THE EFFECT OF LEGALIZED GAMBLING ON STATE GOVERNMENT REVENUE

DOUGLAS M. WALKER and JOHN D. JACKSON

Legalized gambling is an attractive option to state governments facing tightening fiscal constraints. Yet, the empirical evidence on the effect of gambling on state revenues is limited. Most studies examine a single industry in a single state, and for a relatively short period of time. This study provides a more general analysis of gambling industries and their effects on state revenues. We use data on gambling volume and state government revenues net of federal government transfers for all 50 states from 1985 to 2000. We find that lotteries and horse racing tend to increase state revenues, while casinos and greyhound racing tend to decrease state revenues. (*JEL* H2, H7, L8)

I. INTRODUCTION

Legalized gambling has become an accepted form of entertainment in the United States, with every state except Hawaii and Utah offering some form of gambling. Each gambling industry is either run by or regulated by state governments. Nominally, the primary reason for legalizing gambling—especially recently in the cases of lotteries and casinos—is to provide alternative revenue sources to those which states typically employ. Arguably, the intended effect of these new revenue sources is to increase state revenues and reduce fiscal pressure. Oddly, few researchers have attempted to analyze whether this intended effect has, in fact, been realized. This neglect raises the important empirical question: What is the relationship actually observed between legalized gambling and state government revenues? This is a critical question, especially as many states struggle to deal with increasingly serious fiscal shortfalls. The issue also has significant international importance, as casinos spread worldwide.

The proponents of legalized gambling point to total taxes paid by gambling industries as an indication of the benefits of gambling to the states. Table 1 lists government revenue by state from commercial casino taxes, lotteries, and pari-mutuel taxes for 2004.

Walker: Associate Professor, Department of Economics and Finance, College of Charleston, 5 Liberty Street, Charleston, SC 29401. Phone 843-953-8192, Fax 843-953-0754, E-mail WalkerD@cofc.edu
Jackson: Professor, Department of Economics, Auburn University, Auburn, AL 36849. Phone 334-844-2926, Fax 334-844-4615, E-mail jacksjd@auburn.edu

Although the tax revenue from legalized gambling is sizable in many states, this does not necessarily mean that legalized gambling has contributed to a *net increase* in overall state revenues. As people spend more of their income on gambling activities, their spending on other goods and services is likely to decline. Thus, the net effect of legalized gambling on state receipts depends on complicated relationships among spending on gambling industries, spending on non-gambling industries, and the tax rates imposed on the various forms of spending. Furthermore, politicians could substitute revenues from these new gambling sources for those from existing sources, leading to an ambiguous net effect on total state revenue. Clearly, the introduction of a new good does not necessarily imply increases in government revenue will follow.

In this paper, we perform a relatively comprehensive analysis of the relationship between legalized gambling and state government revenues. We perform a panel data analysis on all 50 states for the 1985–2000 period, using annual data. We utilize data on gambling volume at casinos, Indian casinos, greyhound racing, horse racing, and lotteries; and total state government revenues net of transfers from the federal government. Our findings indicate mixed results. Lotteries and horse racing appear to have a positive impact on total state government receipts, but casinos and greyhound racing appear to have a negative effect on state revenues. Therefore, we argue that there is not a unique monotonic relationship between generic legalized gambling activity and overall state revenues. Of course, the effect of legalized

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TABLE 1
Gambling-Related State Government Revenue, 2004 (millions $)[a]

	(1) Commercial Casino Taxes	(2) Net Lottery Receipts[b]	(3) Pari-mutuel Taxes	(4) Total Gambling Tax Revenue (= 1 + 2 + 3)	(5) Net State Revenue[c]	(6)% of State Revenue from Gambling (= 4/5)
Alabama	—	—	3.2	3.2	15290.8	0.0
Alaska	—	—	—	0.0	6659.0	0.0
Arizona	—	108.0	0.6	108.6	17171.2	0.6
Arkansas	—	—	4.6	4.6	10206.4	0.0
California	—	1045.8	42.1	1087.9	183736.7	0.6
Colorado	99.5	113.7	4.5	217.7	18550.8	1.2
Connecticut	—	283.9	10.7	294.6	15396.0	1.9
Delaware	—	283.9	0.2	284.1	4675.6	6.1
Florida	—	1042.3	26.7	1069.0	58567.5	1.8
Georgia	—	783.6	—	783.6	25774.2	3.0
Hawaii	—	—	—	0.0	6596.7	0.0
Idaho	—	25.9	—	25.9	5376.4	0.5
Illinois	801.7	542.1	12.0	1355.8	48605.4	2.8
Indiana	760.5	200.8	4.8	966.1	20005.8	4.8
Iowa	250.6	53.5	3.2	307.3	11379.6	2.7
Kansas	—	70.0	3.5	73.5	8077.7	0.9
Kentucky	—	196.3	15.5	211.8	14286.5	1.5
Louisiana	448.2	121.8	20.4	590.4	16830.2	3.5
Maine	—	42.6	4.5	47.1	5749.7	0.8
Maryland	—	466.2	3.0	469.2	22168.1	2.1
Massachusetts	—	1153.9	5.7	1159.6	32989.3	3.5
Michigan	279.4	684.9	11.8	976.1	43978.8	2.2
Minnesota	—	82.6	1.5	84.1	23501.1	0.4
Mississippi	333.0	—	—	333.0	10122.3	3.3
Missouri	403.1	219.3	—	622.4	19082.9	3.3
Montana	—	9.2	0.1	9.3	3758.2	0.2
Nebraska	—	19.4	0.3	19.7	5954.8	0.3
Nevada	887.0	—	—	887.0	8567.2	10.4
New Hampshire	—	73.7	4.1	77.8	4718.2	1.6
New Jersey	470.6	795.9	—	1266.5	41582.2	3.0
New Mexico	—	36.0	1.2	37.2	8375.6	0.4
New York	—	1959.2	36.1	1995.3	95301.4	2.1
North Carolina	—	—	—	0.0	33326.6	0.0
North Dakota	—	—	2.6	2.6	4037.1	0.1
Ohio	—	600.9	15.9	616.8	61963.2	1.0
Oklahoma	—	—	2.8	2.8	13037.6	0.0
Oregon	—	195.9	2.9	198.8	20341.0	1.0
Pennsylvania	—	837.3	26.6	863.9	54037.2	1.6
Rhode Island	—	278.4	4.7	283.1	5279.2	5.4
South Carolina	—	290.9	—	290.9	15420.3	1.9
South Dakota	11.9	116.6	0.9	129.4	2644.1	4.9
Tennessee	—	—	—	0.0	15148.6	0.0
Texas	—	1063.1	11.8	1074.9	65706.8	1.6
Utah	—	—	—	0.0	10357.4	0.0
Vermont	—	20.1	—	20.1	2988.5	0.7
Virginia	—	422.2	—	422.2	29648.8	1.4
Washington	—	120.3	1.8	122.1	28416.7	0.4
West Virginia	—	520.5	9.5	530.0	8374.9	6.3
Wisconsin	—	140.6	1.8	142.4	28157.6	0.5
Wyoming		—	0.2	0.2	3240.1	0.0

Notes: Indian casino revenues are not included because reliable data are not available. Data sources: Casino taxes from American Gaming Association (2006); other data from Statistical Abstract of the United States.

[a]Data in this table are in nominal terms.

[b]This figure is total lottery ticket sales minus jackpots and administrative costs.

[c]This is total state government receipts minus funding from the federal government.

gambling in a particular state or states may differ from the general effects we find.

The paper is organized as follows. Section II is a literature review. In Section III, we describe the data used and develop our model. The results are presented and discussed in Section IV, and Section V is a summary and conclusion.

II. LITERATURE REVIEW

There is a long-established literature on "optimal taxes," which focuses on setting tax rates in an effort to minimize distortions or maximize welfare (i.e., efficiency). Such papers include Ramsey (1927), Mirrlees (1971), and Slemrod (1990). Several studies have focused on the goal of revenue maximization from excise taxes, for example, Lott and Miller (1973, 1974) and Caputo and Ostrom (1996). With respect to legalized gambling and government revenues, there have been several theoretical treatments, notably Clotfelter and Cook (1991, appendix to chapter 11) and Mason and Stranahan (1996). Empirical studies of gambling industries and their effects on state budgets are still rather scarce, but there has been a substantial amount of work on lotteries. For example, Garrett (2001) examines revenue maximization from lotteries; Tosun and Skidmore (2004) analyze the effects of new lottery adoptions in nearby states on West Virginia lottery revenue. Much of the lottery research has focused on the decision to adopt the lottery; the works by Alm, McKee, and Skidmore (1993) and Jackson, Saurman, and Shughart (1994) are representative of such studies. Comprehensive lottery analyses include Clotfelter and Cook (1991) and Borg, Mason, and Shapiro (1991).

Whether legalized gambling affects overall state government revenue depends on several factors. First, in many states there is more than one type of legal gambling. The extent to which the different gambling industries are substitutes (or complements) to each other will have an impact on the state revenues from gambling. The relationships between gambling industries and non-gambling industries are also important, for example, to the extent that consumers substitute gambling for other types of expenditure. The tax rates applied to the various types of spending are among a number of other important factors.

Here we provide a brief summary of some of the empirical papers that are relevant to our analysis of gambling and state government revenue. There are two basic types of study discussed below. The first type includes papers that primarily analyze the relationships among gambling industries, whether or not state tax revenue is explicitly considered. The second type includes papers that focus specifically on the relationship between gambling industries and state tax revenues.

Some of the papers that address interindustry relationships are of Elliot and Navin (2002), Fink and Rork (2003), Grote and Matheson (2006), Gulley and Scott (1989), Kearney (2005), Mobilia (1992), Ray (2001), Siegel and Anders (2001), Thalheimer and Ali (1995), and Walker and Jackson (2008).

Elliot and Navin (2002) run a probit model to test the factors that affect the probability of lottery adoption, then model the determinants of lottery sales in 48 states, from 1989 to 1995. In analyzing how other gambling industries affect lottery sales, they use the number of Indian casinos in the state and the highest gross revenues per capita for a lottery and gaming in any neighboring state. They find that casinos and pari-mutuels harm the lottery, and that adjacent state lotteries have a small negative effect on in-state lottery sales. The number of Indian casinos in a state and riverboat casinos in neighboring states do not significantly affect lottery sales. The note by Fink and Rork (2003) extends the work by Elliott and Navin (2002) by taking into account the fact that states self-select when legalizing casinos. They argue that low-revenue lottery states are more likely to legalize casinos, and treat casino legalization as endogenous. This partly explains the negative relationship between casinos and lotteries.

Grote and Matheson (2006) consider the effect of large, multi-state lotteries (e.g., Powerball) on smaller in-state lotteries. Although the introduction of the multi-state lotteries may have a negative impact on the smaller in-state games, the overall effect on state lottery revenue tends to be positive.

Gulley and Scott (1989) examine the relationship between lotteries and pari-mutuels prior to the explosion of casino gambling. They used a sample of 61 racetracks from 1978 to 1980. They found that \$1 in lottery ticket purchases leads to 18¢ less in racing handle. However, these results are not statistically significant. The states still benefit because, despite the potential cannibalization, overall tax revenues would increase because of the relatively high lottery tax.

Kearney (2005) examines household expenditure data from 1982 to 1998, a period during which 21 states implemented a state lottery. Among other issues, she studies the source of lottery ticket expenditures. Kearney finds that spending on lottery tickets is financed completely by a reduction in non-gambling expenditures. This implies that other forms of gambling are not harmed by a lottery, but that non-gambling industries are. One might expect, as noted above, that the lottery would therefore increase overall state revenues because the lottery tax is significantly higher than taxes on most other types of expenditure.

Mobilia (1992) analyzes the impact of lotteries on greyhound and horse racing attendance and total bets (handle) from 1972 to 1986. She notes that a lottery dummy is negative and significant for pari-mutuel attendance, but not for per attendee handle. Ray (2001) finds that horse racing and casino dummies have significantly negative effects on total state greyhound handle, from 1991 to 1998. Both Mobilia (1992) and Ray (2001) analyze all relevant racing states.

Siegel and Anders (2001) test the effect of Arizona Indian casinos on the state's lottery sales from 1993 to 1998. Independent variables include the number of Indian casino slot machines, horse and greyhound handle, plus a trend. They find the number of slots to have a significantly negative effect on lottery sales, but horse and dog racing have no effect.

Thalheimer and Ali (1995) model attendance and handle at three horse racetracks in the Ohio-Kentucky border market from 1960 to 1987. They find that the lottery (measured by payout rate) reduces the handle at racetracks. However, the state that has both lotteries and racetracks benefits in terms of overall tax revenue. The other state (without lottery) loses, as do all the racetracks. This suggests that lotteries harm horse racing. Major sporting events are also found to have a negative effect on horse racing.

In our earlier paper (2008), we examine state-level relationships among gambling industries. We utilized annual revenue or handle data on the various industries and estimated a SUR model. Our results indicate that casinos and lotteries have a negative effect on each other; lotteries and dog racing are complementary; and horse racing and casinos are complementary. Our results do not paint a simple, consistent relationship among the different gaming industries. This suggests that the relationships among gambling industries and net state revenues may also be inconsistent.

Although many of these studies do not directly address the effect of the gambling industries on state revenues, their results are informative, because knowing whether the different industries act as complements or substitutes has obvious implications for their effects on tax revenues. It is noteworthy that the interindustry results are not all consistent.

Papers that directly examine the effect of gambling industries on state revenues include Anders, Siegel, and Yacoub (1998), Borg, Mason, and Shapiro (1993), Davis, Filer, and Moak (1992), Fink, Marco, and Rork (2004), Mason and Stranahan (1996), Popp and Stehwien (2002), and Siegel and Anders (1999).

Anders, Siegel, and Yacoub (1998) examine the effect of Indian casinos on transactions tax revenue of one Arizona county. Because Indian casino revenues are not taxed by the state, politicians may be concerned that increases in casino expenditures will result in less spending on taxable goods and services. In their model estimating state tax revenues from 1990 to 1996, the authors include a dummy for the introduction of casinos. The coefficient is negative and significant, which suggests that tax losses from the retail, restaurant, bar, hotel, and amusement sectors were significant. The study of Popp and Stehwien (2002) can be seen as a complement to the study of Anders, Siegel, and Yacoub (1998), but applied to New Mexico county-level tax revenue, from 1990 to 1997. The explanatory variables in their model include employment, unemployment rate, wages, and dummies for Indian reservation, the first and second casino present, and the first and second adjacent county casino present. They find that the casinos have a negative effect on tax revenues within the county. But the effect of neighboring county casinos is somewhat odd: the first has a negative effect, while the second one has a positive effect on county tax revenue.

Borg, Mason, and Shapiro (1993) use a time series analysis and find that $1 in net lottery revenue has a cost of 15–23¢ in other types of government revenue, particularly sales and excise taxes, but that the lottery leads to an overall increase in revenues. Fink, Marco, and Rork (2004) also study the overall revenue effect of lotteries. Their results are partially consistent with those of Borg, Mason, and Shapiro (1993). However, Fink, Marco, and Rork (2004) find

that overall state tax revenue *decreases* when lottery revenues increase. Both of these papers consider lotteries, but do not account for other types of gambling in their models.

Davis, Filer, and Moak (1992) test the factors that determine whether or not a state will adopt a lottery, the timing of adoption, and the level of revenue a state can expect if it adopts a lottery. The authors find that state lottery revenue is higher the smaller the state government's revenue from the pari-mutuel industry and the smaller the percentage of bordering states that have lotteries.

Finally, Siegel and Anders (1999) examine Missouri sales tax revenues at the county level (1994–1996) as a result of introducing riverboat casinos. Like Anders, Siegel, and Yacoub (1998), they find taxes from certain amusement industries are negatively impacted. Siegel and Anders (1999) estimate that a 10% increase in gambling tax revenue leads to about a 4% decline in tax revenues from other amusement and recreation sources. However, there is no clear and consistent negative effect on other types of tax revenues.

These various studies have certainly enhanced understanding of the economic effects of gambling and the relationships among gambling industries. For the most part, however, the literature does not provide information on the *overall effect of all types of legalized gambling* on other industries or on state revenues. That is, most of the analyses are (1) on the impact of a single industry on one other industry, and not vice versa; (2) on the impact of a single industry on state tax revenue; (3) for relatively short time periods; or (4) on a single state or a small number of states. None of the studies reviewed attempts to jointly consider multiple forms of legalized gambling and their overall impact on state total revenue. As a result, one is left with an incomplete picture of how legalized gambling, all types considered, affects state government revenues in the longer term. The purpose of our present study is to supplement the literature by providing a more comprehensive analysis. We examine the relationship between legalized gambling and total state government revenues, net of federal transfers, for all states from 1985 to 2000.

III. DATA AND MODEL

We wish to model total state government revenue, net of any transfers from the federal government. We are interested in whether the existence of one or more type of legalized gambling in a state will affect overall revenue to the state government. The answer depends on the tax rate applied to gambling industry revenues and/or profits, the size of the particular gambling industry, and its relationship to other gambling and non-gambling industries, among other factors. We focus on the existence and volume of each type of gambling in each state as the explanatory variables of primary interest. We measure the volume of gambling rather than the actual taxes paid by each industry in each state, for example, because we are more interested in whether there is a *general relationship* between the volume of gambling and overall state revenues than in the effect of a particular tax regime. Obviously gambling tax rates and revenues are very important, as are the taxes applied to non-gambling goods and services. However, we view an examination of optimal tax rates as an extension to this analysis. Consider, for example, that Illinois taxes gross casino revenues at 50% while Nevada's rate is around 7%. Many states have very intricate tax rules, including various tax brackets, slot machine fees, etc., which would be very difficult to model using our state-level panel data. However, such issues would be interesting subjects for subsequent research.

We posit a panel model for all 50 U.S. states during the 1985–2000 period. (Washington, DC is excluded because it is not a state, and its fiscal decisions are handled primarily by the federal government.) We utilize annual data and, consequently, we have 800 observations on each variable. Our dependent variable is total state government revenue from all sources, minus funding from the federal government. It is important to note that federal government contributions to state governments are sizable. "Federal contributions" is also used as an explanatory variable in order to determine the extent to which state government revenues are driven by federal government monies. We use aggregated state government revenue rather than only gambling-related tax revenue, for example, because we wish to pick up any "substitution" effects that may be occurring with other gambling and non-gambling industries.

Our primary explanatory variables measure the *volume* of gambling for five industries: commercial casinos, greyhound racing, horse racing, lotteries, and Indian casinos. Volume is reported as "handle," or the total dollar amount of bets

placed, for greyhound racing, horse racing, and lotteries.[1] For casinos, reported volume is in net gambling revenue, or the revenue kept by the casino after paying winning bets to customers.[2] While it would be preferable to have the same volume measure for all industries, it is difficult to convert casino revenue into casino handle. Although casinos measure handle for slot machines, they only track the "drop" (i.e., the money used by customers to buy casino chips) for table games. Casino revenues are regularly reported at the state level, but handle is not. In any case, having a different measure for casinos is not problematic because revenue is still an accurate measure of volume.

Because Indian casinos are not required to report revenues and there are no reliable sources for Indian casino volume data, we use square footage of Indian casinos as proxy of their volume.[3] This square footage measure is used in estimating the volume of other gambling industries; see the structural equation system below. Indian casinos are thus used to indirectly explain state revenues. We opt for this strategy because most gambling policy discussions deal with the legalization or expansion of non-tribal gambling—because tribal gambling policy is largely outside the discretion of state governments.

To account for potential border crossings by consumers, we created a measure of the availability of the various forms of gambling in adjacent states. We follow Davis, Filer, and Moak (1992) and Walker and Jackson (2008) in using the percentage of adjacent states with each type of gambling. Using these variables will help account for cross-border spending on each of the gambling industries.

We collected a variety of demographic data by state that may help explain government revenues. These include state population, population density (population/square miles), percentage of the population over 25-yr-old holding bachelor degrees, per capita income, percentage of population estimated to be living below poverty level, and percentage of state population over 65-yr-old. Because tourism and legalized gambling may be complementary, at least for casino gambling, we include the estimated level of hotel employment in each state (the number of employees in the industry).[4] We expect that each of these, except "poverty" and possibly "older" (over 65-yr-old) would have a positive impact on state government revenues. Finally, the explanatory variables include a series of regional dummy variables (following Ekelund et al., 2006)[5] and a time trend.

We provide a list of the variables included in the final stage of our empirical analysis; these variables are defined and their summary statistics are listed in Table 2. Not all of the variables discussed earlier are included in the table, because the final stage of the analysis does not provide coefficient estimates on them.

A. *The Model*

A number of theoretical and empirical questions must be addressed before we begin our estimation process. We posit a naïve theoretical model in which the representative state's government revenue is jointly determined with the volume of (up to) four types of state sanctioned gambling activities. The volume of each gaming activity (V_i, $i = 1, \ldots, 4$) is assumed to be determined by the volume of

1. Slot machines and video lottery terminals (VLTs) were available at some racetracks during our sample period. However, this is a relatively recent phenomenon, and these revenues are not included in our data.

2. Casino revenue data are from the American Gaming Association and various states' gaming commissions. Data on lottery ticket sales come from LaFleur's 2001 World Lottery Almanac, 9th edition. Greyhound and horse racing handle are from the 1985–2000 issues of Pari-Mutuel Racing, published by the Association of Racing Commissioners International, Inc. State government revenue data are from the Statistical Abstract of the United States, various editions. All of the data are adjusted for inflation using the CPI from the Bureau of Labor Statistics.

3. Indian casino square footage is calculated by the authors using the casino listing and square footage data at CasinoCity.com, along with phone calls to the casinos to determine opening dates.

4. Hotel employee and per capita income data are from the Bureau of Economic Analysis. Annual estimates for some demographic data are not available, so we created annual estimates by linear interpolation. The years used to derive our annual estimates vary due to availability: *Education* (1990 and 2001), *Older* (1990 and 2001), and *Poverty* (1992 and 2001). These data are from the Census Bureau.

5. We use regional, rather than state, dummies because we already include state-specific dummies to indicate whether a particular type of gambling is legal. An additional advantage of using the regional dummies is that previous evidence suggests that neighboring states influence a particular state's decision to adopt gambling (Calcagno, Walker, and Jackson, 2010). Nevertheless, in one specification we did include state dummies and the results proved insignificant, perhaps as a result of the sizable reduction in the degrees of freedom.

TABLE 2
Variable Names, Descriptions, and Summary Statistics[a]

Variable	Description	Mean	*SD*	Minimum	Maximum
Net State Revenue (dependent variable)	Total state government receipts minus funds received from the federal government[b]	8,985,908,280	10,850,052,900	432,055,749	80,469,221,800
Casino Revenue	State total casino revenues after paying winning bets[b,c]	172,766,208	702,694,559	0	5,576,596,980
Greyhound Handle	State total bets placed on greyhound racing[b,c]	42,362,920	109,092,150	0	893,013,613
Horse Handle	State total bets placed on horse racing[b,c]	204,719,413	431,310,956	0	3,072,320,730
Lottery Sales	State total lottery ticket sales[b,c]	337,022,012	511,046,906	0	2,487,414,330
Casino Dummy	Dummy variable to indicate the presence of commercial casino gambling in the state	0.13	0.34	0	1
Greyhound Dummy	Dummy variable to indicate the presence of legal greyhound (pari-mutuel) racing in the state	0.33	0.47	0	1
Horse Dummy	Dummy variable to indicate the presence of legal horse (pari-mutuel) racing in the state	0.73	0.44	0	1
Lottery Dummy	Dummy variable to indicate the presence of a state-run lottery	0.63	0.48	0	1
Federal Transfers (to the given State)	The amount of state government revenue that is from the federal government[b]	2,353,906,530	2,907,911,340	238,847,584	20,739,256,700
Education	Percentage of the state population aged 25 or higher with a bachelor degree	15.42	5.38	4.01	31.69
Hotel Employees	Estimated number of hotel workers in the state	36,052.05	41,372.53	2,660	232,206
Income Per Capita	State level per capita income[b]	14,506.75	2,331.07	9,221.19	24,068.53
Older	Percentage of state population over 65-yr-old	12.54	2.07	3.37	18.62
Population	Estimated population of the state	5,161,102	5,608,851	453,690	33,871,648
Pop Density	State population divided by square mileage of the state	170.73	236.94	0.931	1,134.47
Poverty	Estimated percentage of state population living below the poverty level	13.85	4.12	6.73	28.08
Year	Time trend	1992.5	4.61	1985	2000
Regional Dummies	Dummy variables for Great Lakes, Mid-East, New England, Plains, Rocky Mountain, Southeast, and Southwest regions. (The Pacific region is the base region.)				

[a]The summary statistics should be interpreted with care, as they are for panel data (50 states, 16 yr). Summary statistics are shown for variables included in the net state revenue model, but not for variables included only in the reduced form equations. Summary statistics for the regional dummies are omitted for brevity.

[b]These variables are adjusted for inflation using the CPI from the Bureau of Labor Statistics.

[c]Industry revenue/handle summary statistics are calculated using only states and years in which the gambling industry was present (i.e., zero observations were not included when calculating the summary statistics).

other gambling activities conducted in the state[6] (to allow for substitution and complementarity among games), the presence of gambling activities in adjacent states ($A_m, m = 1, \ldots, M$; to allow for competition among states for gaming revenue), demographic factors (D_p, $p = 1, \ldots, P$; to allow for exogenous effects on the demand for the gambling activity), and some other variables ($Z_k, k = 1, \ldots, K$) related to the idiosyncratic nature of the data, such as regional dummies and a time trend.

Then state government revenue net of federal transfers (GR), our variable of primary interest, is determined by the presence of the gaming activity as indicated by a set of dummy variables ($G_{i(jt)} = 1$ if gaming activity i is available in state j at time t ($i = 1, \ldots, 4$, $j = 1, \ldots, 50$, and $t = 1, \ldots, 16$), the volume of the gaming activities offered in that state ($V_i, i = 1, \ldots, 4$), federal government transfers (FT) to that state, demographic factors (D_p, $p = 1, \ldots, P$), and other variables, such as regional dummies and a time trend ($Z_k, k = 1, \ldots, K$), related to the idiosyncratic nature of the data.

The gambling volume variables V_i and the demographic variables D_p are defined and discussed earlier in this section. The Ps are indexed in the equation system, because not all demographic variables enter each structural equation. The adjacent state variables (A_m) include the percent of adjacent states offering legalized casino gambling (A_1), the percent of adjacent states offering legalized lotteries (A_2), the percent of adjacent states offering legalized horse racing (A_3), the percent of adjacent states offering legalized dog racing (A_4), the percent of adjacent states having Indian casinos (A_5), and adjacent state Indian casino square footage (A_6). The Z_k variables include dummy variables for seven of the eight census regions and a time trend. Ekelund et al. (2006) found this approach to defining cross section and time series units of observation useful; we adopt their approach for essentially the reasons they offer. Finally, the dummies $G_{i(jt)}$ are included to indicate the presence of the ith gaming activity (in the jth state in the tth period) because not all states offer all gaming activities. In essence, the gaming volume measures are observationally equivalent to interaction variables arising as the product of the various gaming revenues with corresponding dummy variables indicating the presence of the relevant activity. As such, the state revenue equation specification would be incomplete without including the indicator dummies.

The structural equations for the implied system can be written in linear form, with an appended stochastic disturbance term ($\varepsilon_h, h = 1, \ldots, 5$) as

$$V_1 = \beta_0 + \sum_{i=2}^{4} \beta_i V_i + \sum_{m=1}^{M} \gamma_m A_m + \sum_{p=1}^{P_1} \delta_p D_p + \sum_{k=1}^{K} \eta_k Z_k + \varepsilon_1$$

$$V_2 = \beta_0 + \beta_1 V_1 + \sum_{i=3}^{4} \beta_i V_i + \sum_{m=1}^{M} \gamma_m A_m + \sum_{p=1}^{P_2} \delta_p D_p + \sum_{k=1}^{K} \eta_k Z_k + \varepsilon_2$$

$$V_3 = \beta_0 + \beta_4 V_4 + \sum_{i=1}^{2} \beta_i V_i + \sum_{m=1}^{M} \gamma_m A_m + \sum_{p=1}^{P_3} \delta_p D_p + \sum_{k=1}^{K} \eta_k Z_k + \varepsilon_3$$

$$V_4 = \beta_0 + \sum_{i=1}^{3} \beta_i V_i + \sum_{m=1}^{M} \gamma_m A_m + \sum_{p=1}^{P_4} \delta_p D_p + \sum_{k=1}^{K} \eta_k Z_k + \varepsilon_4$$

$$GR = \beta_0 + \sum_{i=1}^{4} \lambda_i G_i + \sum_{i=1}^{4} \beta_i V_i + \lambda FT + \sum_{p=1}^{P_5} \delta_p D_p + \sum_{k=1}^{K} \eta_k Z_k + \varepsilon_5$$

It should be understood that each equation in the above system applies to each state j ($j = 1, \ldots, 50$) and each time period t ($t = 1, \ldots, 16$). While this system forms the framework for our empirical analysis, it is only the last equation in the system that is of interest for our analysis to come. Indeed, the identification properties of the parameters in the first four equations in the system are of no concern to the present inquiry. The system does, however, provide us with a rationale for estimating specific reduced form equations for the various gambling activities in order to correct for their simultaneous determination with government revenue.

Confining our attention to the government revenue (GR) equation for the moment, there are a number of empirical difficulties that arise in its estimation. We have 16 yr of data on each of 50 states. Traditional ways of dealing

6. As noted earlier, Indian casino square footage is used to estimate the volume in each of the other four industries (V_i, $i = 1, \ldots, 4$), which are then used as explanatory variables in the model of state revenue.

with panel data are to estimate either a fixed-effects or a random-effects model. The fixed-effects model simply assumes common slope coefficients but different intercepts across cross-sectional units and/or over time, and accomplishes this correction by including dummy variables for different cross-sectional units and/or time periods. Alternatively, the random-effects model assumes common intercepts and slope coefficients; the cross-sectional and intertemporal differences arise in the disturbance term. That is, the disturbance variance of this model can be partitioned into a model specific component, a cross-sectional specific component, and/or a time-specific component. The typical question that arises is whether the fixed- or random-effects approach to panel data estimation is correct for the problem at hand.

In a recent paper, Ekelund et al. (2006) address this question by arguing that the answer need not be a mutually exclusive choice. They suggest employing the multiplicative heteroscedasticity model discussed by Greene (2000, 518–20). Specifically, that model involves using maximum likelihood techniques to jointly estimate a regression function and a variance function. By incorporating cross-sectional dummies and a time trend into both the regression and variance function specifications, this procedure allows us to account for both the differential intercept aspect of a traditional fixed-effects model concurrently with the cross-region variation in the disturbance variance aspect of a traditional random-effects model. See Ekelund et al. (2006, p. 530, notes 18 and 19) for a thorough explanation of this statistical model. We adopt this procedure to address problems arising from the "panel" nature of our data.

A second estimation problem arises as a result of the possible simultaneous determination of the volumes of the various gambling activities and net government revenue. We employ a "brute force" two stage procedure to address this problem. That is, we obtain two stage least squares (2SLS) estimates of the net revenue equation, literally in two stages. In Stage I, we estimate reduced form equations for each of the gambling volume variables by regressing each in turn on all of the exogenous variables (i.e., all of the right hand side variables except the V_i's) in equation system (1). In Stage II, we estimate the net revenue equation with each of the gambling volume measures replaced by its corresponding estimated value derived from the reduced form estimates of Stage I. This procedure allows us to correct for simultaneity while retaining our multiplicative heteroscedasticity estimation framework.

This two stage procedure highlights a final empirical difficulty that we must address. The problem arises in Stage I. The instrumental variables we derive from the reduced form estimates in the first stage are only as reliable as the parameter estimates used to calculate them. A potential problem with these parameter estimates arises as a result of the left censored nature of the gambling volume measures, the dependent variables in the Stage I regressions. Specifically, the dependent variables in each reduced form regression will have observed values of zero for each state and in each time period for which the state did not allow that type of gambling. Ignoring this type of left censoring in a dependent variable can lead to inconsistent parameter estimates.

We use Heckman's (1976, 1979) two-step approach to address this problem. For each particular gaming activity, we estimate a probit equation explaining the probability of adoption. If state j legally offered gaming activity i in time period t, the dependent variable in the relevant probit equation receives a value of one; zero, otherwise. The explanatory variables in the probit equations are the same as those in the reduced forms. The estimated probit index values from these models are then used to compute inverse Mills ratios (IMRs) for the various gambling activities, which in turn, are included in the relevant reduced form models as additional explanatory variables. This procedure corrects for biases in coefficient estimates due to censoring, so that gambling volume estimates derived from estimating these augmented reduced form equations can be viewed as appropriate instruments for Stage II estimation.

While this "tobit" correction assures more reliable coefficient estimates in our reduced form equations and hence better instruments for gambling volumes in the state revenue equation, the zero observations in these measures still do not address completely the fact that some states do not offer some of the gambling activities. To measure the *ceteris paribus* difference between state revenue averaged across states offering the ith gaming activity and states that do not, we include the dummy variable G_i for the $i = 1, \ldots, 4$ gaming activities. As an interpretive note, the coefficient on the dummy tells us this difference while the coefficient on the corresponding volume measure tells us the marginal effect on

state revenue from an additional dollar of handle or revenue for that activity; the *ceteris paribus* total effect of that gambling activity is the sum of these two effects.

In light of all of these issues, we estimate the net government revenue (*GR*) equation in equation system (1). Our model accounts for both fixed and random effects by including the trend and regional dummies. And our use of the Heckman two-step approach in the multiplicative heteroscedasticity framework corrects for left-censoring in the reduced form equations prior to using the "brute force" two stage procedure outlined above. We further address the left-censoring through the introduction of industry dummies. Thus, we correct for simultaneity between tax revenues and gambling industry volumes within a partially left censored, panel data framework.

IV. RESULTS

The results are presented in Table 3. Our discussion of the results focuses on the gambling industry variables in the regression function. We partition the effect of the gambling industries on net state revenue into two components. The dummy variables indicate the average impact on net state revenue from having a particular type of gambling in the state. The industry volume variables measure the marginal impact of an additional dollar of handle (for lottery and racing) or revenue (for casinos). The interpretation of the coefficients is not straightforward, however, as the gambling industries are not present in each state, have different histories, regulations, tax schemes, etc. It should be emphasized that the coefficient estimates represent effects on the "average state" (i.e., the hypothetical state taking on the average values for the explanatory variables—not necessarily any of the actual states in the sample) in the average year (same *caveat*); coefficients can be interpreted as applying to a particular state only to the extent that the state exhibits the mean state characteristics and behavior.

We discuss each industry, in turn, focusing on the overall impact from the dummy and volume variables. The *Lottery Dummy* variable is statistically significant and positive suggesting that states with a lottery will have state revenue that is on average $315 million greater than non-lottery states, *ceteris paribus*. However, each additional $1 of ticket sales is associated with a statistically insignificant $0.30 *decline* in net state revenues. This point estimate conflicts with the fact that the average state's effective tax on lottery tickets is about 30%, but this estimated effect could as easily be zero. The insignificance of the marginal impact may be the result of "revenue substitution." As Kearney (2005) found, lottery expenditures come at the expense of reduction in non-gambling expenditures, which may be the reason we find no significant marginal revenue effect from lottery ticket sales. Recall that we are partitioning the full effect into two components. The existence of lotteries together with the insignificant marginal impacts, nevertheless, shows that the lottery has an overall economically and statistically positive effect on state revenues.

The *Casino Dummy* variable indicates that the existence of casinos in a state is associated with a decrease of net state revenue of $90 million. This effect is not statistically significant, that is, the average state revenue for states having casinos is roughly the same as for those not having casinos. However, *Casino Revenue* suggests that each additional dollar of casino revenue causes a $1.44 decline in state revenue. This is a statistically significant impact. It is useful at this point to interpret the casino result in terms of estimated handle—to be consistent with the other industries' volume measures (i.e., handle). Suppose the relationship between casino revenues and handle is such that revenue equals around 5% of handle.[7] Then the coefficient on *Casino Revenue* implies that for each additional dollar of casino *handle*, net state revenues will fall by only $0.07. Although it is statistically significant, the negative marginal impact of casinos is fairly minor, suggesting only a mild "substitution" effect away from other consumer expenditures and ultimately, a decline in state tax revenues that may or may

7. This estimate is somewhat arbitrary. Determining the exact relationship between casino revenue and handle is complicated by table games. (Handle *is* tracked by slot machines, however, and a generally accepted industry average is that revenue is 5% of handle.) Although the casino "edge" is well known for table games to be less than 5% of each dollar bet, players typically bet winnings from previous plays. Thus, handle may vary greatly. For example, a player who buys $100 in chips and bets it all on a single hand of blackjack and loses would create $100 revenue for the casino. The handle for this player would also be $100. But if the player instead bet $25 on blackjack hands until he lost all his money, and he was able to play 50 hands on his original $100 chip purchase, then casino revenue from that player is $100, but handle is $1,250. For a general explanation of casino revenue and handle, see Hannum and Cabot (2005, chapter 3).

TABLE 3
Effects of Legalized Gambling on State Government Revenue

Variable	Regression Function[a]	Variable	Regression Function[a]
Constant	9.49e10* (2.96)	Great Lakes	−6.23e8 (−1.63)
Casino Revenue[b]	−1.44* (−5.81)	Mid-East	−5.93e8 (−1.40)
Casino Dummy	−9.02e7 (−0.76)	New England	−1.91e9* (7.62)
Greyhound Handle[b]	−7.61* (−4.94)	Plains	−1.37e9* (−5.14)
Greyhound Dummy	−1.57e8* (−2.77)	Rocky Mountain	−1.06e9* (−3.87)
Horse Handle[b]	−1.46* (−3.12)	Southeast	−1.58e9* (−4.81)
Horse Dummy	6.71e8* (6.72)	Southwest	−1.97e9* (−4.52)
Lottery Sales[b]	−0.30 (−0.77)		
Lottery Dummy	3.15e8* (2.96)	**Variable**	**Variance Function[a]**
Federal Transfers	2.32e6* (22.59)	Sigma	0.00 (0.09)
Education	−2.66e7 (−1.49)	Great Lakes	−2.49e5 (−1.17)
Hotel Employees	3.59e4* (5.01)	Mid-East	−1.49e5 (−0.70)
Income Per Capita	2.02e5* (7.30)	New England	−3.49e6* (−17.08)
Older	4.37e7 (1.06)	Plains	−1.97e6* (−10.04)
Population	566.35* (8.74)	Rocky Mountain	−4.68e6* (−21.86)
Pop Density	2.18e6* (7.36)	Southeast	−1.44e6* (−8.17)
Poverty	−5.04e6 (−0.26)	Southwest	2.80e5 (1.23)
Year	−4.89e7* (−2.99)	*Year*	1.34e5* (12.41)
		$\chi^2(8)$[c]	621.58*
		Log Likelihood	−6703.4

[a]The coefficients are reported with *t*-statistics in parentheses.
[b]The gambling variables are estimated values from a reduced form regression which has also been corrected for their left censoring (see the discussion concerning left censoring in Stage I above).
[c]The hypothesis is that the slope coefficients in both the regression function and the variance function are jointly zero.
*Significant at the 0.01 level.

not be economically significant. Obviously, this effect need not hold in each casino jurisdiction. Nevada, for example, derives a significant proportion of its state revenue from casinos, and we would be very surprised if the negative marginal impact we estimate applies to Nevada. But for the average state, it appears that casinos have a small but negative net impact on state revenues.

Our results on horse racing indicate a large positive and statistically significant impact from the existence of horse racing ($671 million). This large effect is perhaps because of a cumulative economic development effect in states with horse racing. The industry is rather mature, and it plays a significant role in some local economies. The effect of the industry, compounded over time, may explain the large existence effect on net state revenues. (Such an effect is unlikely to occur in lottery states, for example, because lotteries require little capital investment.) However, for each additional dollar of horse racing handle, there is a statistically significant −$1.46 effect on net state revenue. As with the other types of gambling discussed above, this represents a significant tax substitution effect. This negative impact of horse racing may be due, in part, to the recent strongly negative trend in horse racing handle that is attributable in part to the spread of casinos. Consideration of the total effect of horse racing on state revenue for the average state offering it is revealing. The total effect on state revenue will be positive so long as less than about $460 million is spent playing the horses. Because only about $277 million is spent in the average state allowing horse racing ($204 million considering all states; see Table 2), there is an average positive impact on state revenues of about $266 million for the average state.

Finally, we present the greyhound racing results. The existence of greyhound racing in a state is estimated to have a significant and negative impact on average net state revenue for those states offering it of about $157 million. Furthermore, each additional dollar of greyhound handle is estimated to reduce net state revenue by a whopping and statistically significant $7.61. Even if we adopt an extremely conservative point estimate that is two standard deviations below $7.61, the marginal effect on state revenue of an extra dollar bet on the dogs is

still a decrease of $4.50. Frankly, this marginal effect is very difficult to explain, especially considering the greyhound industry is relatively small in most states. We note that the greyhound industry produces questionable results of similar (negative) magnitude no matter what specification we have attempted in this analysis.

The large constant term is statistically significant. As expected, the *Federal Transfers* variable has a statistically positive effect on state revenues, even after these funds have been subtracted from total state government receipts. (Recall that the dependent variable in each model is net state revenue.) This suggests that federal funding drives other forms of state revenues, or at least that the formulae used to allocate these federal transfers are tied closely to the respective state's revenue efforts from its own sources.

The *Income Per Capita* variable shows that net tax revenues are significantly larger in states with higher per capita incomes. *Poverty* has a negative coefficient, but the effect is not statistically significant. These results are consistent with a priori expectations. The *Hotel Employee* variable is positive and strongly significant, which suggests that tourism has a strong positive impact on state revenues. This makes sense, as tourist expenditures are often heavily taxed (e.g., hotels, car rentals, etc.). *Population* is positive and significant, as would be expected because we analyze total, rather than per capita, net revenues. *Population Density* is positive. Large urban areas would be expected to generate more revenues and monitoring tax collections is less costly than in less populated regions. Both *Education* and the percentage of the population aged 65 or higher (*Older*) are insignificant.

Most of the regional dummies in the regression equations are negative and significant. The Pacific region was the base region to which the others were compared. The time trend appears to be negative and significant. These results on the regional dummies and the time trend taken together suggest that a two-way fixed-effects model of the regression function is reasonable.

The results of the variance function are also displayed in Table 3. The estimates for the variable *sigma* are estimates of that part of the variance not affected by the other variables in the variance function. In other words, if all of the other variables in the variance function were insignificant, the antilog of the estimate for *sigma* would be the constant variance estimate for the homoscedastic regression function. To the degree that other variables are significant in the variance function, the regression function is heteroscedastic and its disturbance variance depends on these measures. Clearly, the latter case is the relevant one here, as four of the regions are significant in the variance function estimate and the time trend is positive and highly significant. This means that the variance of the regression function varies significantly across regions and over time, indicating a two-way random-effects specification of the net revenue equation also to be appropriate.

Finally, it is worth noting that our results here, that is, that the regression function exhibits different constant terms across regions while the variance of the model varies both across regions and over time, demonstrates that the multiplicative heteroscedasticity approach allows a level of generality not available in the typical fixed/random-effects approach to analyzing panel data. These results further suggest that the usual approach may be overly restrictive, and in turn, by imposing inappropriate restrictions, could have generated a possibly vast set of inappropriate parameter estimates.

A. Discussion

When we consider the overall impact of each industry—both the "existence" effect measured by the industry dummy variables and the "marginal effect" as measured by the industry volume variables—we can summarize the estimated impacts of each industry on net state revenues. According to our analysis, casinos and greyhound racing have a negative impact on net state revenues, while lotteries and horse racing have a positive impact. While our results can be compared with other studies in the literature (such as those discussed in Section II), keep in mind that our results are more comprehensive, in the sense that our models consider the simultaneous effect of all of the gambling industries in all states. Most of the previous studies have considered only one industry and often only within a single state.

The positive effect from lotteries is not surprising, because the average tax rate from lotteries is significantly higher than taxes on most other goods and services. The positive horse racing finding is also consistent with other studies in the literature. The casino and greyhound racing results indicate substitution away from other, revenue productive forms of spending which, ultimately, leads to a reduction in state revenues.

We are surprised by the casino results. Although the magnitude of the marginal effect is small, it is statistically significant and negative. Policymakers and voters seem quite certain that casino gambling is an effective type of "voluntary" taxation, perhaps because of the licensing fees and relatively high taxes on gross gambling revenues. In most states' policy debates over casinos, the question has been whether the tax benefits (along with other potential economic growth effects) were worth the potential social costs imposed by pathological gamblers. Our results here indicate that the benefits side of the casino question is less of a certainty than is suggested in much of the public debate or literature.

The discrepancy between horse and greyhound racing—that the two forms of racing do not have the same direction of effect on net state revenues—is an unexpected result. Previous evidence has indicated that these industries are substitutes, and one would expect that they would then have a similar effect on state revenues. Perhaps horse racing has a positive effect because there are more major events in horse racing (e.g., the Triple Crown) than there are for greyhound racing. These events draw a significant amount of tourism that is not seen with the typical greyhound race.

V. SUMMARY AND CONCLUSION

In this paper, we have tested the effects of gambling volume on total state government receipts net of federal government transfer funding. We use a multiplicative heteroscedastic maximum likelihood estimation procedure with data for all 50 states over the 1985–2000 period. We find that lotteries and horse racing tend to supplement net state government revenue on average, while casinos and greyhound racing tend to have a negative impact. Of course, the effects of a particular industry in a particular state, or during a particular time period, may vary from our results. For example, we would be very surprised if casino gambling did not have a positive impact on revenues in Nevada and Mississippi, because these markets generate a significant amount of tourism.

Overall, our results make it clear that voters and policymakers cannot simply assume that the introduction or expansion of legalized gambling will have a positive effect on net state revenues. Indeed, one of the most popular policy proposals during recent fiscal crises is casino legalization. Our results show that casinos may be counterproductive in the long run in terms of tax revenue generation, *mutatis mutandis*.

We certainly acknowledge that there are other possible ways of modeling state revenues. We attempted several different specifications of the model. However, more serious complications were encountered with the alternatives we tested. Ultimately, we believe the model we present here to be the best one, given our data. Obviously there are several possible extensions to this work. For example, it would be useful for states to understand the optimal mix of gambling, in terms of tax revenue maximization. Our results do not address that issue. Another important issue is how the gambling tax structure impacts net revenues. Such issues could be analyzed at the individual state's level. We hope that this study provides a foundation for future research on these issues.

This study provides new information on the general relationships between legalized gambling industries and state government revenue. It is the first study to consider the effects of the different forms of legalized gambling simultaneously and in all states. To our knowledge, this is the first study of its type in any country. The analysis could be replicated in other countries, as there is no a priori reason to believe that the U.S. results would hold worldwide. Such information would be valuable to other countries' governments that may be considering casino legalization, lotteries, or pari-mutuels, as well as to governments of countries with already flourishing gambling industries (e.g., Australia and Canada). For the United States, our results provide new and important information for policymakers and voters. States or localities that are searching for ways to raise revenue should carefully research their particular situation before introducing new forms of gambling, as the effect on total state revenues is not necessarily positive. Legalized gambling may not always be the "golden egg" that it is sometimes promoted to be.

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