CHAPTER 7

Analysis of 'Value per Permit'

7.1 Introduction

The analysis of the number of building permits in the preceding chapters yielded a statistically significant effect of the two-rate tax on the level of construction activity. But the two-rate tax should not only give landowners an incentive to develop the land, but also result in a greater value of construction per permit, because the percentage increase in the total property tax is lower if land is taxed at a higher rate than buildings compared to a town where land and buildings are taxed at an equal rate. The analysis in this chapter uses the Census data to examine the impact of the two-rate tax on the value of construction per permit in Pennsylvania between 1980 and 1994. Section 7.2 describes a general model which seeks to explain the value of construction activity. Section 7.3 introduces several econometric refinements to the model and displays the estimation results, and Section 7.4 concludes.

7.2 Setup of the model

The total value of construction in a municipality is the product of the number of permits issued and their average value. In seeking explanations of value per permit, it would be more informative to examine the value of each individual building permit rather than the average value of all permits. Unfortunately, only the number of permits and their total value in a given year are reported in the Census data set, so that the analysis in this chapter uses the average value per building permit as the dependent variable. But the variance of the average value per permit is unlikely to be constant among municipalities. The variance will decrease with the number of permits issued, because the variance in the average of values drawn from any distribution declines as the sample size increases. This makes it again necessary to control for heteroskedasticity during the estimation.

Like the number of permits, the value per building permit depends on a large number of factors; for most of these factors, data are very difficult to collect on the municipality level.[174] The limited availability of data restricts the analysis to the independent variables that were introduced in Chapter 4: population density, income, population change, and the adjusted tax differential. The impact of population density on the value per permit ought to be positive for nonresidential construction, as business districts tend to be located in areas which (due to higher demand) usually have higher land prices than areas which are less densely populated. The higher the population density, the more expensive it will be to construct buildings in prime locations. The opposite ought to be true for residential construction, as towns tend to have their residential areas closer to the periphery where construction is cheaper, and the more expensive the prime locations become, the more residential construction will be done in cheaper areas.

Income can be expected to have a positive impact on residential and nonresidential construction, as wealthier people can build more expensive houses, and richer areas will also have more exclusive stores and business buildings. Population change ought to influence the value positively, too: people tend to leave areas which are in bad economic condition, where not much money is available for expensive buildings. And finally, a higher tax differential should also lead to a higher value per permit, as the tax on the value of construction is lower than in a town with a flat tax on land and structures.

In the analysis of number of permits, one could expect that political or macro-economic events would influence the decision to erect a new building, which made it appropriate to take these effects into account by including yearly dummy variables. It is not obvious whether similar events also affect the decision to erect a cheap or an expensive building. If the value per permit is measured in real terms, the impact of inflation is excluded, and yearly dummies might be unnecessary. Similarly, even though the decision to construct a new building depends on the general economic climate, and the number of issued building permits will therefore be serially correlated, the decision to build cheap or expensive buildings is not likely to depend much on the value of earlier construction; serial correlation can be expected to play a much smaller role.

Economic theory does not suggest a particular relationship between the dependent and independent variables, so that it is possible that this relationship could take various forms. It is convenient, however, to assume a multiplicative relationship, because this allows estimation

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[174] For example, Matthis and Zech (1982) use the vacancy rate for rental units and the average rate of construction worker for all 27 cities in their study. Bourassa (1987, 1990) uses for his studies of Pittsburgh's, McKeesport's and New Castle's construction value (among other variables): resident employment, the home mortgage interest rate, the estimated dollar value of city subsidized mortgages, an index of residential construction costs, and the dollar value of residential rehabilitation projects.

in a loglinear form, and because the coefficients of the independent variables can easily be interpreted as elasticities. The relationship which is assumed for the estimation is therefore

$$vpp_{i,t} = \beta_1^* \cdot D_{i,t}^{\beta_2} \cdot I_{i,t}^{\beta_3} \cdot \left(\frac{P_{i,t-1}}{P_{i,t-2}}\right)^{\beta_4} \cdot f(ATD_{i,t})^{\beta_5} \cdot YD_t^* \cdot \epsilon_{i,t}^* \qquad (7.1)$$

where $vpp_{i,t}$ is the real value per permit in municipality *i* in year *t*, $D_{i,t}$ is density, $I_{i,t}$ is income, $P_{i,t-1} / P_{i,t-2}$ is the ratio of the population in two consecutive years, $ATD_{i,t}$ is the adjusted tax differential, YD_t^* is a yearly dummy, and $\varepsilon_{i,t}^*$ is an error term.

To be able to loglinearize the equation it is necessary to ensure that none of its components be either negative or zero. Density, income, and the population ratio are always positive. The adjusted tax differential is zero for all municipalities with a single-tax; to guarantee that it enters the equation with a strictly positive value, the transformation $f(ATD_{i,t}) = exp(ATD_{i,t})$ is used. Real value per permit is zero for all places which do not issue a single permit during a year. But these observations do not yield any information about value per permit, so that only observations with at least one building permit should enter the analysis; this ensures that the value per permit is always larger than zero, and makes it possible to loglinearize equation 7.1 to

$$\begin{aligned} \log(vpp_{i,t}) = \beta_1 &+ \beta_2 \log(D_{i,t}) + \beta_3 \log(I_{i,t}) + \beta_4 \log\left(\frac{P_{i,t-1}}{P_{i,t-2}}\right) \\ &+ \beta_5\ ATD_{i,t} + YD_t + \epsilon_{i,t}\ , \end{aligned} \qquad (7.2)$$

where β_1 is $\log(\beta_1^*)$, YD_t is $\log(YD_t^*)$, and $\varepsilon_{i,t}$ is $\log(\varepsilon_{i,t}^*)$.

7.3 Estimation and refinements of the model

Table 7.1 shows the estimation results with OLS for the 4 data sets. Density has a negative impact on residential value per permit, and a positive impact on nonresidential value per permit. The impact of income is significantly positive for all data sets, and population change is not significant. The tax coefficient is positive and significant for all data sets except for residential construction of whole units. But the explanatory power of the model is very low: the R^2 varies between 4 percent and 22 percent. It is necessary to examine the deficiencies of the estimation more closely.

If the variance of the value per permit varies with the number of permits issued, OLS will yield inefficient estimates because it will underestimate the variance of the coefficients. It can be expected that the variance of the observations will decrease with the number of permits, for the following reason: if *n* observations A_1, *i*=1..*n*, are independent and identically

Table 7.1 Estimation results of OLS and Weighted Least Squares (WLS)

	Residential Whole Units		Residential Additions & Alterations		Nonresidential Whole Units		Nonresidential Additions & Alterations	
	OLS	WLS	OLS	WLS	OLS	WLS	OLS	WLS
Intercept	12.2829 (0.2003)	12.2316 (0.1955)	8.9134 (0.2492)	8.9693 (0.2467)	9.433 (0.7412)	8.8597 (0.7411)	8.6704 (0.6266)	7.9509 (0.5726)
ATD	0.0244 (0.0237)	0.0284 (0.0220)	0.0703 (0.0264)	0.0942 (0.0258)	0.2524 (0.0623)	0.3121 (0.0581)	0.1394 (0.0617)	0.2685 (0.0494)
log(Density)	-0.2034 (0.0230)	-0.1986 (0.0224)	-0.0636 (0.0284)	-0.0730 (0.0282)	0.2899 (0.0852)	0.3670 (0.0851)	0.1066 (0.0714)	0.2133 (0.0650)
log(Income)	0.8504 (0.0418)	0.8428 (0.0396)	0.7146 (0.0535)	0.7027 (0.0511)	1.0031 (0.1508)	0.9560 (0.1509)	0.8710 (0.1321)	0.6732 (0.1090)
log(PopChange)	-2.2228 (1.3583)	-2.7380 (1.3308)	2.7014 (1.7235)	3.2058 (1.7143)	3.1428 (4.9124)	2.5315 (4.9133)	-1.7458 (4.2598)	1.8440 (3.8207)
R^2	0.2183	0.2365	0.0889	0.0967	0.0564	0.0653	0.0396	0.0496

Note: Standard errors are shown in parentheses. Coefficients of yearly dummies and of municipality dummies are not shown.

distributed, the variance of their sum is n Var(A_i), for any i, and the variance of their average is 1/n Var(A_i). If n denotes the number of permits, and A_1 the value of permit i, then the variance of the average value of construction in a municipality with n permits is 1/n times the variance of a municipality that has issued only a single permit. Observations with more permits will have a lower variance, and should therefore have a greater influence on the estimates than observations with fewer permits.

A formal test for heteroskedasticity is the Goldfeld-Quandt test.[175] To perform this test the data is separated into three groups, where the first group consists of the observations with few permits, and the second consists of the observations with many permits. To enhance the power of the test, the middle group with an average number of permits is dropped.[176] Under the null hypothesis the disturbance variances are the same in the first and the second group. For both groups the sums of squared residuals are estimated by OLS, and the test statistic is the ratio of the sums of squared residuals.

Because this test will be used to determine if heteroskedasticity could be removed, it is informative to examine if this test is actually able to confirm the hypothesized heteroskedasticity of the data. For the data set of residential construction of whole units the first group was chosen to consist of 800 observations with less than 4 buildings per year, and the second group was chosen to consist of 840 observations with more than 7 buildings per year.[177] The middle group with 437 observations was excluded. The residual sum of squares of the first group is 178.2, and of the second group it is 136.5, which yields a test statistic of 1.31. The critical value for F[781,821] for 99 percent confidence is 1.23, so that the statistic is significant on the 99 percent level, and, as expected, the assumption of homoskedasticity can be rejected. The test statistics for the other data sets are similar. Figure 7.1 shows the plot of the residual versus the log of new buildings, and confirms the conjecture of heteroskedasticity. The variance is not constant, but clearly decreases with the number of new buildings.

How should heteroskedasticity be introduced into the model? As observations with more permits should have a greater influence on the estimates than observations with fewer permits, the variation in the variance of the observations can be reduced by weighting the

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[175] Goldfeld and Quandt (1965), pp. 540-541.

[176] See Goldfeld and Quandt (1965), p. 541, and Harvey and Phillips (1974), p. 310.

[177] The data set of residential whole buildings uses the sum of the building permits for one- , two- , three- and four-, and more-that-four-family buildings. A four-family building is counted as four housing units in the data set. But heteroskedasticity will be primarily caused by the total number of new buildings, and not by the total number of units build. The weight should therefore be related to the number of buildings, and not to the number of units. The other three data sets are not aggregates over multi-unit buildings, and the number of permits is equal to the number of buildings, so that no adjustment needs to be made.

sums of squares by the number of permits, and by maximizing the weighted sum of squares.

Yet building permits do not have identical properties, and one cannot assume that the coefficients α and β of A and B are equal to 1; weighting the observations by the number of permits will therefore not necessarily restore homoskedasticity. To determine the adequate weight, I calculated different weights by using different exponents on the number of permits, and performed the Goldfeld-Quandt test on the weighted regressions until a weight was found for which the test did not reject homoskedasticity. Figure 7.2 shows for residential construction of whole units the plot of the log of buildings versus the residuals, weighted by $(buildings)^{0.125}$; it suggests that the weighting procedure has removed the heteroskedasticity.

Table 7.1 also shows the estimation results with weighted least squares for the 4 data sets. Now the impact of density is significantly positive for all four data sets; the effect of income remains significantly positive, and population change has a significantly negative impact on residential construction value, and an insignificant impact on nonresidential construction value. The tax coefficient is significantly positive for all four data sets. But the R^2 of the model has not improved very much; it is possible that important explanatory variables have been omitted, and that the Goldfeld-Quandt test detected the influence of some of these omitted variables.

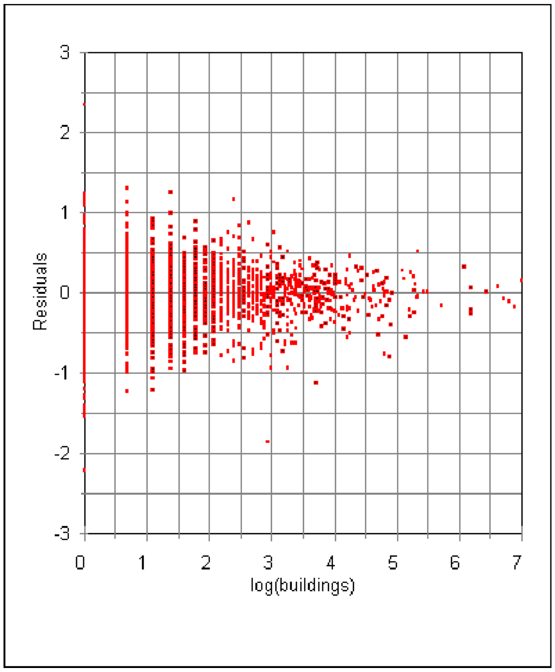

Figure 7.1 Relationship between log(buildings) and the residuals in the OLS regression.

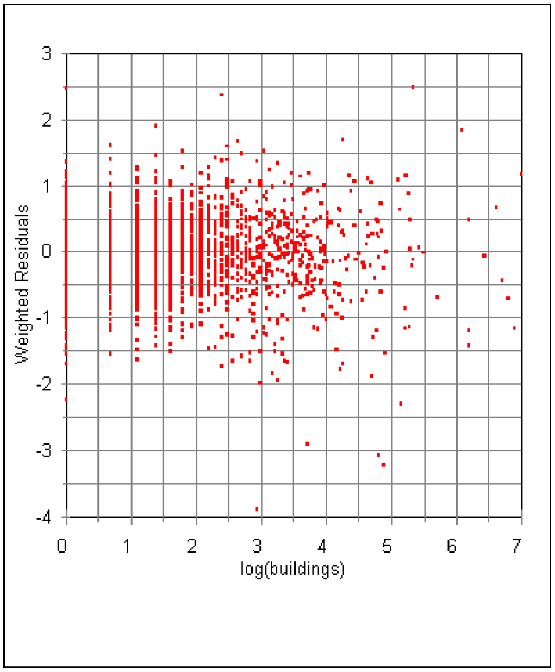

Figure 7.2 Relationship between log(buildings) and the weighted residuals in the WLS regression.

Comparison with the analysis of the number of permits suggests that a fixed effects model, where a dummy variable is used for all but one municipality to adjust the vertical intercept, would yield a better result than a model without such dummies. It also suggested the possibility that not only the *level* of the two-rate tax, but rather a *change* in the two-rate tax gives incentives for greater value per permit. Table 7.2 shows the results of the weighted least squares fixed effects model for both of these possibilities: Model I is estimated with the value of the adjusted tax differential, and Model II is estimated with the change of the tax differential compared to last year, and with the change of last year's tax differential with respect to the year before as two additional explanatory variables.[178]

The fixed effects model yields different results compared to the model without municipality dummies. On one hand, income still has a significantly positive effect on the value of construction in all data sets but nonresidential construction of whole units, and population change is still negative for the construction of whole units, and positive for additions and alterations, albeit not statistically significant. Density has lost its significant positive influence. The impact of the two-rate taxes has changed, too. If only the current value of the tax differential is considered (Model I), the impact is negative but not significant for three of the four data sets, and positive but not significant for nonresidential whole units.

It is worth asking if the additional 210-215 variables (depending on which data set is used) improve the model by enough to justify the lost degrees of freedom. Even though the R^2 improves to values between 43 percent and 52 percent, this improvement might still be insignificant given that the number of explanatory variables increased more than elevenfold. The F-test statistic for Model I compares this model with the WLS model from Table 7.1 that does not use dummy variables for the municipalities. The statistic is significant for all data sets, which means that the use of the dummy variables is justified.[179]

Even if the change and the lagged change in the tax differential are included in the model, the overall impact of the tax differential does not change much. Except for residential whole units, the coefficients of the change in the tax differential are positive, but not statistically significant. Only for residential additions and alterations, the lagged change is barely significant. The F-test statistic for Model II examines if the additional two parameter improve the predictive power by enough to justify their use: the critical value for $F(2,\infty)$ is

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[178] For unknown reasons LIMDEP is unable to estimate the fixed effects weighted least squares model for any of the four data sets. The estimation results in Table 7.2 are therefore obtained with SAS. However, it is satisfying to notice that LIMDEP and SAS yield the same coefficients and standard errors for the results in Tables 7.1 and 7.2.

[179] The F-statistic is not completely accurate, because Model I in Table 7.2 also uses slightly different weights to restore homoskedasticity than the WLS model in Table 7.1. Still, given that the weights are not too different in the two models, the test statistic is of some importance.

Table 7.2 Estimation results of the weighted least squares fixed effects model

	Residential Whole Units		Residential Additions & Alterations		Nonresidential Whole Units		Nonresidential Additions & Alterations	
	Model I	Model II	Model I	Model II	Model I	Model II	Model I	Model II
Intercept	10.0359 (2.6762)	9.9013 (2.6829)	0.9577 (3.2161)	1.5007 (3.2243)	16.5653 (10.1058)	17.820 (10.1409)	9.7695 (6.7709)	10.6013 (6.8210)
ATD	-0.0086 (0.0337)	-0.0139 (0.05429)	-0.0132 (0.0343)	-0.0965 (0.0512)	0.0649 (0.0730)	-0.1015 (0.1341)	-0.0688 (0.0796)	-0.1280 (0.0952)
ATD change	-	-0.1780 (0.1017)	-	0.1198 (0.0754)	-	0.2437 (0.1903)	-	0.0524 (0.1370)
ATD lagged change	-	0.0253 (0.0767)	-	0.1653 (0.0768)	-	0.2819 (0.1962)	-	0.1871 (0.1347)
log(Density)	0.0557 (0.3273)	0.0717 (0.3282)	0.8128 (0.3937)	0.7465 (0.3947)	-0.5699 (1.2399)	-0.7288 (1.2446)	0.0249 (0.8269)	-0.0775 (0.8333)
log(Income)	1.0836 (0.2036)	1.0948 (0.2036)	1.2975 (0.2397)	1.2948 (0.2395)	0.6176 (0.8066)	0.6850 (0.8080)	1.1823 (0.5145)	1.1943 (0.5146)
log(PopChange)	-2.5930 (1.6180)	-2.6049 (1.6177)	8.0984 (2.0889)	8.1039 (2.0877)	-4.2616 (6.2134)	-4.4727 (6.2150)	3.5703 (4.3494)	3.3879 (4.3531)
R^2	0.5162	0.5171	0.4257	0.4269	0.4517	0.4526	0.4584	0.4590
F statistic	5.5832	1.7507	7.0556	2.5089	5.4517	1.1193	5.8014	0.9674
Durbin-Watson	1.855	1.851	1.802	1.805	2.202	2.206	2.033	2.033

Note: Standard errors are shown in parentheses. Coefficients of yearly dummies and of municipality dummies are not shown. The F statistic for model I compares model I with the WLS model without municipality dummies in Table 7.1. The F statistic for model II compares model II with model I.

4.61 at 99 percent, and 3.00 at 95 percent confidence, which means that the joint impact of the two additional variables is not statistically significant in any data set.

The Durbin-Watson test statistic, which measures the first order serial correlation of the data, is relatively close to the critical value of 2 in all data sets. This confirms the conjecture that serial correlation plays only a minor role in the analysis of value per permit.

7.4 Conclusion

The analysis in this chapter did not yield a statistically significant impact of the tax differential. A possible refinement would be a re-definition of the tax variable. The definition used in this study is the current value of the adjusted tax differential in percent in every year. But if construction depends on beliefs about future taxes, and if these beliefs are a function of the whole history of past taxes, then the current tax variable could be described as the discounted sum of all past values of the tax differential. A possible definition of the summed adjusted tax differential, $SATD_t$, would be

$$SATD_t = \sum_{\tau=0}^{t} ATD_{t-\tau} \; \delta^{\tau} \ , \qquad (7.3)$$

where δ is a discount factor. However, because of the term δ in the sum, it would be tedious to estimate this equation with a standard econometric package, and would require more elaborate work.