An Evaluation of Ad valorem and Unit Taxes on Casino Gaming

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WORKING PAPER

Abstract

In several states, casinos pay an ad valorem tax on gross gaming revenue and a tax on casino admissions. A model of a monopoly casino under this unique structure of taxation is developed. A comparative statics analysis and numerical simulation are then conducted to explore the impact of tax-rate changes on consumer welfare, casino profit, and revenue to state and local governments. The analysis is timely as several states are considering changes to tax rates on casino gaming. The results highlight numerous tradeoffs that need to be considered by all relevant parties in the public debate on casino tax policy.

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1. Introduction

Many consumption goods are subject to either a state-imposed ad valorem tax (e.g., the retail sales tax) or a per-unit tax (e.g., the gasoline tax), but not both.[1] The taxation of casino gaming is somewhat unique because several states subject their casinos to a state-imposed ad valorem tax on gross gaming revenue as well as a per-unit tax.[2] However, unlike other industries that have a per-unit tax levied on the quantity of goods sold, the per-unit tax on casinos is based on the number of patrons that enter the casinos. Thus, the per-unit tax is an admissions tax. The joint ad valorem and per-unit tax structure facing casinos is uncommon across industries; such a structure would be analogous to a retail sales establishment (e.g., Walmart) facing a sales tax on total consumer expenditures as well as facing a tax on each consumer that enters its stores.

The states that levy both an ad valorem and per-unit admissions tax on casino gaming - Illinois, Indiana, Iowa, and Missouri - were some of the first states outside of Nevada and New Jersey that legalized casino gaming in the early 1990s.[3] These early casinos were on riverboats that would make several daily trips along the Mississippi River and other major rivers. Having both an ad valorem tax on casino gaming revenue and a per-unit admissions tax served (and still serves) the different needs of the state and local government (Eadington, 1999). States decided to legalize casino gaming in the early 1990s in the face of increasing pressures on state budgets and the public's growing acceptance of gaming (Calcagno, Walker, and Jackson, 2010). The ad valorem tax on casino revenue provides the state government with what it deems as a new source of revenue to fund important state programs, while at the same time maintaining some control over the growth of the casino industry. The admissions tax essentially taxes the amount of foot-traffic to the casino, which requires the use of local infrastructure such as new parking lots or garages, new streets, added police and fire protection, etc. Revenue from the admissions tax compensates local governments for the infrastructure improvements needed to support new casinos as well as maintaining these improvements after the casinos opened.

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[1] In 2014, seven states partially or fully applied sales taxes to the sale of gasoline in addition to the per-unit gasoline tax (CA, CT, GA, IL, IN, MI, and NY). Source: The Tax Foundation.
[2] Gross gaming revenue is defined as total wagers (handle) minus player winnings.
[3] Iowa also has an admissions tax on casino gaming, but unlike Illinois, Indiana, and Missouri, the state of Iowa gives local governments the option of imposing the admissions tax. Source: Iowa Racing and Gaming Commission.

Although the physical structure of casinos in these states has changed from riverboats to fixed-structures, the structure of the ad valorem tax and the admissions tax has not changed.[4] As is typical of most states with casino gaming, the ad valorem tax on casino gaming revenue generally goes to the state government and is commonly earmarked for education, economic development, and local government transfers. Ad valorem tax rates on gross gaming revenue are graduated in Illinois (15 percent to 50 percent) and Indiana (15 percent to 40 percent), and are fixed in Missouri (21 percent). Revenue from the ad valorem tax on casino gaming in these three states was roughly $1.9 billion (roughly 3 percent of the states' total tax revenue) in 2014.[5] Regarding the admissions tax, revenue from this tax is often split between the city government or county government and the respective state government. The per-unit admissions tax rate is $2 in Missouri, $3 in Indiana, and $2 to $3 in Illinois, and generated revenue totaling $192 million in 2014.

Despite the growth of the casino industry over the past several decades and the uncommon casino-tax structure in some states, there has been almost no theoretical evaluation of casino taxation in the academic literature. Exceptions include Smith (2000), Paton, Siegel, and Williams (2001) and Anderson (2005, 2013). Anderson (2005, 2013) provides an economic analysis of the market for casino gaming under ad valorem taxation and discusses the policy implications of casino taxation. Smith (2000) and Paton, Siegel, and Williams (2001) discuss the relative efficiency of an ad valorem tax on gaming (in general) revenues over a per-unit tax on each bet made. The overall lack of research is surprising given that the taxation of casino gaming, and casino gaming in general, often attracts considerable debate both in the public and in state legislatures across the country.

This paper provides a comparative-static analysis of the effects of ad valorem and per-unit taxation in the casino industry, with a specific focus on how both types of taxes affect the major parties in the policy debate – consumers, casinos, and state and local governments. Although the economic effects of ad valorem and per-unit taxation under monopoly have been studied extensively (Suits and Musgrave, 1953) and appear in many microeconomic textbooks, the key difference in the casino industry is that the per-unit tax is levied on each admission to the casino and not levied on casino output. Thus, the economic effects of tax changes may well be different for the casino gaming industry and are thus worthy of study.

[4] Tax rates and revenue for each of the three states were obtained from annual reports provided by the Missouri Gaming Commission, the Illinois Gaming Board, and the Indiana Gaming Commission.
[5] Source: U.S. Census' Annual Survey of State Government Tax Collections and states' annual gaming reports.

The analysis in this paper is based on a representative monopolistic casino rather than the overall market for casino gaming. The use of a representative casino allows a direct assessment, via a comparative static analysis, of how changes in the ad valorem tax rate and the admissions tax rate affect consumer welfare, casino profit, and state and local government casino tax revenue. The results from the comparative static analysis and subsequent numerical simulation also shed light on the efficiency of both forms of casino taxation in general, as well as providing evidence on how partially substituting one tax for another, or abolishing one tax altogether, has impacted casino profit, consumer welfare, and state and local government casino tax revenue. These are both policy-relevant scenarios, as several states have eliminated their admissions tax and other states are considering a change to their casinos' tax rates. The conclusions drawn from the analyses offer both academics and policy-makers new insights that should provide useful for further understanding the economics of casino taxation and the many tradeoffs involved in casino tax policy.

The paper proceeds in five additional sections. In Section 2, the profit maximizing model of a monopoly casino is presented and augmented to account for ad valorem taxation of gross gaming revenue and admissions taxation. In Section 3, the model is used as the basis for a comparative static analysis of how changes in the ad valorem tax rate and the admissions tax rate influence the price of casino gaming, casino output, consumer welfare, casino profit, and revenue to state and local governments. Section 4 of the paper provides insight into the tax-rate effects of changing the casino tax mix under the assumption of revenue neutrality; specifically, by how much, on the margin, would one tax rate need to be raised (lowered) if the other tax rate is lowered (raised) in order to keep total casino tax revenue to state and local governments constant. The analysis can also be used determine the necessary tax rate on one tax if the other tax is abolished. In Section 5, a simulation based on a representative casino is conducted using the comparative static results to provide quantitative insight into the effects of tax changes on the price of casino gaming, casino output, consumer welfare, casino profit, and revenue to state and local governments. Section 6 of the paper is reserved for concluding remarks and suggestions for future research.

2. A Model of a Monopoly Casino Facing Ad valorem and Admissions Taxes

This section presents the model for a profit-maximizing monopolistic casino that faces both an ad valorem tax on its gross gaming revenue as well as a per-unit tax on its admissions. It is this profit

maximization model that serves as the basis for the subsequent comparative static analysis.[6] To begin, it is useful to consider profit for a monopoly casino absent any taxation. This model is similar to the general textbook model of monopoly profit for a representative firm, differing only in the definitions of the price and output for casino gaming. This general model of monopoly profit can then be expanded to account for an ad valorem tax and a per-unit admissions tax.

Profit (π) for the monopoly casino without taxation can be expressed as $\pi = P(Q) \cdot Q - \gamma \cdot Q$, where $P(Q) \cdot Q$ is gross casino gaming revenue and $\gamma \cdot Q$ is total cost. Casino output (Q) is the total amount wagered in the casino, which is commonly referred to as "handle" (see Anderson, 2005, 2013).[7] The price (P) of casino gaming is the percentage of each dollar wagered that is not returned to players. The price of casino gaming is often called the "takeout rate" or "win percentage."[8] Since the casino is assumed to operate in a monopolist market structure, the price of casino gaming is a function of casino output, i.e. $P(Q)$. Fixed costs are assumed to be zero for the casino, and the linear cost function generates average cost equal to marginal cost.

The above expression for casino profit is now modified to account for a single-rate ad valorem tax on gross gaming revenue and a per-unit tax on casino admissions.[9] Under an ad valorem tax (r), there now exists a difference between the price paid by gamblers (P) and the price received by the casino $(P/(1+r))$. Thus, gross casino gaming revenue under the ad valorem tax is $P(Q) \cdot Q/(1+r)$. For a given level of output, an increase in r creates a larger gap between the price paid by gamblers and the price received by the casinos.[10]

A per-unit tax levied on the casino is a tax on admissions and not a tax on casino output, so there is no change to the casino's gross gaming revenue. The admissions tax does affect the casino's cost, however. The casino's total admission tax payment is $t \cdot N$, where t is the per-unit admissions tax rate and N is the

[6] In reality, the market structure for casino gaming more closely resembles monopolistic competition rather than monopoly. However, the profit-maximizing model and profit-maximizing conditions are identical for these two models of market structure; the only difference between the two is that monopolistic competition allows movement in the firm's demand curve due to competitor behavior. Monopoly market structure is assumed here since competitor behavior and other demand shifters are not germane to the analysis and conclusions, and also due to the fact that all casinos in a state generally face the same tax structure.

[7] "Handle" includes both the out-of-pocket wagers by casino patrons and any winnings that are wagered again.

[8] The takeout rate is calculated as 1-[prize payouts]/[total wagers]. See Anderson (2005, 2013).

[9] Some states impose a progressive tax structure on gross casino gaming revenue rather than imposing a single rate. The assumption of a single rate simplifies the analysis herein without altering the conclusions if a progressive ad valorem tax was considered.

[10] Because the ad valorem tax is a tax on gross casino gaming revenue, total casino cost remains as $\gamma \cdot Q$.

number of admissions to the casino. Since admission tax payments do not vary with casino output, these payments can be considered a fixed cost (with respect to output) for the casino.[11] Total cost for the casino with a per-unit admissions tax is $\gamma \cdot Q + t \cdot N$.

With the above modifications to gross gaming revenue and cost under ad valorem and admissions taxation, profit for the monopoly casino facing both taxes is

$$\pi = \frac{P(Q) \cdot Q}{(1+r)} - \gamma \cdot Q - t \cdot N. \quad (1a)$$

Equation (1a) needs to be modified further, however, to better capture the problem at hand. Think about the mechanism by which changes in t and r will impact price, output, profit, consumer surplus, and government revenue: Changes in t and r will influence the casino's optimal choice of Q (based on marginal revenue = marginal cost), which will then influence the optimal P via the demand curve $P(Q)$. Furthermore, the changes in both the optimal Q and the optimal P will change the optimal values of casino profit, casino tax revenue to state and local governments, and consumer surplus. Thus, the expression for casino profit in equation (1a) must be modified to consider Q as an implicit function of t and r:

$$\pi = \frac{P(Q(t,r)) \cdot Q(t,r)}{(1+r)} - \gamma \cdot Q(t,r) - t \cdot N. \quad (1b)$$

The profit equation (1b) serves as the basis for the comparative static analysis conducted in the next section of the paper.

3. Comparative Static Analyses

To organize the presentation, the comparative static analyses are presented in several sections. The first section examines how changes in the admissions tax rate and the ad valorem tax rate influence the casino's optimal level of output (Q) and the price of casino gaming (P). Given the direction of these changes, it is then possible to assess the impact that changes in these tax rates have on consumer surplus. The final sections demonstrates how changes in both tax rates influence the optimal level of casino profit as well as casino tax revenue to state and local governments.

[11] Certainly admission tax payments do vary with the number of admissions (N), so they are not fixed in the general sense of the word. Throughout the analysis, N is not considered to be a choice variable for the casino and thus remains constant.

3.1 The Impact of Taxation on Casino Output and the Price of Casino Gaming

The casino's objective is to choose the level of Q that maximizes its profit. Differentiating equation (1b) with respect to Q yields the following first-order condition for profit maximization:

$$\frac{\partial \pi}{\partial Q} = \frac{1}{(1+r)} \cdot \left[\frac{\partial P(Q(t,r))}{\partial Q(t,r)} \cdot Q(t,r) + P(Q(t,r)) \right] - \gamma = 0 \tag{2a}$$

Equation (2a) provides the optimal value of Q. Assessing how a change in t and a change in r affect the casino's optimal value of Q is done by differentiating equation (2a) with respect to t and with respect to r. First, differentiating equation (2a) with respect to t yields

$$\frac{1}{(1+r)} \cdot \left[\frac{\partial^2 P}{\partial Q^2} \cdot \frac{\partial Q}{\partial t} \cdot Q + 2 \cdot \frac{\partial P}{\partial Q} \cdot \frac{\partial Q}{\partial t} \cdot \right] = 0,$$

$$\equiv \frac{\partial Q}{\partial t} \cdot \left[\frac{\partial^2 P}{\partial Q^2} \cdot Q + 2 \cdot \frac{\partial P}{\partial Q} \right] = 0,$$

$$\frac{\partial Q}{\partial t} = 0. \quad \blacksquare \tag{2b}$$

A change in the admissions tax rate has no impact on the optimal level of output. This is simply because the admissions tax does not influence the marginal cost of producing Q since the tax is not a tax on casino output. Since the admissions tax has no effect on Q, it follows that a change in this tax should have no effect on the optimal price of casino gaming. Indeed, this is easy to demonstrate using the chain rule $\frac{\partial P}{\partial t} = \frac{\partial P}{\partial Q} \cdot \frac{\partial Q}{\partial t}$. Since $\frac{\partial Q}{\partial t} = 0$ from equation (2b), the expected result is

$$\frac{\partial P}{\partial t} = 0. \quad \blacksquare \tag{2c}$$

Now consider the effect of a change in the ad valorem tax on casino output and price. Differentiating equation (2a) with respect to r yields

$$\frac{\partial Q}{\partial r} \cdot \left[\frac{\partial^2 P}{\partial Q^2} \cdot Q + 2 \cdot \frac{\partial P}{\partial Q} \right] \cdot (1+r) - \frac{\partial P}{\partial Q} \cdot Q - P \; = 0,$$

and solving for $\partial Q / \partial r$ yields the result

$$\frac{\partial Q}{\partial r} = \frac{\frac{\partial P}{\partial Q} \cdot Q + P}{\left(\frac{\partial^2 P}{\partial Q^2} \cdot Q + 2 \cdot \frac{\partial P}{\partial Q} \right)(1+r)} \; < 0. \quad \blacksquare \tag{2d}$$

The negative relationship between the ad valorem tax rate and casino output shown in equation (2d) is determined by recognizing that the numerator divided by $(1+r)$ is marginal gaming revenue to the casino (which is > 0), and that the first term in parentheses in the denominator is the slope of the marginal revenue curve (which is < 0). Since this term is negative, this allows the conclusion that changes in the ad valorem tax rate will have a smaller effect on casino output the steeper the slope of the marginal revenue curve. This in turn implies that a change in the ad valorem tax rate will have a smaller effect on casino output the less elastic the demand for casino gaming.[12]

The negative relationship between casino output and the ad valorem tax rate implies a positive relationship between the price of casino gaming and the ad valorem tax rate since the demand curve for casino gaming is downward sloping. This is straightforward to verify using the chain rule $\frac{\partial P}{\partial r} = \frac{\partial P}{\partial Q} \cdot \frac{\partial Q}{\partial r}$, after which substituting equation (2d) for $\frac{\partial Q}{\partial r}$ gives the result

$$\frac{\partial P}{\partial r} = \frac{\frac{\partial P}{\partial Q} \cdot \left(\frac{\partial P}{\partial Q} \cdot Q + P\right)}{\left(\frac{\partial^2 P}{\partial Q^2} \cdot Q + 2 \cdot \frac{\partial P}{\partial Q}\right) \cdot (1+r)} > 0 \quad \text{since } \frac{\partial P}{\partial Q} < 0. \quad \blacksquare \tag{2e}$$

The negative derivative reveals that a change in the ad valorem tax rate will have a larger effect on the price of casino gaming the steeper is the slope of the marginal revenue curve, which implies that an ad valorem tax rate change will have a larger effect on the price of casino gaming the less elastic the demand for casino gaming.

3.2 The Impact of Taxation on Consumer Welfare

The comparative static results in the previous section provide insight into how changes in the ad valorem and admissions tax rates will influence consumer welfare, as measured by consumer surplus. The impact of casino taxation on consumer welfare is analogous to an evaluation of the efficiency of casino taxation with regard to consumers. Certainly consumer surplus (and thus efficiency) under monopoly, even

[12] This is straightforward to show. Assuming a linear inverse demand curve for casino gaming (for simplicity), then the right-hand-side of equation (2d) becomes $[Q + P \cdot \partial Q/\partial P]/[2(1+r)]$. Multiplying the numerator and denominator by $1/Q$ and rearranging terms yields the final equation $[(1+\varepsilon) \cdot Q]/[2(1+r)]$, where ε is the price elasticity of demand for casino gaming. Since a monopolist only produces where $\varepsilon < -1$, then $\partial Q/\partial r$ is smaller in magnitude (less negative) the less elastic the demand for casino gaming. Thalheimer and Ali (2003) and Landers (2008) empirically estimate the price elasticity of demand for casino gaming and find an average price elasticity of demand of around -1.3. See Suits (1979) for a formal description of the relationship between gaming tax rates and revenue to governments.

in the absence of any taxation, is less than if casino gaming existed in a more competitive market structure. Consumer surplus will decrease as the ad valorem tax rate increases because, as shown earlier, a change in the ad valorem tax rate will reduce casino output and increase the price of casino gaming. Thus, both the imposition of an ad valorem tax on gross gaming revenue and an increase in this tax rate will decrease consumer surplus, and the magnitude of the change in consumer surplus will depend upon the elasticity of demand for casino gaming. On the other hand, imposing an admissions tax, as well as changes to the tax rate, will have no impact on consumer surplus because this tax does not affect the casino's profit maximizing level of output and the price of casino gaming.

If consumer welfare is the primary concern for policy-makers, then the admissions tax may be preferred to an ad valorem tax on gross gaming revenue. In reality, of course, revenue yield is likely to be of equal or greater concern and, thus, the lower yields from admission taxes relative to ad valorem taxes on gross gaming revenue would make substituting away from an ad valorem tax in favor of a higher per-unit tax unlikely despite the increase in consumer surplus.[13]

3.3 The Impact of Taxation on Casino Profits

This section explores the impact of changes in the ad valorem tax rate and the admission tax on optimal casino profit. The profit-maximizing values of Q and P are used in equation (1b) to arrive at the expression for optimal casino profits:

$$\pi^* = \frac{P^*(Q^*(t,r)) \cdot Q^*(t,r)}{(1+r)} - \gamma \cdot Q^*(t,r) - t \cdot N, \tag{2f}$$

where '*' denotes the optimal value. The effect of tax changes on optimal casino profit can be determined by differentiating equation (2f) with respect to t and r, as shown below (ignoring '*' hereafter).

First, consider the admissions tax. Differentiating equation (2f) with respect to t yields

$$\frac{\partial \pi}{\partial t} = \frac{1}{(1+r)} \cdot \left[\frac{\partial P}{\partial Q} \cdot \frac{\partial Q}{\partial t} \cdot Q + \frac{\partial Q}{\partial t} \cdot P\right] - \gamma \cdot \frac{\partial Q}{\partial t} - N,$$

and, using the fact that $\frac{\partial Q}{\partial t} = 0$ from equation (2b), the final result is

[13] Just how much the admissions tax would need to be increased in the absence of the ad valorem tax, assuming total tax revenue neutrality, is explored later in the paper.

$$\frac{\partial \pi}{\partial t} = -N < 0 \quad \blacksquare \tag{2g}$$

because a change in the admissions tax only affects the casino's cost and not optimal output or price.

Now consider the change in optimal casino profit resulting from a change in the ad valorem tax rate on gaming revenue. Differentiating equation (2f) with respect to r yields

$$\frac{\partial \pi}{\partial r} = \frac{\frac{\partial Q}{\partial r} \cdot \left[\frac{\partial P}{\partial Q} \cdot Q + P - \gamma(1+r)\right]}{(1+r)} - \frac{P \cdot Q}{(1+r)^2}.$$

By recognizing that the bracketed term is simply marginal revenue minus marginal costs under ad valorem taxation, this term is equal to zero since marginal revenue and marginal costs are equal under profit maximization. The final result is

$$\frac{\partial \pi}{\partial r} = -\frac{P \cdot Q}{(1+r)^2} < 0, \quad \blacksquare \tag{2h}$$

which is interpreted as the reduction (increase) in profits resulting from a greater (smaller) percentage of casino gaming revenue going to the state from a given change in r.

The main conclusion from this section is that the ad valorem tax reduces the casino's profit by reducing the casino's revenue, whereas the admissions tax reduces the casino's profit by increasing the casino's cost via an increase in admission tax payments.

3.4 The Impact of Taxation on Revenue to State and Local Governments

This section examines the effect of changes in the ad valorem tax rate and the admissions tax rate on government revenue. The revenue generated from the taxing of casino gaming is likely to be the predominant concern of policy-makers since revenue from both taxes are earmarked for specific programs or activities. In general, states that levy both taxes on casinos dedicate the ad valorem tax revenue to the state government and the admissions tax revenue to the casino's local government.[14]

First consider changes to admissions tax revenue (R_t) resulting from changes in both t and r. Admission tax revenue is simply $R_t = t \cdot N$. It is easy to see that

[14] It is not uncommon, however, for there to be some revenue sharing from each tax, especially if there only exists an advalorem tax on gross gaming revenue.

$$\frac{\partial R_t}{\partial t} = N \qquad \blacksquare \tag{2i}$$

and

$$\frac{\partial R_t}{\partial r} = 0. \qquad \blacksquare \tag{2j}$$

Now consider changes to ad valorem tax revenue (R_r) resulting from a change in t. Revenue from the ad valorem tax on gross casino revenue is

$$R_r = \frac{r \cdot P(Q(t,r)) \cdot Q(t,r)}{(1+r)}. \tag{2k}$$

Differentiating equation (2k) with respect to t gives

$$\frac{\partial R_r}{\partial t} = \frac{r \cdot \left[\frac{\partial P}{\partial Q} \cdot \frac{\partial Q}{\partial t} \cdot Q + \frac{\partial Q}{\partial t} \cdot P\right]}{(1+r)},$$

or, since it has been established that $\frac{\partial Q}{\partial t} = 0$, the final result is

$$\frac{\partial R_r}{\partial t} = 0 \qquad \blacksquare \tag{2l}$$

Assessing the change in ad valorem tax revenue (R_r) from a change in the ad valorem tax rate is done by differentiating equation (2k) with respect to r. This yields

$$\frac{\partial R_r}{\partial r} = \frac{P \cdot Q}{(1+r)^2} + \left(\frac{r}{1+r}\right) \cdot \frac{\partial Q}{\partial r} \cdot \left[\frac{\partial P}{\partial Q} \cdot Q + P\right], \tag{2m}$$

and by recognizing that the term in brackets is marginal revenue (MR), equation (2m) can be simplified to get the desired result

$$\frac{\partial R_r}{\partial r} = \frac{P \cdot Q}{(1+r)^2} + \left(\frac{r}{1+r}\right) \cdot \frac{\partial GR}{\partial r} \gtrless 0, \qquad \blacksquare \tag{2n}$$

where GR denotes gross casino gaming revenue and $\frac{\partial GR}{\partial r} \equiv \frac{\partial GR}{\partial Q} \cdot \frac{\partial Q}{\partial r} \equiv MR \cdot \frac{\partial Q}{\partial r}$.

The intuition behind the result in equation (2n) and the uncertainty regarding the sign of the derivative is worth noting. The second term of the partial derivative is the reduction in gross casino gaming revenue resulting from a change in output due to a change in the ad valorem tax rate. Since it has been established earlier in the analysis that $\frac{\partial Q}{\partial r} < 0$, the entire second term of the partial derivative in equation (2n)

is negative.[15] The first term on the right-hand side is the change in ad valorem tax revenue to the state resulting from a change in the percent of gaming revenue going to the state. This term is clearly positive. What the two terms in equation (2n) demonstrate together is a sort of Laffer curve effect – the sum of the two effects will be positive as long as an increase in r does not result in a large enough reduction in output (Q) to actually cause casino gaming revenue (the tax base) to decrease in size. For "low" ad valorem tax rates, it seems reasonable that gross gaming revenue will not fall in response to an increase in the tax rate, so that ad valorem tax revenue to the state rises in response to an increase in the ad valorem tax rate, i.e. $\frac{\partial R_r}{\partial r} > 0$.

It is worth concluding this section of the paper with a summary of the comparative static results, which are shown in Table 1. The analysis revealed that changes in the admissions tax have no impact on the price of casino gaming or casino output, whereas increases in the ad valorem tax on gross casino gaming revenue will decrease casino output and raise the price of gaming to consumers. The different impact of each tax is due to the fact that a change in the admissions tax does not influence the casino's marginal cost or marginal revenue since the tax is not levied on output, thereby leaving the profit maximizing quantity of casino output (and thus price) unchanged. However, a change in the ad valorem tax rate on gaming revenue influences marginal revenue and thus affects the profit maximizing quantity of output. Given the established price and quantity changes with respect to changes in each tax, consumer surplus is not affected by changes in the admissions tax but consumer surplus falls in response to an increase in the ad valorem tax rate. Casino profit falls in response to an increase in each tax rate; this fall is induced by an increase in the casino's cost under the admissions tax, whereas the fall in profit under an ad valorem tax on gross gaming revenue is caused by a decrease in the casino's revenue. With respect to tax revenue to state and local governments, the analysis revealed that the tax revenue from one source does not change in response to a change in the rate of the other tax. Tax revenue from the admissions tax and the ad valorem tax on gaming revenue increase as the rate of each respective tax is increased. However, the results regarding ad valorem tax revenue demonstrated the potential for declining tax revenue from an increase in the ad valorem rate if an increase in the tax rate actually decreases casino gaming revenues.

[Table 1]

[15] Combs, Landers, and Spry (2013) find that the elasticity of gross gaming revenue in Illinois casinos with respect to a change in the advalorem rate is approximately -0.23.

4. Changing the Mix of Tax Rates

The following analysis considers the scenario where a state government is considering making a marginal change to either the admissions tax rate or the ad valorem tax rate, where any change will be revenue neutral with respect to total casino tax revenue (revenue from the ad valorem tax plus revenue from the admissions tax). This is a policy-relevant issue, as some states have eliminated one form of casino taxation (e.g., Louisiana eliminated the admissions tax) and others states are currently considering changing their tax mix (e.g., Indiana is currently debating whether or not to lower or eliminate their admissions tax). Changing the casino tax mix has important implications, as evidenced by the differential impacts of each tax on consumer surplus, price, casino output, and casino profit found in the earlier comparative static analysis.

Total casino tax revenue (TR) is the sum of ad valorem tax revenue and admissions tax revenue, that, based on earlier results, can be written as

$$TR = \frac{r \cdot P \cdot Q}{(1+r)} + t \cdot N.$$

Totally differentiating the above expression with respect to t and r and setting $dTR = 0$ (revenue neutrality) gives

$$0 = \frac{\partial TR}{\partial r} \cdot dr + \frac{\partial TR}{\partial t} \cdot dt. \tag{3a}$$

Since it has been shown earlier that changes in r only impact ad valorem tax revenue (R_r) and changes in t only impact admission tax revenue (R_t), equation (3a) can be rewritten as

$$\frac{\partial R_r}{\partial r} \cdot dr = -\frac{\partial R_t}{\partial t} \cdot dt, \tag{3b}$$

which has the intuitive result that, under revenue neutrality, the total change in ad valorem tax revenue from a change in the ad valorem rate must be equal in magnitude (but opposite in sign) to the total change in admissions tax revenue from a change in the admissions tax rate, and vice versa. Further intuition can be gained by substituting the earlier result $\frac{\partial R_t}{\partial t} = N$ and solving equation (3b) for dr and dt, which yields

$$dr = -\frac{N}{\frac{\partial R_r}{\partial r}} \cdot dt \quad \blacksquare \tag{3c}$$

and

$$dt = -\frac{\partial R_r}{\partial r} \cdot \frac{1}{N} \cdot dr. \quad \blacksquare \tag{3d}$$

The differential dr in equation (3c) is the amount by which the ad valorem tax rate on gaming revenue must be adjusted in response to a change in the admissions tax rate. This adjustment is equal to the number of gamblers per additional dollar of revenue times the change in the admissions tax rate. Similarly, the differential dt in equation (3d) is the amount by which the admissions tax rate must be adjusted in response to a change in the ad valorem tax rate. This adjustment is equal to the total change in ad valorem tax revenue per gambler for a given change in r.

Several points are worth mentioning before proceeding. First, the preceding analysis can be used to examine the effect that completely eliminating one tax has on the remaining tax's rate, something that has been done in several states. In this scenario, dt in equation (3c) and dr in equation (3d) are, respectively, the negative of the value of the current tax rate. The earlier comparative static analysis could then shed light on the effect that abolishing one tax has on casino profit, consumer welfare, and revenue to state and local government.

Second, the above analysis assumes that total casino tax revenue remains unchanged. However, any change to the tax mix will not yield a revenue-neutral outcome for both the state government and the local government. For example, if a state decreases the admissions tax rate and increases the ad valorem tax rate, revenue to local government (which receives the bulk of admission tax revenue) will be less and revenue to the state government will be higher. The local government is likely to find this outcome undesirable and perhaps appeal to the state government for a portion of the ad valorem tax revenue. Similarly, revenue sharing from the local government to the state government may be necessary if the admissions tax rate is increased and the ad valorem rate is decreased. The main point is that some revenue-sharing between the two levels of government may be required (or altered if it already exists) given that one level of government would experience less tax revenue after the change to the tax rates.

The third and final point relates to efficiency. It was shown earlier that changes to the ad valorem tax rate affect consumer welfare, whereas changes to the admissions tax leave consumer welfare unchanged. Thus, changes to the tax mix will also affect consumer welfare by increasing or decreasing it depending on the

tax rate adjustments that are made. This fact thus highlights yet another potential trade-off between efficiency and revenue that policy makers must confront.

5. Simulation

This section of the paper presents a quantitative simulation of the comparative statistic results for a representative casino. The idea is to provide numerical calculations for the effects that various tax-change scenarios have on casinos, consumers, and government revenue from casino gaming. The simulation also quantifies many of the policy tradeoffs that were discussed earlier in the paper.

The crucial element needed for the simulation is an inverse demand function for casino gaming, $P(Q)$, from which it is relatively straightforward to calculate an actual value for each comparative static expression. The simulation presented here uses a demand function for casino gaming that is obtained using the coefficients from a model of casino demand estimated by Thalheimer and Ali (2003). The authors estimate the demand for casino gaming using a panel of annual data on casinos located in Iowa, Illinois, and Missouri for the years 1991 to 1998. They regress per capita gross gaming revenue (which they term "handle") on a vector of casino-specific characteristics, including the price of casino gaming (which they term "win percentage").

The coefficient estimates found in Thalheimer and Ali (2003) allow for the construction of an inverse demand curve for a representative casino, which is needed to conduct the simulation. Several steps are taken to construct the inverse demand curve. First, a predicted level of gross gaming revenue that omits the coefficient on the price of casino gaming (call it the "non-price" prediction) was obtained by multiplying the estimated coefficient for each variable by the respective variable's mean value, and then summing the products.[16] Second, various predictions of gross gaming revenue that consider different prices (call these "price predictions") were obtained by multiplying Thalheimer and Ali's (2003) coefficient on price by different values for price.[17] Third, the "non-price" prediction and the various "price-predictions" were then

[16] The coefficients used in the prediction are from Table 2 of Thalheimer and Ali (2003), and the mean value for each variable is shown in their Appendix B.

[17] All states have laws that set a minimum payout percentage (say, 85 percent) for casinos, thus effectively placing an upper bound (say, 15%) on the price of casino gaming to players. Here, it was assumed that the minimum payout percentage was 87 percent and the maximum payout percentage was 97 percent. Thus, gross gaming revenue was predicted using prices ranging from 0.03 (1-0.97) to 0.13 (1-0.87) at increments of 0.01.

summed to arrive at a total predicted level of gross gaming revenue for each different value for the price of gaming.[18] Finally, the constant and slope of the desired inverse demand function were calculated using the predicted level of gross gaming revenue using the extreme values of price.[19]

The simulation also requires values for casino admissions, casino cost, the advalorem tax rate on gross gaming revenue, and the admissions tax rate. Casino admissions are set to $N = 3{,}000{,}000$. This value is roughly the average annual number of admissions to casinos in Iowa, Illinois, and Missouri. The marginal and average cost (γ) per dollar of gross gaming revenue is set to \$0.02.[20] Finally, the initial ad valorem tax rate is set to 20 percent ($r = 0.20$) and the initial rate for the admissions tax is set to $t = \$2$.

Given the inverse demand curve and the assumed values above, the casino's profit maximization problem (equation 1b) is solved for the optimal level of casino output (equation 2a). This value then allows for the calculation of the price of casino gaming, consumer surplus, casino profit, ad valorem tax revenue, and admissions tax revenue. These calculated annual values, shown in the top panel of Table 2, describe the initial environment in which there are no changes in the initial tax rates. In this initial environment, the representative casino maximizes profit at an output level of \$807.5 million in gross wagers. The price of casino gaming at this level of output is \$0.078, which translates to a payback percentage of 92.3 percent. The casino earns a profit of \$30.4 million and consumer surplus is \$21.8 million. Revenue from the 20 percent ad valorem tax rate is \$10.5 million, and admissions tax revenue at the rate of \$2 is \$6 million.

[Table 2]

Panel A demonstrates the effect from each of two independent tax rate changes: a \$1 increase in the admissions tax rate holding the ad valorem rate constant; or a one percentage-point increase in the ad valorem rate holding the admissions tax rate constant. Both tax rate changes assume non-neutral total casino

[18] Because Thalheimer and Ali's (2003) dependent variable is the natural log of per capita gaming revenue, the predictions were multiplied by average population (found in their Appendix B) and then converted using the exponential function to get a predicted level of gross gaming revenue.

[19] Specifically, the intercept for the demand curve is equal to gross gaming revenue when price equals 0.03. The slope of the demand curve is equal to the difference in gross gaming revenue at price = 0.13 and price = 0.03, divided by the change in price (which is 0.13-0.03 = 0.1). With the constant and slope in hand, the demand curve was then inverted to arrive at the representative casino's inverse demand function $P(Q) = 0.13227791 - 6.70437\text{e}-11 \cdot Q$ that is used in the simulation. As a side note, the price elasticity of demand generated from the demand curve (using mean values of P and Q) is -1.59, which is in general agreement with the estimates obtained in earlier studies (Thalheimer and Ali, 2003; Landers, 2008).

[20] Zheng (2001) reports that casinos have general and administrative costs of 37 to 52 percent of revenue, depending upon the size of the casino. An assumed payout rate of about 95 percent implies that the casino retains 5 cents for every dollar wagered. So, here it was assumed that the casino has costs equal to 40 percent of revenue, or \$0.02 ($\$0.05 \cdot 0.4$) for every dollar wagered.

tax revenue (ad valorem tax revenue + admissions tax revenue). For each variable of interest, the new value of the variable is shown first, followed by the change from the initial condition (shown in brackets), and finally the percentage change from the initial condition (shown in braces). The simulation reveals that a $1 increase in the admissions tax rate holding the ad valorem tax rate constant yields no change in the price of casino gaming, output, consumer surplus, or ad valorem tax revenue. Admissions tax revenue increases by $3 million (a 50 percent increase) and casino profit drops by $3 million (a 9.9 percent decrease). With respect to increasing the ad valorem rate by one percentage-point holding the admissions tax constant, the simulation reveals a decrease in casino output of 0.20 percent, an increase in the price of gaming of 0.13 percent, a drop in consumer surplus (0.37 percent) and a drop in casino profit (1.4 percent), an increase in ad valorem tax revenue (4.1 percent), and no change in admissions tax revenue.

Panel B demonstrates the effects from each of the same two independent tax changes described above, but this time under the assumption of neutral total casino tax revenue relative to total casino tax revenue in the initial environment. Using equation (3c), a $1 increase in the admissions tax requires an ad valorem tax rate of $r \approx 0.135$ (a reduction of ≈ 0.065) in order to keep total casino tax revenue constant. Similarly, using equation (3d), a one percentage-point increase in the ad valorem tax rate requires an admissions tax rate of $t \approx \$1.86$ (a decrease of $\approx \$0.14$) in order to keep total casino tax revenue constant.

The data in Panel B (again, all relative to the initial condition) reveal that the tax changes under tax revenue neutrality are quite different depending upon which tax was initially changed, thus demonstrating the many tradeoffs faced by policy-makers, consumers, and casinos. For example, increasing the admissions tax by $1 and reducing the ad valorem rate yields an increase in casino output, consumer surplus, and casino profit; and a decrease in the price of gaming. For the same amount of total casino tax revenue, policy-makers could instead increase the ad valorem tax rate and lower the admissions tax rate, but this action would decrease casino output, consumer surplus, and casino profit; and increase the price of gaming. So, casinos and gamblers will benefit if the government increases the admissions tax rate and reduces the ad valorem tax rate, and both parties will lose if the government increases the ad valorem rate and reduces the admission tax rate. Total casino tax revenue to the government is the same in both cases, so, in terms of tax revenue yield, the government should be indifferent between each scenario. Of course, tax revenue to the local government

and tax revenue to the state government are each affected differently under each tax scenario, thus likely requiring some form of revenue sharing between the two.

The analysis in Panel C is similar to the analysis in Panel B, except Panel C considers the effects of abolishing one tax. Abolishing the ad valorem tax requires an admissions tax rate of $t \approx \$5.51$, an increase of \$3.51 (176 percent) from the initial tax rate of \$2 in order to keep total casino tax revenue constant. Abolishing the admissions tax requires an ad valorem tax rate of $r \approx 0.36$, an increase of 16 percentage-points (80 percent) from the initial rate. Clearly, abolishing one tax requires a significant increase in the rate of the remaining tax. The directional effects on casinos and gamblers are the same as those found in panel B, but the magnitude of each effect is larger. The analysis in Panel C, like the analysis in Panel B, demonstrates the differing impacts on casinos and gamblers from each of the two revenue-neutral tax policies.

6. Discussion and Concluding Comments

The casino gaming industry is subject to state-imposed ad valorem taxes on gross gaming revenue as well as per-unit taxes, where the per-unit tax is a tax on casino admissions rather than a tax on casino output. This somewhat unique tax structure facing the casino industry has received very little attention in the academic literature. This paper served as a starting point for research on this structure of taxation by developing a model for a profit-maximizing casino facing both types of taxes and then conducting a comparative-static analysis and simulation of the effects of ad valorem and per-unit taxation on several policy-relevant variables, such as the price of casino gaming, casino output, casino profit, consumer surplus, and tax revenue to state and local governments. These variables are relevant to all parties in the public debate on the taxation of casino gaming.

The comparative static analysis demonstrated that changes in the rate for each type of tax will have quite different impacts on casino profit, consumers, and revenue to state and local governments. The simulation analysis for a representative casino provided a numerical assessment of these various effects. Both the comparative static analysis and the simulation provide insight into the mix of taxes and tax rates that would be preferred by the casino industry, consumers, and state and local governments, each of whom has different objectives. One finding is that the admissions tax, unlike the ad valorem tax on gross gaming revenue, does not affect the casino's profit maximizing level of output, the price of casino gaming, and,

consumer surplus. Another important finding is that any policy to change one tax rate may harm or benefit consumers or the casino, depending upon the final mix of tax rates that is chosen. This is true regardless of whether or not the government pursues a revenue-neutral casino tax policy. Given that several states have abolished their admissions tax and have increase their ad valorem tax on gaming revenue, and several others are considering doing so, the results highlight the conflicting objectives of consumers, casinos, and state and local governments. These conflicting objectives demonstrate the many trade-offs to be made in casino tax policy.

The partial equilibrium analysis presented here provides a framework for future research. One avenue for future research is to study casino taxation within a general equilibrium framework that considers the competitive effects from other casinos as well as other sectors of the local economy. Casinos within the same state are subject to the same tax rates, so the general equilibrium framework may also consider competition with bordering states and regions. This competition would essentially increase and decrease the demand curve for the representative casino, yielding a new profit maximizing level of output and price, and thus tax revenue, consumer surplus, and casino profit. Similarly, casinos not only compete with each other, but also with other businesses in the area that generate tax revenue (from sales taxes, income taxes, hotel occupancy taxes, etc.) for state and local governments. This potential substitution has been studied empirically (Anders, Siegel, and Yacoub, 1998; Walker and Jackson, 2011; Nichols, Tosun, and Yang, 2015), but a general equilibrium framework may provide additional insights into how changing casino tax rates within this competitive framework would affect local businesses, employment, and total tax revenue to governments (Geisler and Nichols, 2016).

While the analysis here provides insights into the efficiency of ad valorem taxes on gross gaming revenue and the tax on casino admissions, determining the adequacy of both taxes is important as well. How well does each revenue source allow state and local governments to meet their budget goals? How does the growth and variability of each tax base (casino admissions and gaming revenue) perform relative to economic conditions? Nichols and Tosun (2008) provide some indirect evidence on the adequacy of ad valorem taxes on gross gaming revenue by estimating long-run and short-run income elasticities for gross casino gaming revenue. To date no work has examined the adequacy of the admission tax. An understanding of the adequacy of both forms of taxes would provide information on the proper mix of casino taxes needed to

meet adequacy goals; of course, realizing that a casino tax policy to meet adequacy goals (by raising, lowering, or abolishing a tax) would likely have implications for efficiency and casino profit. This would result in yet another potential tradeoff policy makers would have to consider in their formulation of casino tax policy.

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Table 1 - Summary of Comparative Static Results for Tax Rate Changes[a]

	Per-Unit Admissions Tax (t)	Ad Valorem Tax on Gaming Revenue (r)
Casino Output (Q)	$\frac{\partial Q}{\partial t} = 0$	$\frac{\partial Q}{\partial r} < 0$
Price of Casino Gaming (P)	$\frac{\partial P}{\partial t} = 0$	$\frac{\partial P}{\partial r} > 0$
Consumer Surplus (CS) [b]	$\frac{\partial CS}{\partial t} = 0$	$\frac{\partial CS}{\partial r} < 0$
Casino Profit (π)	$\frac{\partial \pi}{\partial t} < 0$	$\frac{\partial \pi}{\partial r} < 0$
Admissions Tax Revenue (R_t)	$\frac{\partial R_t}{\partial t} > 0$	$\frac{\partial R_t}{\partial r} = 0$
Ad Valorem Tax Revenue (R_r)	$\frac{\partial R_r}{\partial t} = 0$	$\frac{\partial R_r}{\partial r} > 0$

[a] See text for the calculations of each derivative.
[b] The derivative for consumer surplus (CS) is signed by considering the change in price and the change in output.

Table 2 - Simulation of Casino Tax Changes for a Representative Casino*

Initial Environment: $N = 3{,}000{,}000$, $AC = MC = \$0.02$, $r = 0.20$, $t = \$2$

	Price ($)	Output ($)	Consumer Surplus ($)	Casino Profit ($)	Ad valorem Tax Revenue ($)	Admission Tax Revenue ($)
	0.0781	807,517,380	21,859,073	30,431,789	10,516,427	6,000,000

PANEL A: Impact of Tax Rate Change - non-neutral total casino tax revenue

Tax Change Scenarios	Price [Δ] {%Δ}	Output [Δ] {%Δ}	Consumer Surplus [Δ] {%Δ}	Casino Profit [Δ] {%Δ}	Ad Valorem Tax Revenue [Δ] {%Δ}	Admission Tax Revenue [Δ] {%Δ}
↑t by \$1 , $\bar{r}$	0.0781 [0] {0.0%}	807,517,380 [0] {0.0%}	21,859,073 [0] {0.0%}	27,431,789 [-3,000,000] {-9.9%}	10,516,427 [0] {0.0%}	9,000,000 [+3,000,000] {+50.0%}
↑r by 0.01 , $\bar{t}$	0.0782 [+0.0001] {+0.13%}	806,025,816 [-1,491,564] {-0.18%}	21,778,396 [-80,677] {-0.37%}	29,997,349 [-434,440] {-1.4%}	10,944,752 [+428,324] {+4.1%}	6,000,000 [0] {0.0%}

PANEL B: Impact of Tax Rate Change - neutral total casino tax revenue

Tax Change Scenarios	Price [Δ] {%Δ}	Output [Δ] {%Δ}	Consumer Surplus [Δ] {%Δ}	Casino Profit [Δ] {%Δ}	Ad Valorem Tax Revenue [Δ] {%Δ}	Admission Tax Revenue [Δ] {%Δ}
↑t by \$1 requires $r \approx 0.13468$	0.0775 [-0.0006] {-0.77%}	817,260,279 [+9,739,916] {+1.2%}	22,389,726 [+530,489] {+2.4%}	30,464,388 [+31,615] {+0.11%}	7,516,412 [-3,000,000] {-28.5%}	9,000,000 [+3,000,000] {+50.0%}
↑r by 0.01 requires $t \approx 1.85722$	0.0782 [-0.0001] {+0.13%}	806,025,816 [-1,491,564] {-0.18%}	21,778,396 [-80,677] {-0.37%}	30,425,689 [-6,100] {-0.02%}	10,944,752 [+428,324] {+4.1%}	5,571,675 [-428,324] {-7.2%}

PANEL C: Impact of Abolishing One Tax - neutral total casino tax revenue

Tax Change Scenarios	Price [Δ] {%Δ}	Output [Δ] {%Δ}	Consumer Surplus [Δ] {%Δ}	Casino Profit [Δ] {%Δ}	Ad Valorem Tax Revenue [Δ] {%Δ}	Admission Tax Revenue [Δ] {%Δ}
$r = 0$ requires $t \approx 5.5055$	0.0761 [-0.002] {-2.6%}	837,348,668 [+29,831,288] {+3.7%}	23,503,940 [+1,644,866] {+7.5%}	30,491,439 [+59,650] {+0.20%}	0 [-10,516,427] {-100.0%}	16,516,427 [+10,516,427] {+175.3%}
$t = 0$ requires $r \approx 0.3593$	0.0797 [+0.0016] {+2.1%}	783,763,620 [-23,753,760] {-2.9%}	20,591,984 [-1,267,089] {-5.8%}	30,298,950 [-132,840] {-0.44%}	16,516,427 [+6,000,000] {+57.1%}	0 [-6,000,000] {-100.0%}

* All values are in 1998 dollars and are based on Thalheimer and Ali's (2003) estimated demand for casino gaming and the comparative static calculations presented earlier. See text for details. Each value in brackets is the change from the initial environment. Each value in braces is the percentage change from the initial environment.