Shocks to the Property Tax Base and Implications for Local Public Finance

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Abstract

The bursting of the house price bubble in 2008-09 has led to a situation where local governments that rely on property tax revenues are in a precarious position. With a dramatic decline in house and other real estate prices, the property tax base is reduced substantially. If there is no change in the effective tax rate applied to the property tax base, revenues fall substantially, affecting the local government's ability to provide public goods and services. School districts, cities and counties are all affected, as are other units of local government that rely on property tax revenues. In this paper, I use a traditional model of a local government and its decisive voter to analyze the potential impacts of a shock to the property tax base. I also develop a model of revenue replacement in response to a tax base shock that takes an optimal tax approach and incorporates adjustment cots. Then, I suggest an empirical approach to estimating the replacement revenue effect and I illustrate the application of that approach using the elimination of the Nebraska *ad valorem* property tax on motor vehicles.

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1 Introduction and Background

With the bursting of the housing asset bubble in 2008-09 local governments that rely on property tax revenues are in jeopardy of losing a substantial portion of their tax bases with a corresponding loss of tax revenue. Dramatic declines in house and other real estate prices have reduced the property tax base significantly in many areas and have done so substantially in some particular metropolitan areas. For example, the Case-Shiller index for the twenty largest metropolitan areas in the United States indicates that house prices fell 29.4 percent from the peak in July of 2006 through the end of 2009. Such a decline, if reflected in a similar reduction in the assessed values of homes, confronts local governments with unprecedented reductions in the property tax base. If there is no change in the effective tax rate applied to the property tax base, revenues fall substantially, affecting the local governments's ability to provide public goods and services. School districts, cities and counties are all affected, as are other units of local government that rely on property tax revenues. In this paper, I use a traditional model of a local government and its decisive voter to analyze the potential impacts of a shock to the property tax base. I also suggest an empirical approach to estimating the replacement revenue effect.

At this point in the current economy cycle, we have very little evidence on how local governments may be adjusting to dramatic reductions in the value of their property tax bases. There may, in fact, be little adjustment yet. One reason for this is the revenue received by state and local governments via the federal recovery act (ARRA). That act has provided substantial replacement revenue for local government budgets specifically for K-12 teachers and others. Hence, the impact of reduced property tax bases has not yet been fully felt. Another reason why local governments may not have felt much impact is due to the inertia built into their property assessment systems. Changes in market value of property may take several years to have an impact on assessed value.

One recent study that examines the sensitivity of property tax revenues to house prices is that of Lutz (2008). His estimations indicate that the long-run elasticity of property tax revenues with respect to house prices is approximately 0.4. Furthermore, he finds that it takes three years for house price changes to be reflected in property tax revenues. In the particular case of house price declines, Lutz finds that the elasticity estimates are negative, indicating that policy makers offset price declines with increases in the effective tax rate. The result is that revenues do not fall proportionately with house price declines. This result is tenuous, however, as the data used in the Lutz study included relatively few cases of house price declines.

Another approach is to examine the literature to see how local governments adjust their property tax revenue in response to other revenue source shocks. For example, Dye and Reschovsky (2008) find that school districts adjust their property tax levies in response to changes in state aid for education. Their estimates indicate that school districts increase property taxes by 23 cents per dollar reduction in state aid. While this result does not tell us anything about how districts may adjust in response to a property tax base shock, it is suggestive that the adjustment may not be directly proportional.

In what follows, I present a general theoretical model of the local government budget and the demand for local public goods by a decisive voter. Using that framework I consider the potential effects of shocks to the property tax base. Following that, I present a simple model of how local governments may adjust revenue sources, based on an optimal tax approach that incorporates adjustment cots, and propose an empirical framework for eventual estimation of the replacement response.

2 A General Theoretical Model

To begin, we consider a traditional model of local government finance based on the simple approach in Inman (1978). In this case we have a local government that derives revenue from two tax sources and receives a grant from a higher level of government. The key feature of this model is that the local government can adjust its reliance on one form of tax in response to either a change in the other tax source or a change in the intergovernmental grant. This type of model has been used extensively in the literature to investigate various ways in which the local government may adjust its revenue reliance in response to changes in one of the tax sources or the intergovernmental grant. For example, Anderson (1994) used this approach to model a simultaneous system of equations explaining how school districts responded to a state policy change that forced them to reduce their property tax reliance in Nebraska.

2.1 Traditional model set-up

We can begin by specifying the revenue derived by a local government unit as coming from two tax instruments, A and B. The property tax base of community i is given by X_{Ai} and reflects the total taxable value of property in the community. The property tax rate is denoted t_A. Therefore, the total property tax revenue is the product of the tax rate and the tax base: $R_A = t_A X_{Ai}$. There is an alternative tax source, B which could be a sales or income tax. We denote the revenue generated by the alternative tax by $R_B = t_B X_{Bi}$, where t_B is the tax rate and X_{Bi} is the alternate tax base in community i. Hence, the total revenue to the local government in the community is written as the sum of the two tax sources:

$$R = R_A + R_B = t_A X_{A_i} + t_B X_{B_i}. \tag{1}$$

There is also intergovernmental revenue that comes to the local government in the form of grant revenue. The grant has a lump sum component denoted z and a matching component where the match rate is m. Local government expenditures depend on the level of the local public good provided. We can use s to denote the level of local public good provided and the cost of providing that level as $k(s)$. It is not necessary to make any particular assumption about the structure of the cost function, other than to assume that the marginal cost is positive.

The local government's budget can be written as,

$$t_A X_{A_i} + t_B X_{B_i} = k(s)(1 - m) - z. \tag{2}$$

In this expression, the left-hand-side represents total own-source revenue from the two tax sources and the right-hand-side represents the cost of providing the public good at level s net of grant receipts.

If we solve the local government's budget relationship for the alternative tax rate as a function of the property tax rate, we have,

$$t_B = [k(s)(1-m) - z - t_A X_{A_i}]/X_{B_i}. \tag{3}$$

This expression defines the potential trade-off between the alternative tax revenue sources in terms of the tax rates. The explicit trade-off is given by the slope of this relationship, or the derivative,

$$\frac{dt_B}{dt_A} = -\frac{X_{A_i}}{X_{B_i}}, \tag{4}$$

which indicates that the change in the alternative tax rate needed to compensate for a change in the property tax rate is minus the ratio of the two tax bases. The intercepts are given by the two expressions,

$$t_B = [k(s)(1-m) - z)/X_{B_i}, \tag{5}$$

$$t_A = [k(s)(1-m) - z]/X_{A_i}. \tag{6}$$

These expressions indicate that relying on a single tax source, whether the property tax or the income tax, requires a tax rate determined by public good cost minus state grant revenue divided by the relevant tax base. An increase in the cost of providing the public good shifts the budget line outward in a parallel fashion. Similarly, a decrease in the matching grant rate or the lump-sum grant amount shifts the line outward. An increase (decrease) in either tax base has the effect of reducing (increasing) the intercept for that tax rate.

While the above characterization specifies the financing options available, it does not take into account the community's demand for the public service. We turn to that issue at this point.

Taking a decisive voter approach, we assume that the demand for the public service is given by the function $s = s(\tau, y, z)$ where τ is the marginal tax price of the public good/service, y is income before local taxes, and z is the lump-sum grant from the state government. We assume that the partial derivatives are as follows: $s_\tau < 0$, $s_y > 0$, and $s_z > 0$. Here, we are assuming that the demand curve for the local public good/service is downward sloping reflecting the fact that as the marginal tax price rises the quantity demanded falls. The public good is normal in the sense that as income rises, demand for the good also rises. In addition, as the state lump-sum grant rises more of the local public good is demanded.

In order to specify the price of the public good, we begin with the out-of-pocket cost of a dollar of local taxes. Let $\pi = 1 - \tau - \zeta$ denote the cost, where τ is the combined federal and state marginal tax rate (accounting for deductibility) and ζ is the property tax credit that may be provided by the state government. We assume that the local government can determine its own property tax rate, but not its own income tax rate. Decisive voter i in local government j, faces the net tax paid for the public good (assuming both taxes are deductible)

$$\pi(t_A X_{A_i} + t_B X_{B_i}). \tag{7}$$

The marginal tax price of the public good can be written as,

$$\pi(1-m)(X_{B_i}/X_{A_i}). \tag{8}$$

Note that the tax price for voter i depends crucially on his share of the total property value in the local government jurisdiction, $X_{A_{ij}}/X_{A_i}$ The greater (smaller) the decisive voter's share of the property tax base, the higher (lower) her marginal tax price for the local public good.

If we solve the local government's budget equation for the property tax rate, we have,

$$t_A = [k(s)(1-m) - z - t_B X_{B_i}]/X_{A_i}. \tag{9}$$

Differentiating this expression with respect to the quantity of the public good/service s gives,

$$\frac{dt_A}{ds} = (1-m)k'(s)/X_{A_i}. \tag{10}$$

So, as the quantity of the public good increases, the property tax rate will rise at a rate that depends on the intergovernmental matching grant rate m, the marginal cost of the public good $k'(s)$, and the inverse of the local government's property tax base X_{Ai}. The smaller the grant matching rate, the greater the marginal cost of the public good, or the smaller the property tax base in the jurisdiction, the faster the property tax rate rises with increased demand for the public good.

The grant mechanism affects the property tax rate as increases in both the lump-sum portion of the grant and the matching rate enable the local government to reduce the property tax rate. The effect of an increase in both grant parameters can be seen in the following derivatives.

$$\begin{aligned} \frac{dt_A}{dz} &= -\frac{1}{X_{A_i}} \\ \frac{dt_A}{dm} &= -\frac{k(s)}{X_{A_i}} \end{aligned} \tag{11}$$

Of course, the impact of a more generous intergovernmental grant may be to reduce the property tax rate, increase spending, or a combination of both responses. Furthermore, there is the question of whether grant funding sticks where it hits, as discussed in the flypaper effect literature.

2.2 Impact of a property tax base shock

In order to investigate the effects of a shock to the property tax base, consider first the budget constraint of the local government. From equation (3) we have the alternative tax rate necessary for any given level of the property tax rate and the two tax bases. Differentiating t_B with respect to X_{A_i} gives,

$$\frac{\partial t_B}{\partial X_{A_i}} = -\frac{t_A}{X_{B_i}}. \tag{12}$$

This derivative indicates that in the local government budget, a reduction in the property value requires an increase in the alternative tax rate, the size of which depends on the property tax rate relative to the alternative tax base.

The impact of a shock to property values includes an effect on the marginal tax price for the decisive voter.

$$\frac{\partial \tau}{\partial X_{A_i}} = -\frac{\pi X_{A_i}}{X_{A_i}^2} + \frac{\pi(1-m)}{X_{Ai}} \frac{\partial X_{A_i}}{\partial X_{A_{ij}}}. \tag{13}$$

So, the tax price for the decisive voter is inversely related to the change in property value. The partial derivative in the second term on the right-hand-side captures the extent to which the aggregate property value in the local government jurisdiction is affected by a change in the decisive voter's property value. A negative shock to property value causes the tax price to rise. The extent of the increase, however, depends on the share of jurisdiction property value X_{A_i} owned by the decisive voter.

Differentiating equation (9) with respect to X_{A_i} gives,

$$\frac{\partial t_A}{\partial X_{Ai}} = -\frac{[k(s)(1-m) - z - t_B X_{B_i}]}{X_{A_i}^2}, \tag{14}$$

indicating that a negative shock to the property value X_{A_i} causes the property tax rate to rise at a rate that is inversely related to the square of the property value. For a given cost of the public good, net of the state grant, and a given level of revenue generated by the income tax, there is an inverse relationship between property value and the property tax rate. Furthermore, this derivative indicates that the inverse relationship is not linear. As the property value falls, the required increase in the tax rate to maintain the same level of public good provision, accelerates.

3 An Optimal Tax Response to a Shock

In this section we consider an alternative way of thinking about the adjustment process that may be used by local governments as they respond to a property tax base shock. We will consider an optimal tax response of the government. The advantage of this approach is that it takes into account adjustment costs of altering tax source reliance. In addition, this approach suggests an empirical strategy that can be used to estimate the government's response.

3.1 Impact of a shock on the effective property tax rate

We begin by considering how a shock to the property tax base affects the effective property tax rate. That provides a link to the adjustment cost that the local government faces as it contemplates how to respond to the shock.

In the particular case of a shock to the property tax base as has been experienced by many U.S. cities in the recent past, we must consider how the shock affects the effective tax rate. The effective rate of property tax t_A^e is the product of the nominal tax rate and the assessment ratio r, $t_A^e = t_A^n r$, where the assessment ratio r is defined as the assessed value of the property divided by the market value, $r = AV/MV$. A shock to the property tax base that reduces its value by the factor $(1 - \delta)$ may in the short-run raise the effective tax rate applied to property. That occurs if the nominal tax rate and the assessed value are unchanged while the market value of the property shrinks by the factor $(1 - \delta)$. In this case, the assessment ratio rises due to the reduction in the market value from MV to $MV(1 - \delta)$ and no accompanying change in assessed value, so the effective tax rate rises. With an increase in the effective tax rate, the efficiency cost of raising revenue with the property tax also rises.

If the shock to the property tax base is accompanied by a simultaneous adjustment in assessed values of an equal amount, the assessment ratio is unaffected. Both MV and AV shrink by the factor $(1 - \delta)$ and the assessment ratio is unchanged. Given the inherent lag in the assessment process, this may eventually occur, but we expect that initially the effective tax rate rises and only later returns to its previous level as assessments decline following reductions in market value.

To date, we have limited evidence on how the property tax base adjusts during a time of rapidly falling market prices. Lutz (2008) has explored the connection between property tax revenue and appreciating house prices, in particular. He provides evidence that the elasticity of property tax revenue with respect to house prices is approximately 0.4, which is substantially less than proportional. Furthermore, he finds that it takes three years for changes in house prices to have an impact on property tax revenues. This type of evidence suggests that during a period of falling house prices the effective tax rate is likely to be rising substantially and for a prolonged period of time until full adjustment occurs.

3.2 An optimal tax response to a shock

In thinking about the local government response to a property tax base shock, we can adapt the model of Keen (2009) and Keen and Lockwood (2006). Keen (2009) has suggested an approach to modeling the response of a less developed country when forced to reduce reliance on trade tax revenue, increasing alternate non-trade tax revenues. Keen and Lockwood (2006) modeled the implementation of a VAT by OECD countries using a similar model. In our case, we are concerned with a local government's response when forced to reduce its reliance on property tax revenue. The analogy is straightforward and insightful.

The total revenue the government derives from the two tax sources is,

$$R = R_A + R_B, \tag{15}$$

where R_A is the revenue generated from the property tax and R_B is the revenue generated by an alternative tax. We assume that there are adjustment costs associated with changes in tax revenue reliance that are related to the marginal efficiency costs of the tax sources. Of course, we know that those excess burdens are proportional to the square of the tax rates applied. For fixed tax bases, as would be the case in the very short run, that means the adjustment costs are proportional to the square of the revenue derived from each tax source. Furthermore, the adjustment costs for each tax depends on the characteristics of the local government unit and its economy, expressed as $\theta_i(X)$, $i = A, B$, where the adjustment cost is a function of the vector of local economy attributes X. The larger the parameter $\theta_i(X)$ the less efficient is the tax source as the marginal efficiency cost is larger.

The utility of the revenue generated, net of adjustment costs is thus given by the expression:

$$\lambda V(R, X) - .5\theta_A(X){R_A}^2 - .5\theta_B(X){R_B}^2, \tag{16}$$

where we arbitrarily give equal weight to the adjustment cost for each tax source. The parameter λ allows us to parameterize the strength of the preference by the voters for total local government revenue. The larger λ the greater the strength of the preference for local government services.

This specification assumes that the efficiency costs of the two tax instruments are independent. A more general specification would allow for interactions with the possibility of efficiency enhancing tax changes. Becker and Mulligan (2003) allow for three different specifications of the inefficiency of the tax system in their model: average deadweight cost, total deadweight cost, and marginal deadweight cost. In the present paper it is not necessary to distinguish the separate cases. It is sufficient to consider the simple case where the efficiency cost of taxation is proportional to the square of the revenue derived.

3.2.1 Adjusting reliance on tax sources

We begin by assuming the government has available two tax instruments A and B. It chooses the combination of tax instruments and thereby the revenues R_A and R_B to maximize the utility of total revenue $R = R_A + R_B$ net of efficiency costs of raising that revenue. Embedding the revenue constraint into the objective function, the local government is assumed to choose revenue reliance on the two tax instruments in order to maximize the function,

$$\lambda V(R, X) - .5\theta_A(X){R_A}^2 - .5\theta_B(X)(R - R_A)^2. \tag{17}$$

Differentiating this expression with respect to R_A yields the first order necessary condition:

$$\frac{R_A}{R} = \frac{\theta_B(X)}{\theta_A(X) + \theta_B(X)}. \tag{18}$$

This necessary condition indicates that at the optimum (with $V_R = 0$) the share of total tax revenue derived from tax instrument A should be inversely proportional to the adjustment cost $\theta_A(X)$ for that tax. For example, equation (18) indicates that the share of total jurisdiction revenue derived from the property tax should be equal to the share of total adjustment cost attributed to the alternative sales or income tax. The larger the adjustment cost related to relying heavily on the property tax, the larger the denominator in the expression on the right-hand-side of equation (18) and the smaller should be the reliance on the property tax.

If we perturb the first order conditions for changes in the two revenue sources R_A and R_B, along with λ and θ_A we obtain the following system of equations:

$$\begin{bmatrix} V''(R) - \theta_A & V'' \\ V'' & V''(R) - \theta_B \end{bmatrix} \begin{bmatrix} dR_A \\ dR_B \end{bmatrix} = \begin{bmatrix} -V' & R_A \\ -V' & 0 \end{bmatrix} \begin{bmatrix} d\lambda \\ d\theta_A \end{bmatrix}. \tag{19}$$

Which we can solve for the changes in the two tax instruments,

$$\begin{bmatrix} dR_A \\ dR_B \end{bmatrix} = \frac{1}{D} \begin{bmatrix} \theta_B V'' & (V'' - \theta_B)R_A \\ \theta_A V' & -V''R_A \end{bmatrix} \begin{bmatrix} d\lambda \\ d\theta_A \end{bmatrix}, \tag{20}$$

where $D = (V'' - \theta_A)(V'' - \theta_B)$, which is strictly positive. The second of these derivatives indicates that an efficiency improvement in tax instrument A, which reduces the size of θ_A, will increase the revenue reliance on that tax instrument. The final derivative above indicates that an efficiency improvement in tax instrument A will decrease the revenue reliance on the other tax instrument B. Using this system of differentials we can prove the following three propositions regarding reliance on the tax instruments.

Proposition 2 *An increase (decrease) in the taste for government, in the sense that the utility of government revenue is directly proportional to λ increases, will increase (decrease) the optimal amount of revenue generated from both tax instruments.*

Proof. In order to prove this result, we must sign the derivative $\frac{dR_i}{d\lambda}$. Taking the derivative yields the result,

$$\frac{dR_i}{d\lambda} = \frac{\theta_i V'}{D} > 0. \tag{21}$$

Since this expression is strictly positive, we have the result that an increase in the taste for government increases the revenue generated from both tax instruments. ■

Thus, an increase in the taste for government that drives a larger public sector will require increased reliance on both tax instruments, although not necessarily by an equal amount. Notice that the difference in the size of the optimal revenue reliance response for instruments A and B is based on differences in the efficiency of the tax instruments. The more (less) efficient the tax instrument, the greater (smaller) the increase in reliance on that instrument.

Proposition 3 *An efficiency improvement (detriment) in tax instrument A, which reduces the size of the parameter θ_A, will increase (decrease) the optimal amount of revenue reliance on that tax instrument.*

Proof. In order to prove this result, we must sign the derivative $\frac{dR_A}{d\theta_A}$. Taking the derivative yields the result,

$$\frac{dR_A}{d\theta_A} = \frac{(V'' - \theta_B)R_A}{D} < 0. \tag{22}$$

Since this expression is strictly negative, we have the result that an efficiency improvement (detriment) in tax instrument A that reduces (increases) the size of θ_A will increase (decrease) the revenue reliance on that tax instrument. ■

Hence, this result indicates that the local government should optimally rely more heavily on a tax instrument when its efficiency of collection improves. Furthermore, the next proposition indicates that the local government should also reduce reliance on the now relatively less efficient tax instrument.

Proposition 4 *An efficiency improvement (detriment) in tax instrument A will decrease (increase) the optimal revenue reliance on the other tax instrument B, but will increase (decrease) overall revenue generated by the combination of the two tax instruments.*

Proof. In order to prove the first part of this result, we must sign the derivative $\frac{dR_B}{d\theta_A}$. Taking the derivative yields the result,

$$\frac{dR_B}{d\theta_A} = \frac{-V''R_A}{D} > 0. \tag{23}$$

Since this expression is strictly positive, we have the result that an efficiency improvement (detriment) in tax instrument A will decrease (increase) revenue reliance on the other tax instrument B. To prove the second part of the proposition requires showing that the derivative $\frac{dR}{d\theta_A} < 0$. Using the two derivatives $\frac{dR_i}{d\theta_i}$ for $i = A, B$, we can compute the total derivative,

$$\frac{dR}{d\theta_A} = \frac{dR_A}{d\theta_A} + \frac{dR_B}{d\theta_A} = \frac{(V'' - \theta_B)R_A}{D} + \frac{-V''R_A}{D} = -\frac{\theta_B R_A}{D} < 0. \tag{24}$$

Since this derivative is strictly negative, an efficiency improvement (detriment) in tax instrument A that decreases (increases) θ_A has the effect of increasing (decreasing) total revenue R. ■

When applied to the U.S. situation with a negative shock to the property tax base of many cities causing the efficiency cost of raising revenue with that tax instrument, these results indicate that the optimal response should be to reduce reliance on the property tax, increase reliance on alternative tax instruments, and generate less overall revenue in the process of that adjustment.

3.2.2 Response to a forced change in tax revenue

With this result in hand, we can also investigate the change in total revenue derived by the government in response to a forced change in tax instrument A. In response to that reduction, the government will replace tax A revenue with alternative tax B revenue. The following proposition explains the government's response to a forced change in tax A revenue.

Proposition 5 *Less than full replacement is the optimal response to a shock to the tax system that reduces tax revenue from one instrument.*

Proof. In order to prove this result, we must sign the derivative $\frac{dR}{dR_A}$. Taking the derivative, we obtain the expression

$$\frac{dR}{dR_A} = \frac{\theta_B(X)}{\theta_B(X) - V_{RR}(R, X)}. \tag{25}$$

Since this derivative lies strictly within the interval $[0, 1]$ we have the implication that less than full revenue recovery is optimal. ■

Notice that the extent of revenue recovery after a forced change in revenue reliance depends on the adjustment cost of the alternative revenue source $\theta_B(X)$ as well as on the rate of change in the marginal value of overall public revenue, $V_{RR}(R, X)$. Revenue recovery will be greater the less costly it is to replace property tax revenue with income tax revenue (i.e. $\theta_B(X)$ is smaller), or the more rapidly the marginal value of public revenue decreases with its overall level (i.e. $V_{RR}(R, X)$ is larger in absolute value).

3.2.3 Empirical strategy

The results above suggest a reasonable estimation strategy.

$$R_{B_{it}} = \alpha_i + \beta_0 R_{B_{i,t-1}} + \beta_1 R_{A_{it}} + \beta_2 X_{it} + \beta_3 X_{it} R_{A_{it}} + \mu_t + \varepsilon_{it} \tag{26}$$

In this regression equation $R_{B_{it}}$ is alternative tax revenue in local government i at time t. The symbol X represents a measure of economic output of the locality, if we are using state level revenue data, and other characteristics of the state's economy and tax structure. If we are using local data, perhaps measures from County Business Patterns or some other source can be used for these X controls. We would include dichotomous variables for states or localities with unique tax sources (e.g. Alaska with substantial oil tax revenues, or Las Vegas with gaming revenue) or without one of the major taxes (e.g. Texas without a state income tax).

Our primary interest is in the replacement strategy followed by the local government. In the short-run, replacement with income tax revenue in response to a forced reduction in property tax revenue is simply $-\beta_1$, while in the long-run, replacement is given by the expression:

$$\phi = \frac{-\beta_1}{(1-\beta_0)}, \tag{27}$$

where $\phi = 1$ indicates full replacement and $\phi = 0$ indicates no replacement. Hence, we can run regressions such as equation (26) and test the null hypothesis that $\phi = 1$, versus the alternative that it is not.

3.2.4 Nebraska property tax example

In 1997 Nebraska legislative bill LB271 eliminated the *ad valorem* property tax applied to motor vehicles in Nebraska. This change was made in an effort to reduce reliance on the property tax to fund local government units, in this case cities and counties. As a partial revenue replacement, the state implemented a uniform statewide tax and fee system on motor vehicles. The motor vehicle fee is small, generally between \$5 and \$30 per vehicle and the revenue generated is distributed to cities and counties based on the same factors that distribute Highway Trust Fund monies. The replacement motor vehicle tax is only loosely based on the value of the vehicle, with the tax base related to the manufacturers suggested retail price (MSRP) when the vehicle is new, declining from that value as the vehicle ages. The tax base is no longer the market value of the vehicle as determined by sales studies. A state legislature historical chronology indicates that the replacement (non-property) tax was intended to generate approximately \$15 million less revenue than the former *ad valorem* tax, which in its final year (1996) generated approximately \$152 million, but when implemented it actually generated about \$30 million less. On the history of this tax policy change, see Nebraska Legislature (2010).

We can use the empirical strategy suggested above to determine the actual short and long-run impacts of the change in the property tax base. Aside from the non-property tax motor vehicle replacement revenue involved, we can test whether local governments adjusted their reliance on non-motor vehicle property taxes in response to the change in the property tax base. To do so, we can adapt equation (26) and use annual state data to estimate the relevant coefficients. In this case, the single X variable used is Nebraska total GDP. Since the state GPD series breaks in 1997 when the SIC classification system was replaced with the NAICS system, I extrapolated backwards from the 1997 NAICS GDP figure using annual changes from the pre-1997 SIC-based GDP figures. Since I am using total state GDP, there should be no problem of continuity of definition. The two tax sources used in estimating the equation are total non-motor vehicle property tax revenue, and motor vehicle property tax revenue.

Using annual data over the period 1989-2008 a variant of equation (25) was estimated where R_{B_t} is non-motor vehicle property tax tax revenue in year t, $R_{B_{t-1}}$ is lagged non-motor vehicle property tax revenue, R_{A_t} is motor vehicle property tax revenue in year t, and X_t is state GDP in year t. The adjusted R^2 for the estimated equation is $\overline{R}^2 = 0.994$ and the standard error of the regression is $SE = 37682796$. The F statistic for the regression model is $F = 779.6282$ which has the associated prob value of $p = 0.0000$. Obviously, the equation fits well due to the fact that it is estimated in levels. More interestingly, we can use the Keen method above to assess the extent to which the loss of motor vehicle property tax revenue was replaced by non-motor vehicle property tax revenue.

The estimated coefficients $\widehat{\beta}_0 = 0.238$ and $\widehat{\beta}_1 = 4.734$, indicate that in the short-run local governments in the state replaced approximately 24 percent of the lost property tax revenue from elimination of the *ad valorem* motor vehicle tax with other property tax revenue In the long-run, the replacement estimate is given by the estimate of ϕ from equation (27), which is $\phi = 0.064$. This estimate indicates that in the long-run only about 6 percent of the lost property tax revenue was replaced with other property taxes.

4 Summary and Conclusions

In this paper I have explored the implications of a shock to the property tax base using both a simple model of a decisive voter and a local government unit facing a budget constraint in which it derives revenue from two tax instruments and receives an intergovernmental grant. A shock in that model. has the effect of increasing reliance on the alternative tax instrument, the amount of which depends on the property tax rate and the alternative tax instrument base. Furthermore, a shock to the property tax base causes the property tax rate to rise by an amount that depends on the cost of providing the public good, the parameters of the intergovernmental grant mechanism, and the two tax bases. In particular, the property tax rate will rise at a rate that is inversely related to the square of the property tax base. The importance of this modeling approach is to bring tax and grant revenue together in a unified budget. Given the current situation where a property tax shock is accompanied by increased federal stimulus funding via grant mechanisms, this approach is timely and useful. The weakness of this approach is that there is no adjustment cost included in the model for switching tax instrument reliance from one tax to another.

In order to include adjustment costs, I also developed a simple optimal tax approach for a local government unit deriving revenue from two tax sources, where each tax has an associated efficiency cost of collection. In that model I show that a shock to the property tax base has the effect of decreasing the optimal reliance on that tax instrument, an increase in the reliance on the alternative tax instrument, and a reduction in overall revenue generated by the combination of the two tax instruments.

Finally, I presented an elementary method to empirically test the extent to which a local government unit substitutes an alternative tax source for the property tax when a shock occurs. Using annual data from the State of Nebraska, I estimated the extent to which the elimination of the property tax on motor vehicles in 1997 was replaced with other revenue. My empirical estimates indicate that in the short-run the state replaced approximately 24 percent of the lost motor vehicle property tax revenue with other property tax revenue. In the long-run the replacement rate was only 6 percent.

There are several areas where additional research can extend our understanding of the effects of property tax base shocks. First, we need a clearer picture of the link between falling house prices and assessed values. This is key to knowing how the effective rate of taxation changes. Most of the existing literature has been focussed on the many ways that state and local governments limit increases in the rate of property taxation during periods of rapidly rising house prices. At this point we have no good evidence on the downward adjustment process. Perhaps investigating the experience of a city such as Boston, which has undergone several cycles of boom and bust in recent years, would be instructive. Second, we need to investigate the adjustment costs involved in changing tax instrument reliance. The existing literature provides us with no evidence on this issue. Finally, we should develop the optimal tax model with its adjustment costs to incorporate the effects of intergovernmental grants as well. That way, we can begin to model the combined effects of shocks to the property tax base together with large changes in grant revenues, both larger stimulus increases and the impending problem of falling off the cliff.

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