

# *Distribution and Dynamics in a Simple Tax Regime Transition*

by

Mark V. Van Boening  
University of Mississippi

and

Nathaniel T. Wilcox  
University of Houston

## Abstract

We examine transitions between excise tax and license fee regimes in the laboratory. The regimes have matched equilibrium Marshallian surplus, but license fees generate more tax revenue. The license fees are large “avoidable costs,” known to hamper competitive equilibrium convergence. With moderately experienced subjects, the prolonged transition to the license fee equilibrium has these features: (1) Prices below equilibrium levels, resulting in firm losses; (2) Marshallian surplus above equilibrium levels; and (3) transitional windfalls for the tax authority. With highly experienced subjects, license fees lead to the instability and lower seller profits and efficiency observed in past avoidable cost markets.

Keywords: Tax Regime Transitions, Avoidable Costs, Double Auctions, Experimental Methods.

JEL Classification Codes: C9, H2

March 2003

Wilcox (corresponding author): Department of Economics, University of Houston, Houston, TX 77204-5019. Phone 713-743-3840, fax to 713-743-3798, or e-mail to [nwilcox@mail.uh.edu](mailto:nwilcox@mail.uh.edu).

## **Introduction.**

The comparative statics of tax regimes in competitive equilibrium are well understood. As Stern (1992, pp. 287-8) says, “Economists have considerable experience in the theoretical analysis and comparison of different policy regimes.” However, Stern goes on to suggest that “They have rather less experience and success in analyzing the problems of transition from one regime to another...The problems of transition pose important theoretical and immediate policy challenges and no doubt will be lively topics of further research.” Where transitions are prolonged, and have properties that are sufficiently distinct from the long-run equilibrium properties of the new regime, transitional periods may be interesting in their own right, both for optimal tax policy and for understanding the political economy of tax regime change.

In this paper, we describe an experimental change in tax regimes whose transitional dynamics look potentially interesting in just these senses. The transition of particular interest is from an existing excise tax regime to a “license fee” regime where the “fee” is levied per period of activity, rather than per unit of output as with the excise tax. With moderately experienced subjects, this transition is slow and overshoots the new license fee equilibrium, resulting in sustained losses to firms, a large temporary windfall for the tax authority, and total market surplus that is temporarily larger than predicted by the competitive equilibrium.

Under the license fee regime, each firm decides, in each market period, whether to pay a tax allowing it to be “active” (i.e., sell output) during that period; but the size of the license fee itself is independent of the number of units the firm sells in any period. Such license fees are not true lump-sum taxes since they are avoided by inactivity; therefore they can cause distortions at the extensive

margin. Nevertheless, a license fee regime can occasionally produce Pareto improvements over an excise tax regime since it causes no distortion at the intensive margin.

From the viewpoint of each firm, however, substantial license fees can be viewed as large “avoidable costs” (Telser 1978)—essentially, large marginal costs associated with the first unit of output sold in some period. Various experimental work shows that large avoidable production costs disrupt the competitive equilibrium tendencies of many decentralized trading institutions (Van Boening and Wilcox 1996, 2003; Durham et al. 1996; Archibald et al. 2002). Under these conditions, sellers frequently lose money and equilibrium convergence is slow and erratic; and once equilibrium is achieved, it is not nearly so stable as it is when there are no large avoidable costs. We conjectured that these empirical regularities might also hold when the avoidable costs in question are a transfer like a license fee (rather than a real production cost) and in fact they do.

The temporary windfalls of tax revenue and total surplus we observe during these transitions, however, are different from what has been seen in past experiments on avoidable cost markets. In past experiments, efficiency has been unusually low, primarily because avoidable costs have been real resource costs rather than transfers, but also because benchmark equilibria in past work were first-best (so that all out-of-equilibrium allocations decreased total surplus) rather than distorted (as occurs at an equilibrium subject to a non-lump-sum tax).

We observe a systematic tendency for the transitional price trajectory to overshoot its new license fee equilibrium value as well. This is probably an informational phenomenon. Firms’ costs and profits are heterogenous and private information in our experiment and, moreover, all firms can profitably operate in the excise tax equilibrium. As a result, firms neither know ex ante whether they are high or low cost producers, nor does experience in the excise tax regime reveal this information. By contrast, the transition to the license fee regime involves a “shakeout period” in

which a high cost firm must exit. Our interpretation is that at least for some firms, a transitional period of negative profits (for at least the high cost firm) is necessary to produce the information firms need to make decisions that are consistent with the new license fee equilibrium.

## **I. Regimes and Institution.**

By an excise tax, we mean a per-unit-sold payment by a firm. By a license fee, we mean a per-period-active payment by a firm: If the firm is “active” in a specified time period (that is, sells any units), it must pay the license fee once during that period (for instance, truck registration fees). Notice that from a firm’s ex ante viewpoint, license fees are “avoidable costs”—large variable costs avoided by being inactive for a period (for instance, mothballing a truck). Of course, once a license fee is paid, it becomes a sunk cost over the remainder of the licensed time period. But when a period ends, all firms’ “licenses” expire, so that as new periods begin, each seller must again decide whether to incur the license fee and sell output.

As mentioned earlier, large avoidable costs vastly slow convergence to CE allocations and undermine the stability of attained CE allocations in past experiments. This has been replicated for several institutions, but is perhaps most surprising in the case of the “double auction” or DA market (Van Boening and Wilcox 1996). Thirty years of experiments show that DA markets almost always converge very rapidly to CE prices and allocations (Plott 1989). In this sense it is the paradigmatic competitive institution of the laboratory, and this is why we use it for our comparison of excise tax and license fee regimes. Agents in a DA submit offers to buy or sell that are publicly displayed to all other agents, and binding contracts occur when any agent accepts an outstanding offer made by another agent. This public offer and contracting activity continues for a specified time period.

Our comparison of “pure” versions of excise tax and license fee regimes is for maximum design contrast (and hence statistical power) rather than realism. In practice, policy makers frequently employ these regimes in concert. Moreover, we note that most (if not all) actual changes in tax policy are “incremental.” That is, a wholesale switch between two dissimilar regimes, as in this experiment, is probably a very rare event in the world outside of the laboratory (though these kinds of changes are the occasional stuff of policy debates).

## **II. Theory and Design.**

License fees can sometimes improve on excise taxes since they can transfer rents to a tax authority, when rents are present. Marginal firms may exit because of either kind of tax; but the marginal decisions of remaining firms are not distorted by license fees as they are by excise taxes. As a result the license fee can, under certain circumstances, earn tax revenue equal to that earned by any excise tax and increase total surplus. Alternatively, the tax authority may choose a license fee which earns more revenue than an excise tax but leaves total surplus unchanged. We examine the latter case for reasons described below.

### **II-A. Experimental background.**

For contextual purposes, we briefly review our design and findings in Van Boening and Wilcox (1996). Consider a market with four identical buyers who each value 4 units of a good at a constant 250 per unit. Four sellers  $i = 1$  to 4 each have a capacity constraint  $c_i$ , large avoidable costs  $a_i$  and no marginal costs. Put differently, each seller has a “batch production” cost function  $C_i(0) = 0$  and  $C_i(q_i) = a_i \forall q_i \leq c_i$ . Table 1 displays  $a_i$ ,  $c_i$  and average cost at capacity  $\alpha_i = a_i/c_i$  for each of

the four sellers in this design. Given 16 units of demand at  $p \leq 250$ , some reflection reveals that the CE for this market is  $Q^e = 16$  units and  $p^e \in [180,210]$ . We find that double auctions facing this market structure converge very slowly (if at all) to the CE; and efficiency, measured as the percentage of CE Marshallian surplus, tends to be erratic and low. This is true even for highly experienced subjects.

Why is efficiency unusually low? Part of the problem is that, in this structure, quantity deviations from the CE result in sizeable losses of surplus. As a result, supply instabilities can have large consequences. Inelastic demand in the neighborhood of the CE, and the pure avoidable cost technology, are the culprits. Underproduction leaves high-value demand unfilled, usually at zero marginal production cost, while overproduction has zero value to buyers and can only activate unnecessary capacity at a very high avoidable cost. The potential for large surplus losses from CE deviations, combined with the sluggish convergence and instability of these markets, has produced unusually low efficiency in experiments where avoidable costs are real production costs.

## **II-B. Implications for license fees.**

Supply instability appears to be a robust phenomenon in Van Boening and Wilcox's (1996) avoidable cost double auction markets. Although license fees are similar to an avoidable cost, the license fee regime examined here differs from these previous avoidable cost markets in three important ways, as follows: (1) Demand is more elastic (so that a given quantity reduction from equilibrium output has smaller efficiency consequences); (2) The license fees here are transfers rather than real resource costs; and (3) The CE of the markets in this study involve a downward production distortion from the untaxed CE level (as happens with many taxes). The latter two modifications set a stage where overproduction (relative to the distorted CE) can enhance

efficiency. It follows that any destabilizing effects of an avoidable license fee may either increase or decrease efficiency relative to the CE with the license fee, depending on the relative frequency and severity of episodes of over- and underproduction (relative to the CE). For this reason, we compare an excise tax regime CE and a license fee regime CE which are matched in total CE surplus, but where the license fee should yield more CE tax revenue.

### **II-C. Broad features of the design.**

Sellers' production costs and buyers' marginal valuations are identical under the two tax regimes. The demand curve is elastic in the neighborhood of the CE, and firms have standard upward-sloping marginal production cost schedules and no avoidable or fixed production costs. Under the excise tax regime, sellers pay an amount  $\tau$ , in addition to any production costs, for each unit they sell to buyers. Under the license fee regime, sellers pay a flat fee  $F$ , in addition to any production costs, if and only if they sell any units to buyers during some trading period. Thus,  $\tau$  is a per-unit-sold tax, whereas  $F$  is a per-period-active tax.

Our design equalizes the CE efficiency of these two tax regimes, but the two regimes should distribute surplus differently in their respective after-tax equilibria. If the license fee destabilizes quantity supplied, and if deviations are more common and/or severe either below or above the CE quantity of the license fee regime, then the efficiency of the license fee regime may either fall short of, or exceed, that of the excise tax regime. If either occurs, it is of interest to know who bears the burden (and who benefits) from any such deviation from competitive efficiency predictions. Finally, we will vary tax regimes within each market session. In our past study (Van Boening and Wilcox 1996), we recommended this for avoidable cost structures because of their unusually high

between-session variability. Under such circumstances, within-session treatment variation greatly improves the power of statistical tests.

Aside from its statistical advantages, the within-session regime variation also allows us to examine regime transition dynamics. Transition dynamics may exhibit characteristics that are markedly different from the equilibrium characteristics of the final regime. Obviously this could be of some importance, either economically or politically or both. There may be transition costs or even transition windfalls during a transition; and those costs or windfalls may be borne in different ways by different agents. We consider these results on transition dynamics to be among the most interesting results from the experiment.

#### **II-D. Details of the design.**

All subjects first participated in training sessions involving ten trading periods—five under each regime—with instruction in the mechanics of each regime and its record-keeping procedures prior to each five-period block. Upon completion of a training session, subjects were recruited for the data collection sessions, which we refer to here as our “test” sessions. The training sessions used structural parameters (that is, costs, values, taxes and fees) that are different from those used in the ten “test” sessions following the training sessions.

Tables 2-A and 2-B show buyer value and seller cost parameters used for our first six test sessions. The tables show marginal costs and marginal values, in cents, for four sellers and four buyers. These are standard ascending marginal production cost schedules and standard descending marginal value schedules. The first six sessions consisted of six periods of an excise tax regime with  $\tau_1 = 55$  cents and twelve periods of a license fee regime with  $F_1 = 260$  cents. Figure 1 shows three different competitive equilibria for this structure. The demand curve  $D$  is generated by the



marginal buyer values shown in Table 2-B, and the supply curve  $S$  is generated by the seller marginal costs shown in Table 2-A. These two curves cross at a no-tax CE of  $p^e_1 = 90$  cents and  $Q^e_1 = 18$  units. The supply curve  $S^\tau$  is the supply curve  $S$  shifted upward by the excise tax  $\tau_1 = 55$  cents, and crosses the demand curve at an excise tax CE of  $p^\tau_1 = 120$  cents and  $q^\tau_1 = 12$  units. In addition to sellers' marginal costs, Table 2-A shows sellers' average costs with a license fee  $F_1 = 260$  cents. With this fee, minimum average total cost is 95 cents for sellers 1, 2 and 3, and 105 cents for seller 4. These are minimum supply prices for these sellers under the license fee regime. At these prices they become willing to supply their maximum output consistent with minimum average cost, and units beyond this are supplied at the marginal cost of those units. In Figure 1, the supply curve labeled  $S^F$  aggregates these four competitive supply functions, and it crosses the demand curve at a license fee CE of  $p^F_1 = 105$  cents and  $Q^F_1 = 15$  units.

The predicted competitive equilibria are thus  $p^\tau_1 = 120$  and  $Q^\tau_1 = 12$  under the  $\tau_1 = 55$  excise tax regime, and  $p^F_1 = 105$  and  $Q^F_1 = 15$  under the  $F_1 = 260$  license fee regime. It is also important to remember that under the license fee regime, the no-tax equilibrium  $p^e_1 = 90$  cents and  $Q^e_1 = 18$  units can become the short-run equilibrium during any market period where all sellers have paid the license fee (because of its sunk and output-independent character). Table 2-C breaks down total equilibrium surplus per period under the two tax regimes for the first six sessions. Total equilibrium surplus is constant, but a regime transition should have quite large distributional effects. License fees should transfer surplus from the sellers to the tax authority and buyers.

As mentioned above, subjects in the first six sessions have been given receive prior experience with the DA trading institution, tax regimes and laboratory procedures from previous training sessions. However, in training session markets, the competitive equilibrium was identical under both tax regimes and the transition from one tax regime to the other is interrupted by a break

for additional instructions. Therefore, though they are experienced with the mechanics of trading and record keeping in the two regimes, subjects in the first six sessions (after the training sessions) are encountering an uninterrupted equilibrium-changing regime transition for the first time (and may not even think of the training session change as a “transition” because of the break for instruction). We also want to see how these subjects will handle an equilibrium-changing regime transition after they have already experienced one. So we recruit subjects from the first six sessions for four “super-experienced” sessions.

To digress briefly, we have mixed feelings about subject experience levels in this particular experiment. On the one hand, experimentalists tend to give more credit and weight to results as subject experience accumulates and, other things equal, we agree with this. On the other hand, we are unsure whether subjects who are “experienced with large regime transitions” are of much practical relevance to the natural world. Large changes in tax regimes are the stuff of some policy discussions (proposals for large revisions of the income tax code are a familiar example), but almost all changes actually enacted in policy are small and incremental. If in fact large regime changes are very infrequent events, it may be less interesting to know how people deal with large regime changes “similar to other large regime changes they have already experienced.” With this digression in mind, then, we return to the design of the super-experienced sessions.

The final four super-experienced sessions each consist of seven periods of the excise tax regime and fourteen periods of the license fee regime. Tables 3-A and 3-B show the underlying structural parameters for these four sessions. While this structure is somewhat different from that used for the first six sessions, the CE comparative statics across tax regimes are essentially similar. Table 3-C shows the breakdown of total equilibrium surplus with an excise tax  $\tau_2 = 66$  and a license fee  $F_2 = 252$ . As before, the two regimes generate equal CE surplus and, relative to the

excise tax regime, the license fee regime should transfer seller surplus to the tax authority and buyers. The predicted competitive equilibria for the design are  $p_2^f = 162$  and  $Q_2^f = 9$  under the excise tax regime with  $\tau_2 = 66$ , and  $p_2^F = 144$  and  $Q_2^F = 12$  under the license fee regime with  $F_2 = 252$ . The no-tax equilibrium (or short-run license fee equilibrium when all sellers sink their license fee) is  $p_2^e \in [126, 132]$  and  $Q_2^e = 15$ .

Table 4 summarizes the characteristics of the ten sessions. Note that half of the sessions begin with license fees and then switch to excise taxes, while the other half begin with excise taxes and switch to license fees.<sup>1</sup> Treatment (that is, regime) order variation controls for order effects when using within-session treatment variations, and also reveals the nature of regime transitions. However, our unequal division of trading periods between the two treatments is less standard (within each session, license fee regimes last twice as long as excise tax regimes). We do this for two reasons. First, we expect license fees to increase the variance of our dependent measures, just as avoidable costs do in Van Boening and Wilcox (1996), so it makes statistical sense to sample that treatment relatively heavily. Second, we allow for the expected slow convergence of avoidable cost double auctions by giving the license fee regime more periods to achieve convergence.

### **III. Experimental Results.**

#### **III-A. Distribution differences between regimes.**

Table 5 details how actual surplus per period differed in the license fee regime and the excise tax regime in each experimental session. From left to right, the four columns show the actual average per-period differences of (1) total surplus, (2) buyer surplus, (3) seller surplus and (4) tax

---

<sup>1</sup> The session names in Table 4 are for expository convenience. Chronologically, these sessions were conducted in a randomized order.

revenue between license fee and excise tax trading periods. The top panel shows data from the first six sessions, and the bottom panel shows data from the final four sessions. The rows labeled “Prediction” are the CE predictions for these differences (copied from Tables 2-C and 3-C), while the rows labeled by session name show the actual per-period difference in each respective session. For example, actual total surplus per period in session Tax1 was 19 cents greater under the license fee regime than the excise tax regime, contrary to the CE predicted difference of zero.

The lower part of the top panel shows p-values for two nonparametric “randomization tests” (Bradley 1968, Pratt and Gibbons 1981) based on data from the first six sessions. Each test treats each column of differences as six observations (one observation per session). The Randomization Test is more powerful than rank-sum tests, and nearly as good as the most powerful parametric test, against one-sided Normally distributed alternatives, and is valid under very general assumptions. Monte Carlo analyses conducted by Moir (1998) suggest that this test compares very favorably to other popular tests in terms of power and robustness.

The tests labeled “Test 1” in Table 5 have null hypotheses that differences in total surplus, buyer and seller surplus, and tax revenue, are zero across the two regimes, versus the one-tailed alternatives that they are in the direction of the CE prediction. The p-values for Test 1 show that our data strongly supports these directional predictions. But when we look at the sizes of these effects, rather than their directions, a different picture emerges. The tests labeled “Test 2” are those associated with two-tailed randomization tests against the null hypotheses that the sizes of the differences are in accord with CE predictions. The first p-value shows that the equality of total surplus across the regimes is rejected, and all of the observed differences show that total surplus is greater under the license fee regime. For Test 2, buyer and seller surplus differences have marginal p-values ( $p = .06$  and  $p = .09$ , respectively), but in each case five of the six observed differences are

smaller in absolute value than CE comparative statics predict. Although the license fee regime does transfer surplus to buyers and take surplus from sellers, those distributional effects are most definitely muted. The story is different for tax revenue, however. In every one of the first six sessions, the difference between the tax revenue generated by license fees and excise taxes is greater than the CE prediction, and the null hypothesis is easily rejected ( $p = .03$ ). In other words, the tax authority gets an unexpected windfall under the license fee regime. In the next section we argue that this is largely the product of prolonged transition dynamics.

The final four sessions cannot significantly support the findings from the first six sessions. Put simply, the lowest possible two-tailed  $p$ -value of the randomization test, given four within-session treatment variations, is 0.125. Therefore,  $p$ -values are omitted for these super-experienced sessions. Nevertheless, while buyer surplus differences between the regimes are usually smaller than predicted—in keeping with the results of the first six sessions—it seems that other significant deviations from competitive predictions have disappeared. However, patterns of transitional dynamics recur in all ten of the sessions, and we now turn to this matter.

### **III-B. Dynamics of regime transitions.**

Figure 2 illustrates the dynamics of the first six sessions. The left (right) panels show sessions that began with the license fee (excise tax) regime. The top graph in each panel shows every contract price in every trading period. The dashed horizontal lines across these graphs are the various CE prices. The lower line represents the no-tax CE price of 90 cents, which is constant across all periods. The upper line represents the CE price of 120 cents during excise tax periods, or the CE price of 105 cents during license fee periods.

Period trading volumes are graphed just below each price graph. Again, the dashed lines across these volume graphs denote various competitive volume levels. The upper line represents the upper bound on no-tax CE volume, which is 19 units in all periods; and the lower line represents the CE volume of 12 units during excise tax periods, or the CE volume of 15 units during license fee periods. And finally, sellers' total surplus or profits in each period are graphed below each volume graph. The solid line across these profit graphs represents zero seller surplus; and the dashed line represents the CE sellers' surplus of 480 cents during excise tax periods, or the CE sellers' surplus of 150 cents during license fee periods.

Figure 2 illustrates the diverse dynamics of the sessions. The upper left panel, for instance, shows session Tax1. In many respects, the price data from Tax1 are fairly ordinary. Most trading prices under the beginning license fee regime are at or near the competitive price, and price variance is fairly low. As in Van Boening and Wilcox (1996), there is great between-session variability among avoidable cost DA sessions. Some are orderly while others are quite erratic, and license fee periods of Tax1 appear to be the orderly kind. By contrast, the license fee periods of session Tax2 show the wild price dynamics seen in many avoidable cost double auctions.

But even in the license fee portion of the relatively quiet session Tax1, the stylized avoidable cost facts observed in Van Boening and Wilcox (1996) are in evidence. Seller surplus rarely reaches its CE value of 150 cents under the license fee regime. This is true despite CE surplus asymmetries favoring the buyers under the license fee regime. As Smith and Williams (1982) show, an ordinary DA market with only marginal production costs would (in the presence of this kind of CE surplus asymmetry) normally give sellers super-competitive surplus prior to CE convergence; that is, prices with such equilibrium surplus asymmetries would normally converge to the CE "from above." Here, almost all price variability in license fee periods is downside

variability that benefits the buyers. In Tax2 these effects are especially severe. There, total seller profits are actually negative in seven of twelve license fee periods. Frequent seller losses are also observed in Van Boening and Wilcox (1996). Volume exceeds the CE value of 15 units as often as not, and is at or near the first-best upper bound of 19 units in five license fee periods of Tax1. There is temporary overproduction relative to the CE under the license fee regime that temporarily enhances efficiency; and this occurs to a greater or lesser extent in all six of the first sessions.

Tax1 also illustrates the sluggish price adjustment that occurs when a license fee regime is replaced by an excise tax regime. The new excise tax CE is only fifteen cents above the license fee CE. Nevertheless, a full eight trading periods after the regime change in Tax1, excise tax regime prices have not reached their CE level. This sluggish adjustment recurs in all three sessions where the excise tax regime follows the license fee regime and in part accounts for the smaller than predicted difference between buyer surplus under license fees and excise taxes shown in Table 5. Strong surplus asymmetries favoring the sellers under the excise tax regime may also play a role here. Again, from Smith and Williams (1982) we know that when equilibrium surplus favors sellers in a marginal cost double auction, prices will usually converge to the CE from below—to the benefit of the buyers. Yet sluggish adjustment and surplus asymmetries are not the whole story. Table 5 showed that the actual difference between license fee and excise tax buyer surplus is smaller than predicted regardless of regime order. And the right hand panels in Figure 2 show that prices do in fact converge to the excise tax CE from below even in those sessions where the excise tax regime comes first.

Transitions from excise taxes to license fees are much rougher, as illustrated in the right panels of Figure 2. The sequences of maximum trading prices observed within each period under the license fee regime (following an excise tax regime) show something very like sluggish price

adjustment from the relatively high excise tax CE prices. But also notice that, both within and across periods of the license fee regime, prices tend to overshoot the CE and tumble into the neighborhood of the no-tax CE. The session Tax6 was quite typical. All four sellers try to sell output in periods 8 through 14, and volume reaches no-tax CE levels in several periods (recall that, when all sellers are active, this is the short-run CE). Prices and profits fall until, in periods 13 and 14, the total profits of sellers are negative. Two sellers exit in period 15 and prices and profits rebound; finally, in period 16, prices and profits begin a fairly orderly ascent toward the license fee CE. Less pronounced instances of this overshooting and damped oscillation of prices and profits are also observed in the license fee periods of sessions Tax4 and Tax5.

Figure 3 shows the dynamics of tax revenues in all of the sessions. The top panel shows the sequence of deviations of tax revenue from its predicted CE value in each trading session of the first six sessions. It is clear that deviations under the sales tax regime are small and as likely to be negative as positive. Neither of these facts hold under the license fee regime. Because tax revenue comes as large license fees, all deviations are large ones. And thirty-nine percent of the seventy-five license fee periods generate positive deviations (periods when all four sellers are active), while a mere three percent of these periods generate negative deviations (periods when just two sellers are active).

Table 5 showed that many surplus effects observed in the first six sessions were absent from the final four super-experienced sessions. But Figure 4 shows that some of the dynamics of the first six sessions are in evidence in the final four sessions. The left panels show the two sessions that begin with the license fee treatment. Once again, prices tend to converge to the CE from below, in spite of the fact that surplus asymmetries favor the buyers. However, the convergence is very orderly and swift for an avoidable cost double auction; and volume and seller profits also rapidly



converge to their CE values. And when the regime is changed to an excise tax regime, price adjustment is less sluggish than in previous sessions. In both of these sessions, prices and profits climb relatively quickly to their CE levels and volume quickly falls to its CE level.

The orderliness of sessions Tax7 and Tax8 contrasts sharply with the sessions Tax9 and Tax10 that begin with the excise tax regime. In both of these sessions, prices under the excise tax regime never reach CE values. In one session prices are consistently too high; in the other they are consistently too low. As a result, volume only reaches its excise tax CE value in a single period of each of these sessions. But when the license fee regime replaces the excise tax regime, trading prices overshoot the license fee CE and are frequently in the neighborhood of the no-tax CE—as was true for less experienced subjects in the sessions Tax4, Tax5 and Tax6. After this overshooting, prices gradually converge from below toward their license fee CE level. This overshooting and gradual convergence takes place with little within-period dispersion in the session Tax10. But session Tax9 produces trading price dynamics reminiscent of the more severe “roller coaster” markets observed in Van Boening and Wilcox (1996). Under the excise tax regime, high within-period price dispersion begins to shrink. But when the license fee regime is put in place in period 9, price dispersion repeatedly explodes and shrinks in rapid succession as periods pass.

The super-experienced sellers in the session Tax9 usually earned zero or negative total profits during the first five periods of the license fee regime. This experience convinced two sellers to exit the market during those periods and remain inactive until the very last period of the session. As a result, trading prices gradually climbed far above the license fee CE. These sellers had experienced severe within-period price collapses and associated negative profits during the first three periods of the license fee regime. They had to be coaxed back into activity by a very long

series of favorable prices; and that did not occur until ten periods after the first three brutal (for sellers) trading periods.

The bottom panel of Figure 3 shows the sequence of deviations of tax revenue from its predicted CE value in each of the final four sessions. It is again clear that, as with the first six sessions, deviations under the excise tax regime are all small, though now perhaps a little more likely to be negative than positive. And while deviations under the license fee are again much larger for obvious reasons, there seems to have been a fairly clear reversal of their typical direction. Just seven percent of the fifty-six license fee periods generated positive deviations (periods when all four sellers are active,) while a greater twenty percent of these periods generated negative deviations (periods when just one or two sellers are active).

#### **IV. Discussion and Conclusions.**

There is one finding in this experiment which generalizes across all experience levels and treatment orders. In all of the license fee treatment periods of the sessions, convergence to equilibrium seems to require a series of periods during which prices are below their competitive equilibrium levels. This is true even though the rent asymmetries of our license fee regimes favor the buyers. Smith and Williams (1982) show that, for pure marginal cost double auctions, prices tend to converge from a direction which transfers some CE surplus away from the side of the market which receives the lion's share of equilibrium surplus. This never occurs in any of our license fee regime sequences, even though CE buyer surplus is more than twice CE seller surplus in those periods.

We think there is a simple and compelling informational explanation for this overshooting. In both designs, three sellers are low cost sellers who should be active producers in the license fee CE, while one is an extramarginal high cost producer. While our instructions tell each seller not to assume that other sellers have the same costs as she does, she is not told what cost differences may be expected, much less whether she is a relatively high cost producer. Moreover, seller costs and profits are private information throughout sessions. Under these informational conditions, negative profits are virtually the only information a seller gets that reveal that she might be a relatively high cost seller. Since the CE price is the minimum average cost of the high cost seller in the license fee designs, it almost necessarily follows that a period of subequilibrium contract prices must precede convergence to the CE price under the license fee regime. That is, overshooting of the license fee CE in the transition from an excise tax regime may be a necessary part of these transition dynamics when costs are private information.<sup>2</sup> This is especially true since all four sellers can be profitably active under the excise tax regime. As a result, previous experience with the excise tax regime does not reveal to sellers which amongst them is the high cost seller.

Sellers do learn some things in the first six sessions; but what they learn causes the license fee regime to operate less efficiently and generate less tax revenue. Sellers seem to learn that someone among their number may not be able to produce profitably under the license fee regime. Armed with this knowledge, they seem much more willing to exit quickly when they experience negative profits. In three of the final four sessions this leads to a relatively orderly convergence to the license fee CE and, as a result, there are few efficiency-enhancing periods of overproduction in these super-experienced sessions.

---

<sup>2</sup> Theoretically, complete information on costs and values—or even well-specified incomplete information—might considerably speed convergence to equilibrium. Paradoxically, giving complete information to subjects in double auction markets frequently has little effect on, or actually slows, convergence to an equilibrium (Smith 1991, pp. 100-105).

As mentioned earlier, one can wonder what it means to be experienced with large regime transitions such as the ones we study here. Most tax policy changes are incremental, and most decision makers may only encounter large changes in tax policy once or twice in a lifetime. Therefore, we cannot say whether more weight should be put on our results with moderately experienced or super-experienced subjects. Our own judgment is that where costs and profits are mostly private information (as they usually are), and where experience with large regime changes is rare or wholly absent (as it usually would be), we would put more weight on our results for the moderately experienced subjects. In such situations, it seems that a tax authority can expect a transitional tax revenue windfall with no efficiency losses (indeed, temporary supercompetitive surplus may be realized). On the other hand, the transition to a license fee equilibrium is brutal for sellers, so they may have strong reasons to fear and fight such taxes—reasons even stronger in regime transitions than comparative statics reasoning alone suggests.

*Acknowledgments: We thank the Graduate Alumni Council of the University of Mississippi College of Business Administration for research funds. We also thank Shawn LaMaster for software help, and Andrew Austin, Timothy Cason, Steven Craig, Janet Kohlhase, Michael Palumbo and William Shughart for helpful comments, though none of them are responsible for remaining errors.*

## REFERENCES

Archibald, Glen, Mark Van Boening and Nathaniel Wilcox. 2002. Avoidable cost: Can collusion succeed where competition fails? In R. M. Isaac and C. Holt, eds., Research in Experimental Economics Vol. 9: Experiments Investigating Market Power, 242-271. Amsterdam: JAI Press.

Bradley, James. 1968. Distribution-Free Statistical Tests. Englewood Cliffs, New Jersey: Prentice-Hall.

Durham, Yvonne, Stephen Rassenti, Vernon Smith, Mark Van Boening and Nathaniel Wilcox. 1996. Can core allocations be achieved in avoidable fixed cost environments using two-part price competition? Annals of Operations Research 68:61-88.

Moir, Robert. 1998. A Monte Carlo analysis of the Fisher randomization technique: Reviving randomization for experimental economists. Experimental Economics 1:87-100.

Plott, Charles. 1989. An updated review of industrial organization: Applications of experimental methods. In R. Schmalensee and R. Willig, eds., Handbook of Industrial Organization 1109-1176. Amsterdam: North-Holland.

Pratt, John and Jean Gibbons. 1981. Concepts of Nonparametric Theory. New York: Springer-Verlag.

Smith, Vernon. 1991. Papers in Experimental Economics. Cambridge: Cambridge University Press.

Smith, Vernon and Arlington Williams. 1982. The effects of rent asymmetries in experimental auction markets. Journal of Economic Behavior and Organization 3:99-116.

Stern, Nicholas. 1992. From the static to the dynamic: Some problems in the theory of taxation. Journal of Public Economics 47:273-297.

Telser, Lester. 1978. Economic Theory and the Core. Chicago: University of Chicago Press.

Van Boening, Mark and Nathaniel Wilcox. 2003. Generalizing the double auction for nonconvexities: An experimental exploration. Houston, TX: University of Houston Department of Economics Working Paper.

Van Boening, Mark and Nathaniel Wilcox. 1996. Avoidable cost: Ride a double auction roller coaster. American Economic Review 86:461-477.

TABLE 1

Avoidable Costs, Capacities and Average Cost at Capacity of the Sellers  
in one of Van Boening and Wilcox's (1996) Avoidable Cost Market Structures

Sellers (i)	Avoidable Costs ( $a_i$ )	Capacity ( $c_i$ )	Average Cost at Capacity ( $\alpha_i = a_i/c_i$ )
1	960	8	120
2	750	5	150
3	540	3	180
4	420	2	210

TABLE 2-A

Seller Costs in cents, with an  $F = 260$  cents License Fee (First Six Test Sessions)

Output of Seller $i$ ( $q_i$ )	Seller 1		Seller 2		Seller 3		Seller 4	
	MC <sub>1</sub>	ATC <sub>1</sub>	MC <sub>2</sub>	ATC <sub>2</sub>	MC <sub>3</sub>	ATC <sub>3</sub>	MC <sub>4</sub>	ATC <sub>4</sub>
1	10	270	10	270	10	270	30	290
2	20	145	15	143	10	140	45	168
3	25	105	30	105	35	105	60	132
4	75	98	70	96	65	95	65	115
5	85	95	90	95	95	95	65	105
6	125	100	115	98	105	97	105	105
7	140	106	150	106	160	106	170	114

Notes: MC is marginal production cost. Total marginal production and tax costs in the Excise Tax treatment equal the marginal costs given above plus  $\tau = 55$ . ATC is the average total cost of each seller under the  $F = 260$  license fee treatment. In the excise tax treatment, average total costs are not relevant to competitive supply (since the marginal production cost schedules are monotonically increasing for all four firms, so that average total cost is always less than marginal cost).

TABLE 2-B

Buyer Values in cents (First Six Test Sessions)

Units Purchased by Buyer $i$	Buyer 1	Buyer 2	Buyer 3	Buyer 4
1	145	140	137	136
2	140	137	133	132
3	125	130	133	132
4	105	110	115	120
5	100	95	90	85
6	65	70	75	80
7	60	55	45	40

TABLE 2-C

CE Total Surplus and its Predicted Division in cents, by Tax Regime (First Six Test Sessions)

Regime	Total Surplus	Buyer Surplus	Seller Surplus	Tax Revenue
License Fee	1320	390	150	780
Excise Tax	1320	180	480	660
Difference	0	210	-330	120



TABLE 3-A

Seller Costs in cents, with an  $F = 252$  cents License Fee (Final Four Test Sessions)

Output of Seller $i$ ( $q_i$ )	Seller 1		Seller 2		Seller 3		Seller 4	
	$MC_1$	$ATC_1$	$MC_2$	$ATC_2$	$MC_3$	$ATC_3$	$MC_4$	$ATC_4$
1	4	256	8	260	12	264	48	300
2	44	150	40	150	48	156	72	186
3	112	138	104	135	84	132	96	156
4	116	132	124	132	132	132	108	144
5	144	135	156	137	168	140	144	144
6	180	142	192	146	204	150	216	156
7	228	155	240	160	252	165	264	172

Notes: MC is marginal production cost. Total marginal production and tax costs in the excise tax treatment equal the marginal costs given above plus  $\tau = 66$ . ATC is the average total cost of each seller under the  $F = 252$  license fee treatment. In the excise tax treatment, average total costs are not relevant to competitive supply (since the marginal production cost schedules are monotonically increasing for all four firms).

TABLE 3-B

Buyer Values in cents (Final Four Test Sessions)

Units Purchased by Buyer $i$	Buyer 1	Buyer 2	Buyer 3	Buyer 4
1	184	182	180	180
2	184	182	180	174
3	150	156	162	168
4	126	132	138	144
5	102	108	114	120
6	72	84	90	96
7	48	54	60	66

TABLE 3-C

CE Total Surplus and its Predicted Division in cents, by Tax Regime (Final Four Test Sessions)

Regime	Total Surplus	Buyer Surplus	Seller Surplus	Tax Revenue
License Fee	1254	354	144	756
Excise Tax	1254	156	504	594
Difference	0	198	-360	162

TABLE 4

Summary of the designs of the ten sessions

Session Names	First Regime (periods)	Second Regime (periods)	Market Structure	Experience of Subjects
Tax1, Tax2 and Tax3	F = 260 (1-12)	$\tau$ = 55 (13-18)	See Tables 2	Training Sessions Only
Tax4, Tax5 and Tax6	$\tau$ = 55 (1-6)	F = 260 (7-18)		
Tax7 and Tax8	F = 252 (1-14)	$\tau$ = 66 (15-21)	See Tables 3	Training Sessions AND participation in one of the sessions Tax1—Tax6
Tax9 and Tax10	$\tau$ = 66 (1-7)	F = 252 (8-21)		

Notes: F = # denotes a license fee regime with the license fee equal to #, and  $\tau$  = # denotes an excise tax regime with the excise tax equal to #. Some of the sessions Tax1-Tax6 actually lasted one or two more periods than 18 total periods, and these extra period results are shown in Figure 2. However, our statistical results, reported in Table 5, do not include the results of any periods beyond period 18 in those sessions. In particular, the first two sessions we conducted lasted twenty periods, the second two nineteen period, and the final two 18 periods. In this manner, we control for any expectations about the final period and avoid associated endgame effects. In the experienced sessions Tax7-Tax10, we dispensed with this precaution; thus the statistical results of Table 5 are based on all 21 periods of data from those four sessions.

TABLE 5

Difference between average per-period surplus in the License Fee and Excise Tax regimes

Session Name	Tax Regime Order	Difference in per-period surplus (License fee surplus minus Excise Tax surplus)			
		Total Surplus	Buyer Surplus	Seller Surplus	Tax Revenue
First Six Sessions					
CE Prediction		0	210	-330	120
Tax1	License, Excise	19	79	-233	173
Tax2	License, Excise	98	193	-341	246
Tax3	License, Excise	119	98	-174	195
Tax4	Excise, License	6	115	-316	207
Tax5	Excise, License	70	221	-323	172
Tax6	Excise, License	215	138	-233	310
Randomization Tests (p-value)					
Test 1	$H_0$ : Diff = 0, $H_A$ : Diff > 0	—	p = 0.02	—	p = 0.02
	$H_0$ : Diff = 0, $H_A$ : Diff < 0	—	—	p = 0.02	—
Test 2	$H_0$ : Diff = CE prediction	p = 0.03	p = 0.06	p = 0.09	p = 0.03
	$H_A$ : Diff ? CE prediction	all 6 > CE	5 of 6 < CE	5 of 6 > CE	all 6 > CE
Final Four Sessions					
CE Prediction		0	198	-360	162
Tax7	License, Excise	-112	114	-361	135
Tax8	License, Excise	0	176	-337	161
Tax9	Excise, License	-144	113	-341	84
Tax10	Excise, License	132	294	-417	255

Notes: All data are from the period listed in the first two columns of Table 4. The p-values are calculated using the “randomization test” (Bradley 1968; Gibbons 1981). See the text for a discussion of this test.

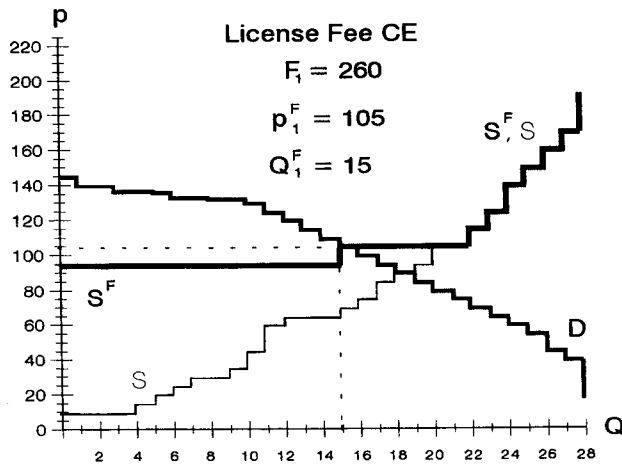
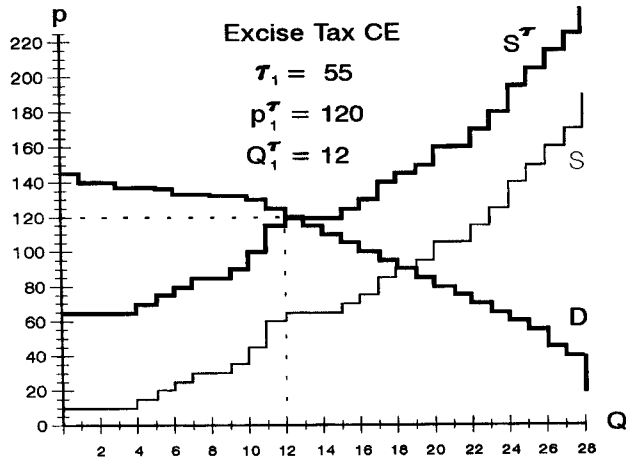
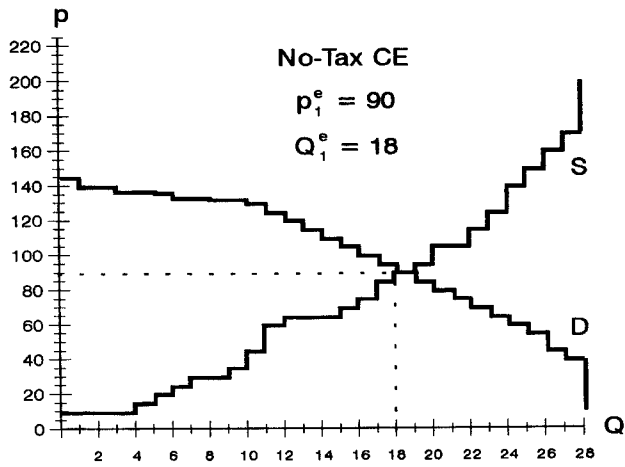


Figure 1. Competitive equilibria of the First Six Sessions.

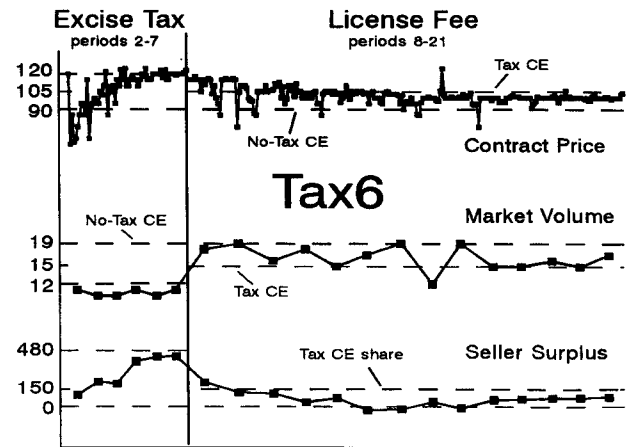
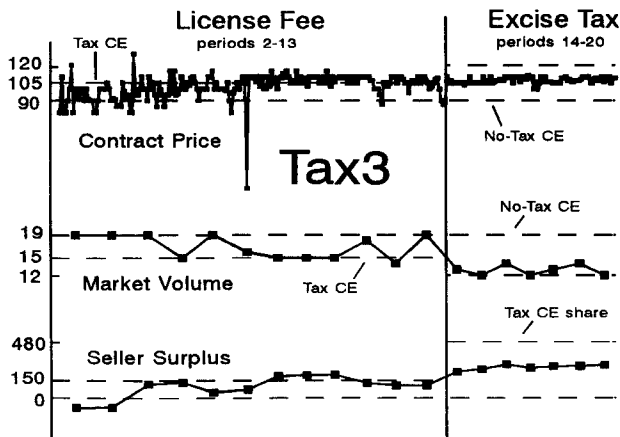
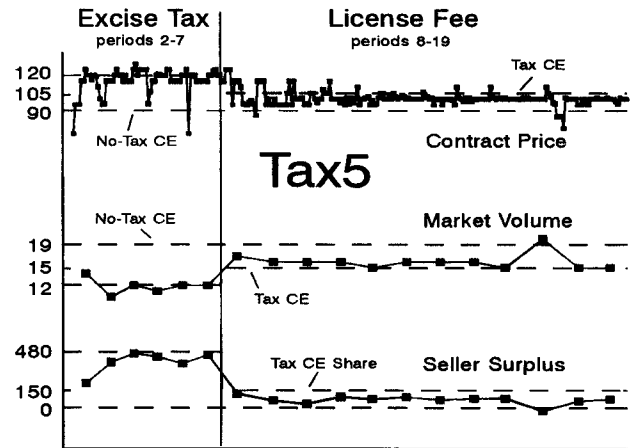
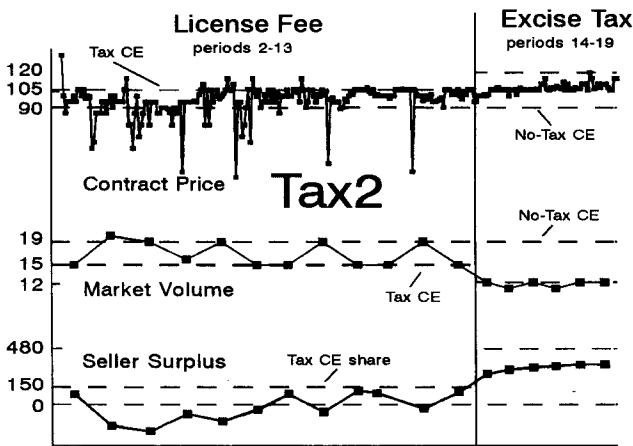
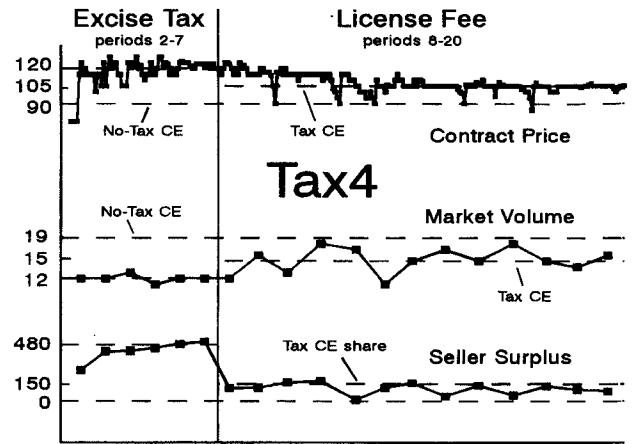
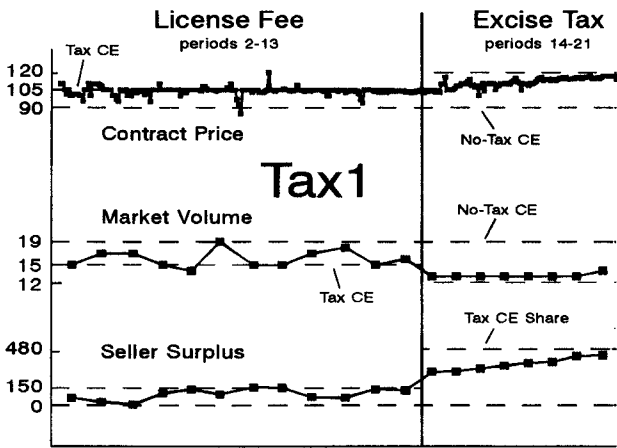


Figure 2. Market Dynamics of the First Six Sessions

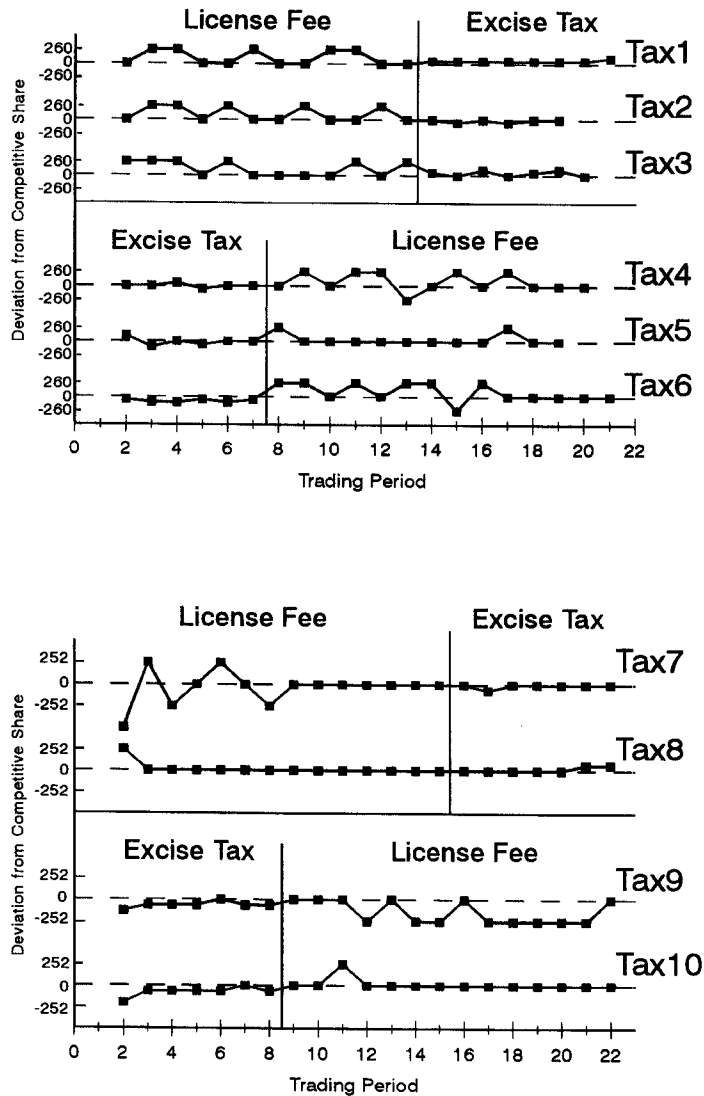


Figure 3. Dynamics of Tax Revenue in the First Six Sessions (top panel) and the Final Four Sessions (bottom panel).

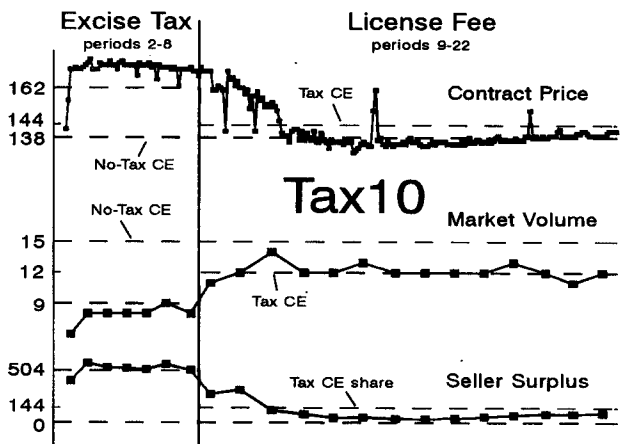
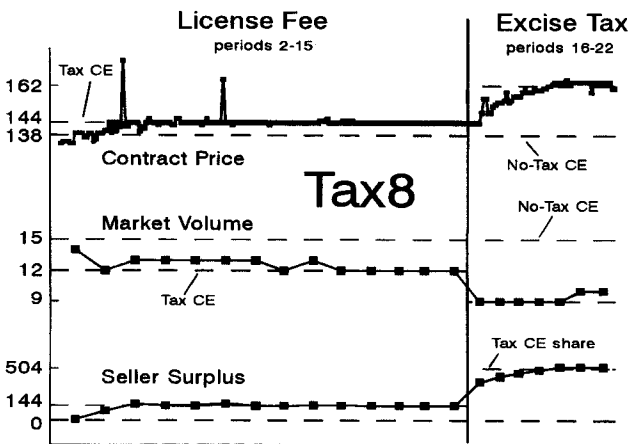
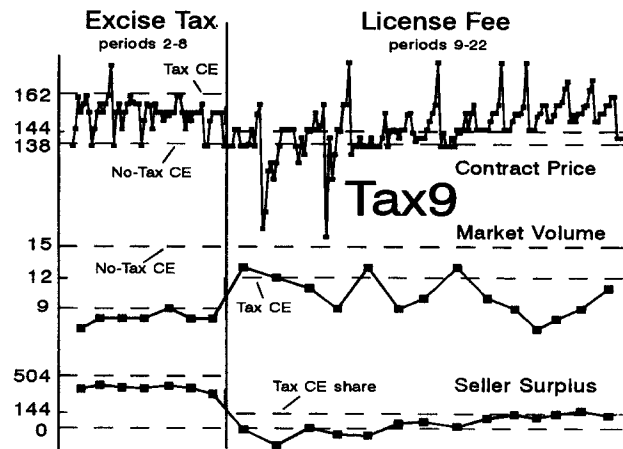
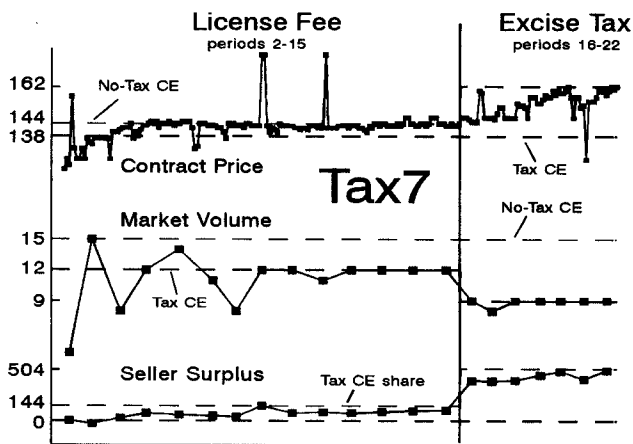


Figure 4 Market Dynamics of the Final Four Sessions.