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# Estimating the Determinants of Property Reassessment Duration: An Empirical Study of Pennsylvania Counties

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**Abstract.** The main purpose of this study is to investigate the determinants of reassessment duration across Pennsylvania county governments. It is the first attempt to estimate the effect of duration and various covariates on reassessment probability. A Weibull model was employed that assumed monotonically changing hazard and survival rates. The results showed reassessment was most likely positively duration dependent. Thus, the results predicted that counties had a low probability of reassessment in the early years of the reassessment cycle and a high probability in later years. Covariate estimates suggested that differences in local economic growth and local fiscal factors had the greatest impact on duration. Counties with high income and population growth had longer durations while counties with high business sector growth had shorter durations. Counties with low expenditures per capita and high growth of property tax burdens had shorter reassessment cycles. The results also predict that counties with tax rates above the statutory limit have longer reassessment durations. Elasticity projections for several covariates showed a moderate response of the survival rate although it was less than unit elastic for all variables.

## 1. Introduction

In many states, property tax reform has been concerned with improving the quality of the assessment process. A fair and efficient property tax requires a broadly defined tax base that reflects market value changes in a timely manner. Equitable distribution of tax shares also requires uniform assessment of properties that are of equal value within the same locality. Unfortunately, most localities reassess properties several years after changes in market values occur. Consequently, they experience a reassessment lag that results in an unfair distribution of the local property tax burden among their taxpayers.

Most states statutorily mandate that local governments reassess their property tax base within a stipulated number of years. However, Pennsylvania has no provision for periodic reassessment in its assessment laws although the state constitution requires uniform assessment. The timing of reassessment has been a long-standing issue in Pennsylvania. Several counties

have not had a complete reassessment in over 20 years and a few have gone more than 30 years without a complete reassessment. Many counties delay reassessment because of taxpayers' resistance to high administrative costs and expectations of higher property taxes. Currently, all Pennsylvania counties use a base year system in which the assessment ratio for property tax purposes is the one that existed when the last reassessment occurred. A recent court case involving Allegheny County found the base-year system unconstitutional.<sup>1</sup> This has heightened public concern that the courts will order complete reassessments in those counties that have not had one in recent years.

Montarti and Weaver (2007) used evidence from a 2000 survey conducted by the International

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<sup>1</sup> On April 29, 2009, the Pennsylvania Supreme Court ruled that the application of the base-year assessment system in Allegheny County was in violation of the state constitution's uniformity clause. See Rujumba (2009).

Association of Assessing Officers (see Almy, 2000) to compare assessment practices in Pennsylvania with those in other states. Their analysis suggested that Pennsylvania probably had the least state direction of the local assessment process. They state (p. 9) that, "the state does not assess any property, does not mandate a reassessment cycle, does not perform any audits, and neither state nor local level officials verify sales data." This lack of statutory direction has led to considerable variation in the duration and frequency of reassessment between counties. Assessed values of taxable property for tax purposes varied between three and 102 percent of actual market value in a recent five-year period (Commonwealth of Pennsylvania, Department of Community and Economic Development, 2004, p. 8).

The failure to update assessed values is associated with several economic and fiscal problems of local governments and their constituents. Infrequent reassessments and the lack of uniformity in the reassessment process distort the distribution of the tax burden within and between counties. Long reassessment cycles favor properties whose market values grow at higher rates. Properties in low-income neighborhoods of a given county face relatively higher property tax burdens because their housing values grow at a lower rate. Further, household and business location decisions may be less than optimal if they located in counties where the fiscal burden was smaller. Third, lengthy reassessment cycles reduce the revenue generating ability of the property tax. When assessed values understate market values, potential revenue is lost. Long reassessment cycles require larger changes in assessed values than shorter reassessment cycles. Fourth, revaluation of assessed values may cause a tax rate illusion among property owners. This occurs as assessed values are adjusted upward, thus allowing more revenue to be collected with the same or lower nominal tax rate. At the same time, the effective tax rate on market value often increases without taxpayers realizing it.<sup>2</sup> Tax rate illusion is more likely in the years immediately following reassessment. Taxpayers are more likely to recognize increases in the effective rate over a longer period.

The major focus of the current study investigates the determinants of reassessment duration in Pennsylvania counties between 1982 and 2006. Pennsylvania counties provide a good sample for testing the deter-

minants of reassessment duration. Local government officials largely decide when reassessment occurs with little influence from the state government. No state mandates prescribe periodic reassessment although the nominal mill rate has a statutory limit in most counties. Thus, the duration of the reassessment decision depends on whether current assessed values generate enough local revenue to support desired expenditures given relevant fiscal, economic and taste variables. This climate has changed somewhat in recent years because the courts have more actively challenged the lack of uniformity in the local reassessment process.<sup>3</sup>

Although no study has investigated the determinants of reassessment duration, several empirical studies have investigated the effect of reassessment on local revenue growth. The next section discusses this empirical literature and gives a brief summary of previous public policy duration studies. Then, the following section provides a summary of the provisions governing county assessment. This includes a statistical analysis of two alternative duration variables. Then, the assumptions and hypotheses in the empirical model are explained in detail. These hypotheses are tested with a survival function that assumes a specific distributional form. A detailed discussion of the empirical results follows. The study concludes with a summary and evaluation of the results and a discussion of possible policy implications.

## 2. Previous research on reassessment, revenue growth and duration analysis

No previous empirical study has investigated the determinants of reassessment duration, but several studies have examined the relation between reassessment and property tax growth. Bloom and Ladd (1982) and Ladd (1991) used data from Massachusetts and North Carolina localities, respectively, to test the effect of reassessment on revenue growth over different durations. They hypothesized a monopoly theory of government in which public officials had an information advantage over taxpayer-voters. Their findings showed that in certain communities the property tax response to revaluation was significantly positive in the years during and immediately following reassessment, but not in later years. These results implied that short-run decreases in the nominal tax rate due to reassessment were proportionately less than the increases in assessed values. Thus, tax rate burden

<sup>2</sup> The effective tax rate is the tax levy as a percentage of market value and the nominal tax rate is the tax levy as a percentage of assessed value. These rates often are quoted as mill rates where the tax levy is expressed as dollars per thousand dollars of the tax base. State tax rate limits use the mill rate to regulate county government nominal rates.

<sup>3</sup> At least six counties were ordered by the courts to conduct countywide reassessments between 1990 and 2005 (Pennsylvania General Assembly, 2007). The six counties were Erie, Carbon, Allegheny, Dauphin, Chester and Lancaster.

was higher after reassessment although nominal rates declined.<sup>4</sup>

Walden and Denaux (2002) also investigated the relation between reassessment and property tax revenues for North Carolina communities. They looked at the trends in several property tax variables over two reassessment cycles. Their results also suggested that the growth of property tax revenues was highest in the first few years after reassessment. However, over the reassessment cycle, effective tax rates decreased even though legislated tax rates increased. This led to an increased gap between potential property tax collections and actual collections over time. This largely was due to the inability of the base year assessed value to keep pace with the current year market value. They showed that this gap contributed to the need to update previous base year assessed values.<sup>5</sup>

Strumpf (1999) assumed an alternative conceptual framework where the duration of reassessment reflected rational voter choice. He argued that voters demand reassessment because it is in their self-interest to increase the tax base and the collection of taxes. Estimation results showed that taxes increased during the year of reassessment and that the duration period for the four Pennsylvania counties in his study approximated their social optimum. Finally, Stine (2005) used a logit model to estimate whether tax rate limits along with other variables influenced the reassessment decision. His results suggested that reassessment allowed local public officials to circumvent tax rate limits to increase property tax revenues.

Kiefer (1988) provides an extensive review of the duration approach and summarizes its applications in economics. Duration analysis also has been widely used to test the effect of policy variables on unemployment duration. For instance, Lalive (2007) summarizes the recent literature in this area. Further, several empirical studies of policy adoptions have used duration analysis.<sup>6</sup> Good examples of policy applications were given by Bennett (1999), Box-Steffensmeier

and Jones (2004) and Jones and Branton (2005). Several recent studies in state and local public finance also used duration analysis to investigate the determinants of various policy adoption decisions. These included studies of sales tax rate changes (Luna et al., 2007), sales tax adoptions (Sjoquist et al., 2007) and property tax incentive and abatement programs (Gibson, 2003, and Anderson and Wassmer, 1995).

### 3. Reassessment duration in Pennsylvania counties

The duration of reassessment cycles is investigated for 66 Pennsylvania counties in this study.<sup>7</sup> The study uses annual information from 1982 to 2006 to calculate duration in years since each county's previous reassessment.<sup>8</sup> The base year is 1981, so reassessments prior to 1982 were not included. Pennsylvania assessment law provides the statutes that govern the assessment process and assessment organization of county governments.<sup>9</sup> However, these statutes say little about the specific time interval over which reassessment is required. The state legislature has a tacit policy of little or no involvement with local property tax administration or collection (Downing, 2003, p. 35).

Several features of the reassessment laws nonetheless influence the assessment process and reassessment duration. Taxable real estate is valued at actual value. Actual value is the price for which a property separately sells. The county may use current market value or it may adopt a base year market value. In practice, counties only use current year market value in the year of property reassessment. Otherwise, counties use base year market value. All property throughout the county must use the same base year market value in determining assessed value. Once base year value is determined, county commissioners in each county determine the predetermined ratio. The predetermined ratio gives a uniform percentage of market value. The predetermined ratio can be set up to 100 percent. The predetermined ratio should reflect accurately the ratio of assessed value to market value in the base year.

<sup>4</sup> If the current assessment ratio is 0.50 and we double assessed value, then the nominal tax rate should decrease by 0.50 in order to generate the same tax revenue. However, if the nominal tax rate decreases by a smaller percentage, then tax revenue should increase and the effective tax rate should increase.

<sup>5</sup> In another study, Lutz (2008) used national data on local governments to test the relation between housing values and property tax revenues. He found that the long-run elasticity of property tax revenues to property values was 0.4. Lutz concludes: "policymakers are estimated to respond to increasing home prices by reducing effective tax rates so as to offset 60 percent of the increase in tax revenue that would have occurred in the absence of a change in the effective tax rate" (p. 566).

<sup>6</sup> Duration analysis is often referred to as the event history approach in policy studies. See Box-Steffensmeier and Jones (2004) for a good background discussion.

<sup>7</sup> Pennsylvania physically has 67 separate county governments. However, Philadelphia's city and county governments are the same. This sample does not include Philadelphia because the size and nature of its revenues and expenditures differ substantially from the other 66 counties.

<sup>8</sup> The Commonwealth of Pennsylvania State Tax Equalization Board provided most of the assessment information, some of which was unpublished. I especially am grateful to Gregory Schoffler, Executive Director of this agency, for his insights on assessment practices and statistics.

<sup>9</sup> See the Department of Community and Economic Development (2004) *Taxation Manual* (pp. 5-9) for a detailed summary of the Pennsylvania assessment laws.

The predetermined ratio tends to overstate the actual assessment ratio as duration increases. This is due to the continuous increase in market value as many properties sell at higher prices while assessed value increases mostly due to additions to the tax base. The Pennsylvania State Tax Equalization Board annually provides an updated assessment ratio referred to as the common level ratio. A frequent use of the common level ratio is for assessment appeals where the assessment ratio varies by more than 15 percent from its established predetermined ratio.

The uniformity clause in the Pennsylvania Constitution (Article VIII, Section 1) requires uniform assessment of all taxable properties within a given county at the same predetermined ratio.<sup>10</sup> This implies that no taxpayer should pay more than their proportionate share of the cost of government. The uniformity clause also implies only one class of property exists for property tax purposes rather than several differential classes such as residential, commercial, land, and so on. An amendment to the constitution permits preferential farmland assessment. Land and improvements must be valued separately, but this distinction is only important for cities and boroughs because they can tax land and improvements at different rates. Counties use the same tax rate to tax assessed value of land and improvements.

It also is a violation of the uniformity clause if a property is reassessed because it is sold. An individual property can only be reassessed when: (1) the property is subdivided; (2) a physical change has been made to the property, such as new construction or change of existing improvements; or (3) the assessment of the property is appealed by either the property owner or the taxing district (Pennsylvania General Assembly, Local Government Commission, 2007, p. 145).

Pennsylvania county governments also face a statutory mill rate limit on their property levy. The limit is on the nominal mill rate because it applies to assessed value rather than market value of taxable property. The nominal mill rate is published annually for each county in *Local Government Financial Statistics* (Pennsylvania Department of Community and Economic Development). Most counties face a limit of 25 mills. Three counties known as second class A counties have

a mill rate limit of 30 mills.<sup>11</sup> Third through eighth class counties may increase their tax rate an additional five percent if they show it is necessary to meet the needs of an approved budget (Pennsylvania Department of Community and Economic Development, 2004, p. 12). Finally, six counties have adopted home rule charters and are not subject to real estate tax rate limits imposed by the legislature.<sup>12</sup> Statutory restrictions also require that a county reduce its tax rate in the first year after reassessment such that the tax levy does not exceed 105 or 110 percent of the total amount levied in the preceding year (Pennsylvania Department of Community and Economic Development, 2004, p. 13).

The State Tax Equalization Board considers reassessment to have occurred if a complete revaluation of all properties was undertaken or if the base year predetermined ratio was changed. A change in the predetermined ratio is less costly and is an expedient way to increase the size of the local property tax base. This allows for increased revenue collection without the necessity of going through the costly process of examining and reassessing individual properties. However, it adjusts the assessment ratio of all property proportionately. Consequently, it does not correct for inequities between different properties caused by different growth rates in market values. A complete and accurate revaluation should correct the disparities in tax burden that have arisen over time. In the past, most reassessments involved a complete revaluation, but this pattern has changed in recent years. Montarti and Weaver (2007, p. 6) reported that only three of the 20 reassessments they observed between 1990 and 1999 involved changing the predetermined ratio. However, 14 of the 33 reassessments observed between 2000 and 2006 involved changing the predetermined ratio.

Table 1 gives the frequency of reassessment for each year between 1982 and 2006. The data showed that 64 counties had at least one reassessment and that two counties did not have any between 1982 and 2006.<sup>13</sup> Further, 35 counties had multiple reassessments. These multiple reassessments included 28

<sup>10</sup> Special provisions apply to certain classes of taxpayers and certain subjects of taxation. The General Assembly of the state legislature made special provisions for forest and farmland, for persons in need because of age, disability, infirmity or poverty, for improvements to deteriorated property or areas and for residential construction. An amendment to the Constitution in November 1997 added exclusion for a portion of the assessed value of homestead property (Pennsylvania Department of Community and Economic Development, 2004, p. 18).

<sup>11</sup> Pennsylvania classifies its 67 counties from first class to eighth class based on population ranges. The rate limit does not apply to Philadelphia, the only first class county. Allegheny was the only second-class county. Bucks, Delaware and Montgomery were the three second class A counties.

<sup>12</sup> The six counties are Allegheny, Delaware, Erie, Lackawanna, Lehigh, and Northampton. All these counties except Allegheny adopted home rule charters in the 1970s. Allegheny County adopted its home rule charter in 2000.

<sup>13</sup> Huntingdon (1978) and Luzerne (1965) were the only two counties that did not have any type of reassessment in this period. The year of their last reassessment is given in parentheses.

counties that reassessed twice, six counties that reassessed three times and one county that reassessed four times. In all, the sample has 99 observations and excludes the two counties with no reassessment.

The data showed that an increasing number of reassessments have occurred in recent years. Many of the recent reassessments were for counties that reassessed property two or more times since 1982. Table 1

showed that 46 reassessments occurred between 1982 and 1996 and 53 reassessments occurred between 1997 and 2006. In the earlier period (1982-1996), only five counties reassessed a second time while 41 counties reassessed for the first time. In the later period (1997-2006) 30 counties reassessed property two or more times while only 23 counties reassessed for the first time.

**Table 1.** Frequency distribution for annual reassessments based on elapsed years.

Calendar Year	Elapsed Years (YRSE)	First Reassessment	Second Reassessment	Third or more Reassessments	Cumulative Frequencies (Percentages)
1982	1	7	0	0	7 (.0707)
1983	2	5	0	0	12 (.1212)
1984	3	0	0	0	12 (.1212)
1985	4	5	0	0	17 (.1717)
1986	5	4	0	0	21 (.2121)
1987	6	1	0	0	22 (.2222)
1988	7	1	1	0	24 (.2424)
1989	8	2	3	0	29 (.2929)
1990	9	4	0	0	33 (.3333)
1991	10	3	0	0	36 (.3636)
1992	11	2	0	0	38 (.3838)
1993	12	3	1	0	42 (.4242)
1994	13	3	0	0	45 (.4545)
1995	14	1	0	0	46 (.4646)
1996	15	0	0	0	46 (.4646)
1997	16	2	3	0	51 (.5152)
1998	17	6	2	1	60 (.6061)
1999	18	1	2	0	63 (.6364)
2000	19	1	0	0	64 (.6465)
2001	20	6	2	1	73 (.7374)
2002	21	2	3	0	78 (.7879)
2003	22	1	4	0	83 (.8384)
2004	23	0	0	1	84 (.8485)
2005	24	4	3	3	94 (.9495)
2006	25	0	4	1	99 (1.000)

Note: The table reports the frequency distributions for elapsed years of new reassessments (YRSE). 'Elapsed years' is the number of years since the base year of 1981.

The cumulative frequency distribution in Table 1 showed that the median duration observation did not occur until 1997 (sixteenth year). However, this distribution was based on the elapsed time measurement of duration. Elapsed time uses the base year of the first reassessment (1981) to measure the duration of all reassessments irrespective of whether it is a county's first reassessment or not. Another way to measure duration is gap time in which the first year of each previous reassessment is the base year. Gap time is the number of years between each new reassessment and the previous reassessment. Gap time is different

from elapsed time for counties that had multiple reassessments.

Table 2 gives the frequency distribution for the gap time measure. Gap time duration was shorter than elapsed time because elapsed time included the cumulative years since the 1981 base year irrespective of whether it was the first or a later reassessment. The median observation for the gap time variable (YRS) occurred in the tenth year and for the elapsed time variable (YRSE) in the sixteenth year. Further, the average duration for reassessments among the 99 observations was 10.7 years for the gap time variable (YRS)

and 14.1 years for the elapsed time variable (YRSE). Another way to show that multiple reassessment counties had shorter durations was to compute their average durations separately using the gap time measure. The average duration for the 64 observations with one reassessment was 11.4 years, while it was 9.7 years for the 35 observations with two or more reassessments. These averages nonetheless suggest reassessment cycles that were relatively long even when the gap time measure was used.

**Table 2.** Frequency distribution for annual reassessments based on gap years.

Gap Years (YRS)	Frequency	Cumulative Frequencies (Percentages)
1	7	7 (.0707)
2	6	13 (.1313)
3	2	15 (.1515)
4	8	23 (.2323)
5	5	28 (.2828)
6	3	31 (.3131)
7	6	36 (.3636)
8	5	41 (.4141)
9	7	48 (.4848)
10	5	53 (.5354)
11	3	56 (.5657)
12	8	64 (.6465)
13	4	68 (.6869)
14	1	69 (.6970)
15	0	69 (.6970)
16	6	75 (.7576)
17	6	81 (.8182)
18	2	83 (.8384)
19	2	85 (.8586)
20	6	92 (.9293)
21	2	94 (.9495)
22	1	95 (.9596)
23	0	95 (.9596)
24	4	99 (1.000)
25	0	99 (1.000)

Note: The table reports the frequency distributions in gap years for new reassessments (YRS). 'Gap years' is the number of years between the previous reassessment and the new reassessment.

## 4. Model specification and duration dependence

### 4.1. Framework

An empirical model is specified in which duration of reassessment is a function of a baseline hazard and covariates. The hazard rate of reassessment gives the conditional probability of reassessment in a given year

assuming that reassessment has not occurred in previous years since the last reassessment. The model provides the framework for answering two important empirical questions concerning the duration of reassessment. The first question concerns the relation between the conditional probability of reassessment and the duration of the reassessment cycle. It asks how the probability of reassessment changes as duration increases. If the rate of change is not constant, then the hazard rate is said to be duration dependent. Zorn (2000, p. 369) refers to duration dependence as positive or negative persistence where the value of the hazard at any point in time depends on the amount of time that has already elapsed. An appropriate distribution function, one in which the hazard rate of reassessment is accurately predicted, is required to answer the question of duration dependence. There are several distributional forms that allow for the measurement of the hazard rate as duration increases. The choice of the appropriate function depends on the properties that apply to the local reassessment decision.

Bennett (1999, pp. 260-261) argues that models which allow for the determination of duration dependence provide substantive information about important features of the political process. These features reflect how reassessment probability changes as duration increases. If the hazard rate for reassessment decreases (negative duration dependence), then the existing assessed value is more difficult to change as duration increases. This implies that these values become institutionalized and self-perpetuating. Local public officials are entrenched in their commitment to the current structural features of the local tax base. Thus, the longer a reassessment cycle lasts, the probability of it subsequently ending decreases. On the other hand, if the hazard rate increases (positive duration dependence), then the existing assessed values become more unacceptable to voters and public officials over time. Local public officials are more willing to change the existing system of values to satisfy the majority of local constituents. Another possibility is that the hazard rate initially increases, reaches a maximum, and then decreases. This suggests that public officials first face increasing pressure to reassess property in the early years of the reassessment cycle, but eventually the pressure decreases after reaching a maximum rate.

The second question concerns the influence of diverse covariates on the probability of reassessment. Specifically, is the probability of reassessment influenced by different covariates that vary across counties? Do changes in the relevant covariates change the duration of reassessment? The effect of a change in a given covariate reflects a shift in the hazard and survival functions. A positive relation implies that reas-

assessment duration increases as the covariate increases. A negative relationship implies a shorter reassessment period as the covariate increases. The complete duration model requires a sufficient specification of the measured independent variables that explain the differences in duration periods and hazard/survival rates across county governments. It is important to select a relevant set of covariates and the correct functional form. Estimates of hazard rates often are sensitive to functional form and the covariates in the model.

The local reassessment process described above suggests the institutionalization of decisions as time passes. Both negative and positive duration dependence are plausible explanations for how reassessment values changed in different counties over a given number of years. Parametric models of duration are useful when the rate of change in the hazard rate is of interest. Their hazard functions possess known mathematical forms with unknown parameters.<sup>14</sup> The empirical analysis assumes that a Weibull distribution applies to the estimation of the reassessment duration data. The Weibull distribution is a widely used monotonic function that allows for the testing of duration dependence.<sup>15</sup> A monotonically increasing hazard rate implies positive duration dependence and a monotonically decreasing hazard rate implies negative duration dependence. If the hazard rate is constant, then there is no duration dependence and the Weibull distribution is the same as the exponential distribution. The exponential function is a special, nested case of the Weibull distribution.

#### 4.2. Empirical model

The model in this study focuses on estimating the survival rates of reassessment with parameters for a given baseline and several covariates. The survival rate is mathematically linked with the hazard rate. It gives the probability of survival beyond the current time period  $t$ . It also gives the proportion of observations surviving beyond  $t$ . The underlying premise of the reassessment model is that public officials are responsive to the demands of local voters. As a starting

point, Weibull hazard and survival functions are assumed. The Weibull survival function is estimated in log-linear form as follows:<sup>16</sup>

$$\log(t_k - t_{k-1})_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_j X_{ij} + \sigma e \quad (1)$$

The various terms in equation (1) are defined as follows:

$(t_k - t_{k-1})_i$  = the survival time from the previous reassessment;

$k$  = the number of the times property has been reassessed since 1982;

$t$  = the number of years from the base year in a given  $k$  reassessment cycle;

$i$  = the observation number;

$j$  = the independent variable number;

$\beta_j$  = the estimated regression coefficient for the covariate  $j$ ;

$X_{ij}$  = the observed values of the covariates; and

$e$  = a stochastic disturbance term scaled by the parameter  $\sigma$ .

Equation (1) gives the accelerated failure time (AFT) estimation of the duration model where the  $\beta_j$ s and  $\sigma$  represent the respective effects of the covariates and duration on the survival rate.

An alternative specification for estimating the Weibull model is the proportional hazard model where the response variable is the hazard rate that depends on the baseline and covariates:<sup>17</sup>

$$f_{ik}(t_k - t_{k-1})_i = f_0 \exp(\beta_1' X_1 + \beta_2' X_2 + \dots + \beta_j' X_{ij}) \quad (2)$$

where  $\beta_j'$  is distinguished from  $\beta_j$  because it is the covariate parameter for the proportional hazard estimation rather than the AFT estimation,  $f_0$  is the baseline hazard parameter and  $X_j$  are the values of the same covariates as in (1). The parameter  $f_0$  is equivalent to  $\exp(\beta_0') p t^{\beta_0' - 1}$  where  $\beta_0'$  is the parameter for the regres-

<sup>14</sup> In contrast, semi-parametric or non-parametric hazard functions make few or no assumptions about the functional form. These functions are used when the main interest is to estimate the effect of covariates on reassessment duration and the hazard rate. The Cox proportional hazards model is a commonly used semi-parametric model in duration studies.

<sup>15</sup> A log-logistic model also was used to estimate reassessment duration. This also is a parametric model that assumes non-monotonic hazard rates. Both models were estimated, but the Weibull estimates were superior. Therefore, the only results presented are for the Weibull model. The results for log-logistic model are available from the author.

<sup>16</sup> The empirical equations used for estimating the Weibull model closely follow the procedure used by Box-Steffensmeir (2004, pp. 25-31).

<sup>17</sup> The Weibull model in this study assumes a single baseline parameter for all  $k$  reassessments in a county. The basis for this assumption is that reassessments cycles within counties were independent. Box-Scheffensmeir et al. (2007, p. 242) allow for multiple baseline parameters when the different  $k$  events are dependent. However, single event models have been the standard approach in the policy adoption literature (Jones and Branton, 2005, p. 438). Event independence probably applies in this study because most reassessment cycles were long even when multiple reassessments occurred.



sion constant term and  $p$  is the shape (or rate of change) parameter of the hazard function.<sup>18</sup> A compact form for equation (2) is written as follows:

$$f_{ik}(t_k - t_{k-1})_i = pt^{p-1} \exp(\beta'X) \quad (3)$$

The vector  $\beta'$  includes the constant term  $\beta_0'$  and the coefficients ( $\beta'_j$ ) of the other covariates. Equation (3) is a proportional hazard model because the exponent of the covariate vector ( $\beta'X$ ) is a proportional shifter of the entire function. The proportionate effect of  $X$  on the conditional probability of ending the current reassessment cycle does not depend on duration (Kiefer, 1988, p. 664). Their combined effect is a multiple for the given baseline estimate ( $f_0$ ) in the hazard function (2).

The estimated parameter  $p$  is used to test for duration dependence. The null hypothesis in this case is that  $p = 1$ . If  $p = 1$ , the Weibull is equivalent to the exponential distribution, in which case the hazard rate is constant over time. Thus, the hypothesis of no duration dependence would not be rejected. Positive duration dependence occurs when  $p > 1$  and indicates that the hazard rate increases as the years since the previous reassessment increases. Negative duration dependence occurs when  $p < 1$  and indicates that the hazard rate decreases as years since the previous reassessment increases.

The independent variables in this study reflect the effect of economic and fiscal variables on the duration of reassessment.<sup>19</sup> The dependent variable is the number of years since the previous reassessment (YRS). This is the gap time measure of duration discussed above. Table 3 provides the definitions and descriptive statistics of all variables, where values are taken from the reassessment year unless otherwise stated. It also includes the elapsed time measure of duration (YRSE). Descriptive statistics for each variable are based on the sample of 99 observations. The statistics for county government revenue, expenditures and real estate tax rates were obtained from *Local Government Financial Statistics* published annually by

the Commonwealth of Pennsylvania, Department of Community and Economic Development. County assessment data were obtained from reports provided by the Commonwealth of Pennsylvania, State Tax Equalization Board. The statistics for annual per capita income and population were obtained from the United States Bureau of Economic Analysis, 2009. Finally, data on number of business establishments were obtained from the United States Census Bureau, 2009.

The primary empirical question concerning the various covariates is to test how changes affect survival. In terms of the AFT model in equation (1), this question concerns whether the respective  $B_j$  coefficients were positive or negative. A positive sign predicted a longer duration while a negative sign predicted a shorter duration as the covariate value increased. These in turn predicted an opposite sign for hazard rates in the proportional hazard model of equation (3). Thus, covariates with positive coefficients had longer durations and lower hazard rates while coefficients with negative signs had shorter durations and higher hazard rates.

County governments faced budgetary and equity objectives in selecting the length of the duration period. First, they attempted to obtain the greatest fiscal benefit from reassessment over time. This required consideration of both the cost of administering reassessment and the revenue gained from the increased assessed valuation of properties. Generally, one expects assessment cost decreases as reassessment duration increases. These costs should be lower if they are spread over more years. On the other hand, revenue enhancement would be greater if the duration of reassessment was shorter. The equity objective suggests the distribution of the tax is fairer if property reassessment occurs over shorter durations. The dispersion of market values tends to increase as duration increases. Higher priced properties benefit at the expense of lower priced properties.

The effect of long term economic variables were represented by the average annual growth rates for county per capita income (GINC), population (GPOP) and the number of county business organizations per capita (GEST). Current local economic conditions also might have affected reassessment duration. Per capita income in the year of reassessment (INC) was assumed to represent differences in the current level of economic activity. The question was whether local economic growth variables and local economic activity increased or decreased the duration of reassessment. The expected significant response of duration to these variables assumes property tax revenues were sensitive to local economic activity and trends.

<sup>18</sup>The duration parameter  $p$  from the proportional hazard function (3) equals  $1/\sigma$  where  $\sigma$  is the duration parameter from the survival function given in equation (1). Further, the coefficient of a given covariate ( $\beta'_j$ ) in the proportional hazards model is equal to  $-(\beta_j/\sigma)$  in the AFT model. The coefficient sign for  $\beta'_j$  is always opposite of the AFT sign for  $\beta_j$  and weighted by the inverse of the duration survival parameter ( $1/\sigma$ ).

<sup>19</sup>The empirical analysis included testing the effect of other covariates. These included the percentage of the population aged 65 and over, percentage of home ownership, property tax share of total county revenue, percentage of property commercial and industrial and the number of school districts per capita. None added significantly to the model. None is included in the model discussion or analysis.

Public officials were more likely to favor reassessment when economic conditions were unfavorable than when they were favorable. Counties that had higher current levels of per capita income and higher growth rates were likely to have longer durations. Real estate taxes were likely to be higher in high income and high growth counties. These counties likely had less of a need to increase their real estate tax base through reassessment. This suggests a positive relation between duration and these covariates. However, counties with low income or low growth rates also might experience longer durations. In that event, these covariates would be inversely related to duration for several reasons. First, the reassessment process involves high administrative costs. Poor or low

growth counties might be unwilling or unable to undertake these costs. Second, taxpayers may perceive reassessment as a way to raise local property taxes. A higher assessed value enables counties to raise taxes with fewer constraints. Poor counties might be less willing to risk higher tax burdens. Third, counties with high business growth might have experienced shorter durations because residents believed they would bear a smaller burden of increased taxes. High business growth enables counties to export more of the tax burden to non-resident commercial and industrial property. Thus, positive or negative coefficients were possible for economic variables depending on the strength of these separate effects.

**Table 3.** Variable definitions and summary statistics.

Variable Name	Definition	Mean	Std Dev.	Min	Max
YRS	Number of years between reassessments based on gap time	10.66	6.62	1	25
LYRS	Log of YRS	2.08	0.87	0	3.18
YRSE	Number of years between reassessments based on elapsed time	14.09	7.83	1	25
LYRSE	Log of YRSE	2.36	0.93	0	3.22
LIM	Binary variable equals 1 if nominal tax rate was about statutory limit in year previous to reassessment; zero otherwise	0.59	0.50	0	1
GTR	Average percentage annual growth rate in the property tax levy as a percentage of market value.	18.61	16.82	1.48	88.91
HOME	Binary variable equals 1 if home rule county; zero otherwise	0.061	0.240	0	1
INC	Current county per capita income	14233	4750	7998	26739
GINC	Average percentage annual growth rate in per capita income from previous reassessment year or base year	1.320	1.804	-6.75	8.856
GPOP	Average percentage annual growth rate in county population from previous reassessment year or base year.	0.330	1.221	-1.72	7.326
GEST	Average percentage annual growth rate in number of business establishments from previous reassessment year or base year.	2.321	2.172	-4.57	9.750
EXP	County government expenditures per capita	267.10	165.0	56.5	739.8

Fiscal variables included in the survival function account for differences across county governments in revenue-generating ability and willingness to pay additional taxes. Most counties had limited ability to change economic activity variables through their tax and spending activities. However, a county could change expenditures, the mill rate or tax base valuation in order to improve fiscal benefit. Variable property tax levies and market value growth rates often change the effective tax rate. This assumes that expenditures drive revenues and that expenditures usually increase over time. The property tax is different from most other taxes because it does not require a change in legislation to change the nominal tax or mill rate. Local public officials often face budgetary pressure to increase the nominal mill rate because of

increasing property tax levies. However, if the nominal mill rate approaches the statutory mill rate limit, then a county may not be able to finance higher tax levies without reassessment and increased assessed values. Higher reassessed value results in a reduction in the nominal rate because the percentage increase in assessed value usually exceeds that of the property tax levy in the first years after reassessment.

Two external variables and two internal variables influenced the ability to raise property tax revenue and the length of the reassessment cycles. The two external variables represented the effects of (1) a county that had nominal mill rates above the statutory mill rate limit (LIM) and (2) a county that had a home rule charter (HOME). The two internal fiscal variables included were the growth of the real tax burden (GTR)

and level of per capita county government expenditures (EXP). Counties that had high growth of their tax rate burden faced greater fiscal stress and were more likely to reassess property. These counties likely would have shorter durations. Expenditures per capita (EXP) also influenced reassessment duration because they required additional property tax financing. Further, expenditures also may have reflected differences in tastes and differences in aid receipts across counties.

Two dummy variables represent the separate effects of LIM and HOME on reassessment duration. Specifically, LIM tests whether counties above the nominal mill rate limit had different durations and survival rates than counties below the limit. Duration should be longer for counties above the mill rate limit because one of the main means of increasing revenue is constrained. Thus, counties above the tax rate limit were likely to have lower survival rates and longer durations. This predicts a positive sign for this variable.

Home rule counties (HOME) were not subject to the statutory limits faced by other counties. The exemption from statutory mill rate limits placed less fiscal pressure on home rule counties to reassess and reduced the probability of reassessment in any given year. They were able to raise additional revenues without necessarily increasing assessed values because the nominal rate could exceed the prescribed rate. Thus, home rule counties were likely to have longer duration periods than other counties. Further, Latzko (2008) provided evidence from Pennsylvania counties that showed home rule counties did not have significantly higher taxes although they had significantly higher levels of expenditures and intergovernmental grants than the other counties. This finding further suggests that home rule counties faced less pressure to reassess property in order to increase real estate taxes.

The timing of reassessment depends upon how the relative burden of property taxes changes over time. Counties with increasing property tax burdens generally favor shorter durations between reassessments. The relative property tax burden will increase because of a high rate of increase in the property tax levy or a low rate of increase in market values. Counties with low rates of property value growth generally face higher tax burdens and greater pressure to reassess. The effect of market value growth on relative property tax burden can be determined by assuming a fixed property tax levy. In this case, changes in the property tax burden reflect the effect of relative changes in market value growth since the previous reassessment.

Heavey (1978) showed that the relative disparity in the tax rate burden between properties is inversely

related to the market value growth rate. Suppose that real tax rate burden in the current reassessment year is  $TR_t$  and real tax rate burden in the previous reassessment year is  $TR_0$ . These tax rates essentially give the tax levy in the previous reassessment year as a percent of each year's market value. The ratio  $(TR_t/TR_0)$  gives the growth of the tax rate burden between two reassessment years (GTR). It is the ratio of the tax rate in the current reassessment year to the tax rate in the previous reassessment year.<sup>20</sup> GTR will be less than one as long as market value increases. The fixed property tax levy will be a smaller percentage of market value in the new reassessment year and  $TR_t$  will be less than  $TR_0$ . Thus, counties with lower ratios had higher market value growth and longer durations between reassessment.

Per capita county government expenditures (EXP) reflect the level and diversity of demand for county government services. The level of these expenditures suggests alternative hypotheses about their effect on reassessment duration. Higher expenditures per capita might reflect a greater need for property tax financing and property reassessment. This predicts that higher expenditure counties have shorter durations. However, higher expenditure levels also imply a large local public sector and a broad range of services. Thus, higher expenditures were likely to be associated with longer durations because of two separate effects. First, counties that offered a relatively high level of public services were likely to have more diverse taxpayer demand. Consequently, it may have been more difficult to agree on the need for reassessment than if the property tax was financing a narrow range of services to taxpayers with more homogeneous tastes. Further, counties with high expenditures were more likely to have services financed by higher levels of government. Intergovernmental aid was likely to have improved the ability to generate revenue and reduced the fiscal pressure on the real estate tax. Thus, higher expenditures may have reflected the effects of both fiscal stress and demand diversity on the duration of the reassessment cycle.

<sup>20</sup> Heavey assumes that market values grow at a constant annual rate  $a$  such that  $MV_t = MV_0 e^{at}$  where  $e$  is the base of natural logarithms,  $MV_t$  is market value in the current reassessment year, and  $MV_0$  is market value in the previous reassessment year. He also assumes that market value and assessed value are equal in the first period, that is,  $MV_0 = AV_0$ . Further, no change occurs in the nominal tax rate (TN) and no reassessment occurs over the reassessment cycle. In this simplified analysis, the nominal and real tax rates are the same in the initial period. GTR is inverse to market value growth, i.e., equals  $(1/e^{at})$ . This follows because the real tax rate in the new reassessment year  $t$  is equal to  $(TN \cdot AV_0) / (MV_0 \cdot e^{at})$ , where TN is the nominal tax rate. If  $TN = TR_0$  and  $AV_0 = MV_0$ , then  $TR_t/TR_0 = (1/e^{at})$ . If  $AV_0$  does not equal  $MV_0$ , then  $TR_t/TR_0 = (1/e^{at}) \cdot (AV_0/MV_0)$ .

## 5. Empirical results

### 5.1. Background details

The maximum likelihood procedure was used to estimate the parameters in the accelerated failure time model of equation (1). Cross sectional observations included data from the reassessment years between 1982 and 2006, a period of 25 years. The sample consisted of 99 observations where the 64 included counties had at least one reassessment and several had more than one. The sample excludes the two counties that did not have any type of reassessment between 1982 and 2006. The value of each observation for the duration variable (YRS) was the number of years since the previous reassessment. Duration and covariate values were limited to annual observations between 1982 and 2006. Thus, information was lost on left censored observations in the years prior to 1982. Further, the duration of right censored observations was unknown. Information on right-censored observations was incorporated into the log-likelihood function on which the maximum likelihood estimation was based. A STATUS variable (Greene, 2002) distinguished between observations that were right-censored and those that had reassessments between 1982 and 2006.

Empirical results for the parameters in the Weibull survival equation (1) were obtained by employing the maximum likelihood procedure. Equation (1A) gives the specification for estimating this model in vector notation:

$$\log(YRS)_i = \beta_j X + \sigma e \quad (1A)$$

In this equation, the log of the duration variable (YRS) depends on a baseline variable and a vector of covariates  $X$ . The duration variable, YRS, was computed from  $(t_k - t_{k-1})_i$  in equation (1). The estimated  $B_j$  coefficients include  $B_0$  for the baseline variable and  $B_1$  through  $B_n$  for  $n$  covariates.  $\sigma$  represents the survival shape parameter for the disturbance term  $e$ .

Reassessment years for all counties were obtained from the unpublished records of the Pennsylvania State Equalization Board (STEB). These reported reassessments were checked against the county's published common level ratio in the year prior to and the year of reassessment.<sup>21</sup> All these counties showed sizeable increases in their common level ratios in the reassessment year. A few counties with sizeable increases in their common level ratio were counted as

reassessed even though they were not included in the records that were obtained from STEB.

Observed values for several covariates used their respective amounts in the new reassessment year. These included per capita income (INC) and per capita county government expenditures (EXP). Growth rate covariates took the difference between the values in the new reassessment year and in the previous reassessment year and divided it by the number of years in the duration period. Growth rate covariates included per capita income (GINC), population (GPOP), business establishments (GEST) and tax burden (GTR). The reassessment year values for per capita income, per capita expenditures and market value of taxable property were deflated by the annual Consumer Price Index.<sup>22</sup> This involved the use of 1981 as the base year. Thus, all growth rate variables and current year variables are expressed in real terms.

Growth rate variables for local income, population and business establishments represented the separate influence of local economy on the tax base and the timing of reassessment. The inclusion of per capita income (INC) in the current reassessment year represented the effect of current performance of the local economy. Per capita income was the only current year economic variable included in the estimation of the duration equation. Market value per capita also was another measure of the local economy. However, per capita income and per capita market value had a positive correlation of 0.71. Income was chosen because it represented a broader measure of economic performance.<sup>23</sup>

Table 4 gives the maximum likelihood estimates for the Weibull model.<sup>24</sup> They include the covariates' estimated coefficients and standard errors. The Akaike information criterion (AIC) gives a measure of overall fit.<sup>25</sup> The duration times for different survival rates were computed from the estimates in the model. The simple correlation matrix for the covariates shows that only per capita income and per capita government expenditures were highly correlated. Their correlation

<sup>22</sup> GTR also included market value as a part of its computation. Specifically, the computation of the average annual growth rate  $a$  used the difference between real market values in the previous and new reassessment years.

<sup>23</sup> The level of market value per capita also was included as a covariate in a separate estimation of the Weibull survival equation. It had the expected positive effect on duration but was not statistically significant.

<sup>24</sup> This procedure was undertaken using LIMDEP. It is described in Greene (2002, pp. 27-23 to 27-24).

<sup>25</sup> Box-Steffensmeier and Jones (2004, p. 44) give the formula for computing AIC as  $-2(\log L) + 2(c+p+1)$ , where  $L$  is the log-likelihood estimated from the log-linear model,  $c$  denotes the number of covariates in the model and  $p$  denotes the number of structural parameters in the model.

<sup>21</sup> The Pennsylvania State Equalization Board annually computes an estimate for each county's assessment ratio of assessed value to market value. The common level ratio shows most substantial changes during the reassessment year. Assessed value increases substantially during the reassessment year and little in other years.

coefficient was 0.74. Therefore, Table 4 includes two separate versions of the estimates for the Weibull model. Version 1 includes INC and the version 2 excludes it. None of the other covariates, including

the growth covariates, had high correlation coefficients. The discussion of the estimation results that follows refer mostly to version 1, which included per capita income.

**Table 4.** Maximum likelihood estimation results for Weibull model.

Variable	Version 1		Version 2	
	Coefficient	Std. Error	Coefficient	Std. Error
Constant	1.933 <sup>a</sup>	0.253	1.774 <sup>a</sup>	0.178
LIM	0.660 <sup>a</sup>	0.118	0.667 <sup>a</sup>	0.118
GTR	-0.012 <sup>a</sup>	0.039	-0.013 <sup>c</sup>	0.004
HOME	0.321	0.359	0.325	0.335
INC	-0.155E-04	0.220E-04		
GINC	0.193 <sup>a</sup>	0.039	0.178 <sup>a</sup>	0.036
GPOP	0.116 <sup>b</sup>	0.056	0.090	0.056
GEST	-0.131 <sup>a</sup>	0.034	-0.119 <sup>a</sup>	0.032
EXP	0.0018 <sup>c</sup>	0.00065	0.0016 <sup>a</sup>	0.00044
$\sigma$	0.465 <sup>a</sup>	0.043	0.466 <sup>a</sup>	0.043
$p$	2.151 <sup>a</sup>	0.198	2.144 <sup>a</sup>	0.198
Log likelihood ratio	-84.23		-84.52	
AIC	188.45		187.03	
<b>Estimated durations at selected hazard rates:</b>				
Survival rates	Version 1		Version 2	
	YRS	YRS	Survival rates	YRS
5%	2.68		5%	2.67
25%	5.98		25%	5.98
50%	9.00		50%	9.00
75%	12.42		75%	12.44

Notes: The upper portion of the table reports maximum-likelihood estimates for two versions of the Weibull model. The estimates were based on the accelerated failure time (AFT) model. The lower portion gives the estimated durations (YRS) at each of the specified survival rates. These were calculated using the estimated coefficients of the AFT results at the covariate means.

<sup>a</sup> Significantly different from zero at the 1 percent level. <sup>b</sup> Significantly different from zero at the 5 percent level.

<sup>c</sup> Significantly different from zero at the 10 percent level.

An alternative estimation of version 1 added a dummy variable for counties that had multiple reassessments. This variable was not statistically significant. This suggests that the duration of reassessment in multiple reassessment counties was not significantly different from counties that only had one reassessment. The results for the other covariates were similar to those reported in Table 4.

Table 5 shows the results from calculating the percentage response of the survival rate to a 10 percent increase and a 1 standard deviation increase in each covariate mean. These are useful measures for comparing the relative effect of each covariate on survival. Figure 1 gives the plot of Weibull model survival function. It plots survival rates at different durations.

## 5.2. Estimates of shape variable, $p$

The estimation results showed that  $p$  was significantly greater than one. The values for the duration

parameter,  $p$ , give the hazard rates for reassessment. The hazard rate is the inverse of sigma ( $\sigma$ ), the duration variable parameter in the AFT equation in Table 4. The finding that  $p$  was significantly greater than one predicted a monotonic increasing hazard rate. This implies a significant positive time dependency conditional on the given values of the covariates. The probability that the computed  $z$ -statistic occurred due to chance is less than 0.01. The results thus suggest that as the years since the previous reassessment increased, the probability of reassessment increased at an increasing rate. Thus, counties that had depended upon given assessed values over a longer period were more likely to reassess property than counties that had shorter reassessment cycles.

The shape parameter for  $\sigma$  in the Weibull survival function was used to compute the conditional probability of reassessment as duration increased. The predicted survival rates used the estimated parameters in

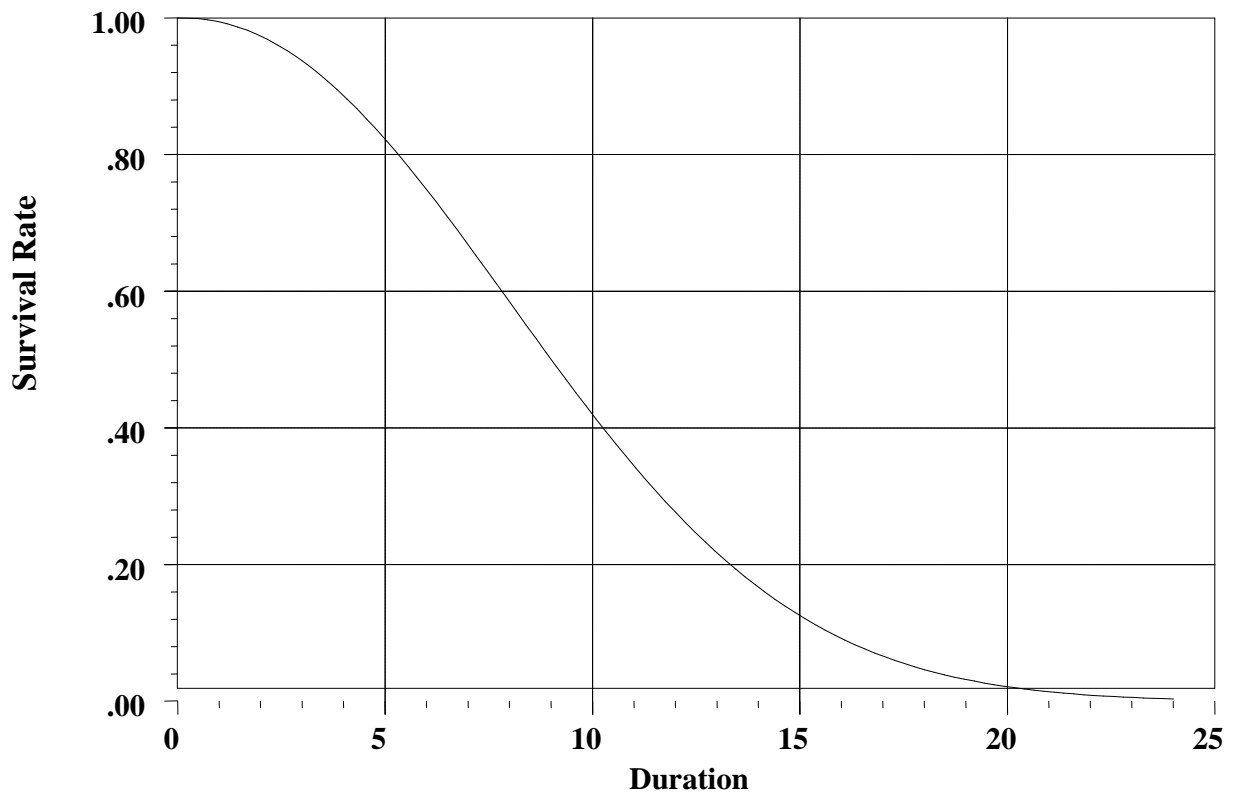
the model at their mean points in the data sample. The Weibull model predicted that the median survival rate (50th percentile) was about nine years. The results also show duration was about 2.7 years at the 95th percentile, 6 years at the 75th percentile and 12.4 years at the 25th percentile. These results suggest on average long durations between reassessments. For instance, it projects that only half the counties were

likely to reassess properties in the first nine years after reassessment and 25 percent of the counties were unlikely to reassess property after more than 12 years. Figure 1 shows the survival rates for the estimated parameters. The plot of the survival rates show probability of reassessment at different durations (YRS). It shows a pattern of monotonically decreasing survival rates.

**Table 5.** The effect on reassessment probability of increasing the covariate means by one standard deviation and 10 percent.

Variable	Mean	Standard Deviation	Effect of increasing the covariate's mean value by	
			One std. dev.	10 percent
GTR	18.61	16.82	-17.62	-2.12
INC	14233	4750	-52.12	-19.80
GINC	1.320	1.804	41.57	2.58
GPOP	0.330	1.221	15.29	0.39
GEST	2.321	2.172	-24.83	-3.00
EXP	267.10	165.04	34.17	4.87

Note: The table reports for each covariate the effect on the conditional probability of reassessment of increasing its mean by one standard deviation or by 10 percent. The estimated coefficients from version 1 of the Weibull results reported in Table 4 were used to make these projections.



**Figure 1.** Weibull survival function.

### 5.3. Covariate estimation results

The Weibull model provides the best estimates for predicting the duration of reassessment decisions.<sup>26</sup> Most of the parameters had the expected signs and most were statistically significant.<sup>27</sup> INC and HOME were not statistically significant at 10 percent level. The results for the two versions were similar. Thus, the high correlation between INC and EXP did not appear to cause problems with multicollinearity. One difference is that the significance of the population growth variable differs between the two versions. It is significant in version 1, but not in version 2.

Covariate estimates suggest that the local economic growth variables and the fiscal variables had the greatest impact on the duration of the reassessment cycle. Increasing survival rates were found for income and population growth (GINC and GPOP) while a decreasing survival rate was found for business growth (GEST). High growth rates for income and population predicted increased reassessment duration while a high growth rate for business firms predicted decreased reassessment duration. The fiscal variables (EXP and LIM) were positively significant. These results predict that increasing expenditures and mill rates above the limit increase the duration of the reassessment cycle. The tax burden variable (GTR) showed that a high growth rate for the real tax rate had a significant negative effect on reassessment duration.<sup>28</sup> Reassessment duration was shorter in counties that faced high growth burdens in paying local property taxes. These relatively high tax burdens occurred because of low rates of growth in the market value of taxable property.

<sup>26</sup>Estimation of the exponential model using the same covariates as the Weibull model showed few significant variables and an inferior model fit. The Weibull model also provided a better rationale for reassessment than other parametric models such as the log-logistic model. The log-logistic model predicted non-monotonic hazard rates. Hazard rates were more likely to decrease after duration reached a certain number of years. Further, log-logistic estimates for the same parameters in the Weibull model showed a higher AIC measure. Box-Steffensmeir and Jones (2004, p. 86) state that the AIC can be used as a goodness of fit measure when comparing non-nested models.

<sup>27</sup>An attempt was made to test for unobserved heterogeneity in the estimation of the survival function. Unmeasured heterogeneity leads to misleading inferences about duration dependence and the included independent variables. A modified Weibull function included a random effect parameter. Estimation of this function showed this parameter to be not statistically significant.

<sup>28</sup>The values for GTR in this study include a weight for the common level ratio in the previous reassessment year. Most of Pennsylvania had assessment ratios that were less than one. In other words, assessed value usually was less than market value. See note 20 for more details.

### 5.4. Projected duration response to covariate change

The projected response of the survival rate to changes in the individual covariates provides a useful comparison of their relative impacts. Coefficient estimates from the Weibull model in Table 4 enable prediction of the effect of specific changes from the mean. Table 5 shows the relative impact of these changes. The fourth column in Table 5 gives the effect on the survival rate of increasing each covariate mean by one standard deviation and the fifth column gives the effect of increasing each covariate mean by 10 percent.<sup>29</sup> The use of the same 10 percent change in the covariate mean has the advantage of enabling comparison of the relative response to the different covariates.<sup>30</sup> These predicted effects assume all other covariates are constant. Further, a change in a covariate also predicts that the survival function shifts without any change in its shape parameter.

The estimated coefficients of the two dummy variables in Table 4 represent the effects of structural differences across counties on the probability of survival. First, counties over the mill rate limit in the year before reassessment had longer durations. Specifically, counties that reached or exceeded this limit had reassessment cycles about 1.94 ( $e^{0.660}$ ) times longer than the counties that were under the limit. Second, the positive sign for the home rule counties implied that they had higher survival rates and longer reassessment cycles than non-home rule counties. Specifically, home rule counties had a duration that was about 1.38 ( $e^{0.321}$ ) times longer than the other counties. However, this coefficient was not statistically significant. Therefore, this suggests that home rule governance did not significantly influence reassessment survival.

The negative coefficient for GTR in Table 4 implied that counties with high real tax rate growth had lower survival rates and shorter reassessment cycles. Table 5 gives the magnitude of the duration variable's response to changes in the mean value of GTR. For instance, suppose the average county's growth in real tax burden increased 10 percent (from 18.62 percent to

<sup>29</sup>The coefficients for the covariates in the hazard function should be equal to the negative value of the estimated coefficients in Table 4 divided by the duration parameter ( $\sigma$ ). Thus, the coefficient value ( $\beta'$ ) for each covariate in the proportional hazards model should equal  $-\beta/\sigma$ . The relative effects on the hazard rate also can be calculated using these coefficients.

<sup>30</sup>In general, the percentage change in the probability of reassessment from a given covariate ( $X_i$ ) is computed by the following:  $((e^{\beta_i X_{i2}} - e^{\beta_i X_{i1}}) / e^{\beta_i X_{i1}})$ . In this case, the pertinent  $\beta_i$  is the estimated coefficient from Table 4 for the covariate  $X_i$ .  $X_{i1}$  is the mean value of the covariate before the change and  $X_{i2}$  is the projected value of the covariate after the change. See Box-Steffensmeier and Jones (2004, p. 60) for further details.

20.47 percent). This predicts its survival rate would decrease about 2.1 percent. Alternatively, if a county had a growth rate that was one standard deviation above the mean growth rate, then its survival rate was about 17.6 percent lower than the average county.<sup>31</sup>

The positive coefficient for EXP suggests that county governments with relatively large public sectors had longer reassessment durations and lower probabilities of reassessment. Counties that had expenditures 10 percent above the mean had survival rates that were 4.9 percent above the rate predicted for the mean county. County expenditures also showed considerable dispersion around the mean. Consequently, counties that had expenditures one standard deviation above the mean had survival rates that were more than one-third higher (34.2 percent) than the average county.

Long-run growth variables had mixed effects on reassessment duration. Survival was positively associated with the growth of income and population and negatively associated with the growth of business establishments. The three growth rate variables showed considerable variability around the mean. The standard deviations for income and population growth were greater than the mean growth while the standard deviation for business growth was almost equal to the mean. We consider the effect of modest increases of 10 percent in these average annual growth rates on duration. These increases predicted the survival rate increased about 2.6 percent for income growth and about 0.39 percent for population growth. On the other hand, a 10 percent increase in the business growth rate decreased the survival rate about 3.0 percent. The corresponding changes for one standard deviation increases in these covariates were 41.6 percent, 15.3 percent and -24.8 percent for income, population and business establishments, respectively. Duration had a substantially larger response to income growth and business growth than to population growth although none was elastic.<sup>32</sup> Consequently, it would take a much larger population change to get an equivalent change in reassessment survival than from income or business growth.

<sup>31</sup> The percentage response in survival differs for different levels and different changes of the covariate. For instance, if there is a one standard deviation decrease in the mean GTR, the survival rate increases about 21.4 percent. However, the differential response for smaller changes is much less. For example, a 10 percent lower growth rate in GTR increases the survival rate by about 2.2 percent. The difference in magnitude between a 10 percent increase and a 10 percent decrease from the mean GTR is small.

<sup>32</sup> An elastic response signifies that the percentage response in duration exceeds the percentage change in the covariate.

## 6. Summary and conclusions

This study's main purpose was to investigate the determinants of property reassessment duration. The application of duration analysis to a cross-section of Pennsylvania counties presented a unique opportunity to examine the influence of duration and relevant explanatory variables on the probability of reassessment. Pennsylvania, unlike most other states, had no statutory limits on the duration between reassessments. Consequently, local public officials and citizens were more likely to play a critical role in reassessment decisions. Further, the statutes do not provide local public officials sufficient incentives to achieve uniformity of assessed values.

This study's estimates provided practical insights to elected officials and administrators who evaluate the determinants of reassessment duration. Clearly, the greater discretion granted to Pennsylvania county governments has extended their reassessment cycles. Although the probability of reassessment was positively duration dependent, most Pennsylvania counties had reassessment cycles much longer than in states with mandated durations. Local public officials should be cognizant of several local variables affecting reassessment probabilities even though they have limited control over most economic variables. Nonetheless, the empirical results suggest several relevant points in evaluating the net benefits of changing the duration of the reassessment cycle:

1. Local government officials should be aware of the disparities in market value growth of different properties within their jurisdiction. An increasingly inequitable distribution that favors higher valued properties suggests the need for revaluation. Counties with high-income growth and a high level of expenditures bear watching because these variables had a strong positive effect on reassessment duration.
2. The evidence on the shape of the Weibull survival function predicts a pattern in which assessment survival rates were very high in the early years of the reassessment cycle and decreased rapidly in later years. Further, the survival function predicts relatively long reassessment durations even when measured in gap years. This approximates the reassessment duration pattern of Pennsylvania counties. This further suggests that non-mandated reassessment durations were unlikely to be optimal. They fail to satisfy Pennsylvania uniformity objectives in its



statutes. Thus, problems with equity, efficiency and administration were more likely in states like Pennsylvania.

3. There should be sufficient local incentives that encourage the long-run expansion of the business sector. Business growth tended to decrease duration and increase the probability of reassessment. One possible reason is that residential property owners perceived that business expansion shifted more of the tax burden to nonresidents.
4. Duration showed a significant response to local fiscal variables. These were of particular interest because policymakers generally have some control over them. Specifically, the results showed shorter reassessment durations when the growth in the tax rate burden was high and the level of expenditures was low.
5. Responsiveness to local preferences should be an important factor in an environment that allows considerable discretion to local governments in its choice of the reassessment duration. Few taste variables in this study had a significant effect on duration although the positive impact of government expenditures may have reflected taste differences.
6. Local public officials also had to be concerned with long-term trends in the local economy. Growth of income and business activity had sizeable potential effects on reassessment probability. Income growth was positively associated with reassessment duration, while business growth was negatively associated with reassessment duration. Population growth had a positive effect although its coefficient was small.

This study provides a first step in identifying the main determinants of reassessment duration. No previous study has investigated this issue. One area on which future research should focus is the development of a more complete analysis of optimal reassessment duration. This is a critical issue in all states irrespective of whether the duration decision is discretionary or mandatory. Some of the proposals for reforming the assessment process nonetheless have focused on finding uniform durations and valuations across counties.

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