The Statewide Economic Impact of Small-Issue Industrial Revenue Bonds

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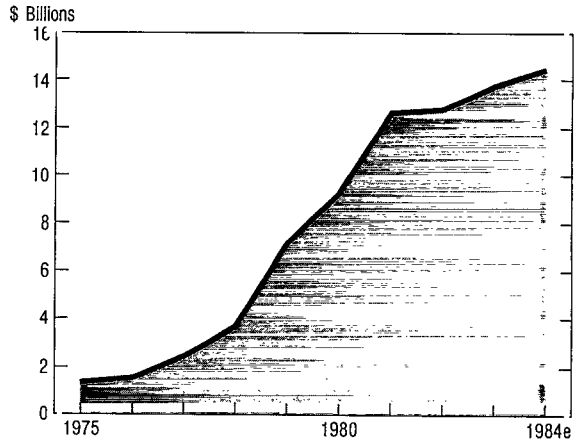
Industrial revenue bonds (IRBs) are tax-exempt debt securities issued by state and local governments to provide financial assistance for a myriad of quasi-public projects—including pollution control and hospital and airport construction—as well as for the expansion of commercial and industrial firms. Because the security for this debt is provided by the assisted firms rather than the issuing governments, IRBs are essentially corporate bonds whose interest is exempt from federal income tax and, in several states, from state income tax. This tax exemption permits the assisted firms to borrow at below-market, tax-exempt interest rates—in effect constituting a subsidy to the assisted firms. This subsidy, in turn, is a tax expenditure of the federal government and several state governments.

Small-issue industrial revenue bond (SIRB) issues, those limited to a maximum of $10 million each, aren't restricted to quasi-public purposes.[1] In the last ten years, SIRB issuance has increased tremendously. From a level of only $1.3 billion in 1975, SIRB issuance has grown nationally at a compound rate of 30 percent per year, reaching an estimated $14.4 billion in 1984 alone (see the accompanying chart).

Nationwide Financing With Small-Issue Industrial Revenue Bonds, 1975–84



e = estimated
Source of basic data: CBO (1984, p. 14)

Because this tremendous increase in the issuance of SIRBs coincides with a period of mounting concern about federal and state budgets, it is especially appropriate for policymakers to investigate whether or not SIRBs are attaining their intended objectives, as defined by state public purpose laws. Foremost among these objectives are the creation or preservation of jobs and the expansion of the property tax base. Corroborating this, a study by the Congressional Budget Office (CBO 1981, p. 19) notes that "in general, IRBs meet state public purpose requirements if they finance projects that create or save jobs, or if they promote economic diversification." As a typical example of state public purpose requirements, the

[1]For more details on the history and use of SIRBs, see the study by the Congressional Budget Office (1981).

Minnesota Municipal Industrial Development Act lists prevention of "the emergence of . . . areas of chronic unemployment" as an objective and then cites "the need for more intensive development and use of land to provide an adequate tax base" to finance local government services.[2]

Are these objectives being attained? They are, according to some sources. The Advisory Commission on Intergovernmental Relations (1984, p. 121), for example, cites two studies supporting the use of IRBs to boost employment. The first, conducted for the New York State Economic Development Council, concluded that tax-exempt financings significantly increased total employment in New York State; the second, a survey by the Massachusetts Industrial Finance Agency, concluded that IRBs would create 32,000 jobs in Massachusetts by the end of 1981. Similar claims are made about job growth in Minnesota. According to listings of employment projections within facilities approved for IRB assistance between 1978 and 1983, Minnesota state agencies forecasted that over 86,000 new jobs—or over half of Minnesota's total employment growth in that period—would be created within facilities financially assisted by billions of dollars worth of IRBs.[3] Moreover, because many of these new jobs were to be situated in private buildings which these states' agencies presumed would not have been built except for the use of below-market financing, substantial increases in local property tax bases are implicit in these agencies' job estimates.

The results of this paper stand in contrast to these claims, which have not been based on sophisticated analysis. By presenting theoretical arguments and empirical evidence, the paper suggests that SIRBs have probably created little or no statewide employment gains and, at least in Minnesota, have not significantly expanded the statewide aggregate local property tax base.

Theoretical Arguments

The application of microeconomic theory suggests three effects that might contribute to my argument that SIRBs have not significantly increased state employment and property tax base. For convenience I dub the three effects *intrastate competition, capital-labor substitution,* and *interstate competition.*

Intrastate Competition

In the past, SIRBs have often been used to help new firms locate or expand into markets that were already quite competitive within a single state. The excess competition engendered by the new firms' locations may adversely affect the incumbent competing firms and consequently lower their future employment and property tax payment growth. This intrastate competition may wholly or largely negate the employment and tax base growth provided by the firms subsidized by SIRBs. In fact, under some conditions, intrastate competitive effects may be so severe that statewide employment and tax base growth is actually lowered by the subsidized entry of competitors.

The severity of the effect of intrastate competition depends on the prevailing conditions in the markets entered by the SIRB-subsidized firms. To see this, first consider what happens when a SIRB-subsidized firm enters or expands into a market without barriers to entry.[4] When product demand grows in a market without barriers to entry, subsidies like SIRBs aren't necessary to entice firms to enter or expand: the profit potential inherent in growing demand already suffices to entice firms to do so. In this case, it would be incorrect to attribute any market-wide job or tax base growth to the subsidy. But in a market where product demand is stable or shrinking, then subsidies like SIRBs would indeed be necessary to entice entry or expansion. However, the absence of barriers to entry ensures that the subsidized entry or expansion will increase market competition enough to cause some incumbent competitors to leave the market. If the incumbent competitors' capital can easily be moved out of the state, and is indeed moved, then an accurate statewide impact estimate would subtract the incumbents' employment and tax base within the state from the subsidized firm's employment and tax base. The net impacts would be positive only if the subsidized firm was more labor and/or property intensive than the exiting incumbents, and would be negative conversely.

This argument presumes that the subsidized firm enters or expands into a market with no barriers to entry, so incumbent firms could tolerate no additional competition. But even if there were barriers to entry keeping incumbent firms' profits high enough to tolerate additional competition from the subsidized firm, incumbent employment levels and future expansion plans would still be curbed by the additional competition from the subsidized firm. Once again, accurate statewide impact esti-

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[2]Minnesota Statute, Section 474.01 (1984).

[3]Statistics compiled from the annual reports on municipal revenue bonds, available from the Minnesota Department of Energy and Economic Development. These statistics list IRBs approved for issuance rather than those actually issued. Because some approved issues were undoubtedly never actually issued, these data overstate the amount of revenue bonding; nonetheless, they appear to be the best available data for the purposes of this paper.

[4]In this paper, a *barrier to entry* in a market is any external circumstance which prevents firms from producing in the market at the minimum possible cost. Examples of such barriers include government chartering requirements and private patent protection of an incumbent firm's production processes.

mates must subtract the incumbents' foregone, in-state employment and tax base from the subsidized firm's employment and tax base. In Appendix A, I've derived impact formulas incorporating the incumbent firms' foregone employment and tax base in a market with barriers to entry. Despite the fact that no incumbents leave the market in these circumstances and despite the assumption that firms can hire all the workers they want without having to pay higher wages, these formulas indicate that the net employment and tax base impacts may be negative even under quite plausible market demand conditions.[5]

The intrastate competitive effect may have been intensified by the recent trend of using SIRBs to subsidize entry and expansion into commercial and retail markets—markets usually quite competitive within states. A report by the CBO (1981, p. 18) notes that "although past use of IRBs was largely for manufacturing, more and more states have issued bonds for commercial ventures, including office buildings, retail stores, and shopping centers. The current sales volume reflects this trend toward less traditional uses." In Minnesota, for instance, no IRBs were approved for commercial or retail projects between 1970 and 1974, but 49 such issues were approved between 1974 and 1977. Since then, the trend toward heavier issuance in support of commercial and retail activities has continued, commanding 45 percent of the $3.3 billion of approved IRB issues in the Minneapolis–St. Paul metropolitan area between 1978 and 1983.[6] The CBO (1981, p. 63) notes that in Pennsylvania, 60 percent of all SIRBs were used to support commercial and retail ventures. The trend is evident elsewhere, too. For example, between 1975 and 1980, K-Mart used $220.5 million of IRBs to help finance 96 stores in 19 states; and in 1979, McDonald's used them to help finance 32 new outlets in Ohio and Pennsylvania alone (CBO 1981, p. 23). This observed popularity of SIRB issuance to support locally competitive commercial and retail activity suggests that studies which haven't estimated intrastate competitive effects may overstate the job and tax base impacts of SIRBs.

Capital-Labor Substitution

Even if subsidies were granted to all other firms competing with SIRB-assisted firms to avoid the effect of intrastate competition, the second effect—capital-labor substitution—is another reason to doubt the usefulness of SIRBs in increasing statewide employment. Because SIRBs lower the cost of capital for assisted firms, these firms have an incentive to substitute capital for labor in making their products. In fact, under special conditions enough substitution can occur that state employment may actually be lowered by capital subsidies such as SIRBs.[7] This substitution would be absent if, for example, the subsidy took the neutral form of a cash grant which lowers total firm operating and capital costs. And the opposite incentive, favoring the substitution of labor for capital, could be created by government programs which solely reduce firms' labor costs.

Because SIRBs are usually granted to facilitate the construction of buildings, the substitution of capital for labor is most likely to take the form of larger or more expensive buildings than would otherwise be constructed with a neutral subsidy (one that lowers the prices of capital and labor by the same percentage) or with government programs that reduce labor costs. As a result, even if capital-labor substitution is weak enough so that statewide employment could be increased by capital subsidies (such as SIRBs, property tax abatements, or suboptimal corporate tax rates), employment could be more cost effectively increased by measures to reduce labor costs. (This result has been derived in Myers, Rogstad, and Wehner 1973 and in McLure 1971.) However, the property tax base is indeed more cost effectively increased by capital subsidies such as SIRBs.

Interstate Competition

The third effect that casts doubt on the efficacy of SIRBs in increasing statewide employment and/or property tax base is the interstate competition for jobs and tax base created by the nationwide use of SIRBs. The CBO (1984) found that IRBs were issued in all states. At first blush, it might even be guessed that interstate competition results in no net gain in total employment or tax base for the nation. Jobs and buildings may merely be shuffled among states engaged in a game of robbing Peter to pay Paul—where Paul also robs Peter. This so-called *zero-*

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[5]In Appendix A, I model a simple industry that has identical firms which possess only one variable input (labor) and whose profits accrue to owners of a fixed property input. A barrier to entry is posited which keeps profits above normal. Under the assumption of constant output elasticity with respect to labor, an entry-inducing subsidy lowers net industry employment and profits (and hence firm property values) when the market elasticity of demand is less than one, and raises it conversely. In this simple model, however, no attempt is made to capture possible effects on residential property values due to employment-induced population migration.

[6]See note 3.

[7]In Appendix B, the standard two-sector general equilibrium model is used to examine this issue. Following McLure (1971), I interpret the first sector as a state which subsidizes capital for all firms (assumed to produce a homogeneous good) within its boundaries and the second sector as the "rest of the world." McLure's (1970) results are modified to imply that, after capital subsidies are granted, net state employment will fall approximately when the elasticity of demand for the state's good is less than the elasticity of substitution in its production. Appendix B provides details and an intuitive interpretation of this result.

sum game conjecture (the conjecture that one state's gain is another's loss) has been embraced by numerous observers, including the prestigious Advisory Commission on Intergovermental Relations (ACIR 1984, p. 131), which concludes that

> when viewed strictly from a state economic development standpoint, there are persuasive arguments for using private purpose industrial development bonds; when viewed from a national standpoint, it [the use of IRBs] takes on the appearance of a zero-sum game.

If the SIRB game is indeed a zero-sum game—that is, if total nationwide employment and tax base is unaffected by SIRB issuance—and if each state subsidizes all its firms in order to avoid intrastate competitive effects, then preliminary computer simulations I've conducted show a number of possible outcomes of this game.[8] One possible outcome is that states will simply continue to subsidize capital more and more, without end, in a vain attempt to maximize their own employment levels, which cannot all be increased in a zero-sum game. Another possible outcome is that employment-maximizing states will subsidize capital only to the point where their capital-labor substitution is so severe that further capital subsidies would actually lower their own employment levels. If so, further SIRB issuance by a state may end up lowering its employment level, even though other states don't retaliate with additional SIRB issuance.

Even if the zero-sum game conjecture were true, in considering the statewide impact of SIRBs it must be remembered that states which did not vigorously play the game by issuing lots of SIRBs might have lost employment or tax base to states that did, as claimed by the ACIR quotation (1984, p. 131). If so, the statewide (but not the nationwide) impact should be attributed to SIRBs. But because of the intrastate competitive and capital-labor substitution effects, it is not a foregone conclusion that a state's past issuance of SIRBs helped it keep up with other states.

Empirical Evidence

So far, no empirical evidence has been considered in this examination of the effectiveness of SIRB issuance for stimulating statewide employment and tax base growth. We have seen how, in theory, the effects of intrastate competition, capital-labor substitution, and interstate competition all might have caused past SIRB issuance to be ineffective in stimulating such growth. But SIRBs weren't *necessarily* ineffective. After all, intrastate competition wasn't always a factor in past SIRB use and needn't always have resulted in little or no impact even when it was a factor.[9] Capital-labor substitution might not have been as severe an impediment to increasing employment within states which used SIRBs most frequently. And interstate competition may not have been a zero-sum game; rather, the widespread, massive use of SIRBs may have lowered the cost of capital for enough firms nationally to have increased nationwide investment and subsequently fostered growth of the nation's capital stock and employment. Only empirical evidence, to which we now turn, can determine the degree to which these three effects have impeded the effectiveness of SIRBs.

Two types of empirical methods may be helpful in estimating the employment and property tax base impacts of development subsidies such as SIRBs. Neither of these methods are dependent in any way on the theoretical arguments already presented. As such, the validity of any results obtained by using these methods doesn't depend upon whether or not we believe in the three effects presented.

Cross Section Methods

The first method is to conduct a cross section, multiple regression[10] of state employment and/or tax base growth on possible explanatory variables, including measures of economic development subsidies such as SIRBs. For example, to determine if SIRB issuance has affected state employment growth, we might regress state employment growth over some period on values of various average state input costs (for example, labor and land), proxies for state climate (average state temperature), various state tax and spending statistics, and the dollar value of state SIRBs issued. If such a study were carefully conducted and if its regression coefficient on SIRBs issued were then found to be statistically significant and positive, we could infer that increased SIRB issuance was associated with increased state employment over the period studied, even after controlling for other factors which influenced state employment.

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[8]Using the method of Ballentine (1978), I conducted simulations of the standard two-sector model of general equilibrium, interpreting each sector as a state subsidizing all its firms' capital stocks. Thus, this is a model of a "border war" between just two states, with each state controlling the subsidy rate on its own firms' capital. Each state attempts to maximize its own firms' total employment. Because labor is inelastically supplied to the two-state economy, the game is zero sum. In the simulations conducted, I explored the dependence of the states' noncooperative strategies on the technological and taste parameters of the two-state economy.

[9]See note 5 or Appendix A for conditions under which subsidies could increase net state employment and property tax base despite intrastate competition.

[10]See any introductory book on statistics or econometrics (for example, Maddala 1977) for an introduction to cross section, multiple regression techniques.

In what appears to be the most recent study of this kind, Michael Wasylenko ran such a regression based on prior work for the Minnesota Tax Study Commission (1984). He regressed the percentage change in employment between 1973 and 1980 in all fifty states, in each of six key economic sectors of each state and for the aggregate of these sectors, on 15 suspected key determinants of employment (most measured in 1977). At my request, he added another possible determinant: the average level of SIRB issuance in 1977–79, scaled by total employment in 1977.[11] Of these 16 possible employment determinants, 6 of them (wage rates, electricity costs, growth of tax effort, per capita income, the average maximum daily temperature in July, and educational expenses per dollar of income) significantly helped determine (at the 0.10 level) employment growth; the SIRB measure, however, had no statistically significant effect on state aggregate employment growth. Furthermore, the SIRB measure had no statistically significant effect on employment growth in any of the six economic sectors separately tested. (See Appendix C for the estimated aggregate regression equation.)

Some problems, however, are associated with the use of cross section, multiple regression techniques in determining the effectiveness of SIRBs. First, the techniques implicitly assume that the response patterns of state employment to the levels of the suspected determining variables are identical across states. For example, in the regression it is implicitly assumed that a one-dollar change in a state's level of the SIRB measure causes the same magnitude of change in *any* state's employment level. This assumption may not be approximately valid, due to interstate differences in the effectiveness of SIRBs. Second, cross section studies do not capture possible delayed effects of SIRBs in a sophisticated manner.

Time Series Methods

In light of these problems, I conducted a time series study—one using methods capable of capturing the lagged, dynamic effects, if any, that Minnesota IRB issuance had on the state's employment and property tax base growth. (I chose Minnesota because it is a major issuer of SIRBs.) The study posed the following question: Does the time series of IRBs issued in Minnesota contain information useful for predicting future growth of employment and of property tax base within the state? To answer this question I used formal statistical tests of *causality*.[12] That is, after using past values of a variable (employment or property tax base) to predict future values of that variable (employment or property tax base), I checked whether or not past values of a second variable (IRB issuance) lent additional help in making these predictions. A finding that IRB issuance *caused* (defined in the statistical sense just given) employment growth would indicate that the issuance did help predict future employment growth. However, it would also be possible to simultaneously find that employment growth caused increased IRB issuance (that is, employment growth helped predict future IRB issuance), perhaps due to a lesser need for subsidies following a period of rapid employment growth. It might also be possible to find unidirectional causality, where IRB issuance caused employment or tax base growth rather than vice versa. If this unidirectional causality were found, I would conclude that there is indeed a statistically significant link between IRB issuance and employment or tax base growth.

I found, however, that *none* of the causality tests (described in Appendix D) indicated unidirectional causality running from IRBs approved in Minnesota to *any* measure of Minnesota property tax base or employment, including both Minnesota's and the Minneapolis–St. Paul metropolitan area's total employment and unemployment rates. There were some unidirectional causal relationships running in the other direction, though—from Minnesota's unemployment rate and personal income change to IRB approvals. This is consistent with a hypothesis that IRB issuance depends more on the general state of the economy—perhaps through its effect on bond market conditions—than vice versa.

Other relevant statistical studies combine cross section and time series methods. Steinnes (1984) conducted a pooled cross section, time series study of the determinants of residence and employment in fifteen states, including Minnesota, over 1973, 1975, 1977, and 1979. He included public issuance of development bonds as an explanatory variable. In the regressions he performed, development bonds were never a statistically significant stimulus to state employment. In fact, in one regression they significantly *lowered* manufacturing employment. A study of county population and employment growth by Carlino and Mills (1985) also concludes that IRBs weren't a statistically significant stimulus to employment growth.

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[11] State SIRB statistics were compiled by the CBO (1981). Although there are probably numerous errors in the data reported to the CBO, this series still provides the best available data, and the CBO has made some attempt to correct known sources of error (such as, for example, the error mentioned in my note 3). Since the results really depend on the relative state issuance of SIRBs, not the absolute levels of state issuance, a fixed reporting error common to all states would not affect the outcome.

[12] For a general introduction to time series methods and a brief discussion of causality concepts, see Granger and Newbold 1977, pp. 1–42, 224–26.

Conclusion

From both cross section and time series evidence, then, I conclude that the ubiquitous issuance of SIRBs has not had a significant impact on either statewide employment or, at least in Minnesota, on property tax base growth. Statistical studies appear to favor the hypothesis that some combination of intrastate competition, capital-labor substitution, and interstate competition has led to the failure of SIRBs to meet their main objectives of increasing a state's employment and property tax base.

These largely negative findings do not necessarily mean that SIRB issuance is undesirable. After all, the findings do not constitute a cost-benefit analysis of SIRB issuance. Such an analysis would have to estimate both the nation's willingness to pay for the socioeconomic benefits of SIRB issuance and the nation's opportunity costs stemming from that issuance. Thus far, no such cost-benefit analysis has been undertaken, and job and property tax base growth might not even be major factors in such an analysis. But if Congress views statewide job and aggregate local property tax base growth as the primary objectives of SIRBs, then my negative findings help support recent congressional actions which limit the issuance of SIRBs and phase out their federal income tax exemption after 1986.

Does this paper yield any positive suggestions that state and local governments might jointly use in pursuing statewide job and aggregate local property tax base growth? I think it does. The paper suggests that state and local governments should work to minimize the granting of subsidies to firms with in-state competitors in markets with low or nonexistent barriers to entry; that is, excessive intrastate competition shouldn't be subsidized. Also, the discussion of capital-labor substitution suggests that economic development programs should be tailored to provide direct aid toward achieving a specific objective. If, for example, providing jobs for the hard-to-employ is a chief objective, programs directly lowering the cost of employing these individuals are more effective than capital subsidies such as SIRBs. These programs could take the form of wage subsidies, lower payroll taxes, or worker-training programs. Finally, some of the statistical studies cited support the view that policies to attract and retain residents, rather than firms, may present more effective means for stimulating economic activity.[13] According to this view, the cost-effective provision of basic state and local services as well as those services that enhance the quality of life—such as mosquito control and projects to make cities more livable in winter—may play an effective role in state and local governments' development strategies.

[13] See, for example, Steinnes 1984, p. 40, and Carlino and Mills 1985, pp. 14–15, for recent evidence supporting the hypothesis that jobs follow people rather than vice versa.

Appendix A
On Intrastate Competition

This appendix presents a simple model of intrastate competition which shows how a firm's subsidized entry into a market with a barrier to entry would not drive out any incumbent firms but would still possibly result in reduced total statewide employment.

I assume that the firms competing with the subsidized entrant are identical and located in the same state and that all the firms produce their single output using a common, constant elasticity production function of one variable input (labor), supplied perfectly elastically within the same state. All firms' profits accrue to owners of their fixed real property (land and building) input. Accordingly, firm property value is just the discounted present value of future firm profits. To simplify matters, I ignore other capital inputs and their accumulation, reducing matters to the computation of static industry equilibrium.

I also assume the existence of some barrier to entry which permits the incumbent competitors to earn above-normal profits. To envision such a barrier to entry, suppose that in the market there is a fixed amount of land available for a prospective entrant to locate on and that the land is all owned by the incumbent firms' owners. These owners may then attempt to charge the prospective entrant a higher-than-competitive price for the essential land. This excessive land price constitutes a barrier which prevents the prospective entrant from entering the market at minimum cost, thereby permitting the incumbent firms to earn above-normal profits.

Given this entry barrier, a sufficiently large land-purchase subsidy would entice a prospective entrant to enter the market. Because the incumbent firms are assumed to be earning above-normal profits when this happens, it is possible that none of them will exit when the subsidized firm enters. To analyze what happens when the incumbent N-firm market equilibrium becomes an $(N+1)$-firm equilibrium (with the subsidized entrant included), I assume that all firms treat the output price parametrically. Thus, I compare an N-firm short-run competitive equilibrium with an $(N+1)$-firm short-run competitive equilibrium.

I adopt the following notation:

L = equilibrium market employment

N = number of firms in the market

e_{LN} = elasticity of equilibrium market employment with respect to the number of firms

L_i = labor used by the ith firm

$f(L_i) = L_i^{\alpha}$ = production function common to all firms

p = price of the good produced by the firms

w = wage paid to labor

$D(p)$ = demand curve for the good

$e_D = -D'p/D$ = price elasticity of demand

$*$ = percentage differential of variable $d(\cdot)/(\cdot)$

π = total profits of all firms.

I make the following assumptions:

a. $\alpha > 0$ (The marginal product is positive.)

b. $\alpha < 1$ (This ensures diminishing returns to the variable input, labor, and results in above-normal profit for each firm in equilibrium, as required by the model.)

c. $e_D \geq 0$ (The law of demand applies.)

d. The labor supply is perfectly elastic at the (fixed) market wage w.

Under assumptions a and b, a necessary and sufficient condition for profit maximization is

$$\text{(A1)} \quad w/p = f'(L_i) = \alpha L_i^{\alpha-1}.$$

The market equilibrium condition is

$$\text{(A2)} \quad Nf(L_i) = NL_i^{\alpha} = D(p).$$

Because the N firms are identical, $L_i = L/N$. Substituting this into (A1) and (A2) provides two equilibrium equations in the two unknowns, L and p, for a given N (remember that assumption d fixes the constant market wage w). Logarithmically differentiating (A1) and (A2) and denoting percentage differentials with asterisks, I find that

$$\text{(A3)} \quad p^* = (1-\alpha)(L^*-N^*)$$

$$\text{(A4)} \quad N^* + \alpha(L^*-N^*) = -e_D p^*.$$

Substituting (A3) into (A4), dividing by N^*, and solving for $L^*/N^* = e_{LN}$, I compute

$$\text{(A5)} \quad e_{LN} = [(e_D-1)(1-\alpha)]/\{[e_D(1-\alpha)] + \alpha\}.$$

By assumption b, (A5) yields the result mentioned in note 4; that is,

$$\text{(A6)} \quad e_{LN} \gtreqless 0 \text{ as } e_D \gtreqless 1.$$

Equation (A6) has a simple economic interpretation. When $e_D < 1$, total industry revenue falls despite the expansion of industry output caused by the subsidized firm's entry. As a result, each firm cuts back employment enough so that total layoffs outweigh the additional employment provided by the new entrant.

Under the same assumptions, the effect on total market profits and (because all profits accrue to the owners of the fixed property input) on the total property value of the markets' firms can be worked out by a similar technique. Denoting the total profits of all the firms in the market with the symbol π, the elasticity of π with respect to the number of firms N turns out to be

$$\text{(A7)} \quad e_{\pi N} = e_{LN}.$$

From (A6), I thus obtain the other result mentioned in note 4; that is,

$$\text{(A8)} \quad e_{\pi N} \gtreqless 0 \text{ as } e_D \gtreqless 1.$$

Appendix B
On Capital-Labor Substitution

In this appendix, a simple model is presented which illustrates the important roles that capital-labor substitution can play in decreasing the net employment stimulus of subsidized entry and in influencing the growth of property tax base.

To isolate the role of capital-labor substitution, I assume that all firms producing a common product, called X, within a state receive the benefits of a capital subsidy or some other program to reduce capital costs. Intrastate competitive effects are thus absent from this model. These subsidized firms compete for labor and capital inputs with other unsubsidized firms which produce a possibly different common product, called Y. All firms produce under constant returns to scale and are assumed to produce and purchase inputs under competitive conditions. Labor and capital are assumed to be inelastically supplied to the two-sector economy.

These assumptions let me apply the powerful two-sector model of general equilibrium tax incidence (see Harberger 1974) to examine the employment impact of a capital subsidy that lowers the price of capital to all firms producing X. In what follows, I expand on McLure's (1970) more general two-sector analysis which permits less-than-perfect mobility of capital and labor across sectors.

All firms in sector (state) X pay the price $p_k \cdot (1+T_{kx})$ per unit of capital, where p_k is the gross-of-tax price of capital. By choosing the subsidy rate $T_{kx} < 0$, the state can subsidize capital for all its firms. A similar notation permits the modelling of labor subsidies. McLure (1970) examines the dependence of his model's general equilibrium on the subsidy rate by differentiating the equilibrium conditions with respect to the subsidy rate.

By reversing the labeling of capital and labor, equation (14) of McLure (1970, p. 117) yields

$$\text{(B1)} \quad (dL_x/L_x)/dT_{kx} = \{e_L e_K[Eg_k s_x(K_x/K_y) + f_k s_y(E-s_x)]\}/|D|.$$

where

L_x = labor used by sector-X firms

K_x = capital used by sector-X firms

e_L = parameter measuring the mobility of labor between sectors and equaling the elasticity of L_x with respect to the ratio of the two sectors' labor prices

e_K = parameter measuring the mobility of capital between sectors and equaling the elasticity of K_x with respect to the ratio of the two sectors' capital prices

E = (positive) elasticity of demand for sector-X output with respect to the ratio of the price of X to the price of Y

f_k = initial share of capital in sector X

g_k = initial share of capital in sector Y

s_x = elasticity of substitution in sector X

s_y = elasticity of substitution in sector Y

$|D|$ = determinant computed in McLure 1970.

Because a capital subsidy is a negative capital tax, $dT_{kx} < 0$. McLure (1970) points out that $|D| < 0$, so a capital subsidy causes the sign of (dL_x/L_x) to equal the sign of the numerator in (B1). Dividing by $e_L e_K > 0$,

$$\text{(B2)} \quad \text{sign}\,(dL_x/L_x) = \text{sign}[Eg_k s_x(K_x/K_y) + f_k s_y(E - s_x)].$$

Because McLure chooses units of capital and labor so that their prices are initially equal to one, constant returns to scale dictate that $y = K_y + L_y$ and $x = K_x + L_x$. So, $g_k = K_y/y$ and $f_k = K_x/x$. Substituting these relations into (B2) and dividing by $K_x > 0$,

$$\text{(B3)} \quad (dL_x/L_x) \gtreqless 0 \text{ as } E \gtreqless (s_x s_y)/\{[(x/y)s_x] + s_y\}$$

where

x = the presubsidy output of sector X

y = the presubsidy output of sector Y.

Assuming that the subsidized sector X's output is small relative to the rest of the world's output, I can neglect x/y in (B3) to derive the approximate rule

$$\text{(B4)} \quad (dL_x/L_x) \gtreqless 0 \text{ as } E \gtreqless s_x.$$

The economic intuition behind (B4) is readily apparent. Because the use of capital is subsidized in the production of X, it tends to be substituted for labor in X. The labor substituted for, though, always finds employment in the much larger, unsubsidized sector Y. The magnitude of this substitution process depends positively on s_x, the elasticity of substitution in the subsidized sector. But the production of X is stimulated by the lower price of X, made possible by the subsidy to capital in its production. Higher production of X increases the demand for labor to produce it, which counteracts the opposite effect of capital-labor substitution just mentioned. More X will be produced—and hence more labor will be demanded to produce it—when the elasticity of demand E is larger. If $E > s_x$, the production effect dominates the substitution effect, so employment in sector X will increase; the opposite is true when $E < s_x$. Employment in X remains unchanged when $E = s_x$.

As an example of the use of formula (B4), consider the Cobb-Douglas case with perfect factor mobility explored by McLure and Thirsk (1975) in their simplified exposition of the Harberger model. There, $s_x = s_y = E = 1$, so formula (B4) predicts that capital subsidies should approximately have no employment impact at all! In fact, McLure and Thirsk (1975, p. 9, n. 18) do indeed note this in the Cobb-Douglas case, where it is also exactly true with arbitrary sector sizes, in which case the magnitudes of both substitution elasticities matter.

Thus, as in Appendix A, the employment impact of subsidies depends positively on the elasticity of demand. But because of the possibility of capital-labor substitution, the employment impact may be small or even negative, despite highly elastic demand. This occurs when the subsidized sector has a high elasticity of substitution.

These complications are not present when wage subsidies, rather than capital subsidies, are granted. Employment always increases in response to a wage subsidy. Further, McLure (1971) shows that when conditions are such that capital subsidies increase employment, general wage subsidies produce even higher employment.

Unlike the ambiguity in the response of employment to capital subsidies, the capital stock will increase in response to a subsidy on capital, as shown by McLure (1970, p. 118). Furthermore, his equation (14) shows that the increase in capital stock is positively related to the elasticity of demand for the subsidized sector and to the elasticities of substitution in both sectors. The former relationship arises because the subsidized sector's output will increase more when the elasticity of demand is larger, thus creating a positive demand for capital there. The latter relationship arises because increased ease of substitution in the subsidized sector facilitates the substitution of capital for labor there, while increased ease of substitution in the unsubsidized sector facilitates the flow of capital towards the subsidized sector.

In my model, however, the property tax base is not the stock of capital in the subsidized sector but rather the market value of this capital (that is, the unit cost of capital times the capital stock). Harberger (1974) and Mieszkowski (1967) show that the price of capital in response to a subsidy may either rise or fall under the assumptions of this appendix. Conditions most favorable to a subsidy decreasing the price of capital are (1) when the subsidized sector is less capital intensive (that is, more labor intensive) than the unsubsidized sector and (2) when the elasticity of substitution in the subsidized sector is small. The first condition arises because, if capital needs are relatively unimportant in the unsubsidized sector, the unit cost of capital falls as it migrates from the unsubsidized sector, where it is relatively more important. The second condition arises because the capital substitution which helps drive the price-increasing demand for capital is less when the elasticity of substitution is small.

In contrast to capital subsidies, wage subsidies could either raise or lower the capital stock for the same reasons that capital subsidies could either raise or lower employment, as discussed in this appendix.

Appendix C
The Regression Equation

This appendix provides the regression equation (shown in the accompanying table), courtesy of Michael Wasylenko. The table's shaded row, which is the measure of small-issue industrial revenue bond (SIRB) use, indicates that the coefficient on the revenue bond variable (*PIRB*) is negative but not significantly different from zero at the 0.10 level.

The dependent and independent variables used in the regression are explained as follows. The dependent variable *PTOT* is the percentage change of state employment between 1973 and 1980 in an aggregate of six sectors (manufacturing; transportation; wholesale trade; retail trade; finance, insurance, and real estate; and services). The independent variables are defined below:

PRODWG An indicator of the cost of labor, measured by a state's average hourly pay for manufacturing production workers.

PWSTOP An indicator of the cost of unionization, measured by the percentage of working time lost in a state due to union work stoppages.

MEDED76 An indicator of the quality of the labor force, measured by a state's median education level in 1976.

PCP1844 An indicator of labor force availability, measured by the percentage change in a state's population, aged 18 to 44, between 1965 and 1973.

ELEC78 An indicator of a state's cost of energy, measured by the average industrial electrical bill for the 300–600,000 kilowatt-hour class in 1978.

PTEFF10 An indicator of tax trend, measured by the percentage change in a state's overall level of tax effort, as defined by the Advisory Commission on Intergovernmental Relations (ACIR), from 1967 to 1977.

EFFITS0 The ACIR's indicator of the effective income tax rate for taxpayers with income exceeding $50,000, measured by a state's ratio of income taxes paid to total income for this cohort.

PDENST73 A state's population density in 1973.

PCY A state's per capita income in 1977.

EFFCIT79 The ACIR's indicator of the effective corporate tax rate, measured by a state's ratio of corporate tax revenue to corporate income.

MAXTEMP A state's average maximum daily temperature for July over the past 30 years.

MINTEMP A state's average minimum daily temperature for January over the past 30 years.

The Regression Equation

Dependent Variable: *PTOT*

Summary Statistics

Squared Sum of Errors: 2966.871 — *F*-Ratio: 5.52
Degrees of Freedom of Equation: 30 — Probability > *F*: 0.0001
Mean Square Error: 98.895694 — R^2: 0.7466

Independent Variable	DF	Parameter Estimate	Standard Error	*t*-Ratio	Prob > |*t*|
INTERCEPT	1	−315.696838	207.035103	−1.5248	0.1378
PRODWG	1	−7.871908	2.875402	−2.7377	0.0103
PWSTOP	1	−7.825067	17.593942	−0.4448	0.6597
MEDED76	1	15.593398	18.716463	0.8331	0.4114
PCP1844	1	−0.290704	0.303523	−0.9578	0.3458
ELEC78	1	−0.010882	0.004184	−2.6008	0.0143
PTEFF10	1	−0.433374	0.224020	−1.9345	0.0625
EFFITS0	1	−1.383707	1.038945	−1.3318	0.1929
PDENST73	1	−0.016749	0.010051	−1.6664	0.1061
PCY	1	0.015414	0.005065	3.0432	0.0048
EFFCIT79	1	−0.128469	1.295089	−0.0992	0.9216
MAXTEMP	1	1.049970	0.540440	1.9428	0.0615
MINTEMP	1	−0.018881	0.189277	−0.0998	0.9212
PSALETX7	1	−0.242175	0.397099	−0.6099	0.5465
PIRB	1	−0.033032	0.027825	−1.1871	0.2445
WELI77	1	2.885263	3.040904	0.9488	0.3503
EDUCI77	1	4.897233	2.269587	2.1578	0.0391

DF = degrees of freedom
Source: Wasylenko

PSALETX7 An indicator of the diversity of a tax system, measured by a state's sales tax revenue as a percentage of state and local revenue in 1976–77.

PIRB An indicator of SIRB use, measured by a state's average SIRB issuance between 1977 and 1979 as a fraction of total state employment in 1977.

WELI77 An indicator of the welfare burden, measured by total state and local expenditures from own-source revenue on public welfare plus Medicaid as a percentage of state personal income in 1977.

EDUCI77 An indicator of relative education expenditures, measured by total state and local educational expenditures from own-source revenues as a percentage of state personal income in 1977.

With the exception of the SIRB series (*PIRB*), which came from the Congressional Budget Office (1981, pp. 70–71), all data sources are listed in the study by the Minnesota Tax Study Commission (1984, Appendix A).

Appendix D
Tests of Causality

This appendix discusses the causality tests performed to discover relationships between Minnesota's industrial revenue bond (IRB) issuance, employment levels, unemployment rate, and property tax base growth.

I performed the following bivariate causality tests using annual data (*change* means first difference):

The change in Minnesota IRBs approved	vs.	Minnesota civilian employment change
The change in Minnesota IRBs approved	vs.	Minnesota civilian unemployment rate
The change in Minnesota IRBs approved	vs.	Minneapolis–St. Paul SMSA employment change
The change in Minnesota IRBs approved	vs.	Minneapolis–St. Paul SMSA unemployment rate
The change in Minnesota IRBs approved	vs.	Minnesota real property value change
The change in Minnesota IRBs approved	vs.	Minnesota personal income change
The change in Minnesota IRBs approved	vs.	Minneapolis–St. Paul SMSA personal income change

For each of the paired data series listed, causality tests were conducted by testing for the joint significance of the lag coefficients of one series in a bivariate autoregression with the other series. A finding of joint significance was defined to mean that the former series helped cause the latter series. I ran separate tests using annual data with two lags for the period 1960–83 and annual data with one lag for 1970–83. This was done because few or no IRBs were issued in Minnesota before 1970; it was also done to test the sensitivity of the tests to the lag-length specification while still preserving degrees of freedom. Annual changes were used in an attempt to induce stationarity in series whose levels appeared to be nonstationary. However, no attempts were made to perform causality tests with subannual data because the IRB series lists those bonds approved for issuance within a year, rather than their actual (unknown) dates of issuance. Due to this uncertainty and the use of only annual data, time aggregation errors may result.

The only significant causal relationships at the 0.10 level ran from the Minnesota unemployment rate to Minnesota IRBs approved between 1965 and 1982 (the period over which the unemployment rate data were gathered) and from Minnesota personal income change and Minnesota IRBs approved between 1960 and 1983. The unemployment rate relationship became barely insignificant at the 0.10 level between 1970 and 1982 (with one lag), while the personal income relationship definitely disappeared over this later period.

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The views expressed herein are those of the author and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.