Note on Measuring Changes in Capital/Land Ratios Related to Tax Changes

Gregory K. Ingram

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Abstract

Theory strongly supports the conclusion that a reduction in the tax on structures in an urban area will increase the intensity of urban development, measured in terms of the quantity of structures (or capital) per unit of land. However, efforts to provide empirical evidence supporting this conclusion have had only modest success. This note argues that one reason for this modest success it that the likely magnitude of the tax related change in development intensity—about 10 percent—is the same order of magnitude or smaller than measurement errors associated with variables that quantify development intensity.

About the Author

Gregory Ingram, President and CEO of the Lincoln Institute of Land Policy since June 2005, was formerly Director-General, Operations Evaluation at the World Bank, where he also held positions in urban development and research and was Staff Director for the *World Development Report 1994, Infrastructure for Development*. His areas of expertise include urban economics, housing markets, transportation, infrastructure, evaluation, and economic development.

gkingram@lincolninst.edu

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Inputs used vary with relative input prices... It is well known in economics that the ratios of inputs used to produce an output can (and do) vary when the relative prices of the inputs change. The typical economics textbook example of this deals with the move from labor-intensive methods of production to more capital-intensive methods of production as the cost of labor increases relative to the cost of capital. For example, when wages are low, clothing is sewn by hand. As wages rise it becomes more efficient to use simple sewing machines, and then more complex sewing machines, and then perhaps production lines—where steps from cutting the cloth, to sewing, to folding and packaging the final product are highly automated and machine-based. This process happens more readily when it is easy to substitute machines for labor.[1]

…including the intensity of structures on land. This substitution among inputs occurs not only between labor and capital. It also happens in urban areas between land and capital embodied in structures. The cost of constructing a square foot of building space varies relatively little across an urban area, but the price of a square foot of land varies a great deal by location. For example, it is not uncommon for land prices to vary by a factor of 100 between high value center city locations and the urban fringe.[2] Therefore constructing a square foot of building space downtown costs much less relative to the cost of a square foot of downtown land than it does relative to the cost of a square foot of land at the urban fringe. As a result of the large variation in the price of land relative to structures within urban areas, we observe the intensity of structures per unit of land to increase dramatically from the urban fringe where there are low buildings on large lots to the central business district where multi-story buildings predominate. The typical urban skyline embodies this variation in the relative prices of structures and land reflecting the greater density of development in central areas relative to the fringe.

Altering taxes can change development intensity. More intensive development of land when the cost of capital or structures declines relative to the cost of land does not only happen across locations within an urban area. It can also happen over time when the relative prices of structures and land change. Most notably, the cost of structures varies as the taxes levied on structures increase or decrease. Property taxes are typically levied on both land and structures. Taxing land does not affect its supply price because the entire tax is borne by the owner. However, taxing structures increases the supply price of structures. If the tax on structures is removed from structures and shifted to land (or elsewhere), this will reduce the supply price of structures and not affect the supply price of land. Accordingly, such a change should increase the intensity of structures relative to land. Indeed, one of the effects claimed when taxes on structures are removed is that

[1] Some activities, such as producing music from a string quartet, may have few possibilities to substitute machines or other investment for labor—in this case that of musicians. See Baumol, William J. and William G. Bowen (1966), *Performing Arts: The Economic Dilemma*, New York: The Twentieth Century Fund.

[2] For example, Steve Brown, "Land Prices in Downtown Dallas Vary Widely" *Dallas Morning News*, May 3, 2008, reports vacant downtown Dallas land sales at up to $110 per square foot ($4 million per acre). Suburban lots are available for $40,000 per acre with services, and undeveloped acreage for less.

development density will rise and urban areas will become more compact. Alternatively, increasing the tax on structures will reduce development density and increase sprawl.[3]

A framework for predicting development intensity changes. What can be predicted about the magnitude of changes in the intensity of structures when taxes on them are altered? This depends on: (a) the ease with which structures can be substituted for land and (b) on the size of the change in the relative price of structures to land when taxes are changed. The ease of substituting structures for land is summarized by the elasticity of substitution of structures (or capital) for land. This parameter, S, is defined as

$$(1) \qquad S = \frac{\text{(percent change in ratio of capital to land)}}{\text{(percent change in the ratio of cost of land to cost of capital)}}.$$

Therefore the percent change in the ratio of capital to land (the measure of interest), equals the elasticity of substitution, S, multiplied by the percent change in the ratio of the cost of capital to the cost of land.

Components of the cost of capital. Changes in the tax on land will not affect the annual rental cost of land because all of the tax on land will be borne by the landowner. We assume (as an upper limit) that any tax on capital or structures will be borne by the user of the structure. If the tax on structures changes because property taxes are reduced or because the tax on structures is eliminated, what is the likely magnitude of the percent change in the ratio of the cost of capital to the cost of land? The usual expression for the annual cost of capital is

$$\text{Annual cost of capital} = K(r + d + m + t_K) \text{ where}$$

K is the quantity of capital, r is the annual interest rate, d is the annual depreciation rate net of maintenance, m is annual maintenance, and t_K is the tax on capital or structures.

Likely variable values imply a change in development density of around 10 percent. To estimate the order of magnitude of these parameters, we assume that r is the opportunity cost of capital and is ten percent; the sum of annual net depreciation and maintenance is two percent, and the tax on land ranges between one and two percent—a typical value for the property tax rate. Accordingly, the annual cost of capital ranges from 13 to 14 percent with these values. In addition, if the tax on structures was eliminated, the annual cost of capital would fall from 13 or 14 percent to 12 percent, a decline of 8.3 to 16.6 percent. This change in the price of capital would alter the ratio of structures to land depending on the value of the elasticity of substitution. The consensus value for the elasticity of substitution between capital and land is around 0.75 with plausible estimates in the range

[3]J. K. Brueckner and H. A. Kim, "Urban Sprawl and the Property Tax," International Tax and Public Finance, 2003, 10:1, pp. 5-23; W. Oates and R. Schwab, "The Simple Analytics of Land Value Taxation," Ch. 4 in R.F. Dye and R.W. England, in *Land Value Taxation: Theory, Evidence, and Practice,* forthcoming.

of 0.5 to 1.0.[4] This means that an elimination of a typical property tax from structures would increase the ratio of structures to land by between 4 and16 percent, with a typical change likely being on the order of 10 percent. This change would happen over time, and the adjustment would likely appear in building activity for many years.

Empirical measures of the intensity of development have varying definitions. Suppose the adjustment is underway or has occurred. How would the change in development intensity be measured? One common measure of the ratio of structures to land is the floor area ratio, which is the ratio of the area of the habitable floor space in the building to the area of the lot. This measure includes multiple floors in a multistory building. However, it is not the ratio of the gross floor area to the lot size. For houses, the floor area ratio typically encompasses the habitable floor area of the building including habitable attic space and accessory buildings. It typically excludes cellars, basements, covered porches, patios, and balconies. However, there is not a single universal definition for the floor area used in floor area ratios, and differences in definitions across jurisdictions can be important. For example, New York City includes basements in floor area ratios but not cellars.[5] Some communities exclude attics or garages. Some include garages at ground level and exclude garages at the basement level. These differences for single-family homes can be very large. For example, including the basement in a two-story house increases the floor area ratio by 50 percent. Including a 500 square foot two-car garage would increase the floor area ratio for a typical single family home by 20 percent.

Building permit data also pose challenges. An alternative is to focus on new construction rather than existing units and to analyze building permit data. Using the value of building permits is a challenge because the cost of constructing a square foot of residential floor space can easily vary by a factor of three due to quality differences in construction. Thus changes in the value of building permits may not be closely correlated with the size of the structure or with the intensity of development, which is the underlying concept to be measured. Using the number of building permits is problematic because of the strong cycles in housing construction where annual building permits vary by a factor of three over the construction cycle. In addition, if more intense development takes the form of multifamily buildings, the number of building permits can decline while the intensity of development is increasing.

Component building and land prices based on assessment data also may be unreliable. Many jurisdictions report the value of buildings separately from the value of the underlying land in their assessment data files. Unfortunately, few jurisdictions develop building and land values separately. In many assessment files the building values are a constant share of the total property value—which is the main focus of most assessment efforts. Research indicates that the resulting component land and building values

[4] John McDonald, "Capital-Land Substitution in Urban Housing: A Survey of Empirical. Estimates." *Journal of Urban Economics*, 1981, Vol. 9, No. 2, pp. 190–211;Paul Thornes, "Consistent Estimates of the Elasticity of Substitution between Land and Non-Land Inputs in the Production of Housing," *Journal of Urban Economics*, Vol. 42, no. 1(July 1997), pp. 98-108

[5] In New York City, basements have half or more of their walls above grade whereas cellars have more than half of their walls below grade.

contained in assessment or appraisal data contain systematic errors that normally bias downward the estimates of the elasticity of substitution.[6]

Measurement error is similar to or larger than the likely impact to be measured. The point of these examples is to highlight that the underlying measurement error in the level of the capital/land ratio, or the intensity of development, is also large and is likely to be the same (or larger) order of magnitude as the change in the capital/land ratio caused by a change in the tax on structures. Theory is clear that a reduced tax on structures will increase the capital/land ratio. However, because the measurement error is similar to or larger than the impact to be measured, empirical studies will face special challenges in providing compelling and statistically significant results showing that changes in taxes on structures produce observable changes in development intensity.

[6] John M. Clapp, "The Elasticity of Substitution for Land: The Effects of Measurement Errors," *Journal of Urban Economics,* 1980, Vol. 8, No. 2, pp. 255 – 263.

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