Price Controls and the Behavior of Auction Markets: An Experimental Examination

By R. MARK ISAAC AND CHARLES R. PLOTT*

Price ceilings and price floors are common in all market systems. The ancient Greeks and Hellenistic era Egyptians are known to have utilized price controls (see H. Michele, p. 272, and J. P. Levy, p. 41), and numerous public policy questions today involve them. Apparently for as long as price controls have existed, their effects have been debated. For example, Diocletion's favorable view of his price ceilings[1] was disputed by the religious philosopher, Lactantius, who charged that the policy led to "scarcity and...low grade articles" (p. 145).

The standard partial-equilibrium theory about the effects of price controls, the theory which is subjected to so much criticism, does not seem to have changed since Leon Walras. It is applied widely to a variety of market institutional arrangements including auction markets such as those studied below. If the demand schedule is downward sloping and if the supply schedule is increasing as shown in Figure 1, there should be an equilibrium price-quantity pair of ($.60, 20). Nonbinding price controls, such as a price ceiling at or above the equilibrium or a price floor below equilibrium, should have no effects on the market. If the controls are binding, such as a price ceiling at $.55 or a price floor at $.70, then the market achieves an inefficient price-quantity pair with the market price equaling the controlled price.

However, in spite of its prominent textbook status, the applicability of the model is questioned regularly.[2] Criticisms range from complete rejections of economics to elaborate theories of collusion. As an example of the latter, consider the "focal point" hypothesis as found in F. M. Scherer (p. 352). Perhaps the price ceiling will act as a focal point. Sellers, by focusing on a nonbinding ceiling, may be able to tacitly collude to keep prices above the equilibrium. Thus, the otherwise nonbinding price ceiling can have an effect on prices. A similar theory can be advanced about the effects of price floors. For us the existence of this general controversy and the focal point hypothesis regarding the dynamic effects of price controls seemed sufficient to justify a systematic examination of the subject.

The objectives of this study are to examine the applicability and/or accuracy of the textbook model as applied to laboratory auction markets. Our hope is that by studying the implications of price controls in simple controlled settings, we will be in a better position to analyze more complicated markets which have been the traditional subjects of academic and scientific concern. The choice to study auction markets, as opposed to other forms of market institutions, reflected an attempt to maintain continuity with other experimental studies. Our results are not exactly what we expected and they probably raise more questions than they answer.

*University of Arizona and California Institute of Technology, respectively. The financial support of the National Science Foundation and the Caltech Program for Enterprise and Public Policy is gratefully acknowledged. We thank Julie Laherty for her comments on an earlier draft.

[1] The following quotation is excerpted from *Roman Civilization* (pp. 464–66):

> In response to the needs of mankind itself, which appears to be praying for release, we have decided that maximum prices of articles for sale must be established. We have not set down fixed prices, for we do not deem it just to do this, since many provinces occasionally enjoy the fortune of welcome low prices....
>
> It is our pleasure, therefore, that the prices listed in the subjoined schedule be held in observance in the whole of our Empire. And every person shall take note that the liberty to exceed them at will has been ended, but that the blessing of low prices has in no way been impaired in those places where supplies actually abound....
>
> Emperor Diocletian, *The Edict on Prices*, A.D. 301

[2] During the course of preparing this paper, we noted several heated local political discussions concerning "fair trading" of liquor products, rent ceilings, and wage floors for municipal employees.

TABLE 1

		Series I No Experience		Series II Experience		Mixed Experience	
		Experiment	Period	Experiment	Period	Experiment	Period
No Controls		I	all	III	1–3, 7	II	all
		VII	9	VIII	9		
		IX	9–10	X	9–10		
		XII	9–11	VI	7–11		
Controls at Equilibrium	Price ceiling at equilibrium	IV	all				
		V	all				
	Price floor at equilibrium			VI	1–6		
Nonbinding Controls	Price ceiling 5¢ above equilibrium			III	4		
		VII	1–8	VIII	1–8		
	Price floor 5¢ below equilibrium	IX	1–8	X	1–8		
	Price ceiling 10¢ above equilibrium	XI	all				
Binding Controls	Price ceiling 10¢ below equilibrium			III	5–6		
		XII	1–8	VIII	10		

I. Experimental Design

A total of twelve experimental sessions were conducted. These are listed in Table 1 according to the subject's laboratory market experience and according to the price-control institution imposed. The instructions were those of Plott and Vernon Smith (Appendix, pp. 147–52) and Ross Miller, Plott, and Smith (Appendices, pp. 610–21) with a price ceiling (floor) provision added as indicated below. Participants in Series I (recruited from Pasadena City College) had no previous experience in laboratory markets. All participants in Series II (recruited from Caltech) had participated in at least one other laboratory market with parameters differing from the experiments reported here.

The laboratory design of each experimental session consisted of an auction market with four buyers and four sellers. Preferences were induced following the theory of induced preference (see Smith; Plott). Buyers made money by buying from the sellers and reselling to the experimenter according to prespecified terms. Likewise, sellers made money by buying from the experimenter at prespecified costs and reselling to the buyers. In addition, each individual received a five-cent trading commission. The value of the redemption values for each individual is indicated on Figure 1.

Each market involved a series of "trading periods" in which market participants were free to buy and sell. The individual parameters were identical each period. By application of the theory of induced preference (and/or derived demand) the individual parameters become limit prices which can be "summed" in accord with competitive market theory to produce the demand and supply curves represented in Figure 1. These curves remained constant over all periods and, except for small shifts upward by a constant, indicated below, were the same across all experiments.

Markets were organized as two-sided oral auction markets. All participants had free access to the market floor to make bids to buy (offers to sell) or to accept any outstanding offer (bid). Each bid canceled previous bids, and offers canceled previous offers. All ties were broken by random process.

The institutions being examined are a series of price ceilings and price floors. Specifically, the following paragraph is an example of a price ceiling: "During this experiment, no bids or offers may be made or accepted at a

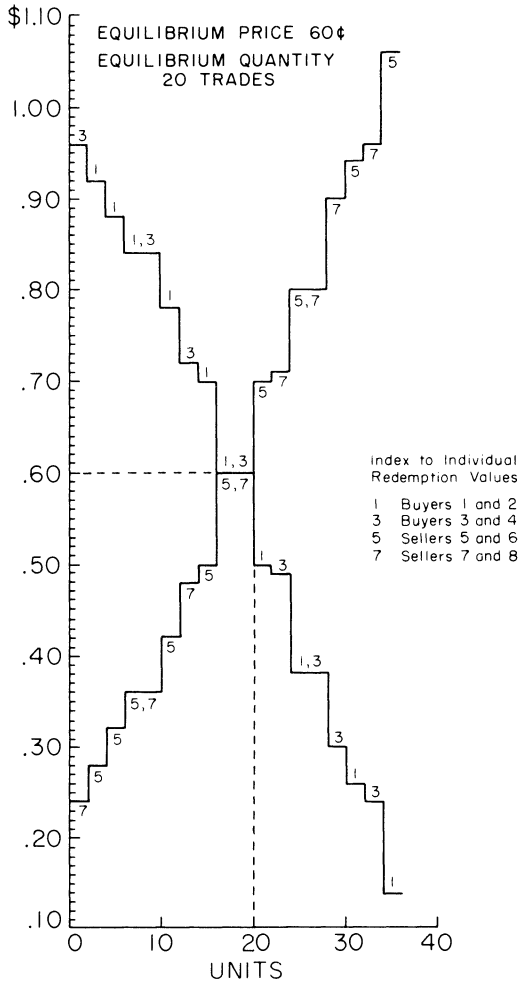

FIGURE 1

price greater than__cents. Of course, you may still make or accept bids or offers at a price less than or equal to this amount."

In general, our experiments can be divided into seven categories as follows ($\bar{P}$ = maximum price, $\underline{P}$ = minimum price, P_0 = competitive equilibrium):

(1) no price controls
(2) & (3) price controls precisely at predicted equilibrium ($\bar{P}=P_0$; $\underline{P}=P_0$)
(4) & (5) strictly nonbinding price controls ($\bar{P}>P_0$; $\underline{P}<P_0$)
(6) & (7) strictly binding price controls ($\bar{P}<P_0$; $\underline{P}>P_0$).

Not all categories were examined because of the expense and the nature of the evidence obtained from the experiments we did run (see Table 1).

The results of the twelve experimental sessions are presented in the following section, with a particular emphasis upon the patterns which exhibit regularity, and upon the relationship between these results and the existing theoretical literature. Additionally, we will consider the significance of our results for future research.

We have focused the study on the following three aspects of market behavior:

1) Price Levels and Market Volume: Price level refers to the average price of a contract during a period. Sometimes the range of prices during a period is referenced. Volume refers to the number of contracts during a period.

2) Market Responses to Institutional Modifications: During the course of several experiments price controls were removed. Occasionally a control was added or changed (see Table 1).

3) Efficiency: The efficiency index developed by Plott and Smith is used here. Markets are 100 percent efficient if and only if the total of subjects' profits and commissions is maximized during a trading period. The efficiency is the actual sum of subjects' profits and commissions divided by the theoretical maximum of this sum. This measure is related to the maximum of consumer's plus producer's surplus.

II. Experimental Results: Some Preliminary Conclusions

We can report two major results and a conjecture. The results are: First, that market behavior under price controls is more closely approximated by the competitive model than by the focal point model; and secondly, that markets under price controls exhibit behavioral regularities which are not included in standard analyses and some of which cannot be explained by the "traditional" competitive model. Specifically, four such regularities were noted: (i) controls at the competitive equilibrium cause market prices to diverge from the competitive equilibrium; (ii) the removal of nonbinding controls induces

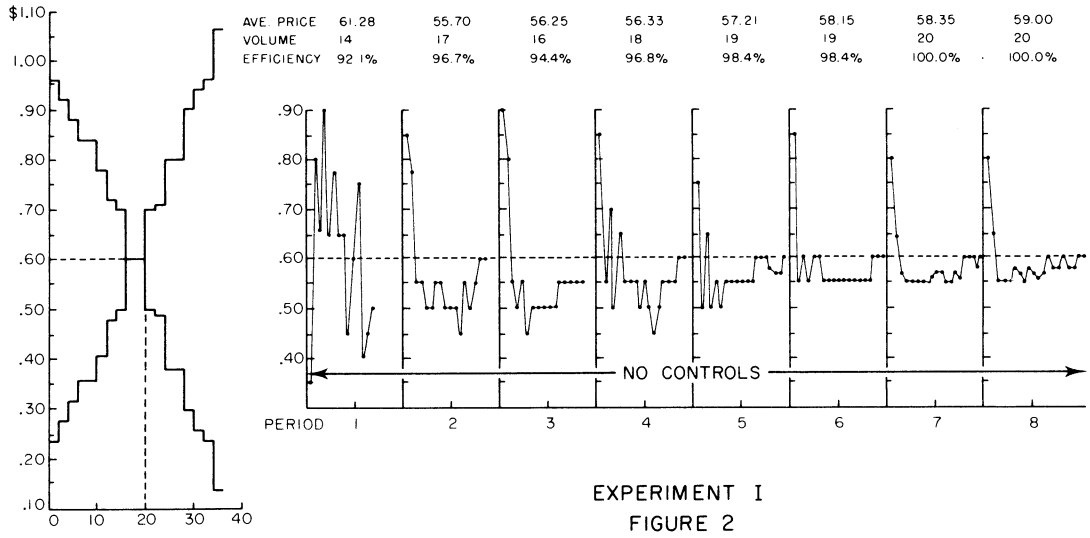

FIGURE 2

changes in market prices; (iii) inefficiencies induced by binding controls are greater than those predicted by the standard application of consumer's surplus analysis. The amount of additional loss depends upon the method of resolving the rationing problem; and finally, (iv) adjustment of prices when binding controls are removed appears to involve an initial discontinuity or "jump" rather than a continuous adjustment. The conjecture is that nonbinding controls act like a "buffer" which holds prices below (above) the "natural" market equilibrium in the case of price ceilings (floors).

Since the two results can be easily demonstrated, we have organized the following subsections, which contain a more detailed examination of the data, in a manner which highlights the nature of the conjecture. First, we discuss the behavior of markets with no controls at all. It is here that the concept of a natural equilibrium (as opposed to the equilibrium point of the competitive model) is explored. The second and third subsections, respectively, address the results of experiments with nonbinding controls and binding controls.

The experimental results are displayed in Figures 2 through 13. Shown in these figures are all contract prices arrayed according to the order (in time) in which the contract occurred. The dotted line always indicates the competitive model equilibrium price (in the absence of controls). During some experiments institutional changes were made, for example, a price control may have been removed or imposed. A double line separates the periods where institutional changes are initially imposed and the nature of the change is indicated on the figure. The equilibrium price, average prices, volume, and efficiencies for each period are on the figures.

A. *No Price Controls*

Three experiments were conducted with no price controls at all. These are Experiments I, II, and III (periods 1, 2, 3, and 7) on Figures 2, 3, and 4. In addition, price controls were removed for selected periods in other experiments (see Table 1).

Laboratory markets (including those examined here), when organized as a "double oral auction"[3] without price controls, invariably exhibit the following properties. These properties are important since they serve as standards against which the effects of price controls can be judged. (a) Efficiencies are high and approach 100 percent and stabilize

[3]We refer specifically to those in which, as here, small trading commissions are paid.

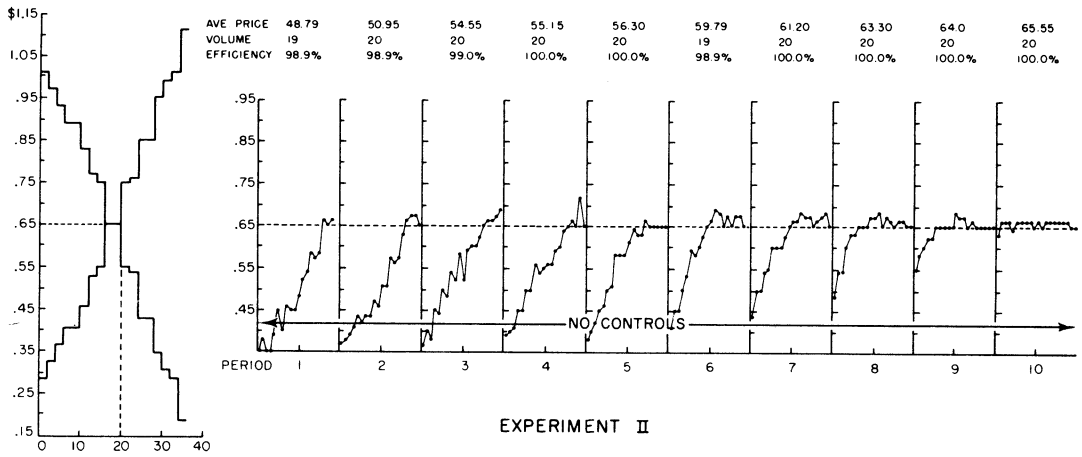

FIGURE 3

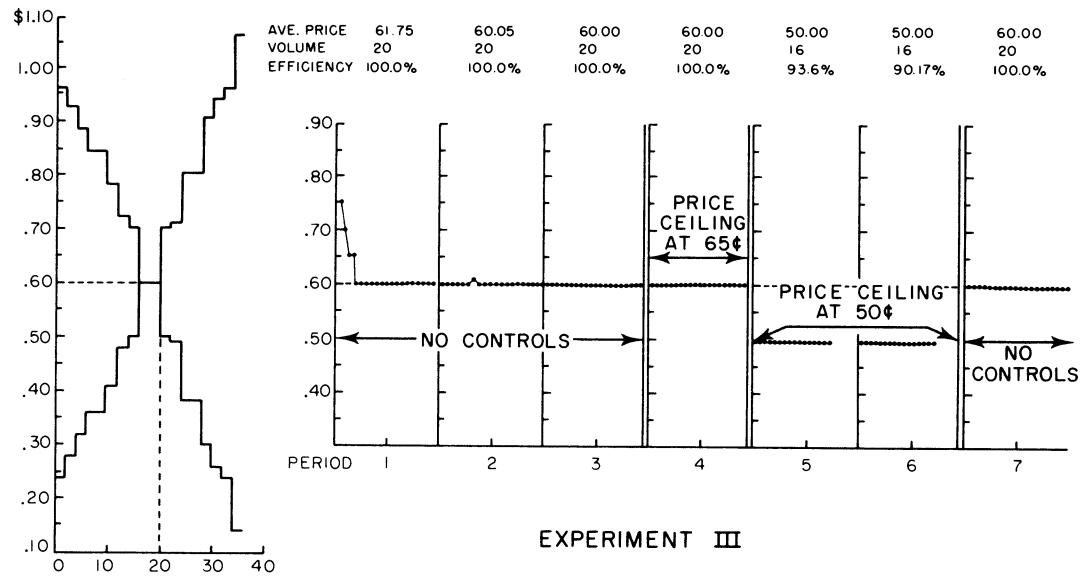

FIGURE 4

once high efficiencies are achieved (i.e., above 98 percent). (b) The variance of prices tends to diminish with replications of periods. (c) If there are many trades at prices other than the equilibrium, they tend to be on both sides of the equilibrium. (d) Average prices tend to stabilize near the competitive equilibrium price.

Experiment III (Figure 4) dramatically demonstrates the frequently observed power of the competitive model. Prices converge almost immediately to the competitive price with zero variance and 100 percent efficiency. While subjects in this experiment did not know the market parameters, they had all had previous experience in laboratory markets. Subject experience is suspected to be a primary reason for the relatively rapid convergence and low variance of Experiment III relative to the other two no-control experiments (I and II).

Sometimes markets have sellers (buyers) who are willing to sell (buy) units at prices considerably below (above) the equilibrium

price even though many trades occur at or above (below) equilibrium. These individuals, who do not seem inclined to "hold out" for one of the better deals are called "relatively soft" sellers (buyers). In Experiment I (Figure 2) notice that the first trade or two in every period is considerably above the other trades. All of these contracts involved the same "soft" buyer. In Experiment II (Figure 3) notice that many low-priced contracts occur at the beginning of each period. These all involved the same two soft sellers whose anxiousness to sell resulted in low contract prices. Exactly why this occurs is not known (in Experiment II, however, one of the soft sellers had no previous experience in laboratory markets) but whatever the reason the behavior is usually "corrected" by the last few periods. It is important to notice, however, that "softness" seems to affect neither the market efficiency (in all three experiments it is over 98 percent by the fifth period and increasing) nor the tendency for trades to occur on both sides of equilibrium. Properties (a), (b), and (c) are exhibited in all three experiments. However, to the extent that the average prices diverge from the equilibrium of the competitive model, we need a concept of a natural equilibrium. The effects of price controls then must be gauged relative to this natural tendency as opposed to the prediction of the competitive model.

The major difficulty with supporting our buffer conjecture above can now be made clear. Indeed the soft trader problem is the reason the result is listed as a conjecture instead of a conclusion. If soft buyers or sellers exist, the average price may remain removed from the competitive equilibrium price. Thus the influence of price controls must be measured against this natural tendency rather than the equilibrium of the model. But the natural tendency cannot be known until the market operates and since the softness of subjects may be modified by any market experience, the very act of observing the "natural equilibrium" which differs from that of the competitive model may cause it to change. Thus, there is currently no "fixed" measure against which the influence of price controls can be identified.

Our initial experimental design was not constructed to deal with this difficulty. At best we are able to establish within our design the plausibility of the buffer conjecture and identify certain properties of the buffer phenomenon if indeed it exists.

B. *Nonbinding Controls*

Nonbinding price controls existed in all or parts of eight of the twelve experimental markets. The first experiments, reported here as Experiment IV (Figure 5) and Experiment V (Figure 6), involved a price ceiling at the competitive equilibrium price and Experiment VI (Figure 7) involved a floor at the competitive equilibrium. The results from these three experiments led to additional experiments with nonbinding controls "near" the equilibrium price (Experiments VII–XI on Figures 8–12, respectively). These will be covered in order below.

Two conclusions can be supported by a reference to all experiments with nonbinding controls. First, the market behavior under nonbinding price controls is more closely approximated by the competitive model than the focal point model advanced in the introduction. In *no* period of any experiment is the average market price closer to the price control than the competitive equilibrium price. When the ceiling is equal to the competitive equilibrium price, the average prices tend to diverge from the ceiling. When the nonbinding price control is not equal to the competitive equilibrium price, the average price (indeed the entire range of prices) of every period is closer to the competitive equilibrium. The rejection of the focal point model in favor of the competitive equilibrium model seems amply justified.

The second conclusion, on the other hand, highlights a possible incompleteness in the traditional model. Removal of a nonbinding price control affects the price level. The action seems to "disequilibrate" the market. Nonbinding price controls are removed in Experiments VI–X (Figures 7–11, respectively). In every case the removal of the nonbinding control is followed by a movement in the average price. The only case where the spirit of this conclusion is violated is Experiment III, period 4 (Figure 4) in which the nonbinding control was added after

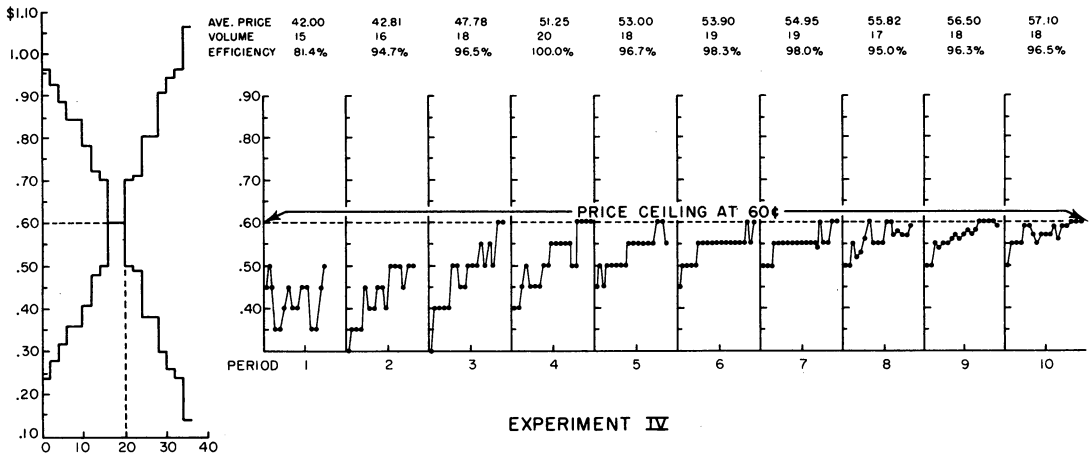

FIGURE 5

the market had already converged and induced no changes at all in the level of prices.

According to traditional models the equilibrating properties of markets depend only upon the magnitude of excess demand. Since the removal of nonbinding price controls does not affect the magnitude of excess demand, the traditional model cannot account for the resulting changes in the price level. Exactly how the traditional model must be supplemented is not clear. Perhaps the removal of controls makes available additional strategies to one side or the other, thereby giving differential advantages. Perhaps any "announcement" in experimental markets will cause "disequilibrations." Perhaps the change creates additional uncertainty, thereby encouraging additional search activity by some participants and conservative or soft trading on the part of the others. Clearly, both additional theory and experiments are needed before the reasons for the phenomenon can be identified.

We turn now to the conjecture, the "buffer hypothesis" by examining first the experiments with price controls placed at the competitive equilibrium (Experiments IV–VI on Figures 5–7). In the price ceiling experiments, IV and V, prices are almost stabilized at an average below the ceiling with few trades at the competitive equilibrium ceilings. Efficiencies remain below 98 percent with marginal units not being traded even though in Experiment IV an efficiency of 100 percent was attained once during an early period. In the price floor experiment, VI (with experienced subjects), prices converged to the floor in a manner seemingly contradictory to the buffer hypothesis, but when the floor was removed (period 7), prices immediately dropped to a lower level. Thus, in the context of the buffer hypothesis the natural equilibrium was below the competitive equilibrium for this group of subjects. Efficiencies in this experiment approximate 100 percent.

Four experiments (VII–X) were conducted with nonbinding controls placed within five cents of the competitive equilibrium. The buffer hypothesis can be applied to all four sessions. The evidence is strongest for Experiments VII–IX where trades seldom if ever occur at prices between the price control and the competitive equilibrium. When the control is removed, prices immediately rise (fall) to above (below) the competitive equilibrium in the case of price ceilings (floor). In Experiments VII and IX the efficiency level did not behave in the stable manner characteristic of markets without controls. Instead, the efficiency sometimes attained the 98 percent level but did not remain. Experiment X differs because prices converged initially below the competitive equilibrium but even in this experiment prices fell when the nonbinding

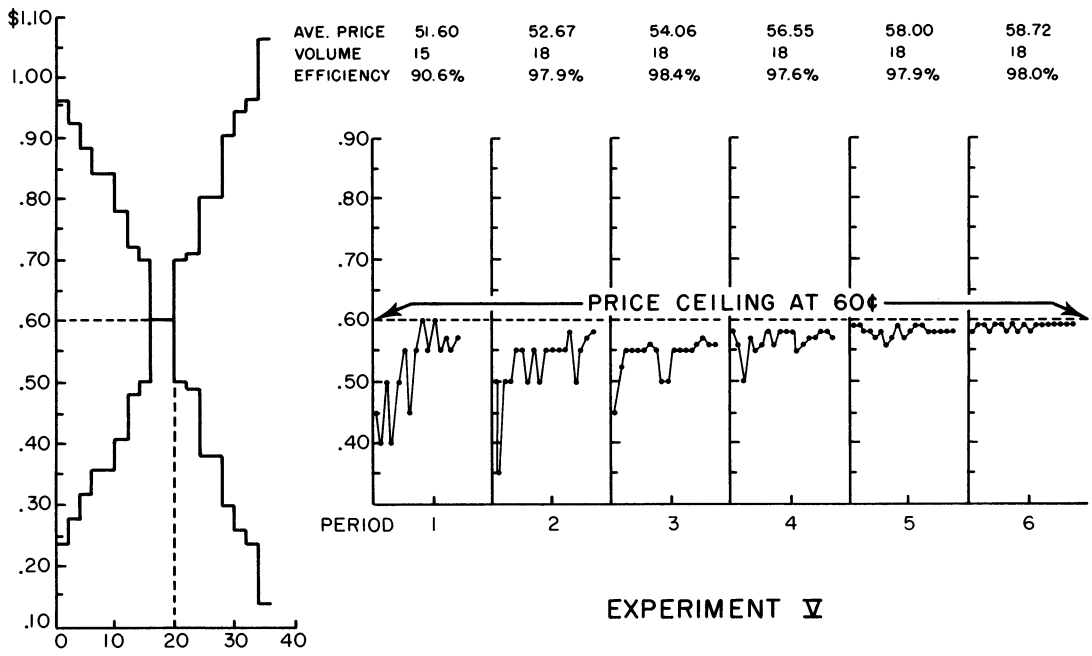

FIGURE 6

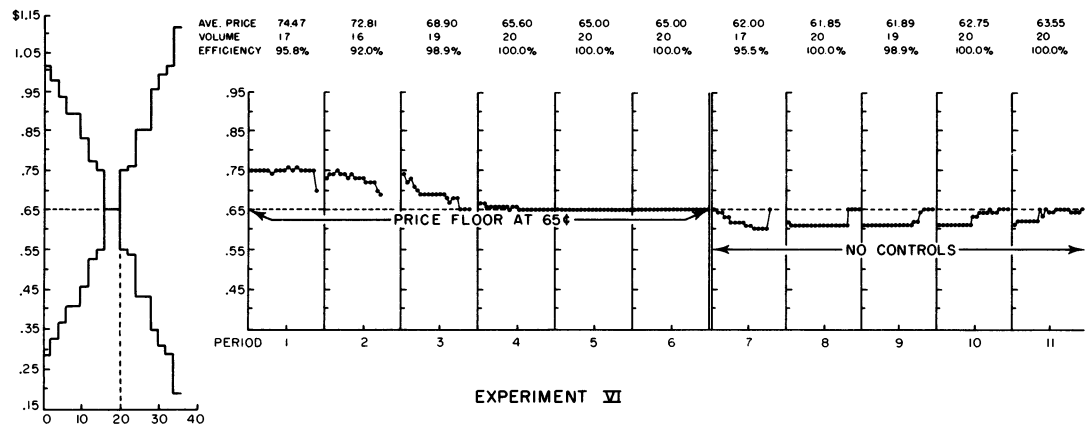

FIGURE 7

floor was removed. Thus, for this experiment application of the buffer hypothesis must assume that the sellers were soft and the nonbinding floor acted to hold prices above the natural equilibrium.

In Experiment XI (Figure 12) a nonbinding ceiling was placed ten cents above the equilibrium. Since prices here converged very close to the competitive equilibrium and since the control remained throughout the whole experiment, we have little to say about it. We suspect, however, that the buffer effect is weak at best here where the control is "far" from the equilibrium price.

As indicated above, we can at best speculate about the reasons for the buffer effect. It may have something to do with the information and "search." The results of Experiment

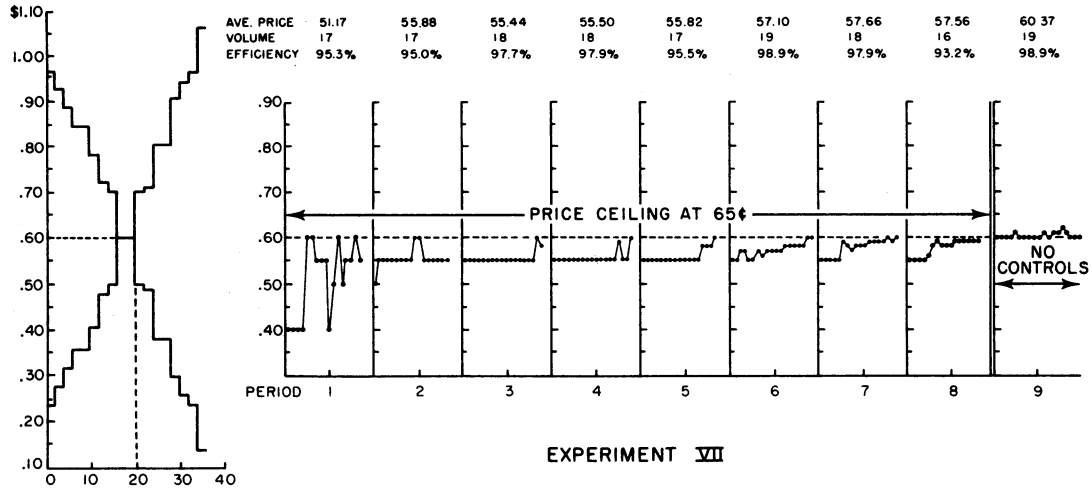

FIGURE 8

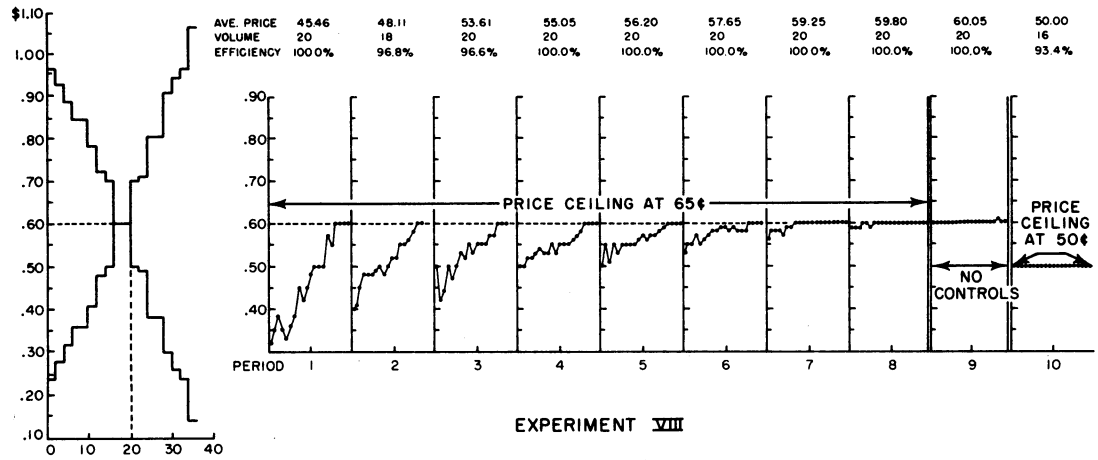

FIGURE 9

III, period 4, were revealing in this respect. Adding a nonbinding ceiling there made no difference at all.

C. *Binding Price Controls*

For the first eight periods of Experiment XII (Figure 13) a price ceiling of fifty cents existed which was below the competitive equilibrium price of sixty cents. The ceiling was removed after the eighth period. In period 10 of Experiment VIII (Figure 9) and in periods 5 and 6 of Experiment III (Figure 4) a price ceiling below the equilibrium was imposed.

The experiments were motivated by the buffer hypothesis. Perhaps the buffer would work to keep prices below a *binding* control. In this respect the control could be viewed as the opposite of the focal point hypothesis as introduced above. Perhaps the ceiling (floor) acts as a signal to the buyers (sellers) and helps them coordinate to hold prices below (above) the ceiling (floor).

As can be seen from all the figures, this alternative hypothesis seems to be wrong.

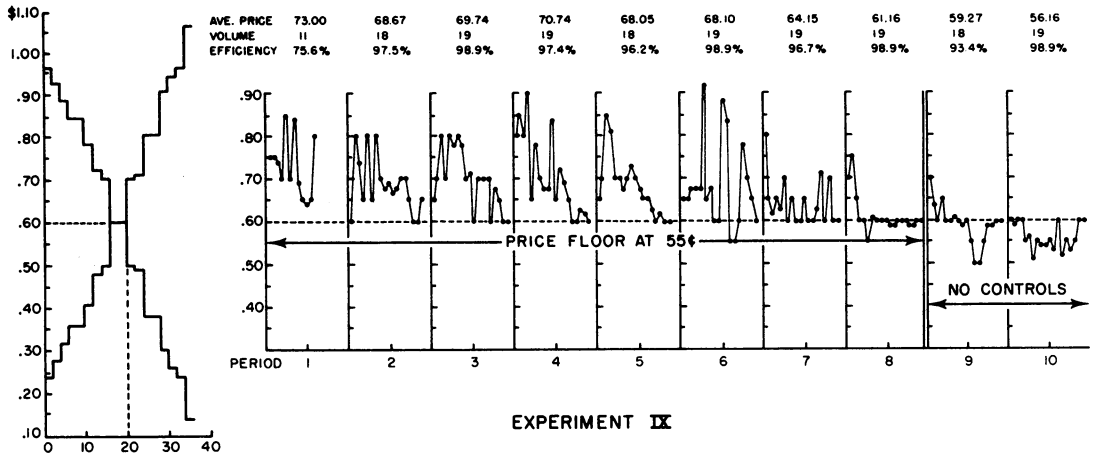

FIGURE 10

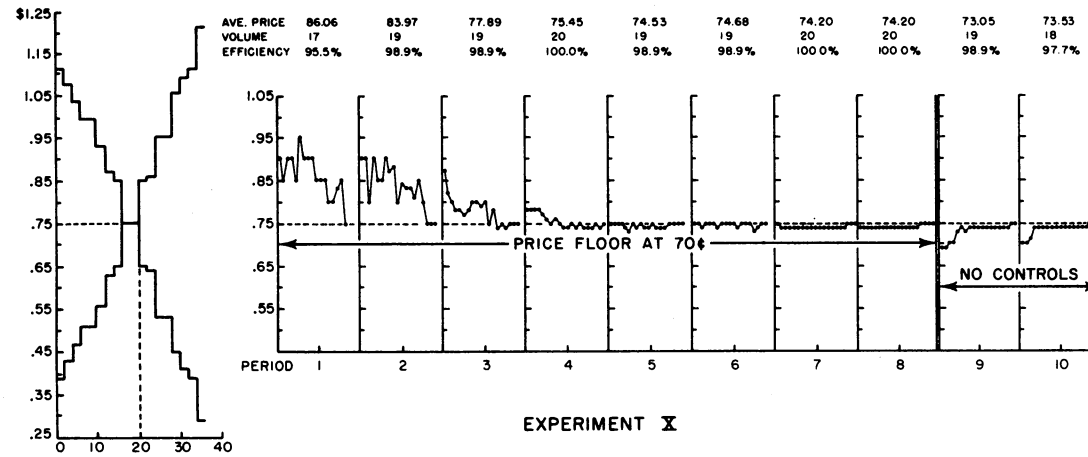

FIGURE 11

Prices converge rapidly to the binding ceilings. Price equals the ceiling and the volume equals the competitive supply function evaluated at the price ceiling. For the case of binding controls the market price behaves as predicted by the traditional model.

In the course of these experiments we discovered two modes of behavior we did not anticipate. The first "unexpected" results occurred when the controls were removed. The adjustment *path* of prices when the binding ceiling is removed differs somewhat from the standard dynamic hypothesis. In period 9 of Experiment XII the binding price ceiling was removed. The mean price jumped immediately to more than thirteen cents *above* equilibrium and then converged down toward equilibrium rather than adjusting continuously upward as suggested by most dynamics models. A discontinuity in adjustment was also present when a binding price ceiling was added in Experiment III (periods 5 and 6) and then removed (period 7). In this market (in which subjects were experienced) prices simply adjusted back immediately to the previously attained equilibrium without "overshooting." This latter result suggests that information, in addition to possibly the

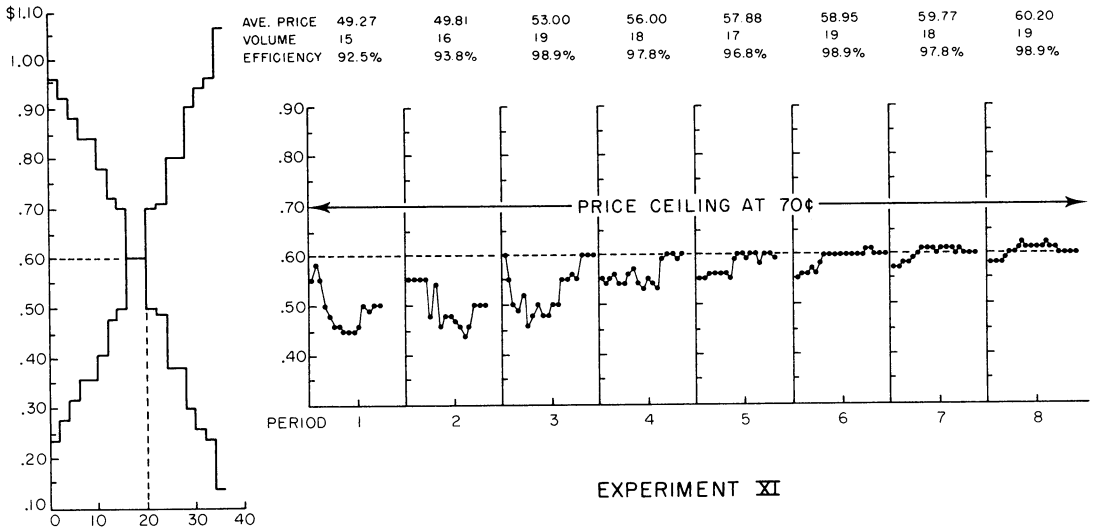

FIGURE 12

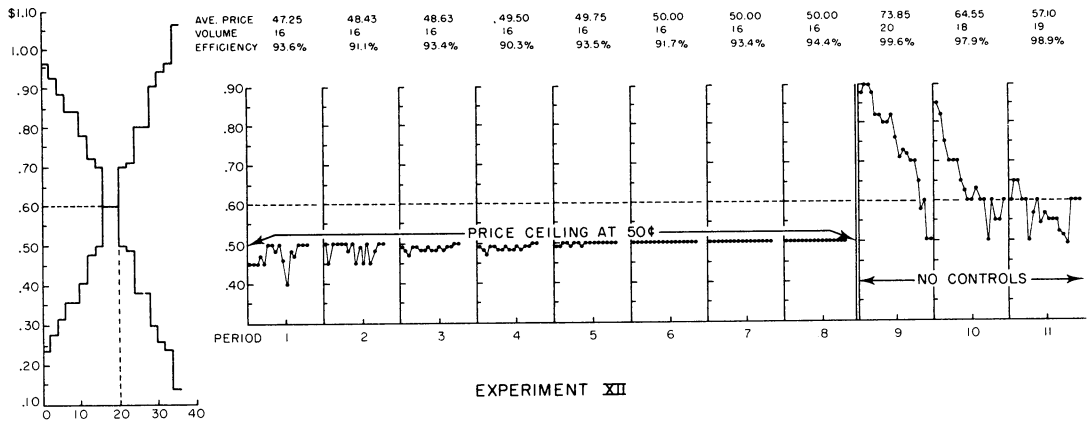

FIGURE 13

magnitude of excess market demand, plays a systematic role in the formation of adjustment paths. Of course more experimentation and theory are necessary.

Secondly, analysis of these experiments with binding controls reveals a source of inefficiency not often stressed in the economics literature. Efficiency losses can result from both the price ceiling as well as the choice of the rationing process used in conjunction with binding price controls. Because of the fifty-cent price ceiling in Experiment XII, at most sixteen units may legally be offered for sale, yet effective demand at fifty cents is twenty-two units. The *minimum* possible loss of efficiency due to the price ceiling occurs when precisely the sixteen demand units with highest redemption value are traded. The maximum attainable efficiency under the price ceiling is 95.73 percent. Whether or not this maximum is attained depends upon the rationing process. In these experiments a first come, first served method was used in which ties were broken by a random process. As can be seen on Figure 13, this rationing process induces its own inefficiencies. In ev-

ery period of Experiment XII efficiency is below the 95.73 percent. Naturally other methods of solving the allocation and queueing problem resulting from the price ceiling may have different efficiency properties.

III. Summary

In summary, we found the familiar partial-equilibrium model works remarkably well to describe laboratory auction market behavior in the presence of price controls and, particularly, when the price controls are strictly binding. However, we also discovered some empirical regularities which the traditional theory cannot explain. Nonbinding price controls seem to affect the average level of prices. Furthermore, price levels and market efficiency can be influenced by removing nonbinding controls. Exactly how the standard model can be extended to explain these results is unclear. The crucial features of the institutions which induce the results have not been identified. Perhaps other institutions induce similar behavior. Perhaps many of our observations can be attributed to the single fact that institutions were *changed* and have nothing at all to do with the essential features of price controls. Nevertheless, the existence of empirical regularities seems undeniable and we offer them as a challenge to theorists who are extending the standard models to include expectations, strategic behavior, and/or the availability of market information to participants.

Subject to qualifications that must accompany any application of laboratory experimental methods, the results presented here are of potential interest to the public policy analyst. Diocletion claimed that his price ceilings would have no effect in regions where they were not binding. These results suggest that he might have been wrong. The observation that the price controls are not binding (in the sense used in partial-equilibrium analysis) is not sufficient to conclude that the controls are neutral either as to the conduct of prices or to market efficiency. Conversely, the fact that market transactions are occurring below a price ceiling or above a price floor will not be sufficient to conclude that removing controls will leave prices and quantities unchanged.

REFERENCES

Lactantius, "The Deaths of the Persecutors," in *Lactantius: The Minor Works*, translated by Sister Mary Francis McDonald, Washington 1964.

J. P. Levy, *The Economic Life of the Ancient World*, Chicago 1964.

Naphtali Lewis and Meyer Reinhold, *Roman Civilization*, Vol. II, New York 1951.

H. Michelle, *The Economics of Ancient Greece*, Cambridge 1957.

R. M. Miller, C. R. Plott, and V. L. Smith, "Intertemporal Competitive Equilibrium: An Empirical Study of Speculation," *Quart. J. Econ.*, Nov. 1977, *91*, 599–624.

C. R. Plott, "The Application of Laboratory Experimental Methods to Public Choice," in Clifford S. Russell, ed., *Collective Decision Making: Applications from Public Choice Theory*, Washington 1979.

_____ **and V. L. Smith,** "An Experimental Examination of Two Exchange Institutions," *Rev. Econ. Stud.*, Feb. 1978, *45*, 133–53.

F. M. Scherer, *Industrial Pricing*, Chicago 1970.

V. L. Smith, "Experimental Economics: Induced Value Theory," *Amer. Econ. Rev. Proc.*, May 1976, *66*, 274–79.

Leon Walras, *Elements d'Economie Politique Pure*, trans. W. Jaffe, *Elements of Pure Economics*, Homewood 1954.