Physical operations within, and on the fringe of, an organization such as a firm usually involve many commodities and correspondingly many attributes. Several individuals share in ownership of the attributes, each owning alone, or with others, some subset of these. Stockholders own some of these attributes, but definitely not all of them. For instance, a firm (or, more accurately, its stockholders) that has a service contract for a copier to which it has the title does not fully own the copier. The firm is not the only party that gains when the copier performs well and loses when it does not. The service supplier is the residual claimant from the servicing operation, gaining if it provides good service and losing if the service is poor, and is thus part owner of the

<sup>3</sup>Barzel (1982).

<sup>4</sup>Alchian (1965) recognizes that ownership of commodities and of organizations may be divided. Posner (1986) discusses property rights and notes that ownership can be divided.

copier. In addition, the copier manufacturer is liable for certain damages caused by the copier, and employees who are able to use the copier privately without charge are also part owners, since, in practice, they have a claim on some of the copier's output. Here, too, restrictions may serve to separate rights and prevent free rides. In Chapter 7 it is shown that such restrictions do not necessarily attenuate rights; instead, they may enhance them.

#### FACTORS THAT AFFECT THE ALLOCATION OF OWNERSHIP

The rights to receive the income flow generated by an asset are a part of the property rights over that asset. The greater is others' inclination to affect the income flow from someone's asset without bearing the full costs of their actions, the lower is the value of the asset. The maximization of the net value of an asset, then, involves that ownership or ownership pattern that can most effectively constrain uncompensated exploitation. The kind of ownership pattern to emerge depends on the variability of such assets.

The rights to an asset generating a flow of service are relatively easy to ensure when the flow can be readily ascertained, because it is easy to impose a charge commensurate with the level of service exchanged. Therefore, when the flow is *known* and *constant*, it is easiest to ensure that rights are also certain. If the flow is *variable* but is fully *predictable*, rights are still easy to ensure, as they are if the flow is not certain but is *unalterable*. It is evident, then, that, given the mean outcome, variability and uncertainty may reduce the value of the asset but need not affect the certainty of ownership.

When the flow of income from an asset may be affected by the exchange parties, ensuring ownership over it is problematic. When the income stream is variable and not fully predictable, it is costly to determine whether the flow is what it should have been in any particular case. Consequently it is also costly to determine whether part of the income stream has been captured by the exchange parties. The exchange parties will engage in wealth-consuming capture activities because they expect to gain from them. The delineation of ownership is problematic, then, when the income stream from the exchanged property is subject to random fluctuations and when both parties can gain by affecting that income stream.

A special case of great importance to understanding the circumstances under which ownership can be ensured arises when only one of two exchange parties can affect the income flow. Making the person who can affect the flow bear full responsibility for her or his actions ensures that

ownership becomes secure. Such a person, being the "residual claimant" to an outcome that only she or he can influence, is the full-fledged owner of the asset.

As a rule, both exchange parties can affect the service flow generated by exchanged assets, a fact that prevents ownership from being fully secure. For instance, the income stream generated by a rented car depends, in part, on how smoothly the car operates. Since used and even new cars are not identical to one another, they are not expected to run equally smoothly. A smooth ride is an attribute that both the owner and the renter can affect. A renter will find it expensive to determine to what extent the smooth ride of the rental car results from its character and to what extent it results from the care given to servicing it; similarly, the owner cannot tell how much the smoothness of the renter car's ride has deteriorated because of the way it has been driven and how much it has deteriorated because of its character. As a result, the owner may get away from skimping on servicing rental cars — doing less of it than owner-drivers would — and renters may be less careful with rented cars than they would be with their own. Each party expects such behavior of the other. Therefore, the demand function for rented cars adjusts for the effects of inadequate servicing, and the supply function adjusts for the effects of careless driving. The net gain in using the rental market, then, is less than it would be were the two parties to exercise greater care. If the smoothness of operations were costlessly measurable, the effect of each transactor on that attribute could be easily determined and accurately charged for. In reality, assessing such marginal charges accurately is prohibitively expensive, and (maximizing) owners will not choose to exercise their rights fully. Some of the income stream, then, is left in the public domain and is partly recaptured by the exchanging parties, who act differently than owner-users would. Whereas rights cannot economically be fully defined when both exchange parties are able to affect the outcome, only one pattern of ownership does maximize the net income from the asset (and thus its value to its original owner). The general principle determining the maximizing allocation of ownership is that the greater a party's inclination to affect the mean income an asset can generate, the greater is the share of the residual that party assumes.

The nominal owner of an asset may seem to have the right to the income the asset can generate. When the highest income the asset can generate requires exchange, some of the income potential will be used up in the process of effecting the exchange. The net income an asset will generate, then, *depends* on the delineation of rights, that is, on how secure rights are over it. In the case described earlier where only one person can affect the income from an asset, it is only when that person

becomes owner of the asset that rights are perfectly well defined, and it is only then that the income is maximized. To say that when rights are well defined income is maximized regardless of who has these rights is meaningless, because, as discussed in Chapter 4, only that assignment of rights that is consistent with maximum income delineates rights perfectly clearly.

#### THE RELATIONSHIP BETWEEN INDIVIDUALS' RIGHTS AND ECONOMIC ORGANIZATIONS

Contracts govern the exchange of property rights and are central to the study of such rights. Some contracting parties consist of individuals acting on their own behalf. Others consist of pairs of organizations such as firms, governments, clubs, and families. In addition, there are contracts between individuals and such organizations. Because individuals' objectives are relatively clear, it is useful to define *all* property rights as rights possessed by individuals. Ultimately, individuals always interact with other individuals, regardless of whether one or both interacting parties represent organizations in some capacity. The payments supermarket shoppers make for merchandise can be viewed as exchanges between individuals and an organization — between customers and the store. Such relationships, however, can always be reduced to the individual level. Here, we consider the relationship between the cashier and the customer, on the one hand, and between the cashier and the store manager, on the other. A cashier in a store has the right to collect money from customers who buy in the store. The cashier, of course, does not usually retain customers' payments; rather, in exchange for an hourly wage, the cashier cedes to the store manager rights over her or his time as well as rights over the cash received from customers. The manager's relationships with other individuals such as the store owners involve, in turn, other sets of exchanged rights. The functioning of any organization can be similarly reduced to the ceding of various rights from one individual associated with it to another.

The assumption of individual maximization, and in particular the assumption that individuals maximize the value of their rights, is useful not only directly in the analysis of individuals' behavior but also indirectly as the assumption underlying the functioning of organizations. The study of private property rights, then, can be applied to all organizations — indeed, to all societies. Individual maximization implies that whenever individuals perceive that certain actions will enhance the value of their rights, they undertake such actions. This always applies, whether the individuals

## *Economic analysis of property rights*

operate in markets, in firms, in families, in tribes, in government, or in any other organization.

### OPERATIONAL FEATURES OF THE PROPERTY RIGHTS MODEL

The exchange value of an asset is a function of the gross income it can generate and of the costs of measuring and policing its exchange. These costs also determine the pattern and the degree of ownership. The ownership of assets' attributes is expected to gravitate into the hands of those people who are most inclined to affect the income flows the attributes can generate. The gross income stream (the market value of the flow of services) an asset can generate, the value of the contributions of different individuals, and the costs of policing and measuring the attributes of the asset determine both how strictly rights to it will be delineated and what its ownership pattern will be. Since these and similar magnitudes are measurable, the ingredients necessary for an operational theory of property rights are available. These operational features also apply to the analysis of constraints.

Because of the costliness of delineating and policing rights, opportunities arise for some people to capture others' wealth. As demonstrated in Chapter 3, these opportunities arise from people's ability to overuse and to underprovide unpriced attributes when exchanging with each other. Exchange partners may impose restrictions on each other in order to reduce the level of undesired behavior. Consequently, property rights, particularly the right to consume (what appears to be) one's property, are often subjected to constraint. The character and incidence of the constraints are predictable. Analysis of the constraints on property rights, therefore, can help make the study of these rights operational.

### THE PROPERTY RIGHTS APPROACH VERSUS THE WALRASIAN MODEL

The significance of the study of property rights results from the fact of positive transaction costs. On the other hand, in the Walrasian, perfectly competitive, model, rights are perfectly delineated and transaction costs are zero. It is useful, then, briefly to contrast the models of the positive costs of transaction with the Walrasian model. A fundamental difference between the two concerns the role of prices. In the Walrasian model, costlessly determined prices suffice for all allocation problems; but costless transacting requires non-price allocation methods and corresponding organizations.

When equilibrium is disturbed in the Walrasian model, a new equilib-

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rium is instantaneously attained because, given zero transaction costs, the cost of adjustment is zero. In that model, a commodity is made up of strictly identical specimens, people are fully informed regarding the exchanged commodities, the terms of trade are always perfectly clear, and trade is instantaneous. As a result, no effort is required to effect exchange other than that to dispense the appropriate amount of cash. Prices alone always suffice to allocate resources to their highest-value uses.

In the Walrasian model, where prices are sufficient for efficient allocation, institutions are superfluous; firms, clubs, tribes, or families cannot enhance efficiency. Yet for a long time economists attempted to address questions of organization by what amounted to ad hoc tinkering with the Walrasian model. Only recently have people begun to take notice of the inevitable inconsistencies in such an approach. The transaction cost model used here explicitly explores the effects of positive information cost on behavior and on organization.

When equilibrium is disturbed in a positive transaction cost world, price adjustment is not expected to be instantaneous. As long as prices are not fully adjusted to new conditions, the quantities demanded are not, in general, equal to those supplied. Nevertheless, it is possible to determine how equilibrium will be attained. Where transaction costs are positive, a whole array of activities is required to effect exchange; cash with which to pay the pecuniary price is helpful but definitely not sufficient. Because of the complexity of exchange, the parties have many opportunities to alter their behavior from one transaction to another. To illustrate, consider first some of the activities required to effect purchases in stores. Buyers must decide, among other things, whether to shop during the busiest hours or at off-peak times; they must identify the location of the desired merchandise; see, by themselves or with the help of the sellers, if the items they seek are available; and determine if they are of the appropriate quality. They must select the specimens they think are best; ascertain the price, sometimes after haggling; and pay (not necessarily in cash). In addition, they may have to take care of warranties and, on occasion, exchange the merchandise. Effecting purchases, then, involves an elaborate set of operations. More important, the costs and valuations of most of these operations can be altered. For instance, at any particular time a seller may be out of an item that is usually in plentiful supply, or the seller may unexpectedly help carry the merchandise to customers' cars. When the market-clearing price changes but the nominal price does not, buyers and sellers have many margins with regard to which they may still adjust. They can gain from such adjustments, and wealth maximization implies that adjustments will be forthcoming.

Sellers can adjust to a price that is lower than the market-clearing level along various margins. A seller who is in control of the quality of the

merchandise or of the number of cashiers per customer will adjust along such margins. Thus supermarkets tend to reduce the speed of service at rush hours. In general, sellers who choose not to adjust prices or who are prevented from adjusting them may still adjust along other margins. Given wealth maximization, the margins along which they will adjust and the corresponding effects on resource allocation are predictable.

The analysis of non-price adjustments or of property rights need not be restricted to the market sector in an economy or to market economies; on the contrary, the results of such analysis apply everywhere. They are as applicable to China during the Red Guard era as they are to Hong Kong or to tribes entirely without a market system. Application, of course, requires knowledge of the underlying constraints, and such knowledge may be harder to come by in some systems than in others. Property rights notions are usually applied to the capitalist market system only; actually, the property rights approach is at its most useful (and the Walrasian model is at its least useful) in systems in which market prices are least used and least allowed to adjust. In Chapter 8 I will discuss briefly the applicability of property rights tools to a non-price economy.

Virtually all governments play a major role with regard to property rights; they also own properties and participate directly in economic activities. In addition, governments are heavily involved with adjudicating and enforcing contracts. A comprehensive analysis of the roles of government is beyond the scope of the present project. These roles of government will be touched upon in Chapter 8, but largely in the process of analyzing the behavior of individuals and enterprises. Customs and mores seem to be additional non-price factors that affect the allocation of resources. However, the effects of these factors on behavior and on the enforcement of contracts will be ignored: Although the factors to be considered are allowed to change, customs and mores, like tastes, are assumed to be stable, and accordingly have no effect on the margin.

#### THE DISTINCTIVENESS OF THE PROPERTY RIGHTS APPROACH

An enormous amount of literature written in the last quarter century departs from the Walrasian, costless transacting, model. This literature, in which the costs of information play a major role, is diverse, and thus far no single model has stood out as the most useful one. Different approaches with a bewildering array of names proliferate: "agency theory," or the "principal-agent model"; "market signaling"; "rent seeking"; "bounded rationality"; "asymmetric information"; and "contract theory." It is difficult to determine the precise differences between, and sometimes within, these approaches, because as a rule many assumptions

are only implicit. Moreover, the empirical work in the area is too meager to help distinguish among them.

I shall make no attempt to sort out these models. I shall offer, however, a few highly stylized suggestions as to why I find models such as these that do not focus on property rights to be less appealing than the property rights model. It should be made clear, though, that the differences among the models often seem more a matter of emphasis than a reflection of different fundamental assumptions.

The "agency theory" starting point is that principals' maximizing attempts are frustrated by agents whose objectives do not coincide with their own.<sup>5</sup> The asserted asymmetry between the two parties is likely to divert attention from the reciprocity of, and perhaps even from the gains from, exchange. The "rent seeking" approach tends to ignore almost to a fault gains from exchange; it concentrates on people's efforts to capture wealth from each other and neglects opportunities to gain through avoiding waste.<sup>6</sup>

The problems inherent in the models based on asset specificity and on the opportunistic capture of quasi rent are very different.<sup>7</sup> Such models usually deal with variables that are exceedingly difficult to observe and to measure. The proxies required to make such models operational are even farther removed from the desired variables than is usually the case in economics. Thus it is particularly difficult to determine precisely what it is that empirical tests confirm or refute. "Market signaling,"<sup>8</sup> like rent seeking, emphasizes exploitation rather than maximization;<sup>9</sup> and as with the asset specificity model, it is difficult to formulate empirical counterparts to the variables the theory suggests.

In contrast, contracts that delineate and reassign ownership are central to the property rights approach. The study of contracts formed by maximizing individuals, and of the performance such contracts induce, tends to maintain a close correspondence between theoretical variables and their empirical counterparts. Knight (1924) was apparently the first to point out explicitly the economic role of property rights, and Gordon's (1954) thrust is similar. Coase (1960), Alchian (1965), and Cheung (1969) bring operational elements to the analysis. The relative ease of rendering the property rights model operational is made clear in the following chapters.

The property rights model developed in Chapters 3 and 4 is used in

<sup>5</sup>Ross (1973) and Jensen and Meckling (1976) are early proponents of agency theory.

<sup>6</sup>Tullock (1967) and Krueger (1974) started the rent-seeking literature.

<sup>7</sup>Williamson (1975) and Klein, Crawford, and Alchian (1978) initiated the notion of the capture of quasi rent.

<sup>8</sup>This approach had been initiated by Arrow (1973) and Spence (1973).

Chapter 5 to follow through on Demsetz's (1967) and Umbeck's (1977) embryonic contributions on rights formation. In Chapter 5 I attempt to show that the property rights model is useful in predicting when new rights will be created and when existing rights will be placed in the public domain. I also argue that such changes pervade economic activity.<sup>9</sup>

<sup>9</sup>Another distinction of my study, although this need not be unique to the property rights approach, is that I take no account of problems of risk aversion; all my attempts to explain behavior proceed under the assumption of risk neutrality. As is shown in Chapter 3, there is much to be gained and little to be lost by assuming people to be risk-neutral.

## 2

### *The public domain: rationing by waiting and price controls*

This chapter consists primarily of an elaborate example — the 1970s price controls on gasoline — that illustrates the usefulness and power of the property rights framework. Chapter 1 contains a property rights proposition central to this book: Unless property rights are perfectly delineated, which, given positive transaction costs, they never are, some valued properties will always be in the public domain. In this chapter the nature of maximization as affected by properties in the public domain is examined and the actual resolutions of several public domain issues are analyzed. Because an analysis of rationing by waiting offers a convenient introduction to the subject of property rights, I will initially concentrate, though briefly, on such an analysis; I will subsequently present the more detailed analysis of maximization under price controls, which brings out major features of the substance and the mechanics of property rights.

#### RATIONING BY WAITING

The rationing by waiting model used here, which is stripped of many real-world features, is most elementary. Using this model makes it easy to concentrate on the public domain issue and ignore peripheral problems. I will use the results of this basic analysis in the subsequent analysis of the 1973–75 price controls on gasoline.

When the government provides commodities at a zero pecuniary price and makes them available on a first-come first-served basis, commodities are allocated strictly by the order in which individuals join the queue, and ultimately by the amount of time individuals spend waiting in line. Even though orderly queues are often encountered, they should not be taken for granted, as the following example illustrates. Suppose it is publicly announced that a package containing \$1 million is to be given to the first in line at a particular place. It might seem that the first person to hear the announcement would rush to the site and wait for the package to arrive.

If, however, no policing of the line is to be provided, the ultimate owner of the \$1 million is likely to be someone with an armored truck and a machine gun. In the absence of policing, the first person to hear such an announcement will probably not bother to join the queue unless she or he is able to compete effectively with owners of machine guns.

The specific nature of restrictions (in the preceding example, first-come first-served and no policing) delineates the margins of competition — in this case firepower rather than time. The queue will be orderly only if the appropriate restrictions are placed upon it. Such restrictions seem to be applied often, and orderly rationing by waiting is a common occurrence. I will assume that the queue is policed enough to be orderly.

The mechanics developed in price theory texts can readily be used to determine the properties of the first-come first-served allocation. On the supply side, the government supplies a fixed quantity of a good. On the demand side, the only change from the textbook mechanics I make in my analysis is to exchange commodities for time rather than for money. Given the fixed supply, forces of demand determine the equilibrium price per unit of the good being distributed in terms of the amount of time spent by individuals in the queue. Almost anything that can be said about money in the standard case can be applied to time when allocation is by waiting.<sup>1</sup>

One evident and important difference between rationing by dollars and rationing by time, however, is that allotment of dollars across individuals differs from the corresponding allotment of time. If there is a good whose waiting time per unit is five minutes, if waiting is the only method of acquiring the good, and if the good cannot be traded, then a person will stand in line to obtain additional units of the good until the value of five minutes of his time reaches the value of one extra unit of the good. For example, when the value of the individual's time is \$12 per hour (or \$1 for five minutes), he will continue to rejoin the line to obtain another unit of the good as long as his marginal valuation of the good exceeds \$1. If the price of the good becomes \$1 instead of five minutes, the analysis proceeds along standard lines. Given that the good cannot be traded, the individuals who ultimately get the good in the original case, however, are those who value it most in time rather than in money.

Changes in the rules governing distribution of the good can be accommodated easily by this model of rationing by waiting. For instance, there is no reason to assume that the given commodity will be doled out in fixed batches. There are other possible rules governing its distribution: Individuals may be allowed as much of it as they desire; access to the line may be limited to once per period or allowed any number of times; and

<sup>1</sup>Barzel (1974, pp. 73–95).

once the commodity is obtained, trading it may be permitted. Each rule constitutes a distinct way of allocating rights to the good.

This basic analysis of rationing by waiting yields one key result: A commodity announced to be free is effectively placed in the public domain and is of no value until ownership is established. Establishing ownership requires that an individual fulfill certain criteria — in the example here, the criterion is to spend five minutes in a queue. Acquisition of the commodity consumes real resources over and above the resources used in production. In the example, ownership of one already produced unit is established by spending five minutes in a queue. Whatever the method by which rights are acquired — and such methods differ from case to case — it is generally true that resources must be spent to gain possession of commodities in the public domain, and that individual maximization applies here no less than to conventional exchange.

#### PRICE CONTROL ANALYSIS

How are property rights allocated to a commodity that is sold at prices below the market equilibrium level? In the model of rationing by waiting, queuing is the means by which ownership is established. Rationing by waiting can be viewed as a special case of price control.

Real-world price controls differ from rationing by waiting in two important ways. First, whereas in the price control analysis all that is required is that the controlled price be lower than the equilibrium price, in the rationing by waiting model I assume that the (money) price is zero.<sup>2</sup> Second, whereas in the rationing by waiting model I assume that competition can occur only through queuing, in the price control analysis that assumption is not always valid.

In the rationing by waiting model, individuals acquire rights to the rationed commodity by spending the appropriate amount of time in the queue. Under price controls, rights allocation is more complex, and the determination of how rights to an asset are actually allocated is essential in the analysis of the controls.<sup>3</sup> In the remainder of this chapter I analyze the early-1970s price controls on gasoline. Before beginning this analysis, however, it is worthwhile to look at a generic price control model.

In the generic model, it is assumed that competition initially emerges as queuing. Consider Figure 2.1, where  $D$  is the demand curve,  $S$  is the supply curve, the equilibrium price and quantity are represented by  $P^*$  and  $Q^*$ , and the control price is represented by  $P_c$ . Assuming that the control price is perfectly enforced, a discrepancy between quantity de-

<sup>2</sup>I focus on price ceilings — below equilibrium price controls — and ignore price floors — above equilibrium price controls.

<sup>3</sup>See Cheung (1974, pp. 53–71).



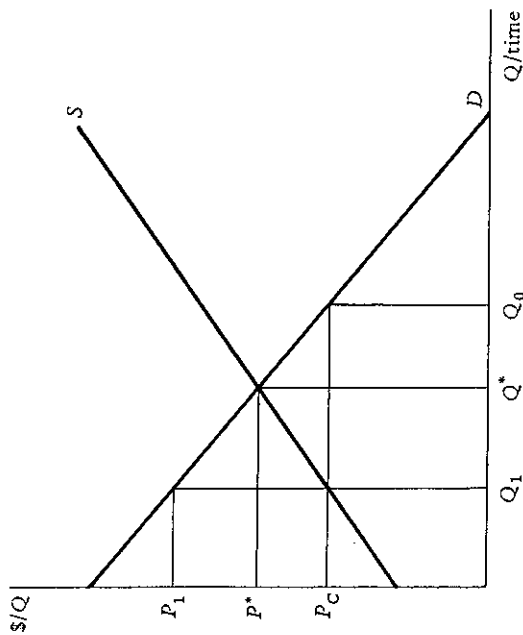


Figure 2.1

manded,  $Q_0$ , and quantity supplied,  $Q_1$ , known as "shortage," will arise. Sellers will only supply  $Q_1$ ;  $Q_0$ , then, is the quantity available to consumers, a quantity for which they will be willing to pay  $P_1$ . Because consumers can pay  $P_C$  only in money, they will spend the difference  $(P_1 - P_C)$  by waiting in line. For example, if  $Q = 100$ ,  $P_C = \$1$ ,  $P_1 = \$2$ , and the opportunity cost for consumers is \$10 per hour, then buyers in the aggregate will spend a total of \$100 in money and ten hours in time to purchase ten units.<sup>4</sup> Because queuing is the only margin of competition, this is the new equilibrium under the price control. As the discussion proceeds, various simplifying assumptions underlying the generic model will be dropped one at a time. It is essential, however, first to describe the control itself and its background.

The price controls

The Economic Stabilization Act of 1970 gave the president of the United States the authority to impose controls on prices. On August 15, 1971, President Richard Nixon imposed a ninety-day economywide freeze of prices at their May 1971 level. This freeze was known as Phase

<sup>4</sup>The area  $(P_1 - P_C) \times Q_1$  in Figure 2.1 represents the dollar value of the time expenditure.

The public domain

I of the price controls.<sup>5</sup> Phase II, which began on November 14, 1971, contained a less stringent set of price regulations, which did allow many firms to raise prices above Phase I levels when input costs increased. Gasoline prices, however, as well as the prices of heating oil, crude oil, and residual fuel, were effectively controlled at the Phase I level. Phase III, introduced on January 11, 1973, initially involved a voluntary form of the Phase II controls. On June 14, 1973, the Nixon administration imposed another economywide price freeze as part of Phase III. This freeze lasted until August 12, 1973, at which time Phase IV, the final phase, began. However, for the petroleum industry, including gasoline retailers, the Phase III freeze continued until September 6, 1973. Phase IV was essentially a period of gradual price deregulation, although petroleum products, including retail gasoline, were still subject to price controls.

For many commodities, the price controls caused such inconveniences as fewer sales made on credit, a smaller variety of goods available, and less frequent free delivery. As a rule, shortages did not arise. In the case of gasoline, the discrepancy between the controlled price and the market-clearing price that would have prevailed without the controls was not small enough to mask some of the effects of the price controls.<sup>6</sup> In the wake of the Arab-Israeli war that erupted on October 6, 1973, the Organization of Arab Petroleum Exporting Countries (OAPEC) restricted exports and raised the price of crude petroleum.<sup>7</sup> Prior to the war, the world price of crude oil had been around \$3 a barrel. On October 16, OAPEC raised the price to nearly \$5 per barrel, and on December 23 the price was raised to \$11.561 per barrel.<sup>8</sup> This drastic price increase — more than threefold in nominal dollars — coupled with price controls led to shortages and queuing in the United States by December 1973. Some aspects of these shortages may conveniently be analyzed using the property rights model.

<sup>5</sup>Much of the information on the Nixon administration price controls comes from Kalt (1981) and Rockoff (1984). In the case of retail gasoline, prices were not explicitly controlled; instead, the margins, or markups, were controlled at various stages. Only the price of crude petroleum was controlled. (This information was provided by Bruce Peterson of the American Petroleum Institute and Del Fogelquist of the Western Oil and Gas Association.) The Cost of Living Council and the Internal Revenue Service were the primary agencies involved with policy and enforcement of the controls.

<sup>6</sup>The meaning of "small enough" is clarified in the last paragraph of this chapter.

<sup>7</sup>OAPEC is an influential subgroup within the Organization of Petroleum Exporting Countries (OPEC).

<sup>8</sup>The average per barrel regulated price of crude oil in the United States was \$3.89 for 1973 and \$6.87 for 1974. See *Statistical Abstract of the United States 1986*, p. 698.

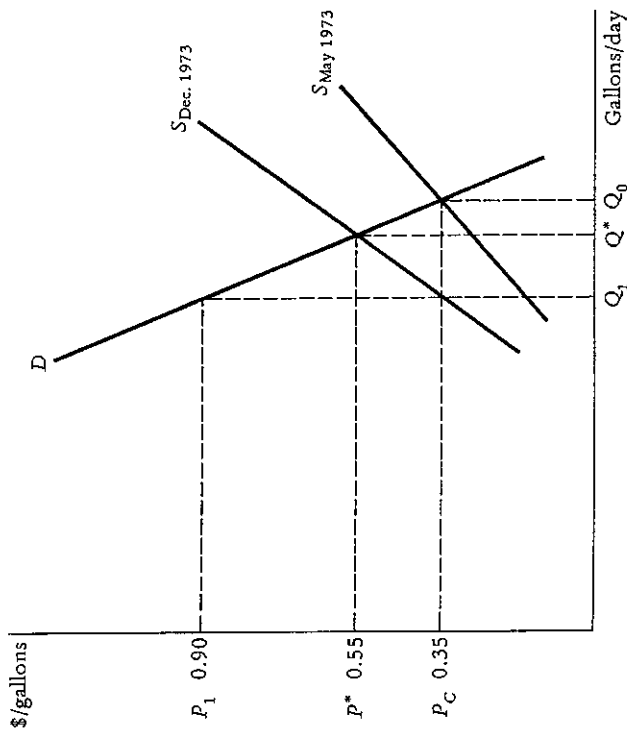


Figure 2.2

The gasoline transaction

Gasoline may appear to be a simple commodity. In the course of this chapter, however, it should become clear that gasoline transactions have numerous valued attributes. Because during the period of price controls market participants were able to alter the levels of attributes not controlled by the government, the actual allocation of property rights differed from that nominally specified by the controls. The examination of this price control episode brings out the strength of the property rights framework in suggesting areas for economic inquiry and in developing refutable implications.

Figure 2.2 depicts the change in circumstances in the gasoline market induced by the 1973 Arab-Israeli war. In May 1971 the price of regular gasoline was about 35 cents per gallon ( $P_C$ ). The crude-oil price hike that resulted from the war caused a shift up and to the left in the supply of gasoline, from something like  $S_{May\ 1973}$  to  $S_{Dec.\ 1973}$ , as depicted in Figure 2.2.<sup>9</sup>

<sup>9</sup>Control of the wholesale price of gasoline complicates, but does not change, the essence of the analysis.

The public domain

In the absence of price controls, the market-clearing price would have been around 55 cents per gallon,  $P^*$ , after this decline in supply.<sup>10</sup> What effect did price controls have on the behavior of market participants? Prior to Cheung's work, the price control literature asserted that a shortage of ( $Q_0 - Q_1$ ) would arise or that the typical consumer would acquire a fraction of the amount of gasoline desired.<sup>11</sup> However, the contention that the shortage would be borne proportionately, randomly, or arbitrarily ignores the postulate of wealth maximization; and in the process the concept of equilibrium was and is often ignored.

Wealth maximization implies that individuals will carry on an activity until, for the marginal unit, net gains are zero. The question that must be asked even when a price is controlled is: Can the buyer or the seller take additional steps to get or to provide another unit at a cost below the added gain? If the answer is yes, an equilibrium has not yet been reached. The notion of a "market-clearing" equilibrium requires that all individuals make whatever moves they wish to make given the existing property rights arrangement. Textbook analyses of a binding price ceiling that conclude that a shortage will exist ignore the possibility of adjustments and thus implicitly deny that individuals maximize if adjustments are available. The way in which margins of adjustment were exploited under gasoline price controls will be examined in the next few sections.

Preliminary considerations of property rights under controls

The Nixon administration could have exercised several options instead of, or in addition to, simply imposing price controls. As the shortage became severe, it could, for instance, have estimated  $Q_1$  (Figure 2.1 or Figure 2.2) and issued coupons for that number of gallons. Had coupons been issued, rights to the purchase of gasoline would have been allocated; and because property rights would have been secure, people would not have needed to spend resources to acquire these rights. In fact, coupons were not issued, so the question at issue is: What property rights system prevailed under price controls?

Earlier, using Figure 2.1, I made the general statement that when the maximum price for a commodity is set at  $P_C$ , the quantity of it that will be available in the marketplace is  $Q_1$ . Underlying this statement are two important assumptions about property rights, one explicit and one implicit. The explicit assumption is that under price controls the sellers' right to set prices is restricted; here, sellers of gasoline were legally prohibited from selling it at any price above 35 cents per gallon. The implicit

<sup>10</sup>As controls were relinquished, the uncontrolled price of gasoline finally leveled off at around 55 cents per gallon in the summer of 1974.

<sup>11</sup>See Cheung (1974) for a review of this literature.

assumption is that sellers retain the right to provide whatever quantity they wish. Given the sellers' marginal cost curve and the control price of 35 cents per gallon, the maximizing quantity they would have offered was  $Q_1$ , as indicated in Figure 2.2. Consumers wished to purchase  $Q_0$  at the control price, but this quantity had no operational relevance: No forces were present to yield this quantity.  $Q_1$  was ultimately the quantity that was allocated among the consumers.  $P_1$  is the maximum price that consumers would pay to purchase the (entire) quantity  $Q_1$ , which in Figure 2.2 is 90 cents per gallon of gasoline.  $Q_2$ , the quantity offered at price  $P_1$ , is the quantity that consumers wanted to purchase at the higher price. In reality, rationing by waiting turned out to be the equilibrating force, given that the maximum price sellers had the right to charge was lower than the one buyers were willing to pay.

*Rationing of gasoline by waiting*

Why did waiting lines for gasoline materialize in the fall of 1973? Shortages are not a cause for waiting, and the regulators had never formally adopted queuing as the method of allocating gasoline. It became clear, however, that queuing, although subject to various exceptions and added controls, was the only method of distribution that was going to be allowed.

Under controls, the actual pecuniary price per gallon of gasoline was positive — 35 cents. Although rationing by waiting was analyzed on the assumption that the pecuniary price is zero, as long as the controlled price of gasoline is held below the market-clearing price, the queuing analysis essentially applies. Gasoline, then, was placed in part in the public domain, and the queue served to establish rights over that unowned component. Gasoline sellers owned the property rights to 35 cents per gallon of gasoline, and buyers could acquire rights to the difference between  $P_1$  and  $P_C$  (which in Figure 2.2 is 55 cents per gallon) by getting in the queue. If the wage rate of the marginal waiter had been \$6 per hour (or 10 cents per minute), the market-clearing queue length would have been five and a half minutes per gallon.<sup>12</sup>

Given that buyers acquired gasoline by a combination of money and

<sup>12</sup>An important complication arises with regard to the mechanics of the queue. It makes a difference, for example, if gasoline is rationed by the gallon or by the tank. In most cases, gas was rationed by the (capacity of the) tank. A person who drove a car with a small tank could get less gasoline than someone whose car had a large tank. Since waiting time was independent of the size of the gas tank, savings associated with purchase size became more prominent, and consequently the expected frequency of people's running out of gas was higher. Independent of shortages, a person could save resources (time) by filling the tank less often, and people occasionally did run out of gas by postponing purchase too long. The expectation is that with price controls, people will run out of gas more often.

time, the conventional demand curve is somewhat misspecified. As usually formulated, it shows how much money people will pay for varying amounts of gasoline when no waiting is required, but not how much they will pay in terms of a combination of money and time. It is easy to construct a modified demand curve in which the price is stated in minutes per gallon, given that 35 cents per gallon must also be paid. Such a demand curve displays marginal valuation in terms of time per unit over and above 35 cents per unit. Compared with the conventional formulation, this type of demand curve varies across individuals, depending on the opportunity cost of their time. Of two individuals who have identical demand for gasoline but who differ in their opportunity cost of time, the one with the low opportunity cost of time will always be able to outbid the other once queuing becomes part of the price of gasoline. In what follows, demand is assumed to account for the two components of price. I will now return to the main problem.

The preceding discussion of the rights of sellers and of buyers brings out the fact that the rights to the value of the gasoline were divided by price controls. The sellers had the right to the value of the gasoline up to the control price, and the buyers could acquire the right to the difference between the control price and their marginal valuation by joining a queue. By paying the control price plus the time price, the buyers could obtain the property rights to a gallon of gasoline. Except for the fact that buyers had to pay a pair of prices, the market for gasoline may be viewed as having functioned normally. Indeed, there are many markets in which both money and time prices are paid by the buyer. A person who insists on eating lunch at noon in the cafeteria is charged a money price by the cashier and faces a time price as well: waiting time. In this case, pecuniary prices for commodities are fixed by the market. In the case of gasoline, the money price was fixed by government.

*What are the regulators regulating?*

The preceding analysis contains many implicit assumptions that tag the waiting price onto the control price. In the next few sections some of these assumptions are altered in order to increase the correspondence between the waiting model and the actual situation.

The approximate average price of gasoline in the United States in May 1971 was 35 cents per gallon, and in the analysis a single control price of 35 cents per gallon was used. Yet the gasoline price controls were based on actual gasoline prices, which were subject to considerable variation. Prices were lower at gas stations nearer to production centers, reflecting lower transportation costs. Prices were higher for premium than for regular gasoline. Prices were lower at gas stations that used low prices as

promotional devices than at gas stations that used other means of promotion. Prices were lower at self-service stations. A self-service station selling regular gasoline at 34 cents per gallon in the summer of 1973 would have had to sell regular at a maximum price of 34 cents during price controls, and a full-service station selling regular at 38 cents during this period would have had its maximum price fixed at 38 cents.<sup>13</sup> A price control constitutes the assignment of property rights; assuming that the regulators could easily ascertain the actual base price and could easily enforce it, delineation was clear in one important respect: Each seller clearly knew what price he could legally charge. In other essential respects, however, delineation was less clear.

What exactly is it that one purchases in a gas station? "Gasoline" is not a sufficient answer. Like all transacted commodities, gasoline has a large number of valuable attributes. For example, when is it available? Is the gas station open nine hours per day or twenty-four hours per day? Is the octane rating 88 or 98? Is the gas station self-service or full-service? It is essential to have specific information about regulation of the attributes of gasoline before its effects can be adequately examined. Ambiguity surrounded the control of such attributes under price controls.

Much of the ambiguity in the scope of controls results directly from the great number and variability of attributes of gasoline. The attributes of gasoline transactions can be classified into those of the gasoline itself and those of the services provided with the gasoline. Gasoline is commonly graded as regular or as premium, depending on the octane rating; here I assume that under the controls premium gasoline had to have a minimum octane rating of 90.<sup>14</sup> Thus "premium gasoline" describes a range of products 90 octane and above, not a strictly defined single product. There are other variations among premium gasolines. For example, Exxon's premium gasoline had performance additives different from Shell's, and the premium gasoline sold in the Rocky Mountains was probably refined differently from that sold at sea-level locations. Price controls essentially ignored most of the variations in gasoline quality. Because it is prohibitively costly to define rights to all the valuable attributes of a commodity, it is not surprising that the control specifications were not fully detailed. Correspondingly, it is expected that regulations also consistently fail to address certain attributes specifically. Indeed, the real-world price con-

<sup>13</sup> Actually, it is difficult to figure out the precise price used by the regulators.

<sup>14</sup> Premium and regular grades are generally determined by industry standards through the American Petroleum Institute (API) and the American Society for Testing and Methods (ASTM). Bruce Peterson of the API reports that the standards are voluntary, although there are some state regulations, with varying degrees of enforcement. No single octane rating is specified to distinguish regular from premium; for purposes of the analysis I assume that premium gasoline must be at least 90 octane and regular can be any octane lower than that.

trols specified just the grade of gasoline and largely ignored other attributes, including attributes of the second type (kind of service provided).

When attributes subject to variability are incompletely specified, the affected parties, correspondingly, are allowed different amounts of leeway, each according to her or his particular circumstances. Consider the following illustration. Two stations, A and B, were selling premium gasoline in the summer of 1973. Station A sold 90-octane premium for 39 cents per gallon, and station B sold 92-octane premium for 43 cents. The lowest octane level at which a gasoline was still considered premium was 90; B could lower its octane from 92 to 90 while staying within the controller's definition of premium.<sup>15</sup> When price controls were imposed, A was allowed to sell premium for no more than 39 cents and B could sell premium for no more than 43 cents. As a result of the price controls, part of the rights to the value of the gasoline was placed in the public domain. In my initial analysis, in which gasoline was implicitly considered as a homogeneous commodity, it was seen that price controls effectively allowed the seller to retain the right to 35 cents per gallon and allowed buyers to capture the remaining value (which had been put in the public domain) by joining a queue. This conclusion must be reexamined in light of the opportunity to adjust the quality of the gasoline.

The regulation did not restrict sellers to the precise quality of gasoline they were selling during the spring of 1973. With product quality as a variable and with a regulation that did not specify all of the relevant quality attributes, property rights had become extremely murky by late 1973. Both station A and station B were required to maintain the octane level of their premium gasolines at no less than 90. Station A was restricted to a maximum price of 39 cents a gallon and to a minimum octane level of 90; station B was restricted to the set minimum octane level but to a maximum price of 43 cents a gallon. Station B, then, could lower its octane to below pre-control levels and still sell the gasoline as premium for 43 cents. If gas stations had to pay refiners 2 cents per gallon for each unit increase in octane level, station B was able to save 4 cents per gallon of premium gasoline. As long as consumers were willing to pay more than 43 cents per gallon for premium gasoline (i.e.,  $P_1 > 0.43$ ), they were willing to pay the higher money price for B's gasoline, provided that the time price they had to pay was correspondingly less than for A's gasoline. Since the time price reflected acquiring rights from the public domain and was not transferred to anybody, there was no countervailing loss from the reduction in waiting time when buying B's gasoline. Station B, by being able to adjust gasoline quality without violating the regulation, could capture some of the value of the gasoline that seemed to end

<sup>15</sup> I am assuming that the retailer was in charge of gasoline quality, which because of price controls at the wholesale level, may not have been so.

up in the public domain as a result of price controls. The government's specification of rights played into the hands of station B.

Two tests of the preceding analysis follow. First, gasoline quality, in terms of octane levels, should have declined as sellers attempted to capture the value that was placed in the public domain. Second, the quantity of antiknock additives (substitutes for octane sold separately from gasoline) should have increased subsequent to the imposition of price controls.

I will now turn to an analysis of gas station services and the attendant impact of price controls. The type and level of services attached to the purchase of gasoline vary considerably from station to station. Full-service stations pump the gas, wash windshields, and provide clean restrooms; self-service stations provide little besides the gasoline itself. As it applied to gasoline, the price control regulation specified nothing about the level of services to be provided along with the gasoline. A simple illustration using two stations, which differ only in the level of services they provide, will serve to isolate the effects of this lack of specification. Station 1 sells regular gasoline for 33 cents per gallon and provides few extra services.<sup>16</sup> Station 2 sells the same regular gasoline for 36 cents, but provides 3 cents' worth of services per gallon in the form of pumping the gas, cleaning the windshield, and checking under the hood. Once price controls are imposed, Station 1 can charge no more than 33 cents per gallon; Station 2 can charge no more than 36 cents. Station 2, like station B in the previous example, has an additional margin of adjustment not available to station 1. Station 2 can reduce its service level to zero, saving 3 cents per gallon in costs, and still sell gasoline for 36 cents, enabling it to avoid losing some of its wealth to the public domain. Consumers will buy all that station 2 can sell at 36 cents a gallon without service so long as the cost of waiting at station 1 exceeds 3 cents per gallon.

The available supply of gasoline declined during the era of price controls, and the number of stations selling it also got smaller. Those stations that had the greatest number of margins at which to adjust were able to tolerate the price control situation longer than those with fewer margins of adjustment. Because consumers would pay the same full price for the same product no matter where they made the purchase, they were indifferent between paying a higher money price and waiting less at the first kind of station and doing the reverse at the second kind. Thus, self-service or no-service stations, the ones having fewer margins at which to adjust to price controls, were expected to be among the first to go out of business. Stations selling premium at the lowest possible octane level were expected

<sup>16</sup>Convenient locations and smoothly functioning pumps are examples of services even low-service gas stations still provided. In general, if under competition a station was selling gasoline at a price higher than what it had paid for it (including transportation), some service must have been provided.

to be similarly affected. These implications are testable, although the data for the latter implication may be more difficult to collect than those for the former implication.

Gas station owners were able to alter still other margins of their product without violating the letter of the regulation. One of these margins was station hours. Station owners could choose their hours of operation, thereby lowering costs without violating the regulation. Selling gasoline in the middle of the night is more costly than during business hours because workers must be paid a higher wage to work at night and because security is more problematic. Perhaps because complex pricing schemes are costly to operate, twenty-four-hour stations charge the same price at all hours. The average cost of twenty-four-hour stations is higher than that of stations open only in daytime hours, and therefore the single price charged by the former must be higher than that charged by the latter. Price controls required stations to retain the old price but did not require them to keep the old hours. Most stations that had been open twenty-four hours a day quickly shortened their hours of service. Such stations were thus able to charge prices higher than those charged by others while incurring the same costs.<sup>17</sup>

Thus far I have considered only the margins of adjustment open to sellers. There also were margins at which buyers alone or buyers and sellers together could adjust in order to minimize dissipation. Resources spent in the queue were not received by others, and the existence of queues indicated that potential gains from sidestepping queues existed. One common way to circumvent price controls, and thus to lower the losses therefrom, was to tie the sale of gasoline to the sale of another product, not subject to price controls. Owners were able to use lubrication and other gas station services to mask the true price of gasoline to the regulators. A customer whose waiting cost for a full tank of gasoline was \$5 was willing to pay up to \$5 above the competitive price of lubrication when it was bundled up with a full tank of gas and no waiting. The seller who provided such bundles was able to capture some of the value that had formerly been dissipated by waiting. At no previous time in history had automobiles been so well lubricated.

#### THE MINIMIZATION OF DISSIPATION

It is useful here to return to the analysis of adjustment by sellers regarding customer service in order to bring out an important point developed by Cheung. In his analysis of price controls Cheung recognizes that the initial attenuation of the property rights structure would put some potential

<sup>17</sup>Eventually, most stations reduced their hours to the minimum (and most convenient to them) required to dispense their gasoline allocation.

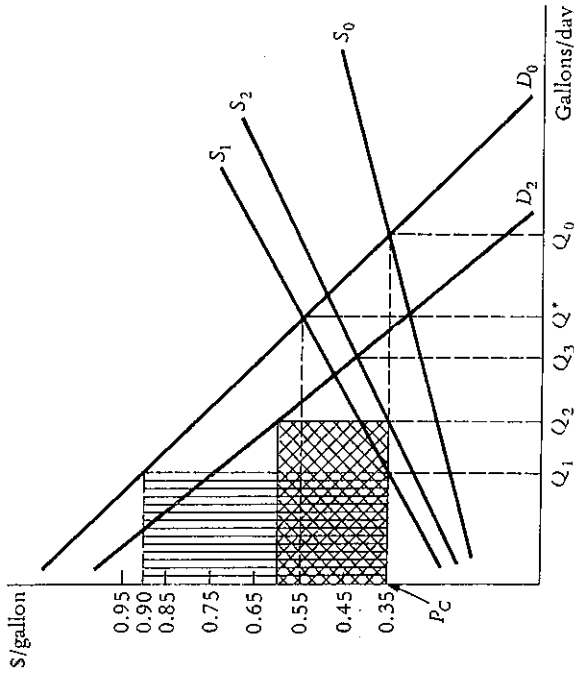


Figure 2.3

income in the public domain, thus leading to income dissipation to the extent that resources were spent to capture the non-exclusive income. An equally important point made by Cheung is that the maximization hypothesis implies that all such dissipation will be a constrained minimum. Dissipation is simply the process of adjusting to new constraints — here the constraint is price controls. By adjusting their levels of service downward as the constraint of price controls became binding, sellers were able to capture value that would otherwise have been left in the public domain. This action is a component of the minimization of dissipation.

Consider the following example, depicted in Figure 2.3.  $S_0$  and  $D_0$  represent the market conditions for full-service regular gasoline before the supply decrease and before the implementation of price controls, and  $P_C$  35 cents per gallon, represents the market price. That price ultimately became the control price. When the supply shifted,  $S_1$  representing the new supply, price controls became binding. Had sellers continued to offer full service, they would have supplied a quantity  $Q_1$  for which consumers were willing to pay 90 cents per gallon. The difference between that price and the control price, 55 cents per gallon, would have been dissipated in the form of time spent in the queue. The total value of the queuing dissipation is shown by the shaded rectangle. This 55 cents per gallon was lost in the sense that the customer's time expenditure was received by no

one. As indicated, the (maximizing) seller could capture some of this dissipated income by reducing gasoline quality and gasoline services.

Because gasoline continued to be sold by the gallon, the coordinates of Figure 2.3 have the right units for the changed product, but the supply and demand curves for the new quality must be redrawn.  $S_2$  is the new supply of gasoline, which required fewer resources because of the elimination of services. Consumers' valuation of the no-service gasoline was less than that of full-service gasoline; the new demand is shown by  $D_2$ . The services eliminated, however, were valued by consumers more than they cost to produce; this is why they were provided to begin with. Therefore, the intersection between  $S_2$  and  $D_2$  (at quantity  $Q_3$ ), the no-service curves, must then be to the left of the intersection between  $D_0$  and  $S_1$  at quantity  $Q^*$ . This is a reflection of a cost of regulation that the adjustments could not eliminate. The dissipation per gallon was reduced (to near 25 cents in the example), and the number of gallons of gasoline ( $Q_2$ ) was larger than in the absence of the adjustment ( $Q_1$ ). The total dissipation, after service reduction, is shown by the hatched area and (combined with the appropriate "welfare triangles") is less than the dissipation without the service reduction.<sup>18</sup>

Before October 1973, the adjustment in gasoline quality was sufficient to yield an equilibrium price as low as 35 cents per gallon, and thus no waiting lines emerged. After October 1973, the price control constraint in the gasoline market was so severe that even when all the available adjustments had been taken advantage of, the equilibrium price exceeded 35 cents a gallon. Consequently, shortages ensued and queues were required to ration the available quantity.

CONCLUSION

Analysis of rationing by waiting and of price controls brings out the fact that because of the complexity of transactions, market participants have many margins besides quantity and price to which they can adjust. Maximization implies that such margins will be exploited, and the pattern of that exploitation is predictable: People will use the lowest-cost methods available to them under the constraints to reclaim the value that the regulations place in the public domain. As a result of such actions, dissipation from the regulations is minimized. In the case of the 1970s gasoline price controls, the adjustments took form as the lowest permitted gasoline octane levels, the shortest possible hours of operation for service stations, and the very frequent lubrication of automobiles.

<sup>18</sup>The service reduction also reduced the magnitude of the shortage induced by price controls. Before the service reduction, the shortage is ( $Q_0 - Q_1$ ). After the service reduction, the shortage falls.