Estimation Of Tax Rate Elasticities Of Durable Assets: Utility Maximizing Approach Using The AIDS Model

by

Fredrick A. Abeyratne

Dissertation submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Agricultural Economics

APPROVED:

Dr. Thomas G. Johnson, Co-Chairman

Dr. Daniel B. Taylor, Co-Chairman

Dr. Brady J. Deaton

Dr. Barbara Craig

Dr. Warren P. Preston

December, 1988

Blacksburg, Virginia

Estimation Of Tax Rate Elasticities Of Durable Assets:

Utility Maximizing Approach Using The AIDS Model

by

Fredrick A. Abeyratne

Dr. Thomas G. Johnson, Co-Chairman

Dr. Daniel B. Taylor, Co-Chairman

Agricultural Economics

(ABSTRACT)

This research originated on the premise that if the response of various tax bases to changes in tax rates is different, local governments can minimize stress on tax bases by placing differential levels of reliance on these tax bases. Therefore, the objective of this research was to estimate and evaluate short-run and long-run, own- and cross-rate elasticities with respect to the following tax bases: real property (commercial, agricultural, and residential), personal property, and machinery and tools.

The analytical model was based on demand theory, and a modified linear approximate Almost Ideal Demand System was used to estimate the elasticities. For the estimation of the long-run elasticities, a partial adjustment model was introduced to the demand system. Data covered 36 counties from Virginia, and covered the period 1981-1985.

The results indicated that in the short-run, the value of commercial property had a negative elastic response, while agricultural property had a positive inelastic response. Machinery and tools and residential property values were not significantly affected, but personal property indicated a negative inelastic response for changes in tax rates. The long-run results indicated that elasticity figures become more elastic for commercial

property, agricultural property, and personal property while for machinery and tools there was a significant inelastic negative response.

With reference to cross-rate elasticities, in the short-run, machinery and tools depicted a complementary relationship with all the other tax bases except residential property. Tax rate changes of commercial property had a substitution relationship with agricultural property.

In the long-run, however, machinery and tools were significantly impacted only on tax rate changes on personal property. Changes in the tax rate on machinery and tools had a significant complimentary impact on personal property and commercial property. Agricultural property had a significant substitution effect with respect to all the other tax bases except personal property.

Hence, the results indicate that different tax bases respond differently to tax rate changes, which local governments can utilize to maintain or increase tax revenues while reducing the tax burden on tax bases which are very sensitive to tax rate changes.

Acknowledgements

My graduate work at the Virginia Polytechnic Institute and State University has been a very rewarding experience for me. After working several years as a full time researcher, I now realize what a difference training at the Ph.D. level can do. Writing this dissertation was the pinnacle of my program, but would not have completed it without constant help from my advisory committee and many other people.

First of all I must thank my co-chairmen, Dr. Thomas G. Johnson and Dr. Daniel B. Taylôr. I am indebted to Dr. Johnson for his original ideas which triggered this dissertation. His continuous guidance, suggestions, and perusal of numerous drafts resulted in this dissertation. Dr. Taylor was a great inspiration to me throughout my graduate program. I acknowledge his guidance and the encouraging words he offered me.

The other members of my committee, Dr. Brady J. Deaton, Dr. Barbara Craig, and Dr. Warren Preston, offered me valuable advice throughout the writing of this dissertation. I greatly appreciate the advice received from Dr. Barbara Craig and Dr. Anya McGuirck, who helped me with my econometric work.

My thanks are also due to several others who helped me to complete this dissertation. First, I must thank all the county revenue officers for sending me some of the required information. My thanks are due to Mr. Raymond Wilson for helping out with entering the data on the computer. All the staff members of the Micro Computer Laboratory of the College of Agriculture and Life Sciences were very helpful to me throughout my program. I especially thank Gerald Spittle, David Woodall-Gainey, Todd Pukanecz, Wendi Biggs and Debra Jordan.

I must thank several others of the Agricultural Economics Department who made my life easy. Mrs. Daisy Ayres was always there to help me out with any administrative problem. Thank You Daisy. Linda Kipps, Joan Boyd, Lee Thunberg, and Donna Crommer were also very helpful whenever I was in trouble. Thank you very much, I appreciate your help.

Several of my colleagues also merit a word of appreciation, for making my life easy while going through a strenuous program. My good friend Rathin Basu was always there for a 'chat' to solve global problems that we are faced with today. I also would like to thank David Kraybill, Thomas Kalb, Thomas Whitney and Mesfin Mirotchie for stimulating discussions, and John Robertson who helped me with computer soft ware.

My first year of the Ph.D. program was financed by the Agrarian Research and Training Institute, Sri Lanka. I greatly appreciate the initiative taken by Mr. T. B. Subasinghe, Director, in releasing the necessary funding to start my program. The rest of the program was funded by the Department of Agricultural Economics, Virginia Polytechnic Institute and State University. I wish to extend my greatest gratitude to the department for extending funds to me to complete my program.

Last, but not the least, my thanks are due to my family. My dear wife, was a constant inspiration to me. She always supported me in what ever I did and also helped me to keep the home fires burning. Thank you very much. I feel sorry I did not have much free time for our daughter, I thank her for putting up with my preoccupation with my studies all these years. I also remember my parents, sisters and brother, who were always concerned about me. Thank you all, very much.

Table of Contents

List of Illustrations

List of Tables

Chapter 1

BACKGROUND AND THE PROBLEM

1.1 The Problem

One of the main roles of a local government is to meet its constituents' demands for public services. Apart from any federal or state grants, the main source of revenue to meet these expenditures is local tax revenues. Hence local governments are faced with the arduous task of collecting sufficient tax revenues from constituents while keeping the tax rates as low as possible. Local governments have an array of taxation instruments or bases available to them. These include residential real property, commercial real property, agricultural property, personal property, machine and tools, retail sales, business licences, excise taxes, building permits, special assessments, and other taxes, licences, and permits.

If the responses of various tax bases to changes in tax rates are different, local governments can place differential levels of reliance on these tax bases for generating revenue. Information on these responses could have significant impacts on the distribution of the tax burden, on the tax revenue to local governments, and on economic incentives to individuals, families, and businesses.

Given the above background, the problem addressed by this study is the limited information available related to the effects of tax rate changes on the level of tax bases, the distribution of tax burdens, the economic incentives facing constituents, and the nature of the jurisdiction's tax base.

There are 95 counties and 41 cities in the state of Virginia. Of the 2,593 million dollars of revenue that was received by these local governments in 1986, 60 percent was from local tax collections. As shown in Table 1.1, 82.4 percent of local collections were from three tax bases namely: real property tax, personal property tax, and sales tax. This pattern has remained about the same since 1983.

The impact of tax rate changes on tax base and revenue can be expressed in terms of elasticities. For example, elasticities can be defined in terms of the percentage change in tax revenue or tax base for a one percent change in the tax rate. With an increase in the tax rate, one would normally expect the value of the tax base to decline because economic agents will move their economic activity elsewhere or invest in a base that is taxed at a lower rate. The own-rate elasticity would indicate the magnitude of response. For example, if the rate-base response is inelastic ($0 > \eta_r > -1$, where η_r = tax rate elasticity), one would expect an increase in the tax rate to lead to an increase in the tax revenue. But if the $\eta_r < -1$, revenue will decline when the tax rate increases.

Table 1.1. Sources of Local Tax Revenues in Virginia (Amount in Dollars)

Source	1983	percentage	1986	Percentage
Real Property	450,870	37.3	576,168	36.8
Personal Property	134,046	11.1	189,385	12.1
Public Service Corporations	60,170	5.0	75,005	4.8
Sales Tax	398,214	32.9	524,808	33.5
Permit Licences	12,339	1.0	16,109	1.0
Fines	11,189	0.9	14,917	0.9
Charges for Services	71,357	5.9	85,903	5.5
Use of Money & Property	37,835	3.1	49,951	3.2
Miscellaneous	31,155	2.6	35,218	2.3
Total	1,207,719	100.0	1,567,467	100.0

Source:
Comparative Report of Local Government Revenue and Expenditure Years Ending June 30, 1983, 1986; Commonwealth of Virginia, Auditor of Public Accounts 1984 and 1987.

Tax rate changes have an effect not only on their own base but also on other bases. This impact can be evaluated with cross elasticities, that is, the percentage change in tax base *i*, for each one percent change in tax rate *j*. In most instances, tax bases are expected to be complimentary to each other because, if the value of a particular tax base declines due to an increase in its tax rate, the values of economic activities that are linked to this tax base are also likely to decline. Therefore, we can expect the value as well the structure of a tax base to change. In the short run, rigidities and fixed costs should lead to a less elastic response to a tax rate change. However, over time the rigidities can be overcome, and a more elastic response can result.

The tax revenues collected by local governments are used to finance public services such as police and fire protection, parks and recreation, and education and health services. Although an increase in tax rates is likely to increase the tax burden on those who own these tax bases, the public services are likely to enhance the value of those tax bases. For example, better public services are likely to attract more residents to a particular locality, enhancing the value of the residential property.

Individuals are faced with two types of price changes for taxable goods and property. One type is the price change resulting from changes in the demand and supply of the tax base concerned. The other is the price change resulting from a change in tax rates. It is likely that the responses to these two effects will differ since public services financed through tax revenues will be perceived to have an impact on the value of the tax base.

1.2 Objectives

The purpose of this research is to evaluate the relative own- and cross-rate elasticities of tax rate-base relationships, in order to aid local government policy makers who formulate tax structures.

The specific objectives are as follows:

1. To estimate the short-run and long-run own-tax rate elasticities with respect to the following tax bases: real property, personal property, and machinery/tools, and

2 To estimate the short-run and long-run cross rate-elasticities of the above tax bases.

1.3 Hypotheses

1. The impact of tax rate increases on an associated tax base is negative.

2. Due to the likely complimentary nature of many tax bases, the cross rate-base elasticities will be negative.

3. The elasticity estimates will become more elastic (in absolute terms) over time.

4. The impact of tax rate change on the value of the tax base will be less than the impact of price change.

1.4 Overview of the Local Tax System in Virginia

There are a number of distinguishing features of the local tax system in the state of Virginia. They are as follows:

(a) Cities and counties in the state are separate tax entities.

(b) A company pays either city or county taxes, depending on its location[1].

(c) Localities are prohibited from granting property tax exemptions to attract new industries or to expand existing industries. Some exceptions are for energy development, and pollution control and to businesses located in the twelve urban enterprise zones.

Ware (1986) identified separately the taxes applicable to corporations or businesses and taxes applicable to individuals. Here the same distinction is used to describe the different taxes, and most of the information given below is from Ware.

1.4.1 Local Business Taxes

1. Real Estate Taxes: Local tax jurisdictions are supposed to assess real estate at full market value. But due to periodic assessments and rising real estate values, actual assessment/sales (assessment/market value) ratios are usually lower than 100 percent.

---

[1] If a company is located within the corporate limits of a town, the company has to pay both county and town taxes. Exceptions to this are utility taxes which are paid only to the town, and county license taxes which are not paid in the town unless the governing body of the town provides that county license taxes may apply to businesses located within the town.

Annually an assessment/sales ratio study is conducted by the State Department of Taxation to compare the assessed value to the selling prices of bonafide sales of real property in each locality. The ratio is utilized to estimate the total true (market) value of real estate for each locality and to determine average effective tax rates throughout the state, assess public service corporation property in each locality of the commonwealth, distribute state aid for elementary-secondary education in the localities, and finally measure the level of uniformity in the assessment of real property within and among jurisdictions throughout the commonwealth. These studies classify real property into residential property, agricultural property, and commercial/industrial property.

The use of the median ratio has been deemed to be the best measure of a locality's true assessment/sales ratio, because the ratio is unaffected by distortions caused by large sales or "extreme" ratios at either end of the spectrum, especially those at the higher end.

An important use of these studies is to determine the "uniformity" of assessment levels within a locality. Clearly, if real property owners are not assessed in a uniform manner, these tax bills will not be uniform relative to the value of property and the property tax will be inequitable. The greater the spread in the assessment ratio for individual real property owners, the greater the inequity in the locality. There are many reasons for this inequity in property taxation such as: long periods between reassessment, difficulty of obtaining fair market values for different types of parcels, unique characteristics of different properties. Regardless of why they exist, these varying ratios lead to inequitable tax burdens.

Differences in taxes among Virginia's localities cannot be measured by comparing the nominal tax rates alone because of the varying assessment procedures employed by the localities. To adjust for functional assessments, the nominal tax rate is multiplied by the median assessment/sales ratio to yield the average effective tax rate. This figure allows an accurate comparison of real estate taxes on similar properties in different taxing jurisdictions. True value per capita is a more meaningful representation of local wealth than a total true-value figure, because it adjusts all the localities to one common denominator -- population.

In 1984 the average effective tax rate on real estate (assessment rate times nominal tax rate) ranged from a low of 0.25 dollars per 100 dollars of fair market value in a rural county to as high as 1.70 dollars per 100 dollars in a northern Virginia city. The average effective true tax rate for all cities and counties in the state, exclusive of town levies, was 0.87 dollars per 100 dollars (Ware).

2. Motor Vehicles Taxes: Virginia local governments use a variety of methods to determine the taxable value of automobiles and trucks, including a pricing guide which depends on the age and weight of the vehicle and a percentage of the original cost. The percentage of these values that is taxable and the nominal tax rate applied to these also vary greatly by community.

3. Sales and Use Taxes: The state of Virginia as well as cities and counties imposes sales and use taxes on businesses. Both taxes are collected at the same time, i.e., when the sales take place.

4. Utility Taxes: All cities and counties and those towns which provide municipal services (such as electricity, gas, water, and telephone services) have the authority to levy a tax on the utility bills of business firms. Localities are prohibited from imposing the tax at a rate higher than 20 percent, unless they had higher rates in effect on July 1, 1972, in which case they may continue the same rate, but cannot increase it.

5. Machinery and Tools: A percentage of original total capitalization cost or a depreciated cost of machinery and tools used for manufacturing (other than energy conversion equipment), are used to estimate the taxable value. This percentage can vary widely by locality. All other motor vehicles, other than ones defined under motor vehicles above and delivery equipment used in manufacturing are included in machinery and tools and are taxed as such.

6. Tangible Personal Property Tax: These include office equipment, furniture, fixtures, machines, tools, and other vehicles and equipment. A percentage of original cost is used to value such property for tax purposes.

7. Merchants Capital and/or License Tax: Either of the above can be levied by counties, cities, or towns in Virginia. Capital is defined as inventory of stock on hand, certain rental passenger cars, all other taxable personal property except money, accounts receivable over bills, accounts payable, and tangible personal property not offered for sale or merchandise. The nominal tax rate and the percentage of the property tax that is subject to tax vary by locality.

The license tax is usually based on the amount of gross purchases during the tax year, but it is sometimes imposed on gross receipts instead. Direct sellers of consumer products who conduct business in private residences and maintain no public business location are required to obtain local business revenue licenses.

1.4.2 Major Personal Taxes

The other major source of tax revenues for local cities and counties is individuals.

1. Real Estate and Tangible Personal Property: The real estate tax is imposed on land, minerals, buildings and improvements, mobile homes and standing timber trees. The tangible personal property tax applies to motor vehicles, air craft, campers, trailers, boats and other water craft, and farm machinery and livestock. Some local authorities either exempt or tax at lower rates farm machinery and livestock.

2. Sales and Use Tax: As described earlier, sales and use taxes are collected along with the state sales and use tax.

3 Excise Tax: On items such as cigarettes, admissions, room rentals, and meals certain localities impose a tax, which vary from one locality to another.

4 Utility Taxes: Individuals as well as businesses are levied a tax on their use of municipal utilities.

1.5 Literature Review

Studies of the impact of income and the tax rates on tax revenues and tax base at the state level go as far back as the early 1950s. Most of these studies are indirectly relevant to the present study, since they were concentrating only on the income elasticity of tax revenues, that is, the responsiveness of tax revenue to changes in tax payers' income. Although earlier studies neglected the issue of rate elasticities, with the development of methods to estimate income elasticities, the issue of the impact of tax rate changes on the tax revenues was addressed indirectly. Therefore, the following literature review will trace the development of methods used to estimate rate elasticities through the studies that were explicitly done to estimate income elasticities.

Early research was concerned with the stability of tax revenue, for successful implementation of state expenditure plans. One of the earliest studies was by Grooves and Khan (G-K) (1952). They raised the point that although built-in stability of tax structure at the federal level was desirable, the concern of the individual states had been less with controlling business cycles and more with revenue stability throughout the cycle, in order to permit orderly planning for development purposes. Hence they suggested it was more desirable for elasticities to be less than one for the total of state and local tax revenue with respect to income. With this hypothesis in their highly quoted study they used the following model to estimate elasticities.

$$R = aY^b$$

where R = tax revenue
y = state income payments to individuals
a = constant term
b = income elasticity of tax revenue

They wrote:

> stability of revenue is, properly speaking, a special case of adequacy. By adequacy is meant not only the capacity of a particular tax to produce a given initial amount of revenue but also its capacity to sustain this level in such a manner as to permit the maintenance of a given volume and quantity of governmental services.(p.87)

In their empirical work they demonstrated, using time series data from seven states (for periods where yields remained relatively uninfluenced over a reasonable period of time by changes in the law concerning rates, definition of tax base, or administration), the following: For certain types of taxes like the poll taxes, the administered property taxes and licenses, the elasticity coefficient was 0.8 or less, for sales taxes it was close to unity, and for individual and corporate net income taxes the coefficient was generally above 1.5. They showed, however, that when all taxes are combined in the state and local tax system, the overall (state and local) elasticity coefficient is such that there may be no stability problem.

During times of changing prices, money income changes proportionately to the price level. Thus the tax revenue also has to change in the same proportion for the stability criteria to hold. Therefore, although they did not perform empirical tests, Grooves and Khan hypothesized that tax yield should depart from zero elasticity to the extent that variations in income are due to price changes. Also they stated that the degree of elasticity of a graduated income tax depends on the distribution of income as well as the rate schedule.

Netzer (1958) used the same model as G-K and estimated the income elasticity of property tax revenue. His estimate of elasticity (1.0) was much higher than that of G-K (0.22). This difference can be attributed to the following factor. G-K used property tax assessments to measure elasticity, whereas Netzer used estimates of the change in market value of taxable property, or in other words he used property tax at a constant effective rate. Mushkin (1961) examined the income elasticity of the property tax base (full market value) in five states that had initiated market sales-ratio or appraisal studies for equalization purposes.

Unlike the above studies which used time series data, Kurnov (1963) used cross sectional data of the full value of locally assessed taxable real property for 48 states. He used the cross sectional data with the equilibrium assumption that the relationship between income and market value of taxable property among states for a given year reflected the relationship over time between the aggregate income and the aggregate market value for all states. Kurnov used state personal income as the independent variable and market value of different types of property as the dependent variable in separate equations. Except for farm property, all the other elasticities were nearly one. This verified Netzer's finding.

In a multistate study Davis (1962) tested the hypothesis that revenues from consumption taxes are insensitive to income. This hypothesis had been put forward by many before him, though not empirically tested (Saligman 1925, Hanson 1960, Ross 1957, Hanson and Perloff, 1944). Davis's hypothesis is based on the following assumptions: The sales tax revenue has a positive relationship to personal income. Since revenue, per se, rises and falls with business activity, the sales tax levy exerts a dampening impact on changes in income. In the very broad sense, consumption levies along with almost every other kind of tax inhibit counter cyclical characteristics. In an effort to isolate exogenous influences on tax collections, revenue was adjusted for rate of taxation. Here it was assumed that distribution of income did not appreciably affect tax revenues. Using sales tax revenue as the dependent variable, the estimated geometric average of coefficients of income were not significantly different from one. Davis noted that if the consumption taxes are insensitive to real income the estimate must be equal to zero. But when nominal income was used, without adjusting for trends, it included changes in prices as well as effects due to changes in population and technology. He found that, for a given change in income, 25 percent of that change was, on the average, associated with changes in prices. With trend factors, the evidence is consistent with unit elasticity of income and thus instability. Davis stated that the possibility of an income elasticity greater than one lies in the specific relationship that exists between the tax base and income. The exemption of food and certain services, for example, may permit taxable consumption to have an income elasticity that exceeds one. In such a case, a proportional tax rate on an income elastic base will produce revenues which are also income elastic.

Bridges (1964) estimated the income elasticity of the property tax base using state cross sectional data. He pointed out the problems of using time series data such as changing income elasticity over time and the unavailability of time series data for market value of the property tax base. He used estimates of market value of locally assessed real property to estimate the income elasticity of the property tax base. He also suggested that, in order to take into account any population differences among states, it was more useful to use per capita elasticities.

Wilford (1965) was the first to concerned about the tax-rate-revenue elasticity coefficient of various taxes. This coefficient is instrumental in explaining the revenue responsiveness of statutory tax rate changes. Prior to Wilford's study, the income elasticity of tax revenue was estimated by adjusting the tax revenues to changes in taxes rates. That is, revenue figures were converted to a common basis to show the amount of money collected per one percent of tax. This implied the revenue-rate elasticity would be equal to one.

Mathematically:

$$(1.1) \qquad \frac{\partial R}{\partial r}\frac{r}{R} = 1,$$

where r = statutory tax rate or average tax rate, and
R = Tax Revenue.

Alternatively, Wilford used the following model:

$$(1.2) \qquad \log R = \log c + e \log Y + f \log r,$$

where: Y = aggregate personal income.

Hence the implicit assumption of f= 1 in adjusting revenue data can substantially alter the estimated coefficient, e, and mislead interpretation of revenue-yield stability of the taxes under study. The estimates of the rate-revenue coefficient indicated that the assumption of unit elasticity was incorrect. He suggested that if the purpose of raising the tax rate was to obtain a maximum increase in revenue, then taxes exhibiting the highest revenue-rate elasticity should be preferred, since demand for these goods is generally insensitive to price changes (ex. cigarettes and alcoholic beverages).

Wilford also questioned the use of aggregate income as an independent variable. If the goal of the state is development (which Wilford defined as increase in per capita income) rather than just growth (increase in the aggregate income), then population plays a major role in the specification of the model. By extending the analysis to per capita income elasticities, he estimated that per capita income elasticities were much larger than those found using aggregated data. He suggested that for those states encountering substantial growth in per capita income, the relevant revenue-income elasticity coefficient for policy decisions should be based on per capita income. Other areas find their advancing aggregate incomes offset by population growth and thus the aggregate income figure may be more appropriate for computing the revenue-income elasticity coefficient.

Harris (1966), in an attempt to circumvent the problem of rate and base changes, applied sets of effective rates to a size distribution of adjusted gross income for the period 1952-61. The effective rates were calculated using standard deductions for single tax payers and married couples with two children. The resulting "synthetic" tax series was regressed upon personal income using:

$$\log R = a + b \log Y \qquad (1.3)$$

The method used by Harris assumes that each joint return takes the standard deduction and four exemptions. On this assumption, he estimated the tax for a joint return of the mean tax payer in each income class in the base year. Harris assumed that each single return takes one exemption and the standard deduction and estimated the tax for a single return of the mean tax payer in each income class in the base year. He then calculated the effective rates in the base year for a single and a joint return. These effective rates were weighted by the proportion of joint (p_j) and single ($1 - p_j$) returns in each year, yielding effective rates each year. These effective rates were used to simulate tax revenues from income in each income class for all years.

Singer (1968) suggested a method of using dummy variables to take account of changes that occurred in the tax rate. Dummy variables were introduced whenever there was a change in rates, taxable income base, or withholding procedures. All these changes can be approximated by dummy variables taking the value of 0 before the change in rate, base, or federal law and the value of 1 after the change.

The models he tested were:

$$(1.4) \qquad T = a + bY + \sum_{i=1}^{n} c_i D_i \quad i = 1,n,$$

$$(1.5) \qquad \log T = a + b \log Y + \sum_{i=1}^{n} c_i D_i \quad i = 1, n,$$

where;

Y = aggregate and per capita income,

T = Tax revenue,

D = Dummy variables.

He also used slope dummies to test whether the significance level of coefficients would change, but they did not make any difference. The logarithmic model did not show any superiority over the linear model in terms of goodness of fit or significance level of coefficients.

Legler and Shapiro (1968) reiterated that adequacy means (and requires) that tax revenues, to support increasing demands for public services, rise more rapidly than personal income. He observed that, in response to financial crisis, many states have adjusted the tax structure in a patchwork basis. Though they did increase their tax revenue, in many states the result was a proliferation of individual tax levies which caused voter opposition to rate increases and new taxes.

Legler and Shapiro stated that studies by G-K and Wilford (1965) had two weaknesses:

1. They suggested that state tax revenues vary with income, but ignored the specific mechanism by which revenue vary.

2. These studies were based on the assumption that the yields of one tax are unaffected by the yields of any other tax. Thus the responsiveness of a given tax to growth in income was examined independently of other taxes.

By using aggregate revenue from a number of tax sources, G-K took the interdependence into consideration but they ignored changes in tax rate. Wilford (1965) relaxed the assumption of unitary rate elasticity of total revenue. But he ignored the interdependence aspect. Legler and Shapiro showed that for the unitary rate elasticity assumption to hold, demand for goods has to be perfectly inelastic.

Wilford (1965) also observed that if population is constant and per capita income rises, then the marginal propensity to consume (MPC) and the composition of the market basket change. This in turn affects the responsiveness of sales tax receipts to income changes. The market basket is important when the sales tax is not general and/or incorporates exemptions or non-taxables. However, Legler and Shapiro pointed out that Wilford (1965) failed to account for the interrelationships among the individual taxes and the relationship between population and per capita income effects. Legler and Shapiro introduced a model that considers the entire tax system, dropping the assumption of independence and allowing tax changes to alter relative prices throughout the economy.

For example, considering an economy with two goods, of which only one is subject to a sales tax, would yield the following identities:

(1.6) $TE = Cu + Ct_{(1+r_2)}$

where:

TE = Total expenditure,

Cu = Expenditure on untaxed good,

Ct = expenditure on taxed good, and

(1.7) $TR = r_1 Y + r_2 Ct,$

where:

r_1 = income tax rate,

r_2 = tax rate of taxed goods,

Y = income, and

TR = total tax revenue.

They stated that the distribution of consumption expenditure between taxed and untaxed goods is determined by income and substitution effects. As income changes, the distribution of consumption expenditure between luxury and nonluxury goods changes. If only luxury goods are taxed, tax revenue will increase faster than income. The second effect is the price or substitution effect. As the sales tax is raised, ceteris paribus, taxed goods become relatively more expensive than untaxed goods and, to the extent that there are significant cross elasticities of demand for taxed and untaxed goods, consumers buy more of the untaxed goods. Thus the consumption function for taxed goods is written as:

(1.8) $Ct = Ct(y, Y, N, p, r_2)$

Where:

y = per capita income,

Y = income,

N = population,

p = relative price,

r_2 = sales tax.

Note that in the above equation, since both y and N are included, Y does not contribute any new information. Hence in the tax revenue equation Legler and Shapiro dropped the Y variable. Thus:

(1.9) $(R) = R(y, N, p, r_1, r_2)$

where, R = tax revenue.

Also, in estimating the equation, the relative price of taxed versus untaxed goods (p) was dropped, based on the assumption that the relative prices have not changed over the sample period, and average income tax rates were used to overcome a degrees-of-freedom problem.

For the first time in the literature, in this area of research, Legler and Shapiro observed that cross elasticities are also important. For example, when the income tax rates increase, disposable income is reduced, which in turn reduces the consumption of taxable goods, resulting in a drop in sales tax receipts. The final outcome on tax revenue depends on which effect dominates. Equation 1.9 provided a means of determining the responsiveness of state tax revenues to changes in growth and policy variables. The coefficients are particularly useful in analyzing the adequacies of a state tax structure and in making policy recommendations when they are used in conjunction with trends in per capita income and population growth. For, example the empirical results for California showed a high per capita income elasticity and an insignificant population elasticity, although the population growth rate was greater than the per-capita income growth. Hence it was concluded that the California tax structure did not take advantage of the type of growth its economy was experiencing.

Wilford (1965) used the tax rate as an explicit independent variable. Ray (1966) added an index to measure changes in the legal definition of tax base since the tax base is also determined by the state legislature. He showed that, by omitting the tax base variable, income and the error term will be correlated since with changes in income, tax base changes too. Hence omitting the effects of tax base changes results in biased estimates.

Mushkin and Lupo (1967) used proxies for the tax base and effective tax rates to compensate for interstate variations. To predict future tax revenues, they used historical trends in the tax base rather than historical trends of tax revenue. This technique automatically built changes in tax rates and structure over time without distinguishing yields of altered tax rates from yields flowing from economic growth.

Their model was:

(1.10) $\log B = \log A + e \log Y,$

where: B = taxable sales and use tax base.

Liu (1969), reviewing Legler and Shapiro's findings while acknowledging their contribution of relaxing the assumption of the independence of tax revenues, was critical on a number of other grounds. Liu showed that, to get unitary revenue elasticity expenditure on taxable goods would have to be perfectly inelastic with respect to the tax rate. He criticized their assumption that state income and growth were independent of tax yields on the grounds that it isolates the relationship between government revenue collected from its own sources and government expenditure, which may in turn, give some feed-back effect upon state income and growth. In short, a simultaneous relationship seems to exist among the variables of population, state income and wealth, consumption expenditure, and tax yields. Hence, Liu suggested, it may be more desirable theoretically to use a simultaneous equation model with tax revenues, government expenditure, and state per capita income as dependent variables. He also mentioned that, rather than dropping the relative price variable between taxed and untaxed goods, a weighted consumer price index should have been used.

Singer (1970), reviewing past studies, observed that they suffered from a major analytical shortcoming by assuming that elasticity of tax revenue with respect to income was constant over a wide range of income. As GNP and personal income (PY) increase secularly, aggregate taxable income rises (at approximately the growth rate of GNP and PY), and taxable income (TY) per tax return rises at the same rate less the rate of increase in population. In this process, Singer identified three phenomena:

(a) Exemption effect: at low levels of income, small increases in personal income or adjusted gross income are accompanied by very large percentage increases in TY (from a zero base) and very high income elasticity. It vanishes only when all tax-payers have positive taxable income.

(b) Rate effect: the high income elasticity of taxable income resulting from the exemption effect will continue under a rate effect. That is, under a progressive rate structure, increases in taxable income per return will cause effective average and marginal tax rates to rise, and tax revenues will rise more rapidly than taxable income. Once all the tax-payers have reached the maximum marginal tax rate, the rate effect will vanish. Till then the increase in tax revenue will be greater than the increase in taxable income.

(c) Base effect: future values of income elasticity will then depend on the base effect, that effect being the extent to which the taxable income base increases at a rate different from the rate of growth in adjusted gross income (AGI) or PY. On the basis of the slow growth rate of deductions and exclusions (such as transfer payments), the base effect seems likely to yield elasticities slightly greater than unity, over a wide range of tax revenues and personal incomes.

The simple regression equation models used by researchers like G-K are acceptable at the federal level since the exemption effect is met at very low levels of income and the range of progressivity extends to very high income levels. The estimate of income elasticity will then include both rate and base effects, which may be assumed to remain stable over a wide range of AGI and PY. States, however, do not have rate schedules as progressive as that of the federal government. Therefore, when the usual estimation method is used, the elasticities estimated will tend to overstate the true elasticity of income by an increasing amount as the rate effect contributes smaller and smaller increments to total revenue. With these effects in mind, Singer suggested a state level model in which tax revenue depends on total income and its distribution.

Berney and Freiches (1973) evaluated various methods used for estimating elasticities to see whether elasticity coefficients were sensitive to methods used. Using actual tax revenues and predicted tax revenues, they calculated a ratio. They concluded that especially when there have been significant changes in both the tax rate and the tax base, multivariate regression models predict the tax revenues more accurately than do simple regression models.

Williams et al. (1973) suggested that further work is needed to measure the short-run impact of the determinants of tax yield and proposed the following equation to measure the short run cyclical performance of various taxes.

(1.11) $$\frac{\Delta R}{R} = d + e\frac{\Delta Y}{Y}$$

Where; e = average short-run coefficient of income elasticity of revenue

d = constant term

Williams et al. argued that, since rate and base changes are built in by legislative action, revenue should not be adjusted for changes in rate or base for calculation of elasticity coefficients. This approach appears to beg the issue of utilizing regression equations to estimate state revenue and avoids the arduous task of weeding out the many rate and base changes over a typical sample. Hence the resulting elasticities are almost meaningless.

Wilford (1975) in a subsequent study, rather than using the tax rate as an explicit independent variable, used dummy variables for rate and base changes. For the income variable he used the gross state product and gross state product per capita in separate equations. He estimated both linear and logarithmic functional forms for Louisiana. For the dependent variable he used various categories like sales tax, personal income tax, etc. In terms of comparability with the earlier studies, the per capita elasticities were higher than aggregate gross state product elasticities. Different functional forms did not give significantly different estimates. He found that most of the Louisiana taxes show low responsiveness to change in state income. Also since only 57 percent of state revenue was from income-related bases, there was a high reliance on non-income bases (severance revenues). Thus he suggested a more income elastic revenue base.

Wasylenka (1975), reviewing the article by Harris, noted that the assumption that tax payers in all income classes take the standard deduction results in an overestimate of the effective tax rate and biases the estimate of the income tax elasticity upward. He also noted that Singer (1968) used dummy variables to take account of discretionary changes in the tax structure but that a single intercept dummy may not be sufficient to capture the effects of the discretionary changes in the tax structure on tax revenues. A discretionary change may result not only in a change in the intercept but also a change in the slope or elasticity. Hence, the addition of slope dummies will cause a substantial loss in the degrees of freedom. Wasylenka suggested an alternative method of estimating the income elasticities of state personal taxes. His method isolates the non-discretionary changes in tax revenue in response to income and calculates the effective tax rates directly. In this method a base year is first selected. Second, the effective base ratio in each income class in the base year is calculated as the ratio of taxable income (i.e. total income minus deductions and exemptions) in each income class to the total income in the income class. Then the effective tax rate is calculated as the ratio of the tax liability to taxable income in each income class. Using these rates he was able to estimate the tax base and tax revenues that would have been collected each year if the income had been subjected to the tax structure of the base year. He also refined the above method to account for the changing characteristics of types of returns in any income class over time. Basically, he corrected for the fact that the lowest income classes submit a smaller percentage of joint returns (families) than the same income class did ten years ago.

One of the first studies to suggest that base selection can influence the income elasticity of a sales tax was the 1962 study by Davis. He said "The possibility of an income elasticity greater than 1.0 lies in the specific relationship that exists between the tax base and income. The exemption of food and certain services, for example, may permit taxable consumption to have an income elasticity that exceeds one. In such a case a proportional tax rate on an elastic base will produce revenues that are also income elastic." Legler and Shapiro estimated for several states the elasticities of total tax revenue to per capita income, population, and individual tax rates. They pointed out that a rate change in one base, because of deductibilities and other factors, has effects on revenue collected from other tax bases. Thus the effect must be netted out to obtain the influence of total revenue. Therefore, though Legler and Shapiro accepted, in principle, the influence of base choice on elasticity, they did not test it. Friedlander, Swanson, and Due (1973) compared the income elasticity of sales tax revenue of 15 states, where the sales tax base was different. They concluded that the base does not seem to be a prime determinant of revenue elasticities. Mickesell (1977) observed that although consumption theory suggests that different goods will have different income elasticities, it has not been possible yet to pull out the different pieces of the base. As a result, the influence of base selection on revenue elasticity is unclear. Mickesell, in order to clarify this using data for Illinois, used bases which did not change much over time. The equation fitted was as follows:

$$(1.12) \qquad \ln R = a + b \ln pinc + b \ln rate + b \ln relp + b \ln expr + u$$

Where:

R = revenue collection from the particular business group,

Pinc = Illinois personal income for the year,

rate = the statutory state sales and use tax,

expr = the current year gross national product deflator relative to recent price level experience (The average of the last two years),

relp = The price deflator for the expenditure class relative to the current gross national deflator (to identify the effect of changes in relative prices on consumption patterns),

u = error term.

Mickesell focused on individual sales group activities or different bases. The results indicated that the major base components have positive coefficients, and the income elasticity of tax revenue was not significantly different from 1.0 at the 0.05 level of significance. But there were differences between individual group elasticities, suggesting that the relative collection from business groups would be altered. Hence he concluded that the components of the sales and use tax base do respond differently to changes in personal income. Therefore, he suggested that components of the sales tax base be considered as candidates for selective inclusion and exclusion from the sales tax base for increasing responsiveness.

Although it has not been established in a formal statistical analysis, Greytak and Thursby (1979) observed that state income taxes are associated with declining elasticities. Using a model developed by Box and Cox (1964), this proposition was evaluated by them relating revenue from New York state personal income tax to income tax revenue. Their principal finding was that the revenue-income relation in New York could be characterized by declining elasticity based on the base and rate effect. Greytak and Thursby (1980) replicated the same study for Maryland income tax and considered the *source effect*. Briefly the source effect refers to changes in the relative proportion of income subject to tax (example of non-taxable parts are transfer payments, employee contributions to welfare and pension funds, sick pay, and interest on state and municipal bonds). Differences in the relative growth rates of taxable and non-taxable income, other things equal, alter the rate of revenue growth relative to income. Again they used the Box-Cox method which allows the data to discriminate among alternative functional forms. To take into consideration the *source effect*, a revenue-personal income relation was estimated. It appeared that when allowance was made (ie. excluding transfer payments, etc.) for *source effects* as well, the income elasticity of the income tax was characterized as declining. They concluded that, whatever force may be attributed to base and rate effect, it is not sufficient to justify the a priori generalization of a declining income elasticity.

The relation most likely to be affected by base and rate effects (the revenue elasticity with respect to adjusted gross income), was found to conform to the constant elasticity function. Thus the base and rate effect is not sufficient for declining elasticities, but with personal income (adjusted to account for *source effects*) declining elasticity was evident. Lehman (1976) attributed this finding to the following reason. There has been a long-standing nationwide shift in the source composition of personal income. As a result the attendant differentials in the rate of taxable and non-taxable income growth have steadily reduced the share of personal income, i.e. adjusted gross income, that is subject to taxation.

Many have used the Cobb-Douglas function to estimate income elasticities with the assumption of constant elasticity, i.e. over time the relationship between revenue and income is independent of the imposition of taxes and changes in the revenues from existing taxes. Goode (1984) noted that in a developing country context, tax bases of broad-based income and consumption taxes tend to grow faster than the gross domestic product since the taxed sector grows faster than the untaxed subsistence sector leading to increasing inter-temporal elasticities. Increasing tax elasticities may also follow from improved tax enforcement and administration or from increased use of ad-valorem rather than specific taxes (Leuthold, 1986). Leuthold tested the hypothesis that tax elasticities fluctuate over time, using data from the Ivory Coast. She used a model developed by Box and Cox (1964). Her results showed that elasticities varied, which implies difficulties in obtaining accurate forecasting of tax revenue for policy purposes.

The latest study on this subject was by Sexton and Sexton (1986). They observed that income elasticities provide a potentially cost-effective means to forecast local government revenues and for policy analysis since they may be used to judge the behavior of tax revenues over business cycles (revenue stability) and the capacity to generate necessary growth in revenue (revenue adequacy). Unlike the log-linear models used earlier, Sexton and Sexton used a non-linear model for property valuation and looked at the residential component of the property tax base for county level data in Minnesota and Kansas. They used a structural model for property valuation, explicitly recognizing the importance of both supply and demand sides.

1.6 Chapter Summary

The above literature review highlights the developments that have taken place during the past 35 years in the analysis of the relationship between tax revenues and tax bases, and income and tax rates. The very early studies used simple regression techniques to estimate the income elasticity of tax revenue for different tax bases. In these studies it was implicitly assumed that the rate-revenue elasticity was proportional, and possible interdependence of tax revenues was ignored. Subsequent studies took into account the interdependence of tax revenues, and treated tax rates as independent variables, or used dummy variables to take into account any rate and base changes.

In the early studies, stability of tax revenue was the concern. Hence an inelastic income elasticity was considered a desirable property. However, subsequent authors highlighted the importance of adequacy of tax revenue to meet public demands with increasing incomes.

Certain studies also showed the importance of considering the relationship between progressive taxation and distribution of income. Also, the relative importance of income growth and per capita income growth in income elasticity estimation was highlighted.

Most of the studies conducted so far have concentrated on income elasticities. To avoid specification errors, tax rates were included in the estimations as independent variables, but the policy implications of tax rate elasticities were not explicitly considered. Almost all the studies used state-level time-series data with the usual econometric problems associated with short data sets. All the estimations used single equation regression techniques, ignoring the simultaneous relationships among the variables. While acknowledging the importance of the income elasticity of tax revenue for predicting future tax revenues, the importance of rate elasticity of tax revenue and tax bases have not been studied in any depth.

Within states, there is considerable flexibility. Local authorities can alter tax rates and tax bases for revenue collections. However, the income elasticity studies concentrated mostly on state level estimations.

By placing differential levels of reliance on those tax bases which positively respond to enhanced tax rates, a local government authority can have a significant effect on the distribution of the tax burden and on increasing government revenue. Hence the present research will develop a technique to estimate the response of tax rate changes on the value of tax bases as well as the cross responses. This estimates will enable policy makers to identify the tax bases that will be likely to contribute most to local tax revenues. Such a finding will help policy makers formulate tax structures that will enhance local tax revenues while reducing the tax burden on the most sensitive bases.

Chapter 2

CONCEPTUAL FRAMEWORK

2.1 Introduction

This chapter reviews several concepts of tax theory in order to understand how constituents behave when tax rate changes take place. The chapter begins with a discussion of the nature of public goods that are financed through tax revenues. Then the discussion is focuses on the theoretical concepts of tax burden and incidence and issues of equity and efficiency related to the above concepts. The Tiebout hypothesis and how it relates to tax shifting is also discussed. Finally, characteristics of different tax bases and how they relate to the above concepts and issues are discussed.

2.2 Nature of Public Goods

There are basically three kinds of goods and services that individuals demand. The first category is those produced by private firms and distributed via the market mechanism. For these goods price will determine the quantity demanded and supplied by firms. Price is generated by the market, through the interaction of buyers and sellers. The second category is goods and services supplied by government. These are comprised of utilities such as water, gas, electricity, and other privately consumed goods. Rather than a price, as in the first category, a user charge, defined as the dollars per unit of good or service produced by the government, is usually levied on the receipt of these goods and services (Hirsch, 1970). The third category of goods and services, public goods, is also supplied by the government. These differ from other goods and services in that they have certain characteristics that make it inappropriate for the market to distribute them. Distinguishing features of these public good include (Johnson, 1986):

1. For many types of services, residents cannot be excluded (or can be excluded only at very high costs). Further, there are, in some cases, no reasons to exclude an individual because that individual causes little or no extra cost.

2. The necessary investments are large relative to the population served, and competition among private firms is unlikely.

3. The production of the good or service is subject to diminishing costs, and a private firm would lose money if it equated marginal costs with price.

Examples of these public goods are maintenance of law and order, supply of educational and health services, building and maintenance of roads, and maintenance of parks and recreation areas.

Due to the three characteristics mentioned above, the use of a price as defined by the market mechanism, or a user charge, for distribution is not possible. Hence the government must resort to taxation of its constituents to finance these services. Public goods are available to everyone since one person's use does not diminish its use by others and to exclude an individual from consumption is very costly.

2.3 Concepts of Tax Theory

Taxation is a major instrument of social and economic policy. According to Pechman (1987), it may be used to achieve some or all of the following goals.

1. To transfer resources from the private to the public sector;

2. To distribute the cost of government fairly by income classes (vertical equity) and among people in approximately the same economic circumstances (horizontal equity).

3. To promote economic growth, stability, and efficiency.

Considering the points of impact in the circular flow of income and expenditure in the economy, Musgrave and Musgrave (1980) classified various taxes based on whether they are imposed on the product or factor market, on the seller's or buyer's side, or on the household's or firm's.

There are two kinds of taxes, personal taxes and rem taxes. Personal taxes are taxes that are adjusted to the tax payer's personal ability to pay, while the rem taxes (taxes on things) are imposed on activities or objects as such, i.e., on purchases, sales, and holding of property.

The distinction between personal and rem taxes is important, when it comes to evaluating the equity of the tax system. For example, rem taxes do not consider the ability to pay; hence they may be inferior to well-designed personal taxes, which do consider ability to pay.

There are two basic differences between federal and state/local taxes. The federal part of the tax system is progressive, thus placing a proportionately heavier burden on those who have greater ability to pay. Federal tax receipts are responsive to changes in business activity and therefore automatically cushion the effects on spending of changes in private income. On the other hand, local taxes are not progressive and are less responsive to changes in income. Thus fiscal crises recur at the state and local level during periods of economic constraints or slow growth (Pechman).

Requirements for a "good tax structure," as identified by Musgrave and Musgrave, are as follows:

> 1. The distribution of the tax burden should be equitable. Everyone should be made to pay his or her "fair share";
>
> 2. Taxes should be chosen so as to minimize interference with economic decisions in otherwise efficient markets; such interference imposes "excess burdens" which should be minimized;
>
> 3. Where tax policy is used to achieve other objectives, such as to grant investment incentives, this should be done so as to minimize interference with the equity of the system;
>
> 4. The tax structure should facilitate the use of fiscal policy for stabilization and growth objectives;
>
> 5. The tax system should permit fair and nonarbitrary administration and it should be understandable to the tax payer;
>
> 6. administration and compliance costs should be as low as is compatible with other objectives (p.235).

Stiglitz (1986) mentioned another desirable characteristic, namely, political responsiveness: the tax system should be designed so that individuals can ascertain what they are paying for so that the political system can more accurately reflect the preferences of individuals. All the above objectives are not necessarily in agreement. When conflicts occur, trade-offs among them must be evaluated.

Of the above criteria the literature has concentrated mostly on the issues of equitable distribution and efficiency of tax structures. Boadway and Wildasin (1984) described the efficiency criterion as follows:

> In diverting resources to the public sector, taxes of different sorts impose varying degrees of distortions on the working of the market economy. These distortions impose welfare losses or dead weight losses on the economy, by causing a departure from Pareto optimality (p.226).

These welfare losses are also referred to as excess burden or the welfare cost of taxation. The efficiency criterion judges taxes by the dead weight loss per revenue dollar collected.

The equity criterion is concerned with how the burden of output reduction in the private sector is distributed among the various members of the society under various taxing schemes. This burden includes dead weight loss and value of real resources transferred out due to taxes. There are two types of equity: horizontal and vertical. With horizontal equity individuals with the same welfare level are treated equally. With vertical equity, individuals with differing welfare levels are treated differently. Hence, to judge the degree to which the tax system is horizontally equitable, a value judgement has to be made about the appropriate way to treat people at different utility levels (Boadway and Wildasin).

With reference to the equity criterion there are two schools of thought: Those who subscribe to the benefit principle believe that an equitable tax structure is one under which each tax payer contributes according to the benefits he or she receives from public services. With this principle, the expenditure structure of the public sector is also important. And those who subscribe to the "Ability to pay" principle would have different income classes treated differently in an equitable tax structure. Here the tax problem is independent of expenditure determination.

Reader (1985) noted that fiscal pressure resulting from revenue efforts (defined as percentage of local income taken in the form of local government taxes and user charges) to raise local government revenue may have several effects, as follows:

1. Higher tax rates increase the cost of living for residents and increase the cost of doing business for rural firms. The economic well-being of the community may decline as a result, and immigration of people and firms may be discouraged. Hence, potential tax base declines.

2. Higher taxes can reduce the flexibility of local government budgets because they bring local government revenue closer to the legal limitation. Because local governments are legally required to maintain balanced budgets, binding tax limitations can prevent a locality from responding effectively to recessions, floods, and other emergencies requiring increased expenditure.

3. Higher taxes can heighten political resistance to additional government spending.

4. Tax payers may react to higher taxes by voting down bond referenda required to raise funds for much needed infrastructure.

Revenue efforts according to Reader (1985) are important in policy making because federal and state programs use them when distributing aid to local governments.

2.3.1 Concept of Tax Burden

When the government collects tax revenues and spends them on public services, an equal amount is not available to the private sector. In other words, the opportunity cost of public services is the gross burden which their provision imposes on the private sector as a whole. Tax incidence refers to the way in which the gross burden is shared among individual households. Since public services result in benefits, the entire transaction has to be considered in the calculation of the net gain or burden or to determine the net incidence. Excess burden or deadweight losses occur when the total burden exceeds the revenue collected because of an efficiency loss, since taxes have interfered with consumer and producer decisions. Also changes in aggregate demand and unemployment due to taxation can result in excess burden (Musgrave and Musgrave).

2.3.2 Concept of Tax Incidence

The incidence or burden distribution depends on several factors, such as how a tax is imposed, what rate structure is used, how its base is defined, and how general is its coverage. Economic incidence depends on how the economy responds. This response, in turn, depends on conditions of demand and supply, the structure of the markets, and the time period allowed for adjustments to occur (after a tax change). Because the levying of taxes affects prices and hence resource allocation, it is apparent that the party (household or firm) who is supposed to pay the tax is not necessarily the one who bears the burden of the tax.

When a tax is imposed on an industry, and the price rises so that all of tax is borne by consumers, then the tax is said to have been shifted forward. If the price rises by less than the amount of the tax, then it has been partially shifted forward. If, as a result of the tax, the demand for factors used in the industry declines, and the price of these factors falls, then tax is said to have shifted backwards.

To take into consideration the effect of a tax change on all prices in the economy would require a general equilibrium analysis. Boadway and Wildasin noted, however, that it may be sufficient to consider only the effect of a tax change in the market in which it is imposed if the change induced elsewhere is small. The primary interest of this research is the effects of tax changes in the product market and not the factor market. Hence the following discussion focuses on a partial equilibrium analysis of the product market.

A product tax (rem tax) may be imposed per unit of product (unit tax), or it may be imposed as a percentage of price (ad-valorem tax). General product or sales taxes are necessarily of the ad-valorem form.

The effect of an ad-valorem tax on a competitive market is shown in figure 1. From the perspective of the seller, the tax results in a downward shift of the demand schedule. Unlike the parallel shift in a unit tax case, the shift takes the form of a swivel from DD to D_1D_1, with tax per unit falling as the price falls. The ad-valorem tax rate, commonly expressed as the ratio of tax to net price, equals GL/EL. The equilibrium shifts from A to L. The price paid by the buyer equals GE, and the net price received by the seller is LE. The amount of tax per unit is GL, and tax revenue equals KFGL. Therefore the amount by which the price rises -- the extent to which the consumer bears the tax depends on the slope of the demand and supply curves.

The elasticities of supply and demand will determine the final equilibrium price and quantity and the tax revenue after a tax change. With supply and demand becoming inelastic the revenue increases, and revenue falls as supply and demand become more elastic. The less elastic is demand, the more difficult it is for the buyer to avoid the tax by switching to other products, just as inelastic supply makes tax avoidance more difficult for the seller (Musgrave and Musgrave).

Stiglitz demonstrated that there are several other important factors -- such as, the impact of complimentary and substitute industries, and the government policy changes needed to balance budgets when tax rate changes takes place -- that need to be taken into consideration for a complete incidence analysis.

Much of the tax incidence theory limits itself to analyzing the effects of taxes on relative prices of goods and factors (incidence on the use side and on the source side of income respectively). However, finally what is required is the impact on relative welfare or utility levels of different persons or income groups. Boadway and Wildasin noted that going from the change in relative prices of goods and factors to the change in relative utility of different persons requires a knowledge of how important the various goods and factors are in each household's budget. For example, a tax change that raises the price of capital and reduces the price of labor will help persons who own relatively large amounts of capital rather than persons who are laborers. Studies which extended tax incidence analysis to personal income distributions have used income as the measure of utility.

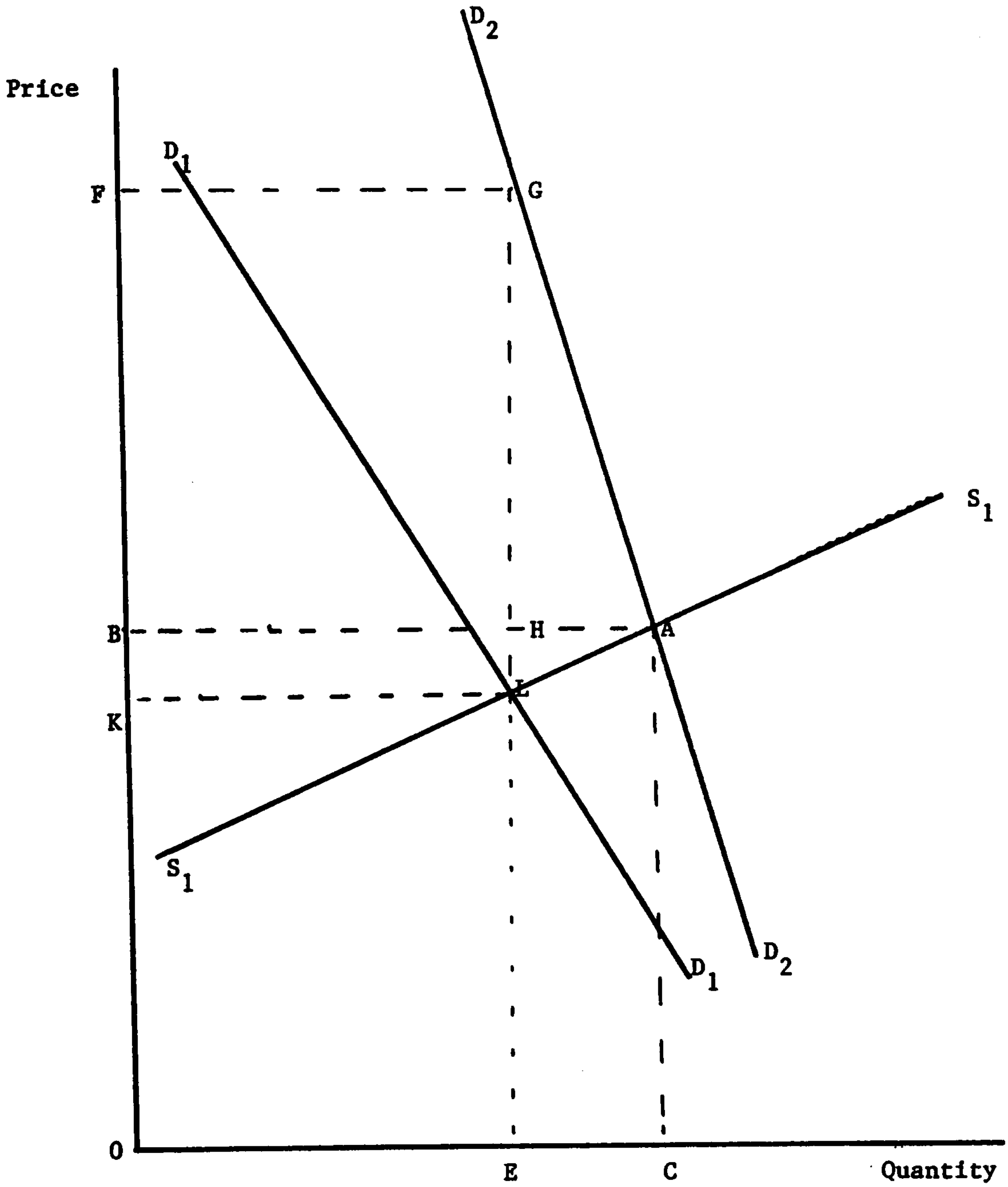

Figure 1. The Case of an Ad-valorem Tax in a Competitive Market

2.3.3 Excess Burden and Efficiency

It was indicated earlier that efficiency is a desirable characteristic of a tax structure. In other words, excess burden must be as small as possible. The excess burden and efficiency issue are addressed in the partial equilibrium analysis below.

Unless imposed in the form of a lump-sum tax, a tax causes an excess burden and can have effects on consumer and producer decisions. Boadway and Wildasin demonstrated the difference between lump-sum and excise taxation (or an ad-valorem tax as commonly used) using a figure such as figure 2.

As shown in figure 2, without any taxes the consumer's budget constraint is AB. With a lump sum tax it moves back to CD where AC is the tax revenue raised in terms of good Y. The consumer equilibrium point is now moved from point i on U_1 to ii on U_2 . The burden of this resource transfer is the difference in utility in going from U_1 to U_2 measured by the amount of income in terms of good Y that is equivalent to the loss of utility from tax. So, the burden of the tax payment is AC, the exact quantity of resources transferred. Therefore, there is no excess burden or dead weight loss with the lump-sum tax, because the lump-sum tax does not distort relative prices of X and Y. To raise the same amount of revenue through excise taxes, the price of X to the consumer must rise until the consumer achieves an equilibrium along the line CD, which represents the locus of all points that yield the amount of revenue AC. Responding to such prices, the consumer will be left at point iii on indifference curve U_3. The increase in the relative price of X due to the tax increase results in a point iii which will be on a lower indifference curve than U_2. Therefore, in this model, an excise tax is definitely

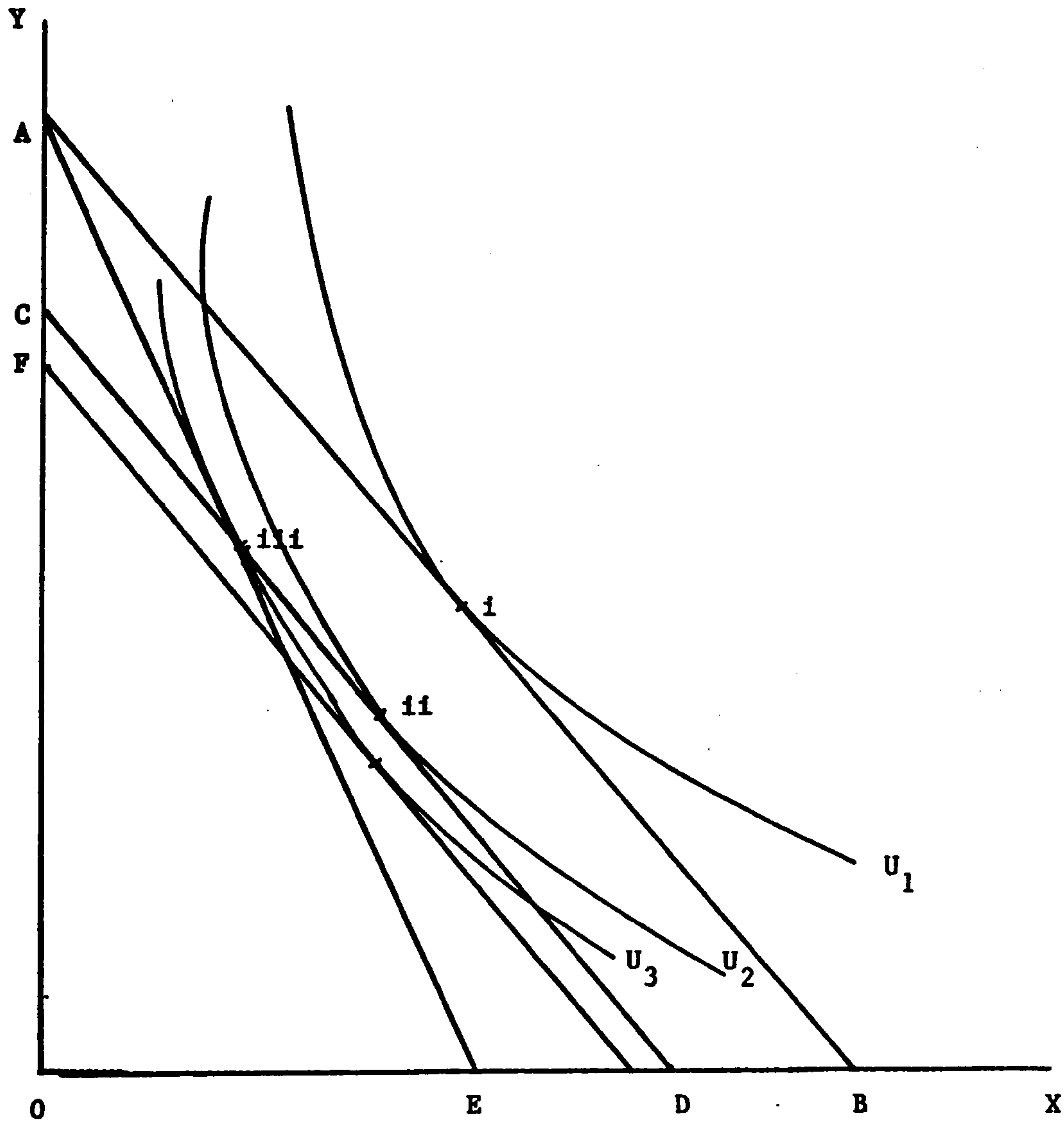

Figure 2. Difference Between Lump-Sum and Excise Taxation

inferior to a lump-sum tax. The excise tax imposes an excess burden or dead weight loss of CF in terms of good Y evaluated at the old prices.

An efficient policy, therefore, should minimize this burden, or efficiency cost. The problem with a lump-sum or head tax is that it is not acceptable on grounds of vertical equity. But the difficulty of the ad-valorem type of excise taxes is that they cause an excess burden. Therefore an efficient tax policy must strike a balance between these competing criteria (Musgrave and Musgrave).

The excess burden or dead weight loss demonstrated in a partial equilibrium analysis for a single individual can be extended to the entire economy by substituting a production possibility curve for a budget line, and a social indifference map for an individual one, as in Little (1951) and Friedman (1952). Boadway and Wildasin demonstrated that the excise tax is inferior to a lump-sum tax since it violates the Pareto optimum conditions: i.e. the marginal rate of product transformation between two goods was not equal to the marginal rate of substitution for the same two goods for an individual, in the presence of a non lump-sum tax.

Boadway and Wildasin also observed that some excise taxes may actually reduce, rather than increase, the dead weight losses in the economy. This will be the case when a tax is levied to correct situations such as external diseconomies arising out of the workings of the market economy. The excise tax can improve the allocation of resources, for example, taxes on such commodities as alcohol, tobacco products and gasoline, since there are many externalities caused by the use of these products that are not compensated through the market mechanism.

The above discussion considered taxation of a single commodity. When both commodities are taxed, the excess tax burden is smaller for the commodity which has the more inelastic demand or, in other words, the same tax revenue can be obtained by taxing the commodity with the more inelastic demand at a lower tax rate. Hence, on efficiency grounds the more inelastic commodity should be taxed.

2.3.4 Equity Issues of Taxation

According to Boadway and Wildasin the efficiency criterion treats a dollar as being of equal social value, no matter to whom it accrues. Therefore it does not take into consideration the vertical equity criterion. With horizontal equity as defined earlier, one has to make value judgments to compare the well-being of two persons. Even with the same income levels, individuals may not be equally well off. However, with income taxation, deducting expenses such as educational expenses and adjusting taxable income to family size help to identify individuals with different levels of welfare.

Vertical equity to has its own problems. Haig (1921) and Simon (1943), suggested a "comprehensive income base" as an equity measure, reflecting the individual's ability to pay. This base includes all incomes of an individual, regardless of source or use. Although this sounds reasonable in terms of vertical equity, for reasons such as different tastes and sources of income, horizontal equity would be violated. Some difficulties with calculating the base as defined above are; adjusting for inflation, fluctuating incomes, and taking care of non-market transactions. Two other measures suggested for an equitable tax system are consumption expenditure and wealth of an individual (Kaldor, 1955, and Mead, 1978).

With administration of tax systems, the cost of administration has to be weighed against the revenue collected. For example, the marginal dollar of administrative cost has to be balanced against the value of more equitable administration.

2.3.5 Burden Avoidance

Before describing specific tax bases, it is important to note the behavior of individuals towards taxation generally. Since tax burdens decrease individuals' incomes, changes in tax policy lead to *tax shifting* strategies, that is, adjustments in behavior in response to changes in tax liability assessments. This behavior is known as *burden avoidance.* Thus the tax burdens are shifted from some tax payers to others who, while they alter their behavior, accept part of the increased tax burden rather than the costs required for complete burden avoidance. The degree of burden avoidance is mainly dependent on how specialized the resource is to a particular employment; the higher the specialization, the lower the degree of burden avoidance. According to Hirsch a resource is specialized if the wage the resource is receiving in its current employment is greater than the wage the resource could earn in its next best alternative employment. Hence the owners of resources earn a *rent.* When confronted with a change in tax incidence or taxation policy, resource owners weigh the costs of shifting the employment outside the jurisdiction versus the gains from burden avoidance. Specifically, resources such as land are heavily geographically specialized and, hence, burden avoidance is very difficult. On the other hand, less specialized resources will be faced with lower costs of burden avoidance. The same arguments apply to firms. A firm can either pass the tax increase on to the consumer (or employees), or move to another jurisdiction.

Another important aspect Hirsch identified was complimentary and substitution relationships among specialized and unspecialized factors of production. For example, if a factor of production leaves the jurisdiction, the marginal product of the specialized, complimentary factors left behind are reduced. Substitute factors enjoy an increased marginal product. This latter effect will mitigate outmigration of the other less specialized factors.

2.3.6 The Tiebout Hypothesis

The Tiebout hypothesis is a concept used to explain how constituents make their preferences for local public goods known (Tiebout, 1956). This theory suggests that constituents "vote with their feet"; that is, they move from one jurisdiction to another in order to receive the public services (and local public goods in general) that most closely match their preferences. There may be obstacles in terms of family ties, job commitments, etc., for such mobility. However, with the growing urbanization of society such constraints tend to be reduced and there is some reason to believe that the Tiebout hypothesis is relevant to the real world. Therefore, the attraction of more people to a particular locality affects the value of property as well. In the Tiebout framework, the individuals' tax liability is the price he or she has to pay to enter a community and consume locally provided public services (Oates 1969).

The theory assumes:

1. Perfect mobility of consumers;

2. Perfect information;

3. A large number of communities offering a wide choice of public services and tax rates;

4. No labor supply or production effects related to choice of residence;

5. No spill-over effects between communities; and

6. Each community has an optimal size;.

This hypothesis helps us understand why individuals who reside in one location (due to better public services) would commute to another location for employment. Hence it is mainly concerned with residential choice. Johnson (1986) however, suggests that by relaxing assumptions 4 and 5, the hypothesis can be generalized to explain some of the location behavior of industries. The Tiebout hypothesis assumes perfect mobility, implying zero re-location costs. However, as discussed earlier, relocation takes place only if savings from burden avoidance outweigh costs of relocation. Hence, in order to use the Tiebout hypothesis to explain location behavior of industries as a response to changes in tax policy, these transaction costs including moving costs must be considered. Relative to tax policy changes, different services offered by different jurisdictions will have to be considered. Depending on the structure and the quality of services, one group of public services is expected to attract households more than employers, resulting in out commuting, while another group of services and a different tax policy will discourage households and encourage firms, thus leading to in-commuting. Thus the relocation of businesses is a function of the tax structure, relocation costs, and the type of services rendered by the local government.

Johnson (1986) made theoretical arguments based on the Tiebout hypothesis with regard to inmigration and outmigration of the labor force. The location of the employment, as described earlier, directly affects the income tax base. But at the local government level, the income tax base is usually irrelevant. Hence, it is important to understand how the

Tiebout hypothesis has implications for the expenditure and wealth base. When tax policy changes, constituents may commute out of the jurisdiction to purchase the taxed goods, or they may even move their businesses out of the jurisdiction. Hence, shifting may occur between jurisdictions as predicted by the Tiebout hypothesis.

2.3.7 Elasticity

Elasticity is verbally expressed as the percentage change in one variable associated with a one-percent change in another.

Mathematically:

(2.1) $\quad if\ y = f(x_i)$

then the elasticity with respect to x_i is:

(2.2) $$\eta_{yx} = \left(\frac{\partial y}{\partial x_i}\right)\left(\frac{x_i}{y}\right)$$

where, η_{yx} = elasticity of y with respect to x.

a. Income elasticity of tax revenue or revenue elasticity: Revenue elasticity is the responsiveness of tax revenue to changes in tax payers' income over time. Its magnitude is directly related to a jurisdiction's tax system, structure, and rate which, together determine the level of future tax revenue.

b. Rate elasticity of tax revenue and rate elasticity of tax base: This is the concept that is of most interest in this research. Rate elasticity is the responsiveness of tax revenue or tax base to a one-percent change in the tax rate.

Mathematically, if:

TR_t = tax revenue from a tax base at fiscal year t,

R_t = Tax rate for a particular tax base at fiscal year t, then:

$$(2.3) \qquad \Delta TR = (TR_{t+1} - TR_t)$$

$$(2.4) \qquad \Delta R = (R_{t+1} - R_t)$$

$$(2.5) \qquad \eta_r = \frac{(\frac{\Delta TR}{TR_t})}{(\frac{\Delta R}{R_t})}$$

It is important to note that there is a close relationship between the rate elasticity of tax revenue and the rate elasticity of the tax base. Mathematically, it can be expressed as follows:

$$(2.6) \qquad TR = (TB)R,$$

$$(2.7) \qquad \frac{\partial TR}{\partial R} = \frac{\partial((TB)R)}{\partial R}$$

$$(2.8) \qquad \eta_r = \frac{\partial TR}{\partial R}\frac{R}{TR} = (\frac{\partial TB}{\partial R}R + TB)\frac{R}{(TB)R} = \eta_b + 1$$

where:

TB = tax base,

R = tax rate,

η_b = elasticity of tax base

η_r = elasticity of tax revenue

Therefore, rate elasticity can be defined as the percentage change in tax revenue or tax base for one-percent change in the tax rate. If for a moment the public expenditure effect is ignored, it would be reasonable to expect the tax base to decline with an increase in tax rate, because economic agents will move economic activity elsewhere or will invest in a less taxed base. The own-rate elasticity would indicate the magnitude of response. For example, if the rate-base response is inelastic ($0 > \eta_b > -1$), an increase in the tax rate should lead to an increase in revenue. But if $\eta_b < -1$, revenue will decline.

Own- rate elasticity indicates the response of a particular tax base or tax revenue to a one-percent change in the tax rate of that particular tax base. The tax rates, while having obvious immediate and direct changes on the tax revenue, also have a long-run impact on the size of the base. For example, tax rate changes will influence decisions regarding location of residences and businesses, places of employment, employment of factors of production, and consumption of durable and non-durable goods. As discussed above, depending on the degree of geographic specialization, and costs of relocation, components of tax bases can shift to other jurisdictions. Highly negative elasticities indicate a large depletion of the size of the tax base and revenue to the jurisdiction with changes in the tax rates. An inelastic measure would indicate that rate increases do not affect the magnitude of the base substantially.

Tax rate changes have effects not only on their own tax bases but also on other tax bases as well. This impact can be evaluated via cross elasticities, that is, the percentage change in tax base *i* for a one-percent change in the tax rate of base *j*. In most cases tax bases are expected to be complimentary to each other. For example, an increase in the machine and tool tax rate may increase tax revenue, but if some firms choose to relocate in another jurisdiction due to changes in the tax rates, real property tax revenue, and sales tax revenue will decline. Therefore, in most cases we expect the cross-rate elasticities to be negative. In the short run, due to rigidities and fixed costs involved, one can expect an inelastic response. However, over time the rigidities can be overcome, resulting in a more elastic response.

2.3.8 Price Elasticities and Rate Elasticities

The above account describing concepts of tax burden and tax incidence and issues of efficiency and equity criteria implicitly assumes that price elasticities are the same as rate elasticities. However, in reality individuals may react differently to a tax rate change than they do to a price change. In these instances the shifts in the supply and demand curves with a tax rate change may not be proportional to the tax rate change. The shift will be dependent on the tax rate change as well as the associated price. In fact, if individuals respond differently to price and tax rate changes, it is possible to define a coefficient which may demonstrate the 'willingness to pay taxes.'

For Example, if, β_1 = estimated coefficient on price, and β_2 = estimated coefficient on tax rate, then, $\beta_2 - \beta_1 = k$, where k is a measure of the 'willingness to pay taxes.' A negative coefficient will indicate less 'willingness to pay taxes' than price, while a positive k would mean greater 'willingness to pay taxes'. A positive β_2 would mean that constituents like to pay more taxes. The rationale for the above is as follows. Assume that tax rate increases result in an immediate increase in the total price an individual has to pay. If individuals react more to price changes than to a tax rate change, this behavior indicates that individuals are more willing to pay taxes, thus resulting in a positive k coefficient. On the other hand, if tax revenues are utilized for local public services, and if individuals believe that benefits derived from the additional public services are more than the tax payments, then the value of property will rise. This increase in value will result in a positive willingness to pay tax coefficient. The more positive the coefficient the higher the 'willingness to pay taxes.'

2.4 Characteristics of the Tax Bases

The above concepts now can be related to each tax base, to explain the response to tax rate changes.

Tax bases can be grouped into three categories: income tax bases, expenditure tax bases, and wealth tax bases.

This research is concerned with tax bases at the local government level and, hence, exclusively with expenditure and wealth tax bases.

2.4.1 Expenditure Base

Expenditure taxes are taxes levied on consumer goods at the point of sale; that is, at the point of sale the sellers pass the sales levy on to the consumer. Whether the seller can pass on the total tax to the consumer was addressed above. When a tax is increased or when tax policy changes, two things happen simultaneously. First, the change affects the cost of production of firms. The natural response to this increase is to cut down production (i.e. reduction in demand for factors of production) and to increase consumer prices. The buyers, on the other hand, avoid increases in prices by shifting to cheaper substitutes. The amount by which the tax reduces purchases will depend upon the elasticity of demand for the commodity in question. The less elastic is the demand, the less will the demand be affected. If the tax is of a general type, such as for all food items, then substitution is not possible, giving rise to an inelastic demand. Also, factors of production can shift to non-taxed or relatively less-taxed competitive industries. However, if the factor is specialized or mostly specific to the taxed industry, it suffers most due to taxation. Furthermore, as factor transfers increase the supply to the relatively less-taxed industries, the affected factors suffer a loss in income. Likewise, industries which are complimentary to the taxed industries will also face reduced good and factor demands.

How much the demand for particular commodities or factors will be affected by a change in the sales tax rate is dependent on the length of time needed to adjust to the change in the tax policy, and the degree of specialization of the factors of production. With larger adjustment periods, consumers have enough time to change their behavior and acquire a taste for substitutes, and the competing industries have enough time to change their production processes to accommodate factors that have shifted away from the taxed industry. Hence for both industry output and factors of production, demand becomes more elastic with time. Therefore, total reductions in output and quantities of purchased factors will be larger over time (Hirsch) and the expenditure tax base will shrink. In addition, if the factors of production are less specialized, it is easier to shift to non-taxed industries, increasing the burden of taxation on the consumers of taxed goods. This shift in turn, will induce consumers to seek less-taxed substitutes outside the jurisdiction (Levin, 1967 and Hamovitch, 1966a).

According to Hirsch, income reductions due to sales taxation are incurred by the following groups: those in the taxed industries, those competitive with factors in the taxed industries, those industries supplying outputs on which consumers choose to economize, and factors competitive with the latter.

There is empirical evidence to show that tax rate differentials between jurisdictions are likely to be important to consumer decisions about where to shop (Maliet, 1955; McAllister, 1961; Hamovitch, 1966b; Mikesell, 1970; Fisher, 1980). These studies concentrated on larger cities, but Mikesell and Kurtzone (1986) analyzed the effect of adverse tax differentials in small jurisdictions and concluded that a temporary sales tax in a small town adversely affects that town's sales tax base. However, Fisher noted that if factor supplies to the relatively untaxed area are not perfectly elastic, then the costs will rise and the tax rate differential variable overstates the actual price differential. Transportation costs are a barrier to the exploitation of tax differentials between jurisdictions. Also, transportation costs often prevent individuals from taking advantage of tax differentials. Thus, the tax rate differential should be more important for high-priced goods or for those goods that can be purchased in large quantities in one trip. The extent to which buyers shift to commodities from lower-tax jurisdictions can be related to the cost of transportation. The size of the geographic area of the taxing jurisdiction and the proximity of alternative, untaxed markets are prime determinants of these costs (Hammovitch 1966b and McAllister).

Another type of expenditure tax is the use tax. It is a levy on the commodities purchased outside the jurisdiction but brought into it for use. The other major expenditure tax is excise taxes on specific commodities such as hotels, restaurants, and others.

2.4.2 Wealth Base

The other important tax base is the wealth base. Wealth taxes are taxes levied on properties (real and personal) that individuals and businesses own. Property taxes are levied at different rates in different localities. The taxes are dependent on the assessed value of assets. Real property levies are assessed on a base defined as the capital value of land and structures, both of which are inputs in the production of an output and will be referred to as an *occupiable space* or *floor space of shelter* (Hirsch). The taxation of real property goes back to the time of Ricardo. Ricardo said that due to the original and indestructible property of soil, genuine surpluses or rents are received by landlords and should be taxed. In another context real property derives some of its value from government services and infrastructure. Hence, an asset owner receives a rent based on windfall gains.

Of all tax bases, land is completely specialized geographically and bears most of the tax burden (Richman, 1967). Structures are also quite specialized, both geographically as well as in terms of their use, and tax shifting is almost impossible. Therefore, relative to income and expenditure bases, structures and land are more likely tax bases. Another advantage of real property taxation is its stable revenues. Revenues tend to be stable because assessments are done infrequently; therefore, the tax base is prevented from changing rapidly when economic activity changes. Within a very narrow margin, land and structures can be used for different purposes but cannot be moved to other jurisdictions. Although land as an asset is immobile, there is a certain amount of flexibility in its use. Although a land tax can be completely capitalized into the value of land and therefore theoretically transferable to a new owner, the flexibility of land use gives owners opportunity to react to policy changes.

Erickson noted that the justification for the inclusion of property taxes in the determination of the asset price is based on the capitalization hypothesis. The theory of capitalization states that taxes imposed on income-producing properties are borne (at least in part) by the owners since the taxes are offset by a compensating reduction in the prices for which the properties are exchanged. According to Netzer (1966) under competitive conditions shifting of taxes to the buyer occurs only if the quantity of land supplied is decreased when the tax is imposed. Total capitalization occurs only if land supply is perfectly inelastic. The extent of monetary reduction in property value is dependent on the elasticity of supply, the size and presumed permanence of the tax increase, and the rate of return available from alternative investments. Empirical findings are somewhat mixed. While Jenson (1933), Oates (1969), and Orr (1968) reported heavy capitalization of property taxes, which is consistent with the Tiebout hypothesis, Daicoff (1961) showed low capitalization. Daicoff interpreted his finding of low capitalization as evidence that government expenditures added more to the value of property than the tax payment detracted. This interpretation suggests that the value of the tax base is dependent not only on the tax rate but on government expenditure as well. Aronson and Hilley (1976) suggested some problems that may arise if property taxes are fully capitalized into property values. They said heavy taxes on property in core cities induce businesses and people to move to the suburbs. This migration of relatively wealthy individuals and on-going businesses from the core city increases the pressure on cities to raise taxes further to meet government expenditures.

The impact of tax policy changes on the market for leased property was analyzed by Netzer (1966). In the short-run, he expected an increase in the tax rate on real property to cause the present value of the structures to fall due to diminishing net expected returns. If the owner finds it difficult to pass the increased taxes to the tenant, the tax burden falls on the owner. Factors that determine the extent to which lease rates can be increased are the rate of improvements to the structures and the rate of new investment in structures. If few new structures are being built, the owners of current structures, can reduce planned improvements and thus increase the effective rents on leased land and structures. However, at some point, tenants will opt to relocate completely outside the jurisdiction if the leases are too high. When relocation occurs, more of the tax burden is capitalized in the value of land. When a jurisdiction is small and surrounding jurisdictions have plenty of space, the costs of moving are relatively small. Therefore tenants can easily move away from the burden of taxation. There is also the possibility that planned investments will be shifted to other jurisdictions.

The second type of wealth tax is personal property. Consumer durables such as automobiles, furniture, appliances, and jewelry are some of the types of personal property typically taxed. Compared to real property, avoidance of taxes is usually much easier with personal property. When there is a change in tax policy, a person owning personal property can dispose of it all by accepting a lower price. Hence over time personal property owners will diminish their stocks of taxable property and will substitute other non-taxable property which offers similar service or utility. The implication of this behavior is a reduced demand for factors which are employed in producing taxable property.

Another type of wealth tax is the taxation of wealth transfers through the use of gift taxes or, if the transfer takes place at the time of death, inheritance taxes. Here again, if the wealth tax is high in a particular jurisdiction, the owners of wealth will have a great incentive to relocate assets outside the jurisdiction prior to transfer. The administration of many types of personal property tax base has been so difficult and costly that local governments have been discouraged from using it (Netzer 1966).

2.4 Chapter Summary

This chapter discussed the nature of goods delivered to constituents financed through tax revenues, concepts of tax theory, and characteristics of tax bases. The need for taxation to finance public goods, since their characteristics make them difficult to be distributed via the market mechanism, was discussed. Of the two types of taxes, personal and rem, personal taxes which are dependent on the ability to pay are not used at local government level. It was discussed that rem taxes, which are used mostly by local governments, are inferior to lump-sum taxes (which are not acceptable on equity grounds) because rem taxes can create inefficiencies through dead-weight losses or excess burden. However, it was shown that the excess burden can be minimized by resorting to tax bases that show inelastic demand and supply. The more inelastic tax bases are heavily specialized; hence burden avoidance has been very low. This specialization make them more reliable or likely tax bases. Also discussed was how the Tiebout hypothesis can be used to explain how and why shifting of tax bases between tax jurisdictions takes place. In the final section, the characteristics of tax bases and how they relate to the above concepts were discussed.

Chapter 3

ANALYTICAL MODEL

3.1 Introduction

This chapter develops an analytical model based on the theory of demand. First, a general model is developed within the utility maximizing framework to include a government expenditure variable. Then, theoretical properties of demand functions and systems are discussed. In the next section the rationale for the use of the Almost Ideal Demand System for this research is discussed. Finally, special implementation issues such as -- aggregation, modification of the model to include the tax rate variable, and methods used to analyze panel data sets -- are discussed.

3.1.1 Public Goods and Demand for Tax Bases: The General Model

Consumption theory is generally based on the allocation of income among private goods by individuals. Although consumers may not choose public goods and services directly, they also derive utility from such goods and services supplied by local governments. The quantity of public services supplied by the local government is constrained by the revenue collected through tax collections.

Owners of tax bases derive benefits from public goods and services. For example, accessibility, via good roads, increases the value of real property. Given a good police service, individuals will receive greater benefits from owning real and personal property. Hence, the total value of the property (or tax bases) is directly related to the level of public services received.

Erickson observed that, since the property tax base is primarily determined by the market value of property, the income elasticity of the property tax base is directly related to the income elasticity of demand for housing. This observation is based on the fact that the component of the property tax assessed on housing is treated as a tax on the consumption of housing services. It is the demand for services on the part of the household which imparts value to the durable good providing these services. The result is a derived demand for the stock of housing. The value of the services provided by the houses and the derived demand for the stock of housing is also partly determined by the public services available. Individuals pay a price in the form of taxes to finance these public services. For example, property tax is the price paid for public services such as a pleasant and safe neighborhood. Erickson also showed that the higher the effective property tax rates the larger the impact of a change in income on the tax base and that increases in tax rates are capitalized into property values.

A decision model based on the median voter approach, as used in local public finance studies, will be developed here to determine the demand for tax bases. According to Chicoine and Walzer (1985), this model assumes that the amount of local public goods is fixed and that the tax price faced by local residents varies with reliance on alternative taxes and intergovernmental aid arrangements. They add:

> With the community as the unit of analysis, voters then select combinations of private goods consistent with the fixed level of local services and the combination of taxes maximizing their well-being, subject to a budget constraint. With this approach the median voter becomes very important and his or her preferences become representative (p.126).

The budget constraint involves both prices paid for private goods and the local taxes collected. An additional governmental budget constraint is an identity, equating total tax revenue and the expenditure for the fixed level of services, that must be met. The objective of the taxpayers is to select from among alternative combinations of tax rates and private goods in order to maximize satisfaction.

The maximizing problem for individual constituents or voters can be expressed as follows:

(3.1) $\max U(X_t, T_{1t}, T_{2t}, G_0)$

subject to

(3.2) $Y_t = P_0 X_t + P_1 T_{1t} + P_2 T_{2t} + R_t$

where,

X_t = quantity of untaxed goods,

T_{1i} and T_{2i} = quantity of taxed good 1 and taxed good 2,

G_0 = local public goods (assumed fixed),

P_0 = price of untaxed goods.,

P_1 and P_2 = price (without tax) of taxed goods,

R_i = tax payments by the i^{th} individual,

Y_i = total income of the i^{th} individual.

As Johnson (1988) noted, if a local public good is indivisible or jointly consumed, as assumed here, each constituent consumes the entire production level; that is:

$$G_0 = G_i = G_j$$

Johnson (1988) also formulated an equation that depicts how much an individual constituent would pay for a public service via taxes as follows.

Let c be the average cost of supplying a unit of public service. Assume that, if the government balances its budget, and collects revenue from constituents through taxes, then the sum of taxes (R), will equal the total cost of producing G_0 ,

Then,

$$(3.3) \qquad R = \sum_{i=1}^{n} R_i = \sum_{i-1}^{n} cG_0 s_i$$

Where, s_i = i^{th} individuals share of taxes. $\sum_{i=1}^{n} s_i = 1$.

However, since the local government identity ultimately constrains voter choices, outlays for the fixed level of local public goods (G_0 when measured in dollars) must equal revenues from the different tax bases; thus, for a two-tax base and a non-tax base:

$$(3.4) \qquad R_i = cG_0 s_i = P_1 T_{1i} r_1 + P_2 T_{2i} r_2$$

where, r_1 and r_2 = tax rates, and

T_{1i} and, T_{2i} are quantities of the tax bases consumed.

Using the above relationships, the budget constraint is:

$$(3.5) \qquad Y_i = P_0 X_0 + P_1 T_{1i} + P_2 T_{2i} + P_1 T_{1i} r_1 + P_2 T_{2i} r_2.$$

In order to maximize an individual's utility with respect to X, T_1 and T_2 and G (fixed), the problem is viewed in the classical Lagrangian framework:

$$(3.6) \qquad \max L = u_i(X_i, T_{1i}, T_{2i}, G_0) + \lambda(Y_i - P_0 X_i - P_1 T_{1i}(1 + r_1) - P_2 T_{2i}(1 + r_2)).$$

Erickson (1981) considered the residential property tax base. She dropped the public service variable based on the assumption that all the service yielding factors are equally available in all the counties. Thus the only observable variation among counties is the price paid for public services -- the property taxes. Erickson's assumption is naive in the sense that public services cannot be equal in all the counties, especially since they are functions of the tax revenues collected. This assumption biases the coefficient of the tax rate. Since the objective of the current study is to estimate the impact of tax rate changes on the value of the tax base, adopting the above strategy would be self defeating.

In fact, the impact of local government expenditures on public services can be considered within the Slutsky framework. Just as a commodity price change has effects beyond its own quantity demanded, a tax rate change has effects that go beyond its own tax base.

(1) Since a tax rate increase results in changed relative prices, there will be a natural tendency for consumers to look for substitutes for goods whose relative prices have increased. This is the substitution effect.

(2) With a tax rate increase on a particular good there is a reduction in the real income of the consumer who cannot find a perfect substitute for this good. This income effect will result in a reduction of purchases of all goods.

(3) An increase in the total price the consumer has to pay due to a tax rate increase does not go unrewarded. Tax revenues are used for public services, which in turn increase the value of the tax base. Hence this increase in the value of the tax base can be considered as a special effect, suggesting that public service expenditures need to be considered explicitly.

The following tax bases are considered in this research: personal property, real property (residential property, agricultural property, and business property), and machinery and tools. Since the sales tax rate did not change during the study period (1981-1985) and does not vary among counties, the sales tax was excluded from the present research.

One of the biggest problems in empirical demand systems-estimation is the degrees-of-freedom problem since many parameters must be estimated. Fortunately, there are a number of classical restrictions or properties of demand systems that serve to reduce the number of dimensions of the parameter space. With single equations they play only a minor role, but with systems these restrictions become more relevant (Deaton and Muellbauer, 1980b). These properties or restrictions are discussed in the next section.

3.1.2 Properties of Demand Functions

(1) Homogeneity Condition (absence of money illusion): One useful and theoretically plausible restriction on demand functions is that they are homogeneous of degree zero in income and prices. In single equation demand models this is the only restriction that has any immediate consequences.

Mathematically:

$$(3.7) \qquad \sum_{j=1}^{n} \varepsilon_{ij} + \eta_i = 0 \quad j = 1,\ldots,n,$$

where:

η_i = income elasticity of demand of i^{th} good and,

ε_{ij} = own and cross-price elasticities of the i^{th} good

Demand equations automatically satisfy the homogeneity condition when the demand system is obtained by constrained maximization of a utility function.

(2) Adding Up or Engel Aggregation (satisfies the budget constraint): **A system of demand functions should satisfy the relevant budget constraint. Mathematically:**

$$(3.8) \qquad \sum_{i=1}^{n} w_i \eta_i = 1$$

Where,

w_i = **budget share of** i^{th} **good**

(3) Slutsky Symmetry Conditions (Fundamental Equation of Value): **This condition follows from the possibility of separating the impact of price into income and substitution effects. The symmetry property says cross-price derivatives of the Hicksian (or compensated) demands are symmetric. The Slutsky equation is defined as:**

$$(3.9) \qquad \frac{\partial q_i}{\partial p_j} = \left(\frac{\partial q_i}{\partial p_j}\right)^{*} - q_j \frac{\partial q_i}{\partial y}$$

$$= k_{ij} - q_j \frac{\partial q_i}{\partial y}$$

where,

$$k_{ij} = \left(\frac{\partial q_j}{\partial p_j}\right)^{*}$$

q_j = **quantity demanded,**

p_j = **unit price,**

y = income.

Then the symmetry restriction is:

$k_{ij} = k_{ji}.$

(4) Negativity Condition: The negativity restriction relates to the matrix of compensated price derivatives. It states that the matrix of substitution terms must be negative semidefinite. This, statement in turn, implies that the diagonal elements (the compensated own-price derivatives) are non-positive and leads to the assumption that the compensated demand curve is downward sloping; that is, the the 'Law of Demand' holds.

Mathematically:

$$k_{ij} < 0 \;\; or \;\; \eta_{ij} + w_i \eta_i < 0$$

(5) Cournot Aggregation: Mathematically:

$$(3.10) \qquad \sum_{i=1}^{n} p_i \left(\frac{\partial q_i}{\partial p_j} \right) = -q_j \qquad where,\ j = 1,\ldots\ldots,n.$$

$$\sum_{i=1}^{n} w_i e_{ij} = -w_j$$

where,

w_j = budget share of the i^{th} commodity

e_{ij} = cross and own price elasticity of demand, i = 1,...,n.

Demand functions which satisfy the Cournot aggregation condition also satisfy both the homogeneity condition and the Engel aggregation. Hence, if the other two types of restrictions are imposed in addition to the Cournot aggregation, they do not provide any additional restrictions.

Each of these general restrictions defines an exact set of relationships between income and price slopes which any complete set of demand functions must possess if it is derivable from the maximization of any utility function. With these restrictions the size of parameter space dwindles from $n(n+1)$ to $1/2(n^2+n-2)$. Even so, when n (the number of equations) is large, the degrees-of-freedom problem still exists (Bieri and de Janvry, 1972). Hence, some other restrictions arising from the interrelationships between commodities or assumptions regarding the interaction of commodities and the nature of utility functions can provide additional theoretical restrictions on parameters of the statistical model. In order to reduce the parameter space still further, we consider the modern restrictions of preference additivity and separability.

(a). Additive Preferences or Additivity Assumption: The property of additive preferences imposes the independence of certain aggregates or groups of utility function arguments. Direct additivity, or want independence, occurs when the marginal utility of good i depends on the quantity of good i but not on the quantity of any other good. Good i is termed want independent if,

$$u_{ij} = 0, \quad or \quad \frac{\partial^2 u}{\partial q_i \partial q_j} = 0, \quad when, (i \neq j)$$

Frisch (1959) showed that when direct additivity is present cross- and own-price elasticity can be identified with the estimation of only n parameters using money flexibility, income elasticity, and budget shares.

Money flexibility and budget shares are defined as follows:

(3.11) $$\textit{Money flexibility}\ (\tilde{w}) = \frac{\partial \lambda}{\partial y}\frac{y}{\lambda}$$

λ = lagrangian multiplier of the utility maximization problem

(3.12) $$\textit{income flexibility}(\phi) = \frac{1}{\tilde{w}}.$$

Then,

(3.13) $$\varepsilon_{ij} = -\eta_i w_j(1 + \phi\eta_j),$$

(3.14) $$\varepsilon_{ii} = -\eta_i[w_i - \phi(1 - w_i\eta_i)],$$

(3.15) $$\tilde{w} = \eta_i \frac{(1 - w_i\eta_i)}{\varepsilon_{ii} + w_i\eta_i}.$$

It is important to note that direct additivity rules out the possibility of specific substitution effects, and the possibility of inferior and complimentary goods. Under the assumption of Almost Additive Preferences, on the other hand, a small amount of interaction is allowed among commodities (Barten, 1964).

(b). Separability Conditions: Additivity permits little or no interaction among commodities. Separability is a relative concept based on the "utility tree" concept developed by Strotz (1957). The frame of reference is some partition of the complete set of n commodities into s mutually exclusive and exhaustive subsets. In general, the separability conditions, which are exact properties of the utility function, require the marginal rate of substitution of certain pairs of commodities to be functionally independent of the quantities of certain other commodities. The idea is that the elements belonging to the commodity bundle may be partitioned into different groups. Budget allocation, then, is a step-wise procedure whereby the consumer first allocates his total budget among groups and then the amount allocated to the group, is allocated among individual commodities within a group.

There are several different forms of separability:

1. Weak Separability: Two goods are weakly separable if they belong to the same group and the ratio of their marginal utilities is independent of the quantity consumed of any good outside the group. Goldman and Uzawa (1964) show that under this property the utility functions assume a non-additive form.

Mathematically, separability is defined as:

(3.16) $$\frac{\partial \frac{u_i}{u_j}}{\partial q_k} = 0 \quad k \neq i,j.$$

2. Strong Separability (Block Additivity): Under this property the utility function is additive among commodity groups. Here the marginal rate of substitution between two commodities i and j from subsets I and J does not depend upon the quantities of commodities outside I and J. Therefore, there is group-wise independence as follows:

$$(3.17)\qquad \frac{\partial \frac{u_i}{u_j}}{\partial q_k} = 0,$$

$i \in G_s,\, j \in G_r, k \in G_t,\ \ G_s \neq G_r \neq G_t.$

*3. **Pearce Separability:*** A utility function is Pearce Separable if the marginal rate of substitution between any two commodities belonging to the same subset is independent of the consumption of all other commodities, including other commodities within the same subset.

Mathematically:

$$(3.18)\qquad \frac{\partial \frac{u_i}{u_j}}{\partial q_k} = 0,\ for\ \forall i,j \in G_s,\ \ k \neq i,j$$

Thus utility function is weakly separable within groups and strongly separable between groups.

3.2 Demand Systems

The systems approach to estimation of the demand functions provides a conceptual framework to deal with the interdependence of demand for various commodities. This systems approach provides information on the degree and nature of the interrelatedness of the demand functions, makes assumptions regarding the interaction of commodities and the nature of utility functions, and makes a formal attempt to incorporate theoretical, both classical and modern, restrictions into the model to insure consumer behavior consistent with theory. It also may alleviate to a large degree the multicollinearity among prices, income, and other exogenous factors (Capps, personal communication).

The systems approach forces recognition that an increase in the consumption of some goods must be balanced by decreases in consumption of others. Use of these constraints allows more realistic descriptions of consumer behavior under varying conditions.

Empirical application requires the specification of functional forms. The empirical model typically follows from the specification of a direct or indirect utility function or the specification of demand equations directly coupled with classical and modern theoretical restrictions.

For some utility functions, the explicit functional form of the demand functions has been derived. In these instances, all classical restrictions are automatically satisfied, and, further, the distinctive utility functions chosen usually yield additional particular restrictions. Unfortunately the number of known, well-behaved utility functions is very limited, and the derivation of demand equations is not always possible (Powel 1966).

Hence, in some circumstances, econometricians have preferred to work with an arbitrary but manageable functional form for the behavioral equations to be estimated, imposing constraints that insure the theoretical plausibility of these equations. However, the theoretical restrictions are typically enforced only at some local set of co-ordinates, often the sample means. Nevertheless, the range of variation of the variables may be such that the restrictions are approximately satisfied at all data points (Capps, personal communication)

Of the several demand systems that have been developed over the years, the Linear Expenditure System and the Almost Ideal Demand System are two of these models that have been used most extensively. The following is an evaluation of these two systems, suggesting that Almost Ideal Demand System is the method better suited for this research.

3.2.1 The Linear Expenditure System (LES)

Lesser (1941) was the first to address the issue of complete demand systems. However, the linear expenditure system (LES) was the first demand system introduced in the literature (Klien and Rubin, 1947-1948). Klien and Rubin showed that one demand system which satisfies the homogeneity, adding up, and symmetry conditions is the LES. In addition this system displays strong additivity. Stone (1954a) was the first person to use utility theory to define and modify the demand equations to be applied to consumption data. His work thus formed a bridge between the old methodology and the new. Stone imposed the Slutsky relationship and the homogeneity conditions, to reduce the number of parameters to be estimated, in deriving the LES. In Stone's formulation a major increase in the degrees of freedom was achieved by deleting most of the compensated cross-price elasticities. If adding up, homogeneity, and symmetry restrictions are all imposed the, $n^2 + n$ original price and outlay derivatives are reduced to (n-1)(1/2 n+1) (Deaton and Muellbauer, 1978). LES has been widely used in subsequent empirical work. See, for example, Haidacher et al. (1982), Howe (1977), Parks (1969), Pollak and Wales (1978), Merz (1983), and Yoshihara (1969).

Klien and Rubin demonstrated that the LES could be derived from an underlying utility function of the form:

$$(3.19) \qquad u = \mu \log(q - \gamma)$$

Where, $\mu = (\mu_i)'$ is the n-component vector of marginal budget shares

$\gamma = (\gamma_i)'$ is the n-component vector of quantities defined as minimum consumption levels,

and q is the quantity consumed.

This interpretation holds only when γ_i is assumed positive (Johnson, Hassan and Green, 1984). The parameter vectors μ and γ are subject to the restrictions $0 < \mu_i < 1 \quad (i = 1,2,\ldots,n), \sum_{i=1}^{n} \mu_i = 1$ and $(q - \gamma) > 0$. Maximizing this utility function subject to the budget constraint $p'q = m$ yields the following demand functions:

$$(3.20) \qquad q = \gamma + (m - p'\gamma)\vec{p}^{\,-1}\mu$$

where,

m = total outlay,

p' is the vector of prices, and, $\vec{p}$ = an n-by-n matrix with the values on the diagonal given by the elements of vector p.

The above can be expressed in terms of individual linear expenditure functions, so named because p_iq_i is linear in m and p. The model is, however, non-linear in μ and γ. The typical linear expenditure function is

$$(3.21) \qquad p_iq_i = p_i\gamma_i + \mu_i(m - \sum_{j=1}^{n} p_j\gamma_j) \qquad j = 1,\ldots,n.$$

The linear expenditure equation has the following interpretation. According to Samuelson (1947-48) if γ_i is the minimum required quantity of good i, then the committed income is $p_i\gamma_i$ and the residual or "supernumerary income" (which is $m - \sum_{i=1}^{n} p_i\gamma_i$) is divided between the goods in the fixed proportions μ_i. There is no reason why γ_i should be positive. Phlips (1983), quotes a case from Solari (1971), which has a negative γ_i.

Yoshihara showed that the demand functions in the LES system are homogeneous of degree zero in prices and income, and satisfy the adding-up restriction, and that the matrix of substitution terms is symmetric and negative semi-definite.

However, there are a number of limitations in the LES which limit its use for the present research. Some of the limitations of the LES model are discussed below.

Deaton and Muellbauer (1980a) note that LES is more specialized than might be needed in practice.

> For example, differentiation of the LES shows that inferiority can only occur for goods with μ_i negative but this violates concavity and, if permitted, would result in the good having a positive price elasticity. Similarly, if concavity is to hold, no two goods may be compliments, every good must be a substitute for every other good (p.66).

Therefore, when using the LES, careful consideration is needed regarding the appropriateness of such relationships. The following discussion explain why LES is inappropriate for this research.

A utility-maximizing consumer will weigh the relative cost of providing public goods by public and private means. Thus, if the price of a (taxed) good increases due to the increase in the tax rate, the quantity demanded should decline. On the other hand the utility-maximizing consumer should be willing to contribute to tax revenue if he/she believes that the tax revenue would be efficiently used for providing public services that would enhance the value of taxed goods such as real property. The final value of the taxed good after a tax rate change, therefore, depends on the relative strengths of capitalization of the negative tax rate change effects and the positive public service effects. According to the Tiebout hypothesis, people are attracted to localities with preferred quantities and qualities of public services balanced against higher real property values (which represent some of the costs of public services). If the capitalization of public services is higher than that of the tax rate changes, a positive relationship can be expected between tax rates and quantity demanded, if it is assumed that the impact of price and tax rate changes act in a similar way. According to the neo-classical theory of consumer demand, a positive price/quantity relationship is allowed only for Giffen goods (i.e., inferior goods). Since, in this case, a positive relationship is possible, the LES is inappropriate for this research.

Also, there is the need to distinguish between the nature of different tax bases. Real Property is largely immobile while personal property is movable. Hence, the real property market corresponds more closely to a spatial market, since the property value depends in part upon its location characteristics such as distance to the city center and public services received. Under these circumstances it is likely that with immobile property tax-rate changes are likely to have a negative impact while the public services effect will have a positive impact. Therefore it is unlikely that with immobile property the above relationship can be explained through the LES if the positive public service effect outweighs the negative tax effect.

In an earlier section it was revealed that many tax bases are likely to behave in a complimentary manner. However, LES does not allow for complimentary relationships.

3.2.2 An Almost Ideal Demand System (AIDS)

The LES, as described above, has a number of limitations, which argue against its use for the present research. An alternative model, first introduced by Deaton and Muellbauer (1978), has many computational advantages. This system is called the Almost Ideal Demand System (AIDS).

Unlike the LES which can be derived from a specific utility function, the AIDS model gives an arbitrary first order approximation to any demand system. Here a specific functional form is specified with enough parameters to ensure a reasonable approximation to whatever the underlying (unknown) function may be (Phlips).

In the AIDS model Deaton and Muellbauer (1978) approximate an arbitrary expenditure function rather than the direct or indirect utility function. The expenditure function is the inverse of the indirect utility function. The expenditure function is defined as the minimum expenditure necessary to attain a specific utility level at given prices.

The AIDS model is a second order approximation of the Price Independent Generalized Linearity Logarithmic (PIGLOG) class of expenditure functions. Such an expenditure function is:

$$(3.22) \qquad \ln c(u, p) = (1 - u)\ln\{a(p)\} + u\ln\{b(p)\},$$

where u lies between zero (subsistence) and one (bliss). The positive, linearly homogeneous functions, a(p) and b(p), can be regarded as the cost of subsistence and bliss respectively (Deaton and Muellbeaur (1980b).

The PIGLOG system can generate aggregate demand functions that are directly compatible with individual utility maximization. Working (1943) and Lesser (1963) were early uses of PIGLOG functions.

A typical equation of the AIDS system is given by:

$$(3.23) \qquad w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln(\frac{x}{P}),$$

where,

w_i = budget share of the i^{th} commodity,

x = outlay on all goods,

p_j = price per unit of j^{th} commodity,

P is a price index defined by:

(3.24) $$\ln P = \alpha_0 + \sum_{j=1}^{n} \alpha_j \ln p_j + \frac{1}{2} \sum_{i=1} \sum_{j=1} \gamma_{ij} \ln p_i \ln p_j.$$

The theoretical restrictions imply particular algebraic relations among parameters.

Adding up requires that, for all commodities:

$$\sum_{i=1}^{n} \alpha_i = 1, \quad \sum_{i=1}^{n} \beta_i = 0, \quad \sum_{i=1}^{n} \gamma_{ij} = 0$$

Homogeneity is satisfied if and only if, for all j,

$$\sum_{j=1}^{n} \gamma_{ij} = 0,$$

while symmetry is satisfied provided:

$$\gamma_{ij} = \gamma_{ji}.$$

However, as is true for other functional forms, negativity cannot be ensured by any restrictions on the parameters alone. Deaton and Muellbauer (1980b) show that negativity can be checked for any given estimates by calculating the eigen values of the Slutsky matrix s_{ij}. Although equation 3.23 as specified does seems linear in parameters, the P variable is also a function of the unknown parameters, so that the AIDS model is non-linear in the parameters of interest. Stone (1954) suggested the following approximation, which allows the use of linear estimation techniques:

$$\text{(3.25)} \qquad \log P = \alpha_0 + \sum_{k=1}^{n} w_k \log p_k.$$

Then the resulting linear system is:

$$\text{(3.26)} \qquad w_i = \alpha_i + \beta_i[\ln x - \alpha_0 - \sum_{k=1}^{n} w_k \ln p_k] + \sum_{j=1}^{n} \gamma_{ij.} \ln p_j.$$

In the complete AIDS equations, there are $2n + n^2$ parameters to be estimated. The number of restrictions mentioned total $(n^2 + n + 4)2$. These restrictions reduce the number of free, unknown structural parameters to $(n^2 + 3n - 4)/2$.

This model has a number of desirable characteristics that are not found in other demand systems: it satisfies axioms of choice; it aggregates perfectly over consumers without invoking parallel linear Engel curves; it has a functional form which is consistent with known household budget data; it is simple to estimate, largely avoiding non-linear estimation; and it can be used to test the restrictions of homogeneity and symmetry through linear restrictions on parameters. Also, Ray (1980) noted that a demand system under the AIDS specification is consistent with known economic theory without requiring additive separability of the utility function.

Deaton and Muellbauer (1980b) also noted that the flexible functional form property of the AIDS cost function (from which AIDS is derived) implies that the demand functions derived from it are first order approximations to any set of demand functions derived from utility-maximizing behavior. But Ray also noted that other flexible functional forms are consistent with utility maximization only if the utility functions are linear logarithmic.

Deaton and Muellbeaur (1980a) assert that homogeneity and symmetry, basic to the assumption of a linear budget constraint and the axioms of choice, are consistently rejected by the data. Ray, however, with Indian data, showed that homogeneity is an acceptable restriction for all items in his results and rejected the presence of money illusion. Goddard (1983) noted that rejection of the theoretical hypothesis may occur even if the theory is true. Rejection can occur because the theory is postulated to apply to the individual consumer, even though it is being tested for estimates of aggregate market demands, and even though those demands are in terms of a representative consumer. Also rejection of the classical restrictions may be due to the approximate nature of the estimations such as the approximate price index. Hence Goddard suggests that even if the restrictions are rejected they should be imposed. In the Deaton and Muellbauer (1980a) study, imposition of the homogeneity restriction was found to introduce serial correlation in the model, suggesting that time trends and/or lagged variables were omitted from the model. Therefore, rejection of the homogeneity condition may be due to incorrect specification of the model as well. Blanciforti and Green (1983) included in their model habit effects as a solution to the problems faced by Deaton and Muellbauer. These habits were assumed to be linear functions of past consumption.

Although Stone's approximation of the price index and imposition of the homogeneity restriction allow the AIDS model to be estimated for each equation using linear OLS, imposition of the symmetry restrictions requires the demand equations be estimated as a system.

3.3 Special Implementation

Deaton and Muellbaur's (1980a) original presentation of the AIDS model was for aggregated British data. They showed that, using the aggregation theory developed by Muellbauer (1975,1976), the aggregation of the individual or household AIDS equations is possible. In their study they did not explicitly consider the family size of the households. In fact they assumed the number of family members to be constant across households. In his subsequent studies Ray (1980, 1982) considered family size as an explicit variable in the context of Indian data. Bezuneh (1985) improved this variable by considering age-sex composition of the households. However, due to data limitations, this research will consider household factors to be constant as described below.

3.3.1 Aggregation

The household AIDS model is given as:

$$(3.27) \qquad w_{ih} = \alpha_i + \beta_i \ln(\frac{x_h}{k_h P}) + \sum_{i=1}^{n} \gamma_{ij} \ln p_j + u_{ih},$$

where,

x_h = per capita income of the h^{th} household,

u_{ih} = error term,

k_h is a measure of household characteristics. These characteristics are used to deflate the budget x_h to bring it to a 'needs corrected' per capita level.

Define the share of aggregate expenditure on good i in the aggregate budget of all households (w') as:

$$(3.28) \qquad w'_i = \sum_{h=1}^{n} p_i q_{ih} / \sum_{h=1}^{n} x_h = \sum_{h=1}^{n} x_h w_{ih} / \sum_{h=1}^{n} x_h,$$

which when substituted into equation 3.27 gives:

$$(3.29) \qquad w'_i = \alpha_1 - \beta_i \log P + \beta_i \{ \sum_{h=1}^{n} x_h \log(x_h/k_h) / \sum_{h=1}^{n} x_h \} + \sum_{j=1}^{n} \gamma_{ij} \log p_j + v_i$$

Deaton and Muellbauer (1980a) defined aggregate index k by

$$(3.30) \qquad \log(x'/k) = \sum_{h=1}^{n} x_h \log(x_h/k_h) / \sum_{h=1}^{n} x_h$$

where x' = aggregate level of total expenditure.

Then equation 3.29 becomes;

(3.31) $$w'_i = \alpha_i + \beta_i \log(x'/kP) + \sum_{j=1} \gamma_{ij} \log p_j + v_i$$

They also noted that

> to the extent k is constant or uncorrelated with x' or p, no omitted variable bias arises from our procedure of omitting k or redefining $\alpha'_i = \alpha_i - \beta_i \log k'$ where k' is the constant or simple mean value of k (p.315)

Using the Deaton and Muellbauer (1980b) assumption, due to the lack of data on k, we will omit the k from our estimation. However, since a county is the unit of analysis there are two other variables that will have major impacts on the budget shares, namely population and local government expenditures. Hence, these two variables are also introduced for estimation purposes. Following Oates' (1969) argument that additional expenditure would tend to yield successively diminishing increments to benefits, the government expenditure variable is expressed in its natural logarithmic form.

Provided x', w' are available, the model is:

(3.32) $$w_i = \alpha_i + \beta_i \ln(\frac{x}{P}) + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \theta_i \ln N + \rho_i \ln G + v_i$$

Where,

N = Population,

ρ = Local government expenditure

3.3.2 Modifications to Include Tax Rates

In the present research it is necessary to define this grouped household model as follows. First, the unit of analysis is a county. Second, the main objective is to estimate the rate elasticities rather than price elasticities. Hence the price variable is redefined to include tax rates as well. Define:

$P_j^1 = p_j(1 + r_j)$, where,

P_i^1 = price paid per unit after tax,

p_i = price before tax,

r_i = tax rate for item i.

Rewriting the model to include tax rates:

$$(3.33) \qquad w_i = \alpha_i + \beta_i \ln(\frac{x}{P}) + \sum_{j=1}^{n} \gamma_{ij} \ln \{p_j(1 + r_j)\} + \theta_i \ln N + \rho_i \ln G + v_i$$

The equation above implicitly assumes that the coefficient with respect the to tax rate variable to be equal to the coefficient of the price variable. Hence this equation is expanded to take into consideration any inequalities between these coefficients. Note that Stone's approximation (equation 3.25) is used for the price index, P.

Then, the final estimable equation takes the form:

$$(3.34) \qquad w_i = \alpha_i^* + \beta_{i0} \ln x - \beta_{i1} w_i \ln p_i - \beta_{i2} w_i \ln(1 + r_i) + \gamma_{i1} \ln p_i + \gamma_{i2} \ln(1 + r_i) +$$

$\theta_i \ln N + \rho_i \ln G + v_i$

where,

w_i = budget shares of non-tax base, machinery/tools, personal property, residential property, agricultural property, and commercial property.

x = per capita expenditure,

p_i = prices of above tax bases,

r_i = tax rates of the above tax bases,

v_i = error term.

(3.35) $\alpha_i^* = \alpha_i + \beta_{i0}\alpha_0$

Based on the above derived equation, the demand system for the tax bases can be defined and elasticities can be computed as follows.

Define:

$E_1 = p_1 q_1$ = the expenditure on tax base 1,

where p_1 is price of a unit of tax base 1,

q_1 quantity of tax base 1,

w_1 = budget share for tax base 1.

$w_1 = \frac{E_1}{x}$; Where x = total outlay

Then own-rate elasticity (η_{11}) = $\frac{\partial E_1}{\partial r_1}\frac{r_1}{E_1} = \frac{\partial (w_1 x)}{\partial r_1}\frac{r_1}{E_1} = \frac{\partial w_1}{\partial r_1}\frac{r_1}{w_1}$

and

Cross-rate elasticity (η_{12}) = $\frac{\partial E_1}{\partial r_2}\frac{r_2}{E_1} = \frac{\partial (w_1 x)}{\partial r_2}\frac{r_2}{E_1} = \frac{\partial w_1}{\partial r_2}\frac{r_2}{w_1}$

3.3.3 Durable Goods Demand

The model derived earlier has some obvious estimation problems. Generally, individuals derive utility by consuming the goods they purchase. With non-durable goods, it fits this notion very precisely. When a consumer purchases a durable good or asset (house, automobile, etc.), the utility derived is from the services that are rendered by this good. These goods will depreciate over time and finally be disposed of when no more services are rendered. In the case of non-durables, services are consumed with the destruction of the goods themselves.

Chow (1960) defines a consumer durable good as a type of capital good which generates services for consumption without being simultaneously destroyed. In the introduction to his book entitled "Demand for automobiles in the U. S.", Chow asserts

> The problem of the demand for consumer durables consists of the demand for the total stock of durable at a point of time and demand for new purchases per period of time. Stock demand and purchase demand are related by the identity that the total stock of durables held by a consumption unit, or by a group of consumption units, at the end of the period equals the sum of its depreciated stock from the end of the last period and its depreciated net purchases during the present period (p.1).

He also stated that the unit of a total stock of a durable good and the unit of services generated from it can be defined in such a way that they are numerically equal, under the assumption of a constant rate of depreciation.

Deaton and Muellbauer (1980b) suggested a simple possible case in which the service flow is proportional to the stock of the durable good (s_t). If deterioration of a stock of durable goods takes place at a constant rate of δ per period, then a stock of s_t at time period t becomes $(1-\delta)s_t$ at the end of the time period. If d_t is the current purchase, $s_t = d_t + (1-\delta)s_{t-1}$

3.3.4 Adjusting Data for Estimation

Some possible avenues for estimating the required data for the present research can be considered as follows. Given that information is available only for the total value of the tax base or stock as defined by Deaton and Muellbauer (1980a) we are faced with the task of estimating the price of a unit of stock and defining the total stock, which is for estimation purposes, equivalent to the the total services it renders per time period. Each tax base is considered separately.

(a) Personal Property: Denote by x_i the quantity of services per period of the i^{th} good, by X_i the amount of stock of the i^{th} good, and by p_i and P_i, respectively, their prices. Then define x_i and X_i in such a way that they are identically equal. For example if X_i is the number of new Fords, x_i is in units of service of one new Ford per period. "The time pattern of generation of service being approximated by assuming a constant rate of depreciation, of the total amount of service from a given quantity of the i^{th} durable good x_i in any period a constant fraction b_i will remain in the next period" (Chow 1960, p.11). Therefore our task is to define the total stock of, say, automobiles which is equivalent to the total services the stock renders per time period.

With durable goods, the consumer would buy additional stock (d_t) only to fill the gap between the desired stock and the existing depreciated stock, as described earlier. A stock of durable goods an individual owns is comprised of different vintages, each with a different price or value. For example a two-year-old unit would give a lesser service than a new good, and the price would reflect the service rendered. Hence all the units can be made comparable only if we express each unit in terms of, say, new equivalents. For example, if a year-old unit is half the price of a new unit, the former is equivalent to half a new unit. In Chow's study, to convert old cars into new car equivalents, he used as weights the price of cars of different vintages as of 1937. Also the prices of various ages of cars in any one year were approximated very well by the assumption of a constant percentage rate of depreciation. Under these circumstances, the price paid for the use of the stock of cars for a year is proportional to the value of the stock itself. Therefore consumption of automobile services can be considered strictly proportional to the stock. The value of the stock can be defined as stock times the relative price.

The above theoretical explanation holds for machinery and tools as well, which is the taxable personal property of businesses.

(b) Real Property: Depending on location, the value or the price of real property will vary substantially. For example, real property near major cities is generally more expensive than property in rural areas. Given that the value of the total tax base is readily available (and represents the value of the stock of real property after having taken into consideration depreciation/appreciation), the stock of real property will have to be estimated in order to evaluate the price of a unit of real property. With respect to residential property, a means of approximating the housing stock has been suggested by Erickson (1981). An initial measure of the stock of housing can be obtained from the census for a particular year. Since information is available with regard to the number of housing permits authorized (and their values), this figure can be added for each year to get an approximate stock of housing for each year. Normally a unit is added within six months after the permit is issued. Dividing the value of the residential property by the stock of housing, we can get an approximate value of a unit of residential property. Notice that this method implicitly assumes constant rate of depreciation, as suggested by Chow (1960). But with housing, it is likely that housing values will appreciate, for a number of reasons, such as investment on maintenance, general increase in prices, and increase in property value due to local government investment in public services. However, if this increase in value is balanced by the reduction in value due to increase in tax rates, appreciation is due only to inflation and investment on maintenance. Hence, if the total value of the tax base is adjusted for these latter variables, residential property, too, must depreciate like other personal property. It is obvious that there are a number of problems with this approach. We have not taken into consideration different kinds and qualities of housing or real property and have also assumed housing is evenly distributed in every county. However, if deviations of estimates from true value occur systematically across counties, these problems are acceptable. The service flow is made equivalent to the value of the total stock using the same method suggested for personal property. The other important components of real property are agricultural and commercial property. Although census information is available with respect to the price of agricultural property, such information is not available for commercial property.

Hence, considering the fact that we are concerned only with county-level data, it is not unrealistic if we make the assumption that the real price of commercial property is constant across counties and over the study period.

It was shown that with durable goods the total value of the base can be defined in such a way as to be equivalent to the total services it renders. When a tax rate changes, the rate change will have two effects: (a) First, it has an impact on current purchases. If the tax rate is higher in a certain jurisdiction compared to another, but there is no difference in price, purchasing can be done in the jurisdiction with lower tax rates. Such movement of purchasing is primarily true for consumer goods, but it can also be true for movable personal property. (b) Second, with durables apart from any taxes that will have to be paid at the time of purchasing, depending on the value of the asset, a certain percentage of their value is paid as taxes annually.

Therefore, variations in the total value of the tax base would reflect the net effect of tax rate changes, for the existing stock, and any impact on the current purchases, where the unit price has been determined earlier. Even though the total past stock may not get traded every year, the opportunity cost of holding the asset is the price of a unit of current purchases.

3.4 Long-Run Effects or Dynamic AIDS

It is reasonable that once a consumer purchases a durable good he/she would use it for a number of years before buying a new unit again. Hence, response to price and tax rate changes may not be instantaneous. Generally with non-durable goods a price or tax change may have instantaneous or short-run responses. But with durable assets there are two problems. Once an investment is made in a durable asset, that asset is not sold for a number of years, perhaps because of transaction costs associated with sales or purchases of durable goods. Also there can be many non-economic reasons why an individual would like to keep the asset invested in. Hence, there will not necessarily be an instantaneous response to changes in prices and taxes. Therefore, long-run responses may be more appropriate when the durable goods market is considered.

Several methods have been proposed and used to incorporate the dynamic behavior of consumers as outlined below.

(1) The first approach is the partial adjustment process, which introduces a lagged dependent variable to the demand equation.

(2) Another approach is to consider that the parameters of the demand model are random. Polak and Wales (1969) used this method for the dynamic LES estimation, assuming minimum subsistence parameters depend on the previous consumption levels. Blanciforti, Green, and King, (1986), and Blanciforti and Green (1983) used this approach on the AIDS model to study U.S. consumer behavior over the postwar period. In this method, to reflect persistence in consumption patterns, the static AIDS model was extended by specifying the intercept term to be a linear function of previous consumption levels. The use of this dynamic version is inappropriate for the present research due to data limitations.

(3) The third approach is to model an intertemporal demand system (Lluch, 1974; Klijn, 1977). This method is based on optimal control theory, but its use is restricted by the severe data requirements.

In the current study the static linear approximate AIDS model is respecified to introduce a partial adjustment process, to take into account long-run and short-run effects.

Define

s_{it} = value of the tax base i,

p_{it} = price per unit of tax base i,

$\frac{s_{it}}{x_t} = w_i$. where,

w_i = budget share,

t = time period,

x_t = total outlay.

Using the AIDS formulation with Stone's approximation (since it allows linear estimation), the partial adjustment model is incorporated as follows:

$$(3.36) \qquad W_{it} = \alpha_0 + \beta_i[\ln x_t - \alpha_0 - \sum_{k=1}^{n} w_{kt} \ln p_{kt}(1 + r_{kt})] + \gamma_i \sum_{j=1}^{n} \ln p_{jt}(1 + r_{kt})$$

$$+ \theta_i \ln N_t + \rho_i \ln G_t$$

The equation for a long-run equilibrium can be defined as follows

If, w^*_{1t} = equilibrium or desired value for budget share of base 1 (For illustrative purposes assume two tax bases only), then

$$(3.37)\qquad w^*_{1t} = \alpha_1 + \beta_1[\ln x_t - w_{1t}\ln p_{1t}(1+r_{1t}) + w_{2t}\ln(p_{2t}(1+r_{2t}))]$$

$$+ \gamma_{11}\ln(p_{1t}(1+r_{1t})) + \gamma_{12}\ln(p_{2t}(1+r_{2t})) + \theta_1 \ln N_t + \rho_1 \ln G_t$$

Where; $\alpha_1 = \alpha_0 + \beta_1\alpha_0$.

The current value of w will adjust to the equilibrium value according to

$$(3.38)\qquad w_{1t} - w_{1t-1} = k(w^*_{1t} - w_{1t-1}),$$

Where, $0 < k < 1$,

Where k is the adjustment coefficient. This coefficient measures the proportion by which the difference between the equilibrium value w^*_{it} and the realized value w_{t-1} is reduced during the period t. The smaller the k, the smaller the adjustment. Incorporating the equilibrium equation in the partial adjustment model:

$$(3.39)\qquad w_{1t} = k\alpha_1 + k\beta_1\{\ln x_t - w_{1t}\ln(p_{1t}(1+r_{1t})) - w_{2t}\ln(p_{1t}(1+r_{2t}))\}$$

$$+ k\gamma_{11}\ln(p_{1t}(1+r_{1t})) + k\gamma_{12}\ln(p_{2t}(1+r_{2t})) + (1-k)w_{1t-1}$$

$$+ \theta_1 \ln N_{1t} + \rho_1 \ln G_t + e_{1t}$$

The elasticities can be interpreted as, for a proportional unit change in the tax rate, the proportional change in the value of a durable asset per time period. Since the price and quantity of the durable goods are known we can calculate the changes in the total stock for a change in the tax rate.

Likewise the equations for the other tax bases can be derived. The error term may not be serially correlated but it is correlated, across equations since budget shares add up to one.

3.5 Pooling Data

The data set used for this research is based on published data. The sources of data and explanation of the variables are discussed in chapter four. The data set is comprised of both cross sectional and time series data. The time-series was necessary to measure the timing of reactions. The cross-section was necessary to provide enough observations to estimate all of the parameters. Pooling of data was believed to give sufficient variation in the sample in order to produce efficient estimates of parameters.

Pooling of data, however, is not without problems. Problems may arise because the disturbance term in a pooled model is a complex one, since it is likely to consist of time-related disturbances, cross-section disturbances, or a combination of both. This is mainly because specification problems arising out of omitted variables are reflected through the disturbance term.

The two main pooling procedures which attempt to resolve these problems are: (a) co-variance analysis involving addition of dummy variables to the model to allow for the changing intercept across time as well as cross-sectionally, and (b) an error or variance component pooling procedure, which improves the efficiency of the ordinary least squares estimation process (that is OLS performed on a pooled data set without any adjustments) by accounting for the existence of the cross-section and time-series disturbances, via a variation of the generalized least-squares estimation process (Pindyck and Rubinfeld 1981).

3.5.1 Co-Variance Model or Least Squares With Dummy Variables

If the intercept term varies over time as well as cross-sectionally in the pooled data set, this can be taken care of by introducing dummy variables.

For example:

$$(3.40) \qquad Y_{it} = \alpha + \beta X_{it} + \gamma_2 W_{2t} + \gamma_3 W_{3t} + ... + \gamma_n W_{nt} + \delta_2 z_{t2} + \delta_3 z_{t3} + ... + \delta_T z_{tT} + \varepsilon_{it}$$

Where;

$W_{it} = 1$ *for the* i^{th} *individual,* $i = 2,..., n.$

$W_{it} = 0$ *otherwise.*

$Z_{it} = 1$ *for the* t^{th} *time period.*

$Z_{it} = 0$ *otherwise.*

Note, to avoid perfect collinearity among the explanatory variables, two dummy variables have been omitted, one for individual effects and one for time effects.

The introduction of dummy variables results in a substantial reduction in the degrees of freedom. By comparing the residual sums of squares associated with the model with those of a model without dummy variables it can be tested whether introduction of dummy variables is justifiable. The appropriate test statistic would be:

$$F_{N+T-2,NT-N-T} = \frac{\frac{(ESS_1 - ESS_2)/q}{(ESS_2)}}{(NT-N-T)}$$

Where ESS_1 and ESS_2 are the residual sums of squares of the OLS (without dummies) and Co-Variance models respectively, and q = number of individual and time-specific dummies.

Another limitation of the Co-variance model is the difficulty of interpreting dummy variable coefficients since the dummies do not directly identify the variables that might cause the regression line to shift over time and over individuals (Pindyck and Rubinfeld, 1981). The Co-Variance model assumes that the slope coefficient is the same for all cross-section units and that only the intercepts are different. If enough observations are available, Maddalla (1977) suggests it is better to test whether slope coefficients are equal or not.

3.5.2 Error or Variance Component Model

This model attempts to solve problems of the disturbance term such as correlation across individual units and over time. The model was introduced by Balestra and Nerlove (1966). This type of correlation would arise if each cross-section unit had a specific time-invariant variable omitted from the equation (Maddalla, 1977). It is assumed that individual error components are uncorrelated with each other and are not autocorrelated (across both cross section and time series units). Hence, unlike the earlier model intercept terms are considered as random variables.

(3.41) $$Y_{it} = \alpha + \beta X_{it} + \varepsilon_{it}$$

$$\varepsilon_{it} = u_i + v_t + w_{it}$$

where;

$u_i \sim (0, \sigma_u^2)$ = cross-section errors

$v_t \sim (0, \sigma_v^2)$ = time-series errors

$w_{it} \sim (0, \sigma_{it}^2)$ = the usual errors

Here it is assumed that the intercept term varies randomly. If only the cross-section errors are random, then it is equivalent to the assumption that the error components have variance $\sigma_u^2 + \sigma_w^2$, since:

$$var(\varepsilon_{it}) = var(u_i) + var(w_{it}) = \sigma_i^2 + \sigma_w^2$$

On the other hand, if the time series intercept had also been random, $var\ \varepsilon_t = \sigma_u^2 + \sigma_v^2 + \sigma_w^2$

The error components model is estimated using a form of generalized least-squares regression and has been shown to be more efficient than the co-variance model estimation process, although both give unbiased and consistent parameter estimates (Pindyck and Rubinfeld, 1981).

3.5.3 Seemingly Uunrelated Regression Model

The earlier mentioned methods are more appropriate for the estimation of pooled single equations when time and individual effects are present. But these methods alone cannot handle some problems that are common with equation systems. The present research is interested in estimating a system of equations. Due to lack of data some variables,such as household characteristics, are omitted. Also, across-equation residuals must be related due to the restriction that the sum of budget shares equal one. In a situation such as this, the appropriate model is the seemingly unrelated regression (SUR) model (Zellner, 1962). In this model the residuals are uncorrelated over time but are correlated across equations. That is:

$$Cov(u_{it}, u_{js}) = \sigma_{ij} \quad if\ t = s,$$

$$Cov(u_{it}, u_{js}) = 0 \quad if\ t \neq s.$$

3.6 Chapter Summary

This chapter developed an estimable model based on the consumer demand theory. Two demand systems, the Linear Expenditure System (LES) and the Almost Ideal Demand System (AIDS), were compared and it was concluded that the latter was more appropriate for the present research. A long-run AIDS model was also developed incorporating the partial adjustment process. Special implementation issues such as aggregation of the household model and modifications required to include the tax rate into the AIDS model were also discussed. The last section discussed problems of pooling cross-section and time-series data and possible estimation techniques to overcome these difficulties.

Chapter 4

DATA AND ESTIMATION TECHNIQUES

4.1 Data

The data for this study are based mostly on published material. The data for 36 Virginia counties were collected for the period 1981 to 1985 (see figure 3). The research was restricted to this period due to limitations in published material. This chapter describes data sources and the specific measures used for each variable.

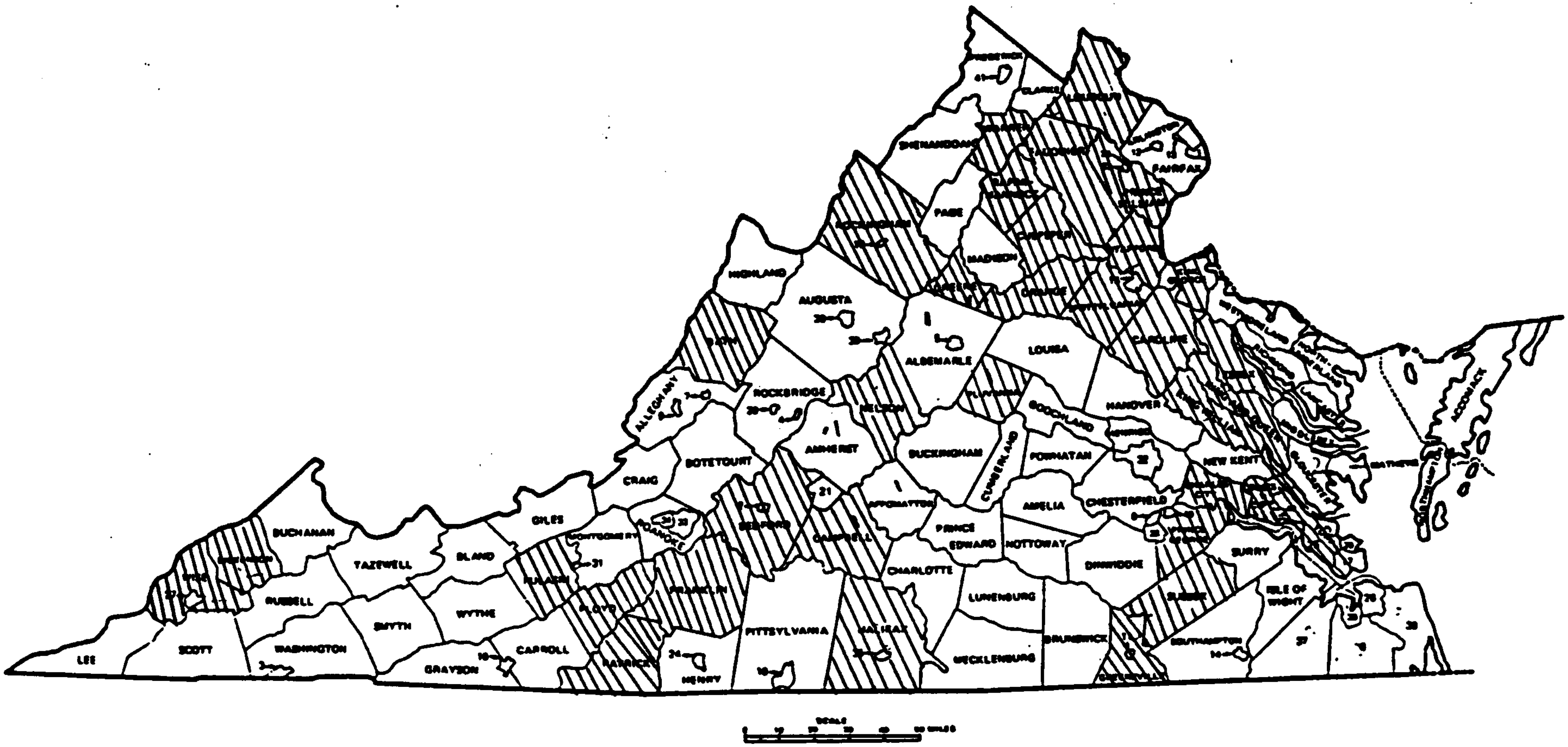

Figure 3. Map Of Virginia with Shaded Areas Showing the Counties Studied.

4.1.1 Local Tax Rates

The Virginia Department of Taxation annually publishes tax rates of counties, cities, and towns for the following tax bases: real estate, tangible personal property, machinery/tools, and merchants' capital. In Chapter 1 the importance of converting nominal real estate tax rates to effective tax rates was discussed. Therefore, the effective tax rates were calculated by multiplying the nominal tax rates of real property by their assessment-to-sales ratios for each locality for each year. Although local constituents are faced with a local tax for retail purchasing, for the period covered by this research, the sales tax rate has not changed. Therefore, it is unlikely that for the period under study, there will be any response in the sales tax bases or sales tax revenue with respect to the sales tax rate. Hence sales tax was excluded from the present research.

4.1.2 Tax Bases

The Virginia Department of Taxation annually publishes, by locality, the value of tangible personal property, machinery/tools, and merchant's capital. Assessed values of real property are categorized into real estate and public service corporations. Although not published, county records are maintained; these records divide real estate property values into the following categories: residential property - urban and rural, commercial and industrial property, and agricultural property.

1. Real Property: In order to get information on the value of different categories of real property, a mail survey was sent to county offices, requesting information covering the period 1975 to 1985. However, due to differences in the data collection techniques of the 95 counties, satisfactory responses were received from only 36 counties. Satisfactory data was received for the five-year period 1981 to 1985. Hence the total number of observations available for estimation purposes was 180. These data provided information on residential property, agricultural property, and commercial/industrial property.

2. Personal Property: As with real property, personal property of private individuals includes a number of categories such as automobiles, boats, and airplanes. Although mobile homes can be categorized as personal property, Spengler (1986) concluded that almost all locations reported taxing mobile homes at the same rate as real estate. In fact the code of Virginia requires that mobile homes be treated as real property even though they can be considered personal property. Of the major categories that come under personal property, only for automobiles is price available on a county basis. Therefore, this research concentrated only on automobiles. This decision was not too restrictive since the bulk of the value of the personal property tax base is comprised of automobiles. Also if price variations of personal property takes place at the same rate as automobiles, the estimated coefficients will not be biased.

4.1.3 Prices

The most difficult information to collect was prices, especially given the fact that each category of tax base is comprised of a group of items of different vintages. While the objective of this research was to estimate tax elasticities rather than price elasticities, tax rate elasticities were estimated relative to price changes. It was important, therefore, to use a reasonable proxy price variable to avoid introducing any bias in the tax rate coefficients. Under these circumstances, the appropriate price variable was weighted index of prices for different tax bases. These indices were compiled by the Center for Public Service (formerly the Taylo Murphy Institute) of the University of Virginia at Charlottesville for the period 1975 to 1984. These studies covered eight Standard Metropolitan Statistical Areas (SMSA). Although the definitions of the SMSA's changed somewhat over time, the studies continued to cover the original areas. The eight SMSA's were Charlottesville, Lynchburg, Newport News-Hampton, Norfolk-Virginia Beach-Portsmouth (Virginia portion), Petersburg-Colonial Heights-Hopewell, Richmond, Roanoke, and the Northern Virginia portion of the Washington DC-MD-Va SMSA. See appendix A for areas under each SMSA.

in these studies the Center for Public Service measured real prices for a typical "market basket" of items. These item prices were then converted into relative and absolute price indices for each of the geographical areas covered. The total indices were made up of data for 257 items, which were combined into seven categories: housing, apparel, personal care, transportation, recreation, medical care, and food. The sources consulted for item selection were the U.S. Bureau Of Labor Statistics (USBLS) consumer price index, the USBLS moderate level city worker's family budget, and the Virginia Department of Labor and Industry food market budget. The weights used were adapted from those used for national indices published by the USBLS.

Some metropolitan areas typically have geographic limitations similar to those of the trading areas of the consumers who live there. Combining counties and cities into metropolitan areas meant that accounting for the problem of shopping in locations other than those which the shoppers reside was substantially alleviated.

Price indices, however, are available only for eight SMSA areas (covering 24 counties). Therefore it was decided to forecast the price indices for the remaining counties using regression techniques. Since each price category included a number of different items, it was almost always impossible to come up with a well defined quantity variable. Regressing the price indices on per capita incomes revealed a very close relationship between these two variables. Hence the estimated coefficients from this regression were used to predict the price indices of other counties based on the per capita income of each county.

Recall that in the system of equations derived in chapter 3 there was an equation for non-taxed goods. In Virginia, few goods are exempted from tax. Although gasoline is not taxed at the pump, it is heavily taxed before it comes to the pump, and this tax is passed on to the consumer. However, though there was a sales tax of 4 percent (local 1 percent plus state 3 percent) on retail purchases, the tax rate did not change over the time series of the data[2]. Therefore retail sales, including the sales tax, can be considered as the "non-tax base." Of the seven major categories used for the calculation of price indices, apparel, food, recreation, household furnishings, and services come mostly under the sales tax base. Hence, the weighted price indices of these categories were used to arrive at a proxy for price.

To develop the price of residential property, the method proposed by Erickson was used, as described in chapter 3. For agricultural property, price estimation was based

---

[2] Since the period of the study the sales tax has increased from 4 percent to 4.5 percent

on farm land value per acre, available from the Census of Agriculture. Periodic census information from 1935 to 1982 was used to predict the farm value per acre from 1981 to 1985 for the 36 counties under investigation. The other important component of real property is commercial property. In the absence of any price data with respect to commercial property, it was decided to assume that the real price of commercial property was constant across counties and over time.

The unit real prices of machinery/tools were based on the producer price index maintained by the U.S. Department of Labor (Bureau of Labor Statistics). However, this information is not available on a county basis. Hence a single price for all counties for a particular year was used for estimation purposes. Although this assumption is not totally satisfactory, it can be justified as follows. Machinery/tools are mostly comprised of heavy capital goods. When investments in such goods are made, investors are likely to purchase these items in a perfectly competitive environment. Any difference in price from one location to another can be attributed solely to transportation costs involved. Hence, barring price differences due to transport costs, it is not unreasonable to expect the price of a unit of machinery/tools to be constant across relatively proximate counties for a given year. Even if there are geographic differences, these differences will be approximately maintained over time.

4.2 Estimation Techniques.

As discussed in chapter 3, the use of panel or pooled cross-sectional, time-series data results in a complex disturbance term. Since a variance-component estimation process gives a more efficient estimate compared to the co-variance estimation procedure, the former method was used.

The software used for estimation was 'Regression Analysis of Time Series' (RATS) version 2.6 (1987), written by Thomas A. Doan and Robert B. Litterman.

Tests were conducted for the presence of multi-collinearity using variance inflation factors, for serial correlation using the Durbin-Watson Statistic, for heteroscedasticity using the Park Test, and for any time and individual effects possible with panel data. Whenever individual or time effects were present, data were transformed using the variance-component model and the Generalized Least Squares (GLS) estimation technique.

When time or individual effects were not present, each equation in the AIDS model was estimated using OLS regression technique. Note that the use of Stone's approximation permits estimation of single linear equations. The homogeneity restrictions were imposed on each of the equations.

Since none of the equations had a unique independent variable (all variables were common to all equations), seemingly unrelated regression (SUR) techniques were not used to estimate the short-run parameters (Havlicek, 1980; Johnston, 1972; and Blancoforti, Green, and King, 1986). However, for the long-run estimation, the lagged dependent variable was used as an independent variable in each equation, introducing non-common variables. As a result Zellnar's SUR method was used. Since this research is not directed towards estimation of compensated rate coefficients, no restrictions other than homogeneity were imposed.

The long-run model as specified would result in biased estimates since the lagged dependent variables and the disturbance terms are correlated. In order to avoid this bias, the strategy used in this research was to lag the fitted values of the dependent variable, and re-estimate the model. There were two methods that were possible in this regard. The first method is to exclude the lagged dependent variable, in the regression model that is used to predict the fitted values of the dependent variable. However, there are problems with this method. In the long-run model the lagged dependent variable is introduced to capture the long-run effects. By excluding this variable, there is likely to be missing variable specification bias. In this situation the error term is likely to pick up the missing variable and may result in autocorrelation, if there are particular patterns in the missing variable. The second method is to introduce the lagged dependent variable and predict the fitted values of the dependent variable for re-estimation purposes. But the problem with this method is that fitted regression uses the lagged dependent variable; hence the fitted values will be dependent on the biased estimates. However, this bias can be eliminated to a great extent by iterating the estimation using the fitted values of the dependent variable repeatedly. When convergence of estimated coefficients occurs, it is likely that the correlation between the lagged dependent variable and the error term is eliminated, resulting in unbiased estimates. Therefore, for this research this second method was used. The long-run model, as illustrated in equation 3.39, was estimated using the seemingly unrelated regression technique. All variables were expressed on a per capita basis in order to reduce the heteroscedasticity introduced by the range of populations in the sample.

Chapter 5

RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents the coefficients and tax rate elasticities estimated using the linear approximate AIDS models. First, the results of tests conducted to test the proposition that tax payers' response to price and tax rate are equal are presented. Second, for each tax base short-run results with respect to elasticity estimates are presented. Third, using the 'dynamic' linear approximate AIDS model, long-run results with respect to elasticities are presented.

5.2 Price and Tax Rate Coefficients

In the original model, suggested in chapter three, the implicit assumption was that, individuals' responses to price changes and tax rate changes were equal. Hence a combined price variable ($p_t(1 + r_t)$) was employed (see equation 3.33). However, it was noted in chapter 2 that individuals may respond differently to tax rate changes vis-a-vis price changes. Therefore, tests were conducted to evaluate this proposition. For the given structure of the model (equation 3.34), the following hypotheses were considered.

(1) H_0 : Coefficient of $W_t \ln p_t$ = coefficient of $W_t \ln(1 + r_t)$
    H_1 : Coefficient of $W_t \ln p_t \neq$ coefficient of $W_t \ln(1 + r_t)$
(2) H_0 : Coefficient of $\ln p_t$ = Coefficient of $\ln(1 + r_t)$
    H_1 :Coefficient of $\ln p_t \neq$ coefficient of $\ln(1 + r_t)$

Of the two sets of hypotheses, the latter is the more critical to the proposition suggested. Hence, a linear restriction was built into the estimating equation; the appropriate test statistic is given below (Maddalla 1977).

$$(5.1) \qquad F = \frac{(RRSS - URSS)/r}{URSS/(n - k - 1)}$$

Where,

F = F statistic,

RRSS = restricted residual sums of squares,

URSS = unrestricted residual sum of squares,

r = number of linearly independent restrictions,

n = sample size, and

k = number of explanatory variables in the unrestricted model.

Table 5.1 gives F-ratio values for the above test. The results of the above test allow the rejection of the null hypothesis at a significance level of five percent. In view of these findings, the estimated coefficients of the expanded version of the AIDS model (equation 3.34) were used for explicit calculation of tax rate elasticities.

Non-equality of price and tax rate coefficients suggests that individuals view changes in the value of goods due to price changes differently from those resulting from tax rate changes. In other words it may indicate individuals' willingness to pay taxes. For example, if individuals perceive that they obtain benefits from local government expenditures, their willingness to pay taxes will be higher than their willingness to pay price. This phenomenon can be captured via the difference between price and tax rate coefficients. For example:

If, β_1 = coefficient of $\ln p_1$,

β_2 = Coefficient of $\ln(1 + r_2)$,

Then greater response to tax implies:

(5.2) $\beta_2 - \beta_1 < 0$,

Table 5.1. Testing Equality of Price and Rate Coefficients

Tax Base	F value	Probability of Rejection	Sample Size
Machinery/Tools	1244.31	0.01	180
Personal Property	353.58	0.01	180
Residential Property	5.30	0.05	180
Agricultural Property	7.42	0.01	180

and greater price response implies:

(5.3) $\beta_2 - \beta_1 > 0.$

Tests were conducted for the following hypothesis:

$H_0: \beta_2 - \beta_1 \leq 0$

$H_1: \beta_2 - \beta_1 > 0$

Table 5.2 gives the differences between the rate and price coefficient and the t-ratios of the above tests. In the short-run, for personal property, residential property, and agricultural property, the difference between the coefficients allows rejection of the null hypothesis in favor of the alternative hypothesis that the difference is more than zero at the five percent level of significance. This result implies greater price response. For machinery/tools, the null hypothesis was rejected in favor of the alternative hypothesis that the difference between the coefficients is less than zero at the five percent level of significance. This result implies greater tax response. For personal property, these results are consistent with those of the k-ratios. However, the long-run results indicated that except for machinery and tools, the differences between the coefficients of the other tax bases were not significant. Further, discussion on the implications of these values is delayed until rate coefficients are discussed.

Table 5.2. Difference between Rate and Price Coefficients

Tax Base	SR (NH)	SR (H)	LR (NH)	LR (H)
Machinery/Tool	-0.0022**	-0.00081**	0.0023**	0.0001**
t-statistic	-10.9977	-5.5708	9.2668	2.340
Personal property	0.1301**	0.0608**	-0.0638	0.0164
t-statistic	4.7681	3.1185	-1.5927	0.5777
Residential Property	0.3819**	0.3741*	0.2316	-0.1188
t-statistic	9.9056	1.8052	1.4229	0.7359
Agricultural Property	0.8567**	0.8767*	0.7536	0.8138
t-statistic	2.6380	1.6115	1.1211	1.3500

LR = Long-Run SR = Short-Run.
H = Homogenous Model NH = Non-Homogenous Model.
** = significant at 5 percent level.
* = significant at 10 percent level.

5.3 Own-Rate Elasticities

5.3.1 The Short-Run Model

The demand categories that were considered for estimation are non-tax, machinery/tools, personal property, residential property, agricultural property, and commercial/industrial property.

Tests for multicollinearity using variance inflation factors did not indicate collinearity problems. Also, no heteroscedasticity was detected by the Park test. However, for all the equations, the Durbin-Watson statistic ranged from 0.50 to 1.43, indicating correlation between disturbance terms (see table 5.3). This result is not surprising since with panel data there are likely to be individual and time effects in the combined disturbance term; that is, the combined error term may be correlated across time and across individual units as, described in chapter three. Tests were conducted to determine the presence of individual and time effects of the combined disturbance terms. The F-ratios with reference to these tests are given in table 5.4. The F-ratio for time correlation effects indicated that the null-hypothesis of no time effects cannot be rejected at the one percent level of significance for any of the equations (critical $F_{4,175}$ = 3.48). On the other hand, tests for individual correlation effects did allow rejection of the null-hypothesis of no individual effects at the one percent level of significance (critical $F_{35,144}$ = 1.86), except for machinery/tools. Therefore, using the variance component model described in chapter three, the data were transformed to take into account any individual effects present. Therefore, Generalized Least Squares (GLS) was necessary to ensure efficient estimates.

Table 5.3. D-W Statistic for the Short-Run Model (n = 180)

Tax Base	D-W Statistic
Non-Tax	0.7031
Machinery/Tools	1.4381
Personal Property	0.7107
Residential Property	0.5807
Agricultural Property	0.5049
Commercial Property	0.5574

Table value D-W ($\alpha = 0.01$), $d_l = 1.44$
$d_u = 1.65$

Table 5.4. F-Ratios for Tests on Time and Individual Effects (n = 180)

tax base	Time Effects	Individual Effects
Non-tax	0.4368	4.2966
Machinery/Tool	0.1734	0.1181
Personal Property	0.0877	5.0390
residential Property	0.0769	16.7045
Agricultural Property	0.2086	16.3935
Commercial Property	0.2048	9.9759
Table F Value ($\alpha = 0.01$)	2.45	1.55

In table 5.5 unrestricted GLS estimates of the transformed data for all the demand equations are given. The linear approximate AIDS model automatically satisfies the adding-up restriction. But the other restrictions had to be imposed. Also in table 5.5 the sum of the coefficients of the price variable (γ_{ij}). are given to test whether the homogeneity restriction is satisfied.

Of the six equations estimated, five bases other than the non-tax category, as discussed in chapter 4, are of interest. For the unrestricted linear approximate AIDS model, the goodness-of-fit values were very good (R^2 ranged from .93 to .99) for all the tax bases.

In this research, the most important variable is the tax rate variable. As specified in the estimated model, it has an impact on the budget shares directly through $\ln(1 + r_i)$, as well as through the product of its own budget share and the tax rate, $w_i \ln(1 + r_i)$. Hence the significance levels of the coefficients on two variables are important. In the unrestricted short run model, for machinery and tools, none of the parameter estimates of the above variables were significant at the five percent level of significance. For personal property, the $\ln(1 + r_3)$ variable was significant at the one percent level of significance. For agricultural property, both the associated rate variables were significant at the one percent level of significance. Rate variables associated with residential property were significant only at the 20 percent level. For commercial property, the $w_6 \ln(1 + r_6)$ variable was significant at one percent while the $\ln(1 + r_6)$ variable was significant only at the ten percent level. For all the tax bases except machinery/tools, tax rate changes had a significant impact on their respective tax bases.

The impact of tax rate changes on the value of the tax base, as specified in chapter 3, is a function not only of the tax rates, but of all the other estimated variables. To avoid any calculation error, all the coefficients were included in the calculations, even if the coefficients were not statistically significant. Hence, this total coefficient is defined as the combined coefficient. However, whether or not the tax rate coefficient is significant was based on the coefficients of $w_i \ln(1 + r_i)$ and $\ln(1 + r_i)$. The combined coefficients are non-linear, resulting in difficulties of deriving formulas for the co-variance of these coefficients. Hence, it was not possible to statistically test the significance of these combined coefficients. Therefore, if either of the above variables is significant, it is believed that the total combined coefficient is likely to be statistically significant. The following discussion is based on the above premise. Hence, some caution is required when interpreting the results. Note that although all the categories of real property are subject to the same tax rate, the impact of the tax rate on the value of each tax base is a function of other tax rates as well as the value of the budget share.

Individual behavior, in the absence of money illusion, will be affected only by real prices and income. Hence tests of homogeneity in this research were conducted on the premise that individual's demand functions will be homogeneous in tax rate changes only if the demand functions are homogeneous in prices and income. Hence a homogeneity restriction was imposed only on the price and total expenditure variables. The sums of γ_{ij} coefficients (as defined in chapter 3), were tested for each equation to determine if they were significantly different from zero (see table 5.5 for sum of γ_{ij} and F-ratio values). Homogeneity was rejected for all but agricultural property at the five percent level of significance.

Although homogeneity was rejected for most of the equations, in accordance with theory, the same model was re-estimated with the homogeneity restriction imposed. There is a difference of opinion with regard to this situation. Some would argue that, in statistical terms, if the homogeneity condition is rejected there is no defense for the

Table 5.5. Short-Run Non-Homogeneous Model Coefficients (n = 180)

Variable	Mach/Tool	Per Prop	Res Prop	Agric Prop	com Prop
Constant	.02479	.03770	.13605	.04218	-.00131
	(10.24)***	(9.30)***	(7.04)***	(2.30)***	(-.02)
income	-.00008	-.00588	-.00621	-.00868	-.00444
	(-.74)	(-3.47)***	(-.42)	(-.27)	(-.13)
wp1	.00115	.01343	-1.23320	1.96744	-1.68930
	(.50)	(.33)	(-3.06)***	(2.04)**	(-1.99)**
wp2	.19281	.00947	.01848	-.16942	-.06920
	(343.9)***	(1.23)	(.29)	(-1.44)	(-.47)
wr2	.00197	-.04952	-.30599	.42935	-.04934
	(1.05)	(-1.63)*	(-1.22)	(.91)	(-.08)
wp3	-.00006	.19191	-.05033	-.13602	-.02085
	(-.29)	(54.85)***	(-1.85)*	(-2.76)***	(-.32)
wr3	.00014	-.01192	.04217	-.09768	.04181
	(.23)	(-1.39)	(.54)	(-.59)	(.24)
wp4	.00004	.00086	.16398	-.08003	-.07665
	(1.23)	(1.79)*	(34.35)***	(-6.84)***	(-7.63)***
wr4	.00122	-.00532	- .32907	-.68629	.66059
	(3.69)***	(-.19)	(-1.46)	(-1.63)*	(1.28)
wp5	.00016	.00168	-.02216	.30466	-.23937
	(1.52)	(1.31)	(-1.76)*	(10.59)***	(-8.93)***
wr5	.00081	-.00038	-.32641	-.80491	.76054
	(2.42)***	(-.01)	(-1.44)	(-1.86)*	(1.46)
wr6	.00155	.00903	-.25346	-2.43862	2.30839
	(2.64)***	(.32)	(-1.03)	(-4.96)***	(4.15)***
price1	.00066	-.15151	-.08403	.47006	.24275
	(.24)	(-5.29)***	(-.36)	(1.02)	(.45)
price2	-.00225	.00219	.00619	-.07028	.05785
	(-11.22)***	(1.88)*	(.62)	(-3.07)***	(2.59)***
rate2	-.00001	-.00046	.00051	.00381	-.00386
	(-.36)	(-2.34)***	(.32)	(1.25)	(-1.04)
price3	-.00059	.13219	.08979	-.41332	-.25495
	(-.23)	(4.85)***	(.39)	(-.95)	(-.49)
rate3	-.00004	-.00196	-.00171	-.00701	.00189
	(-1.16)	(-3.77)***	(-.39)	(-.85)	(.19)
price4	-.00001	-.00081	-.08767	.04572	.04706
	(-.53)	(-1.57)	(-15.76)***	(2.88)***	(4.18)***
Rate4	-.00081	-.00789	.29428	.79943	-.80623
	(-2.95)***	(-.33)	(1.50)	(2.16)**	(-1.79)*
price5	-.00001	.00069	.00499	-.05733	.04195
	(-.58)	(1.70)*	(1.09)	(-4.26)***	(4.59)***
pop	-.00002	-.00013	.00266	.00382	-.00058
	(-1.74)*	(-.76)	(1.40)	(.63)	(-.15)
trc	.00005	.00586	.00317	.02336	-.00363
	(.52)	(3.53)***	(.22)	(.79)	(-.11)
sum of γ_{ij}	-.0022	-.0173	-.0708	-.0251	.1347
$f_{1,158}$	77.49	77.97	18.78	.5407	13.31

t-values are given in parentheses.
See next page for variable names.
*** = significant at 1 percent level.
** = significant at 5 percent level.
* = significant at 10 percent level.

income = per capita total expenditure.
wp1 = price of non-taxed goods times its budget share.
wp2 = price of machinery/tools times its budget share.
wr2 = tax rate of machinery/tools times its budget share.
wp3 = price of personal property times its budget share.
wr3 = tax rate of personal property times its budget share.
wp4 = price of residential property times its budget share.
wr4 = tax rate of residential property times its budget share.
wp5 = price of agricultural property times its budget share.
wr5 = tax rate of agricultural property times its budget share.
wr6 = tax rate of commercial property times its budget share.
price1 = price of non-taxed goods.
price2 = price of machinery and tools.
rate2 = tax rate of machinery and tools.
price3 = price of personal property.
rate3 = tax rate of personal property.
price4 = price of residential property.
rate 4 = tax rate of real property.
price5 = price of agricultural property.
pop = population.
trc = per capita local government expenditure.

Table 5.6. **Short Run Homogeneous Model Coefficients (n = 180)**

Variable	Mach/Tool	Per Prop	Res Prop	Agric Prop	Com Prop
constant	.00500 (4.60)***	.01270 (3.59)***	.08847 (5.27)***	.03789 (2.19)***	.12728 (2.83)***
income	.00015 (1.16)	-.00435 (-2.12)**	-.00861 (-.54)	-.01488 (-.48)	-.00814 (-.24)
wp1	.00609 (2.27)**	-.00504 (-.10)	-1.44851 (-3.44)***	1.83515 (1.93)*	-1.39643 (-1.6)
wp2	.19339 (285.47)***	.01365 (1.46)	.02347 (.35)	-.17304 (-1.47)	-.08929 (-.58)
wr2	.00089 (.39)	-.05842 (-1.58)	-.33516 (-1.27)	.42006 (.89)	.00896 (.01)
wp3	-.00074 (-3.40)***	.18591 (44.46)***	-.07048 (-2.49)***	-.14241 (-2.94)***	.01986 (.30)
wr3	.00290 (4.29)***	.00717 (.71)	.07107 (.86)	-.10355 (-.63)	-.05347 (-.30)
wp4	.00005 (1.39)	-.00028 (-.49)	.15755 (32.93)***	-.08304 (-7.59)***	-.06584 (-6.61)***
wr4	.00060 (1.52)	.00502 (.15)	-.32150 (-1.36)	-.71201 (-1.69)*	.60855 (1.13)
wp5	.00008 (.64)	-.0017 (-1.17)	-.03941 (-3.12)***	.29879 (10.83)***	-.20863 (-7.90)***
wr5	.00082 (2.01)**	.01119 (.34)	-.31915 (-1.33)	-.83433 (-1.94)*	.69658 (1.30)
wr6	.00045 (.65)	.00386 (.11)	-.33183 (-1.27)	-2.500000 (-5.17)***	2.39418 (4.16)***
price1	.01156 (6.07)***	.05398 (2.65)***	.72720 (4.79)***	.72244 (2.38)***	-1.33679 -(4.01)***
price2	-.00082 (-5.73)***	.00739 (6.06)***	.02539 (2.68)***	-.06519 (-2.99)***	.01942 (.95)***
rate2	-.00001 (-.12)	-.00049 (-2.07)**	.00074 (.43)	.00403 (1.33)	-.00392 (-1.01)
price3	-.01482 (-6.06)***	-.06314 (-3.25)***	-.68203 (-4.71)***	-.65326 (-2.25)***	1.24744 (3.92)***
rate3	-.00003 (-.64)	-.00226 (-3.56)***	-.00430 (-.95)	-.00830 (-1.03)	.00567 (.55)
price4	.00001 (.19)	.00029 (.49)	-.08100 (-14.39)***	.05027 (3.46)***	.03643 (3.23)***
rate4	-.00011 (-.35)	-.01431 (-.49)	.29310 (1.42)	.82244 (2.23)***	-.76857 (-1.65)*
price5	-.00001 (-.24)	.00148 (3.09)***	.0104 (2.25)***	-.05426 (-4.25)***	.03349 (3.65)***
pop	-.00001 (.58)	-.00007 (-.34)	.00223 (1.12)	.00285 (.48)	-.00047 (-.11)
trc	-.00016 -(1.38)	.00465 (2.31)***	.00453 (.29)	.02647 (.90)	-.00049 (-.01)

t-values are given in parentheses.
See Table 5.5 for variable names.
*** = significant at 1 percent level.
** = significant at 5 percent level.
* = significant at 10 percent level.

imposition of the restriction. However, recent studies have concluded that the homogeneity condition has been rejected due to aggregation problems, and that imposition of the restriction may reduce the related errors, resulting in more accurate estimates (Blanciforti, Green, and King(1986), Goddard). These same studies compared both models. Following these papers, the current study reports the results of both models, that is, the non-homogeneous model as well as the homogeneous model. The results are given in table 5.6. For machinery/tools, coefficients associated with the tax rate variable were not significant in either of the models. Both coefficients for agriculture property were significant at the five percent level of significance in the homogeneous model while in the non-homogeneous model they were significant at the one percent level. For the rest of the tax bases there were no differences with respect to the significance level of the coefficients in the two models.

It was hypothesized in chapter 1 that an increase in the tax rate would significantly reduce the value of the tax base. The short-run results indicate that the tax rate change did not have a significant impact on the machinery/tools tax base. As hypothesized, a tax rate increase had a significant negative impact on the both personal and commercial property. For residential property, the impact of tax rate change was not significant at the five percent level.

Although it is expected that the local government expenditure variable would have a significant positive impact on the value of residential property, the coefficient was not significant at the five percent level (see tables 5.5 and 5.6). This lack of significance may be attributed to the equilibrium in the supply of local government services. As described by Edel and Sclar, at Tiebout equilibrium there would be no tax and local government expenditure capitalization into property value. However, Oates noted that only in circumstances in which supply side is not in equilibrium is tax and local government expenditure capitalization is possible. Thus, it may be that the results of this research, as far as residential property is concerned at least, are consistent with the Tiebout hypothesis. This result suggests that individuals compare taxes and government services in seeking residential property. Similar results were obtained by Edel and Sclar (1974) at least for certain local services such as school expenditures for the Boston metropolitan area.

Most puzzling, however, is the significant (at the 5 percent level) positive impact of a tax rate increase on the value of agricultural property. Several reasons can be suggested for this response. Of the different bases that were considered in this research, agriculture land is the most immovable. Although other types of real property too are immovable, it is possible, say for businesses, to move to other jurisdictions if taxes are too heavy. Unlike other tax bases, farmers in Virginia have the option of paying real property taxes on the use-value of their property only. Therefore, they get disproportionate rate benefits for each tax dollar spent. Hence, relative to ownership of other tax bases, ownership of agricultural land involves a smaller tax burden. Also, individuals invest in agricultural property not necessarily expecting present gains, but for aesthetic reasons and expected future returns. Benefits from public services may be viewed differently by different property owners. For example, if commercial property owners live in a different jurisdiction, expenditure on the local education system would not be considered a service by the commercial property owners. On the other hand, if agriculture land owners live on the farm, they may consider that public services enhance their property value. Therefore, on the whole, the moderate negative effect of taxes may be overridden by factors such as public services, aesthetic values, and future expectations. Also the supply of agricultural land is fixed, and in many areas of the state there is a high demand for agricultural land. Therefore, due to one or more of the reasons mentioned above, even when the tax rate on agricultural property rises, demand for agricultural land can increase, enhancing its property value.

The elasticity figures given in table 5.7 are the most critical information generated by this research. The short-run elasticity figure for agricultural property is more inelastic in the homogeneous model than in the non-homogeneous model. Recall that the agricultural property tax base was the only tax base for which the homogeneity restriction was not rejected. For other bases, there was very little difference between the models. The own-rate elasticity for commercial property was highly elastic (-5.2856 for the homogeneous model and -4.374 for the non-homogeneous model). However, some caution is required in interpreting this result. Recall that the unit price (p) of commercial property is assumed to be constant while in reality it would be variable. The tax rate may have a negative or positive effect on the demand for tax base (B). In either case it will have the same effect on price and quantity because it will make it either less desirable (small demand and lower price), or more desirable, that is movement along the positive supply curve. The change in price will lead to a movement along the demand curve which, if we ignore it, will be included with the tax rate coefficient. Regardless of the sign of $\frac{\partial p}{\partial TR}$, the $\frac{\partial B}{\partial TR} > \frac{\partial B}{\partial p}$ (where, TR = Tax revenue). Therefore, if the $\frac{\partial p}{\partial TR} > 0$, then $(\frac{\partial BV}{\partial TR}) > 0$ but underestimated (where BV = value of the tax base), and if $\frac{\partial p}{\partial TR} < 0$, then $(\frac{\partial BV}{\partial TR}) < 0$ but too low. Therefore, ignoring price will bias the coefficient down but should not change the sign. A large elasticity figure may be the result. Since the tax rate elasticity of commercial property is elastic, the reduction in the value of commercial property, as a result of a tax rate change may be more than proportionate to the tax rate change. In other words, the tax rate changes are over

Table 5.7. Own Tax Rate-Base Elasticities: Short-Run(SR) and Long-Run(LR)

Tax base	Model	SR Elasticity	LR Elasticity
Machinery/Tools	Non-Homogeneous	0.0000	-.0003**
	Homogeneous	0.0000	-.0019**
Personal Property	Non-Homogeneous	-.0121**	-.0004**
	Homogeneus	-.0170**	-.1380**
Residential Property	Non-Homogeneous	.1409	.1465
	Homogeneous	.1050	.0514
Agricultural Property	Non-Homogeneous	.6705**	3.9500**
	Homogeneous	.1034**	3.5800**
Commercial Property	Non-Homogeneous	-4.3740**	-13.1493**
	Homogeneous	-5.2856**	-4.8162**

** = significant at the five percent level.

capitalized into the commercial property. Therefore, tax revenue collections will reduce more than proportionately to a tax rate increase. Such a conclusion has implications in reduced tax revenues not only in the short-run but also in the long-run, since heavy taxes may induce businesses to go out of the jurisdiction, as suggested by Aronson and Hilley.

From its point of view, when local government increases tax rates it wants to know the changes in the value of the tax base -- due both to the price change (as a result of tax rate change) and to tax rate change. Since variations in the price are ignored in the commercial property equation, the calculated elasticity will include the impact of the tax rate change as well as that of the omitted variable price. Although this looks fine from the government point of view, omitting theoretically justifiable variables causes specification bias. Some of the effects of the omitted variable may also be captured by the disturbance term, resulting in problems such as serial correlation. The ideal would be to include the tax rate variable as well as the price variable and to combine the separate effects (that is, calculate the reduced form) to get the total effect.

With personal property, the tax rate increase shows an inelastic response in both homogeneous (-0.017) and non-homogeneous (-0.0121) models. This low response is advantageous for tax revenue collections, since tax revenues will increase more than proportionately to the tax rate increase. One point to note is that the per capita government expenditure variable was significant (α = 0.05) only for the personal property equation. Edel and Sclar shed some light on how this kind of phenomenon may be possible. They argued that if all public service expenditure items are in a Tiebout equilibrium, taxes will not be capitalized into the value of the tax base. If at least one of the public service markets is in disequilibrium, then tax capitalization is possible. In this context, some inferences can be drawn for the present research. Research by Oates and Edel and Sclar considered separate public service variables, such as school expenditure and highway maintenance, in their research. Rather than thinking in terms of a market for each separate public service variable, it is possible to think of a market for a single variable comprised of all public services for each tax base, as done in the present research. Then in a competitive equilibrium situation, if all public services relevant to a particular tax base are equally available in all the jurisdictions, there will be no capitalization of the public servic e variable as well as of the taxes. In fact this may be one reason why there was no tax capitalization nor public expenditure capitalization on the residential property tax base apparent in this analysis.

5.3.2 The Long-Run Model

In tables 5.8 and 5.9 the coefficients of the long-run models are given. Table 5.7 also gives the long-run tax rate elasticities. It was hypothesized in chapter one that, with durable assets like the tax bases that are under study, the response to tax rate changes would, over time, become more elastic. Oates, interpreting the negative association between property value and tax rates, reasoned that ".... the negative association we have observed between property taxes and home values is primarily a short-run phenomenon, which would disappear over a longer period of time (p.967)". In fact this proposition is somewhat contrary to our hypothesis. However, Oates' proposition is true if the Tiebout equilibrium occurs as suggested by Edel and Sclar. But perfect Tiebout equilibrium occurs only if all the sub markets of public expenditure attain equilibrium. It should be noted that these authors considered only the value of residential property. In fact, it was suggested earlier that the importance of the public service variable in determining property values will differ depending on the circumstances. Thus, while the Tiebout equilibrium may be important for residential property, it may not be vital for commercial property valuations. Therefore, the hypothesis suggested in this research -- that is, that response to tax rate changes will over time become more elastic -- may not be inconsistent with Oates's proposition.

The long-run elasticity figures presented in table 5.7 are mixed. For machinery and tools, the short-run tax rate coefficient was not significant but, in the long-run, consistent with the original hypothesis, was significant (at the one percent level). For personal property the elasticity figure has become more elastic, i.e., -0.017 to -0.1380 in the homogeneous model, but not in the non-homogeneous model. For residential property in both the short-run and the long-run, the tax rate coefficient was not significant. For agriculture and commercial property, (non-homogeneous model) responses have become more elastic in the long-run model.

Recall the difference between price and tax rate coefficients on the budget shares from table 5.2. The difference between these coefficients was positive for both agricultural and residential property. Interestingly, the tax rate coefficient on these tax bases did not indicate negative tax capitalization. Since a positive difference indicates that those who own these particular tax bases consider local public expenditure to be beneficial, the results can be explained. For agricultural property the positive difference was larger than for residential property, in both short-run and long-run models. As indicated earlier since agricultural property owners get disproportionate tax benefits in relative terms, they benefit more from public services than do residential property owners. Hence, consistent with the above finding, it is likely that agricultural property owners are more responsive to prices than to tax rate increases.

Table 5.8. Long-Run Non-Homogeneous Model Coefficients (108)

Variable	Mach/Tool	Per Prop	Res Prop	Agric Prop	Com Prop
Constant	.02508	.03465	.13635	.0494	-.0159
	(9.25)***	(3.47)***	(6.16)***	(4.18)***	(-.31)
income	-.00003	-.00389	-.00733	.0214	-.01299
	(-.87)	(-1.62)*	(-.53)	(1.04)	(-.47)
wp1	.00017	.0253	-.28581	.65399	-.47147
	(.22)	(.57)	(-.93)	(1.35)	(-.83)
wp2	.19172	.00822	-.03277	-.01352	-.15686
	(591.32)***	(.97)	(-.74)	(-.24)	(-1.73)*
wr2	.00098	-.04415	.02393	-.47617	.59066
	(1.60)*	(-1.23)	(.12)	(-1.96)**	(1.5)
wp3	-.00004	.18938	.02053	-.10494	-.06612
	(-.67)	(47.57)***	(1.01)	(-391)***	(-1.57)
wr3	.00002	-.00009	-.13144	-.11064	.19506
	(.08)	(-.01)	(-1.91)*	(-1.02)	(1.52)
wp4	-.000001	.00018	.18629	-.06464	-.09682
	(-.05)	(.26)	(35.61)***	(-7.82)***	(-10.35)***
wr4	.00011	-.00636	-.17399	-.67833	.8734
	(1.10)	(-.19)	(-.94)	(-2.72)***	(2.35)***
wp5	.00002	.00073	.01129	.26969	-.24424
	(.57)	(-.49)	(1.03)	(15.32)***	(-12.23)***
wr5	.00004	-.00089	-.1199	-.63914	.85959
	(.33)	(-.02)	(-.65)	(-2.55)**	(2.30)**
wr6	.00009	.00296	-.03825	-1.47145	1.84271
	(.56)	(.08)	(-.18)	(-4.89)***	(4.56)***
price1	-.00044	-.0778	-.19006	-.0529	.85189
	(-.47)	(-1.86)*	(-.81)	(-.18)	(1.81)*
price2	-.00227	.00368	.01042	-.03617	.03148
	(-9.28)***	(1.5)	(.82)	(-1.72)*	(1.2)
rate2	-.000002	-.00053	.00019	.00232	-.00319
	(-.47)	(-2.62)***	(.19)	(1.8)*	(-1.5)
price3	.00042	.06208	.18174	.06065	-.81722
	(.48)	(1.55)	(.81)	(.21)	(-1.8)*
rate3	-.00002	-.00168	.00406	.00367	-.00338
	(-1.45)	(-2.51)***	(1.08)	(.76)	(-.46)
price4	.00001	-.00005	-.10273	.01577	.06774
	(1.13)	(.091)	(-20.98)***	(1.67)*	7.68)***
rate4	-.00011	-.00328	.12888	.69129	-.90364
	-1.01)	(-.11)	(.78)	(3.13)***	(-2.77)***
price5	-.000003	.00087	-.00319	-.06234	.05618
	(-.54)	(2.16)**	(-.85)	(-7.20)***	(8.26)***
pop	-.000004	.00007	.00253	-.00464	.00238
	(-1.25)	(.36)	(1.61)*	(-1.13)	(.79)
lw2	.00037	-.00356	-.01237	.00722	-.01808
	(.68)	(-.58)	(-.70)	(.85)	(-.84)
trc	.00003	.00417	.0076	.00457	-.00914
	(.65)	(1.8)*	(.57)	(.25)	(-.35)
Sum of γ_{ij}	-0.0023	-0.0112	-0.1038	-0.0749	0.1901
$f_{1,158}$	77.49	77.97	18.78	.5407	13.31

t-values are given in parentheses.
See next page for variable names, *** = significant at 1 percent level, ** = significant at 5 percent level, * = significant at 10 percent

income = per capita total expenditure.
wp1 = price of non-taxed goods times its budget share.
wp2 = price of machinery/tools times its budget share.
wr2 = tax rate of machinery/tools times its budget share.
wp3 = price of personal property times its budget share.
wr3 = tax rate of personal property times its budget share.
wp4 = price of residential property times its budget share.
wr4 = tax rate of residential property times its budget share.
wp5 = price of agricultural property times its budget share.
wr5 = tax rate of agricultural property times its budget share.
wr6 = tax rate of commercial property times its budget share.
price1 = price of non-taxed goods.
price2 = price of machinery and tools.
rate2 = tax rate of machinery and tools.
price3 = price of personal property.
rate3 = tax rate of personal property.
price4 = price of residential property.
rate 4 = tax rate of real property.
price5 = price of agricultural property.
pop = population.
lw2 = one period lagged dependent variable.
trc = per capita local government expenditure.

Table 5.9. Long-Run Homogeneous Model Coefficients (108)

Variable	Mach/Tool	Per Prop	Res Prop	Agric Prop	Com Prop
constant	.00083 (2.34)**	.00387 (.81)	.03425 (2.40)***	.02966 (3.06)***	.18724 (6.36)***
income	-.000005 (-.11)	-.00193 (-.84)	.009356 (.68)	.01464 (.74)	-.0351 (-1.34)
wp1	.00129 (1.69)*	.04447 (1.01)	-.20045 (-.65)	.59942 (1.25)	-.57646 (-1.01)
wp2	.19174 (591.53)	.00896 (1.06)	-.05069 (-1.10)	-.03725 (-.68)	-.13118 (-1.45)
wr2	.00117 (1.98)**	-.03609 (-1.01)	.17929 (.97)	-.38135 (-1.59)	.35099 (.93)
wp3	-.00013 (-2.19)**	.18819 (47.45)***	.00855 (.42)	-.1183 (-4.52)***	-.04383 (-1.05)
wr3	.00039 (1.96)**	.01163 (1.29)	-.04619 (.68)	-.10258 (-.95)	.05852 (.48)
wp4	.00001 (.65)	.00002 .(026)	.17892 (35.33)***	-.07314 (-9.72)***	-.0839 (-9.24)***
wr4	-.00001 (-.79)	.00638 (.19)	-.01409 (-.08)	-.7312 (-2.98)***	.67324 (1.84)*
wp5	.00003 (.88)	.00008 (.06)	-.00665 (-.62)	.25457 (15.39)***	-.2162 (-11.18)***
wr5	.00001 (.05)	.01293 (.38)	.03255 (.18)	-.69516 (-2.83)***	.66634 (1.82)*
wr6	-.00009 (-.59)	.01045 (.30)	-.00517 (-.25)	-1.63767 (-5.66)***	1.85186 (4.62)***
price1	.00187 (2.08)**	.00601 (.20)	.80177 (4.98)***	.52286 (2.55)***	-.79519 (-2.47)***
price2	-.0001 (-2.33)**	.01075 (6.90)***	.05892 (6.01)***	-.00484 (-.26)	-.06249 (-3.25)***
rate2	-.000003 (-.56)	-.00051 (-2.55)***	.00021 (.21)	.00262 (2.07)**	-.0034 (-1.61)*
price3	-.00177 (-2.07)**	-.01794 (-.63)	-.76582 (-4.99)***	-.48908 (-2.50)***	.75593 (2.46)***
rate3	-.00002 (-1.29)	-.00148 (-2.22)**	.00407 (1.08)	.00297 (.62)	-.00421 (-.57)
price4	.00001 (1.06)	.00018 (.31)	-.09557 (-20.43)***	.02892 (3.67)***	.05229 (6.29)***
rate4	.00003 (.32)	-.01159 (.40)	.02328 (.14)	.75598 (3.49)***	-.78585 (-2.44)***
price5	-.000003 (-.53)	.00099 (2.51)***	.0007 (.19)	-.05786 (-6.83)***	.04947 (7.39)***
pop	-.000003 (-.97)	.00011 (.60)	.00297 (1.9)*	-.00665 (-1.66)*	.00299 (1.00)
lw2	.00035 (.63)	-.00563 (-.93)	-.02415 (-1.38)	.00618 (.73)	-.02442 (-1.15)
trc	-.00001 (-.24)	.00236 (1.07)	-.00756 (-.58)	.00338 (.18)	.01534 (.61)

t-values are given in parentheses
See Table 5.8 variable names, *** = significant at 1 percent level;
** = significant at 5 percent; * = significant at 10 percent level.

On the other hand, the difference between the coefficients was negative for machinery/tools a result which demonstrates negative tax capitalization. This result suggests that the individuals who own these tax bases do not consider local government expenditure as beneficial. As was mentioned earlier, the local government expenditure variable had a significant positive impact on personal property. The fact that the difference between the price and tax coefficients is positive suggests that individuals owning personal property consider local government expenditure beneficial, and the overall effect may be positive (i.e., negative tax capitalization is overridden by the positive local government expenditure capitalization).

5.4 Cross-Rate Elasticities.

5.4.1 The Short-Run Model

Negative cross-rate coefficients indicate a complimentary relationship between the bases, while positive coefficients indicate a substitution relationship. In tables 5.10 and 5.11 cross-rate elasticities for the short-run (homogeneous and non-homogeneous) models are presented. In these tables a column indicates the effect of a particular tax rate change across all tax bases. It is important to note that, as in the case of own elasticities, the significance level is based on the coefficients with respect to the tax rate variables, and not on the combined coefficients.

Ironically, while the own-rate coefficient for the non-homogeneous model for machinery/tools was not significant (at the five percent level), the real property tax rates

Table 5.10. Cross-Rate Elasticities of Tax Bases (Short-Run Non-Homogenous)

	Tax Rate Change Of				
variable	Mach/Tool	Per Prop	Res Prop	Agric Prop	Comm Prop
coef w2	.0000	-.00001	-.00095**	-.00069**	-.00063**
elas w2	.0000	-.00373	-.04428	-.03257	-.02959
coef w3	.00002**	-0.00014**	-.00334	-.00508	-.00575
elas w3	.00149	-.01210	-.03445	-.05237	-.05936
coeffw4	.00089	-.00071	-.13870	.25910	.20914
elas w4	.00591	-.00606	.14090	.263231	.21247
coef w5	-.000001	-.00037	.75650	.3759**	.68418**
elas w5	-.000008	-.00520	1.2812	.67050	1.1587
coef w6	-.00085	-.00005	-.75218	-.68249	-.8372**
elas w6	-.02871	-.00199	-3.9298	-3.5657	-4.374

Mach/Tool = Machinery/Tools.
Per Prop = Personal Property.
Res Prop = Residential Property.
Agric Prop = Agricultural Property.
Comm Prop = Commercial Property.
coef w2 = impact on machinery/tool tax base.
elas2 = cross-rate elasticities of machinery and tools.
coef w3 = impact on personal property tax base.
elas3 = cross-rate elasticities of personal property.
coef w4 = impact on residential property tax rate.
elas4 = cross-rate elasticities of residential property.
coef w5 = impact on agricultural property tax base.
elas5 = cross-rate elasticities of agricultural property.
coef w6 = impact on commercial property tax rate.
elas6 = cross rate elasticities of commercial property.
** = significant at the 5 percent level.

Table 5.11. Cross-Rate Elasticities of Tax Bases (Short-Run Homogeneous)

	Tax Rate Change Of				
Variable	Mach/Tool	Per Prop	Res Prop	Agric Prop	Com Prop
coef w2	.0000	-.00003**	-.00028**	-.00024**	-.00010**
elas w2	.0000	-.01288	-.01304	-.01133	-.00485
coef w3	.00004**	-.00020**	-.01107	-.01164	-.00961
elas w3	.00247	-.01700	-.11419	-.12017	-.09918
coef w4	.00102	-.00146	.10340	.25684	.21356
elas w4	.00673	-.01244	.10500	.26094	.21696
coef w5	.00082	-.00055	.29470	.60490**	.70328**
elas w5	.00905	-.00778	.49910	.10340	1.19108
coef w6	-.00091	.00155	-.70982	-.64479	-.20480**
elas w6	-.03071	.06764	-3.70851	-3.36877	-5.2856

Mach/Tool = Machinery/Tools.
Per Prop = Personal Property.
Res Prop = Residential Property.
Agric Prop = Agricultural Property.
Comm Prop = Commercial Property.
coef w2 = impact on machinery/tool tax base.
elas2 = cross-rate elasticities of machinery and tools.
coef w3 = impact on personal property tax base.
elas3 = cross-rate elasticities of personal property.
coef w4 = impact on residential property tax rate.
elas4 = cross-rate elasticities of residential property.
coef w5 = impact on agricultural property tax base.
elas5 = cross-rate elasticities of agricultural property.
coef w6 = impact on commercial property tax rate.
elas6 = cross rate elasticities of commercial property.
** = significant at the 5 percent level.

(all three categories) had a significant negative impact on the machinery/tool tax base. Also, in the homogeneous model changes in the personal property tax rate had a significant negative impact. This is a very important finding, since it shows that machinery/tools have a complimentary relationship with most of the other bases. Although a negative relationship is indicated, the cross-rate elasticities were inelastic (ranging from -0.003 to -0.044), resulting in a more than proportionate increase in tax revenues with an increase in the tax rates of the other bases.

For the personal property tax base, only the tax rate change of machinery/tools had a significant positive impact at the five percent level. However, there is a theoretical problem in justifying this positive inelastic relationship (.0015 for the non-homogeneous model and 0.0025 for the homogeneous model) since in the short-run the machinery/tools tax rate did not have a significant impact on its own base at the five percent level.

There was no significant impact on the residential property tax base due to changes in the tax rates of other tax bases. For agricultural property, the tax rate changes of commercial property had a significant (at the five percent level) substitution effect. This result indicates that, when the total value of commercial property is reduced due to its own tax rate change, the total value of the agricultural tax base goes up, suggesting that either the total quantity under the agricultural tax base has gone up and/or the demand for agricultural property has increased, resulting in a price increase. The elasticity figures of 1.16 for the non-homogeneous model and 1.19 for the homogeneous model indicate that the increase in agricultural land values was more than proportionate to the increase in the commercial property tax rate.

There was no significant impact on the value of commercial property with the tax rate increase on other tax bases. However, at a lower level of significance (at the 20 percent level), agricultural and residential property tax rates had a elastic negative impact on the value of commercial property.

5.4.2 The Long-Run Model

In the short-run the machinery/tool tax base responded in a negative, inelastic fashion to tax rate changes of almost all the other tax bases. However, in the long-run, apart from a significant (at the one percent level) negative inelastic response to personal property taxes in the homogenous model, the impact of other cross rates were not significant at the five percent level of significance (see tables 5.12 and 5.13). The impact of personal property tax rates was more inelastic, in the long-run, than that of the short-run.

In the short-run, both the homogeneous and non-homogeneous models predicted a significant positive impact of the machinery/tools tax on personal property. However, in the long run, the impact was negative and significant (-.0015 for the homogeneous model and -.0004 for the non-homogeneous model). Also, the own-rate coefficient for machinery/tools was significant in the long-run at the one percent level. Hence, it is conceivable that, in the long-run, enterprises that are mostly related to machinery and tools are affected. Commercial property, too, had a significant negative (at the 10 percent level) response in the long-run to changes in the machinery/tools tax rate, where-as in the short run the impact was not significant even at the 10 percent level of significance. This result clearly indicates the complimentary relationship between machinery/tools and the related tax bases, personal property and commercial property, in the long-run. This pattern was similar in both non-homogeneous and homogeneous models.

In the case of residential property values, none of the cross-rates had a significant effect in the long-run or in the short-run. Although residential property is expected to be complimentary with other bases, it seems that utility received is independent of the tax rates on other tax bases.

Agricultural property is the other tax base which was significantly (at the one percent level) affected by cross rate changes (see tables 5.12 and 5.13). Recall that, in the short-run, only the changes in the commercial property tax rates had a significant impact on agricultural property. But in the long-run model (homogeneous as well as non-homogeneous), the cross rates of all the other tax bases, except for personal property, had a significant positive impact (at the one percent level) on agricultural property. In fact, the impact of the residential property tax on agricultural property was elastic (1.15). These results indicate that agricultural property has increasingly become a substitute for other property, as tax rates on other bases change. This behavior can be attributed to a number of possible causes. For example, individuals who own commercial property in near-by cities may be induced to invest in agricultural land in near-by counties for various reasons, perhaps to convert them to commercial property when opportunities arise. Tax rate increases on commercial property, too, may drive such individuals to invest in agricultural land, not necessarily for immediate returns, but rather with future expectations of agricultural returns. Hence it is conceivable that agricultural property, being non-destructible, becomes a substitute for other tax bases.

Table 5.12. Cross-Rate Elasticities of Tax Bases (Long-Run Non-Homogeneous)

	Tax Rate Change Of				
Variable	Mach/Tool	Per Prop	Res Prop	Agric Prop	Com Prop
coef w2	-.000001**	-.000004	-.00011	-.00008	-.00008
elas w2	-.0003	-.00152	-.00512	-.00375	-.00364
coef w3	-.000007**	-.00015**	.00003	-.00196	-.00234
elas w3	-.00045	-.00040	.00026	-.02025	-.02415
coef w4	-.00002	.00199	.14430	.10876	.08677
elas w4	-.00012	.01690	.14650	.11049	.08815
coef w5	.00174*	.00172	.68311**	2.3500**	.54937**
elas w5	.01909	.02438	1.15691	3.9500	.93040
coef w6	-.00223	-.00247	-.88842	-.76642	-2.51680**
elas w6	-.07543	-.10774	-4.64160	-4.00421	-13.14930

Mach/Tool = Machinery/Tools.
Pers Prop = Personal Property.
Res Prop = Residential Property.
Agric Prop = Agricultural Property.
Comm Prop = Commercial Property.
coef w2 = impact on machinery/tool tax base.
elas2 = Cross-rate elasticities of machinery and tools.
coef w3 = impact on personal property tax base.
elas3 = Cross-rate elasticities of personal property.
coef w4 = impact on residential property tax rate.
elas4 = cross-rate elasticities of residential property.
coef w5 = impact on agricultural property tax base.
elas5 = cross-rate elasticities of agricultural property.
coef w6 = impact on commercial property tax rate.
elas6 = cross rate elasticities of commercial property.
** = significant at 5 percent, * = significant at 10 percent level.

Table 5.13. Cross-Rate Elasticities of Tax Bases (Long-Run Homogeneous)

	Tax Rate Change Of				
Variable	Mach/Tool	Per Prop	Res Prop	Agric Prop	Com Prop
coef w2	-.00001**	-.00001**	.00002	.00002	.00003
elas w2	-.00195	-.00288	.00108	.00082	.00119
coef w3	-.00002**	-.0016**	-.00975	-.01022	-.00827
elas w3	-.00153	-.13800	-.10063	-.10547	-.08533
coef w4	-.00041	.00119	.05060	.00856	.49441
elas w4	-.00270	.01007	.05140	.00869	.50229
coef w5	.00156*	.00152	.743427**	2.11000**	.60267**
elas w5	.01717	.02148	1.25904	3.58000	1.02067
coef w6	-.00166	-.00133	-.74318	-.64990	-.9218**
elas w6	-.05631	-.05802	-3.88279	-3.39547	-4.8162

Mach/Tool = Machinery/Tools.
Pers Prop = Personal Property.
Res Prop = Residential Property.
Agric Prop = Agricultural Property.
Comm Prop = Commercial Property.
coef w2 = impact on machinery/tool tax base.
elas2 = Cross-rate elasticities of machinery and tools.
coef w3 = impact on personal property tax base.
elas3 = Cross-rate elasticities of personal property.
coef w4 = impact on residential property tax rate.
elas4 = cross-rate elasticities of residential property.
coef w5 = impact on agricultural property tax base.
elas5 = cross-rate elasticities of agricultural property.
coef w6 = impact on commercial property tax rate.
elas6 = cross rate elasticities of commercial property.
** = significant at 5 percent, * = significant at 10 percent level.

5.5 Chapter Summary

This chapter discussed the results of both the short-run and the long-run models. Consistent with the hypotheses made in chapter 1, the short run results indicated that commercial property and personal property show a significant, negative response to changes in tax rates. While agriculture property showed a positive inelastic own-rate response, the responses of residential property and machinery/tool were not significant for tax rate changes. In the long-run the elasticity figures were more elastic for commercial property, agricultural property, and personal property. The machinery/tool tax base also showed a significant inelastic response in the long-run.

With reference to cross-rate effects, in the short-run, the machinery/tool tax base showed a complimentary relationship with all the tax bases except residential property. But in the long-run this relationship held only for personal property. Agricultural property showed a substitution relationship with all the other tax bases except personal property in the long-run. However, in the short-run this relationship was only with commercial property.

Chapter 6

SUMMARY, CONCLUSIONS AND IMPLICATIONS

6.1 Introduction

This chapter summarizes the major findings of this research and their implication for tax policy. Limitations of the study and suggestions for further research are also discussed.

6.2 Summary of the Dissertation

This research originated with the idea that, if the responses of the various tax bases to changes in tax rates differ then local governments can place differential levels of reliance on these tax bases and maintain or increase tax revenue collections while reducing the burden on sensitive tax bases. Therefore, the purpose of this research was to evaluate the own- and cross-rate elasticities of rate-base relationships in order to aid policy makers of local governments. Although nearly 30 percent of local tax revenue comes as sales tax, the present research excluded the sales tax base from investigation since, during the study period (1981-85), there was no change in the sales tax rate. Therefore research was directed towards five tax bases, namely: machinery/tools, personal property, residential property, agricultural property, and commercial/industrial property. The specific objectives were to estimate short-run and long-run own- and cross-tax rate elasticities with respect to the above tax bases.

Four hypotheses were suggested: (1) the impact of tax rate change on a particular tax base is negative; (2) due to the likely complimentary nature of many tax bases, the cross-rate elasticities will be negative; (3) in the long-run, elasticities will become more elastic; and (4) the impact of tax rate changes on the value of the tax base will be less than the impact of price changes.

The literature review outlined the conceptual issues and development of the research methods used in the past. Most of the earlier research effort has been concentrated on the estimation of income elasticities of different tax bases. Some attempts have been made to estimate tax-rate elasticities with respect to non-durable goods and residential property. This research concentrated not only on residential property but also on other durable property, in order to determine the cross-rate effects.

In chapter two a conceptual framework was built. In this chapter the nature of public goods delivered to constituents financed by tax revenues, and their impact on the value of durable tax bases, were discussed. Also, concepts of tax theory such as tax burden, tax incidence, and issues of equity and efficiency were discussed. Then the impact of supply and demand elasticities on the above issues was discussed. The concepts of tax theory suggested that, since local governments are dependent mostly on rem taxes, which have ad-valorem tax rates, in order to reduce efficiency losses it is important to select tax bases which are inelastic with respect to demand and supply. These tax bases, while reducing the efficiency losses, would contribute to increased tax revenues as well. Finally, the characteristics of tax bases in light of the above concepts and issues were presented.

In chapter three an analytical framework based on demand theory was developed. Following the description of the concepts of utility maximization, two demand systems that are widely used, the Linear expenditure system (LES) and the almost ideal demand system (AIDS), were discussed at length. The rationale for the use of the AIDS model for the present research was also presented.

The data used, which were based mostly on published material, were discussed in chapter four. The data on tax rates, tax revenues, and value of the tax bases were collected from publications of the Department of Taxation in Richmond, Virginia. Some data on real property were provided by the county revenue offices. Price data were based on price indices compiled by the Center for Public Policy at the University of Virginia.

In chapter five results of the research were presented. Although the homogeneity restriction was rejected by all the bases except agricultural property, in accordance with theory this restriction was imposed on all the equations. It was believed that this procedure would result in more accurate estimates. The results indicated that individuals' responses to price changes are different than their responses to tax rate changes. The difference between the coefficient of the tax rate change and the coefficient of the price was defined as the willingness-to-pay-tax coefficient. The results indicated a positive willingness-to-pay-tax coefficient for agricultural property, residential property, and personal property. These results indicated that these bases receive more benefits from local public expenditures relative to tax payments. Hence, their response to price changes was higher than for tax rate changes.

With reference to short-run own tax rate elasticities, the tax rate change did not have a significant impact on the machinery/tools tax base or the residential property tax base. Tax rate increases did have a highly significant elastic negative impact on commercial property and an inelastic negative impact on personal property. The impact of tax rate increases on agricultural property was positive and inelastic. In the long-run the machinery/tools coefficient was significant, resulting in a negative inelastic figure. Consistent with the hypothesis made, own-rate elasticity figures for personal property, agricultural property, and commercial property (non-homogeneous model) are more elastic in the longer run.

With reference to cross-rate elasticities, in the short-run machinery/tools demonstrated an inelastic complimentary relationship with all the other tax bases except with residential property. Therefore, tax rate increases of the other bases had a negative impact on the value of the machinery/tool tax base. But, in the long-run, apart from the negative inelastic impact from personal property, the impact of tax rate changes of other bases was not significant. Residential property and commercial property were not significantly affected by the tax rate changes of the other bases. Agricultural property demonstrated a significant substitution effect from commercial property in the short-run, and this effect became more elastic in the long-run. In the long-run, except for personal property, the tax bases had a significant substitution impact on agricultural property.

6.3 Conclusions and Implications

Of the tax bases investigated, residential property was the least affected by tax rate changes. The propensity not to capitalize taxes or public services into the value of the residential property tax base suggests that public service supply may be in Tiebout equilibrium. Thus, increases in tax revenue from residential property can be expected to be at about the same rate as increases in the residential property tax rate.

The other two categories of real property, agricultural and commercial property, demonstrated contrasting results. Agricultural property showed an inelastic positive response to tax rate increases while commercial property showed an elastic and negative response. It is very important to note that all three categories of real property have the same tax rate in Virginia, but that the different categories of real property respond differently. This result suggests that some efficiencies could be gained if local governments could levy different tax rates on the different categories of real property. Also, real-property tax rate changes will affect the mix of tax bases and constituents. The heavy negative tax capitalization of commercial property suggests that an increase in the tax rate will result in a more than proportionate reduction in its tax revenue. Also, given that the long-run elasticity is more elastic than the short-run elasticity, it is likely that businesses would leave a community in favor of jurisdictions with lower taxes. Another important observation to note is that machinery/tools responded significantly to tax rate changes only in the long-run and that they had a significant inelastic complimentary impact on commercial property. Given that machinery/tools are more likely linked to commercial/industrial property, there is every likelihood that in the long-run the commercial/industrial property tax base would be reduced along with machinery/tools.

On the other hand agricultural property values responded positively to tax rate increases. Agricultural property also showed a substitution relationship with commercial property, suggesting that agricultural property could have higher property taxes. This result also has implications for use value taxation. Taxing commercial property less than agricultural property not only would arrest the exit of commercial property but would also act as an tax incentive for new industries. Since both commercial property and agricultural property depicted a more elastic response in the long-run, structural changes for these durable assets can take place much more easily in the long-run.

Therefore, on the whole it can be concluded that, in order to increase tax revenues, local governments should concentrate on tax bases with negative inelastic responses and positive responses to tax rate changes. Hence, in these terms agricultural property, personal property, and machinery/tools (the latter in the long-run) are potential candidates to bear increased taxes when tax revenue increases are needed. It is important to note that the commercial property tax base is very sensitive to tax rate changes, and care should be taken before commercial property tax rate increases are considered.

6.4 Limitations of the Study

There are several limitations of this research which should be considered when the results are interpreted. Limitations stem mainly from data problems.

As an example, the price of a unit of commercial property was assumed to be constant due to lack of data on prices. In reality, however, the price of commercial property would vary. Omitting this variable may have biased the tax rate coefficient downward.

Likewise, for machinery/tools it was assumed that the price of a unit of machinery was constant across the counties. The time series for this was an index for the Virginia/Maryland/Washington D.C. area. For personal property, the price of automobiles were used as a proxy. Hence the data excluded prices of other personal property such as airplanes and boats. This procedure may also have affected the price coefficient. For residential property it was assumed that, when prices of residential property were calculated, all houses were of equal quality and size.

The data set under investigation was limited to 36 counties covering five years. This time period did not include any years with variations in the sales tax rate. Hence it was not possible to include the sales tax base in the model.

With respect to estimation techniques, this research assumed a linear approximate model. However, more accurate information and non-linear estimation techniques, if used, might have produced more accurate results.

6.5 Suggestions for Further Research.

This research highlighted the negative impact on the value of the commercial property tax base that is likely with an increase in its tax rate. Even within the commercial property tax base, there are certain industries, such as the tobacco industry, which are at an advantage due to locational characteristics such as proximity to tobacco growing areas. Hence further research at a disaggregated level would shed light on the question of which industries are more sensitive to tax rate changes. If certain industries are insensitive to tax rate changes, these are potential revenue sources for local governments. Therefore, if differential responses to tax rate changes were possible, selective tax tax incentives for businesses may be possible.

REFERENCES

Aronson, J.R., and John L. Hilley. *Financing State and Local Governments: Studies of Government Finance.* The Brookings Institution, Washington D.C., 1976.

Balestra, P., and M. Nerlove. "Pooling of Cross-Section and Time-Series Data in Estimation of a Dynamic Model: The Demand for Natural Gas." *Econometrica* 34(4)(1966):585-612.

Barten, A.P. "Consumer Demand Functions Under Conditions of Almost Additive Preferences." *Econometrica* 32(1964):1-39.

Berney, Robert E., and B.H. Freichs. "Income Elasticities of State Tax Revenues: Techniques of Estimation and Their Usefulness for Forecasting." *Public Finance Quarterly* 1(1973):409-25.

Bezuneh, M. "Food Aid and Economic Development: Impact of Food for Work on Labor Allocation, Production and Consumption Behavior of Small Family-Farms in a Semi-Arid Area of Kenya." Unpublished Ph.D. dissertation, Department of Ageicultural Economics, Virginia Polytechnic Institute and State University, 1985.

Bieri, J., and Allain de Janvry. *Empirical Analysis of Demand Under Consumer Budgeting.* Giannini Foundation Monograph No.32. California Agr. Experimental Station, University of California, Davis, 1972.

Blanciforti, Laura., and Richard Green. "An Almost Ideal Demand System incorporating Habits: An Analysis Of Expenditure on food and Aggregate Commodity Groups." *Review of Economics and Statistics* 165(3)(1983):511-515.

Blanciforti, L.A., R.D. Green, G.A. King. *U.S. Consumer Behavior Over the Post War Period: An Almost Ideal Demand System Analysis.* Giannini Foundation Monograph 40. Giannini Foundation of Agricultural Economics University of California. 1986.

Blancoforti, L. R. Green. "The Almost Ideal Demand System. A Comparison and Application to Food Groups." *Agricultural Economic Research* 35(3)(1983):1-9.

Boadway, R. W., and David W. Wildasin. *Public Sector Economics.* Little Brown and Co., Boston and Toronto: 1984.

Box, G.E. and D.R. Cox. "An Analysis of Transformations." *Jnl. of the Royal Statistical Society* 26(1964):211-43.

Bridges, Benjamin. "Income Elasticity of the Property Tax Base." *National Tax Journal* 17(1964):253-64.

Commonwealth, Of Virginia. *Comparative Report of Local Government Revenue and Expenditure.* Auditor of Public Accounts (1984, 1988).

Chicoine, David L., and Norman Walzer. *Governmental Structure and Local Public Finance.*: OelgeschLager, Gunn and Hain, Publishers, Inc Boston, Massachusetts, 1985.

Chow, G.C. *The Demand for Automobiles in the United States: A Study in Consumer Duarables.* North-Holland Publishing Co., 1960.

Craig, E., and A. Heins, "The Effect of Tax Elasticities on Government Expenditure." *Public Choice* 35(1980):267-75.

Daicoff, Darwin W. "Capitalization of the Property Tax." Unpublished Ph.D. Dissertation, University of Michigan, 1961.

Davis, D. G. "The Sensitivity of Consumption Taxes to Fluctuations in Income." *National Tax Journal* 15(1962):281-90.

Deaton, A., and J. Muellbauer. *An Almost Ideal Demand System.* Department of Economics, University of Bristol, 1978.

Deaton, Angus., and John. Muellbauer. "An Almost Ideal Demand System." *Am. Economic Review* 70(1980a):312-326.

Deaton, Angus., and J. Muellbauer. *Economics and Consumer Behavior.* Cambridge University Press Cambridge, 1980b.

Department of Taxation. *Virginia Assessment, Sales Ratio Study.* Richmond, Virginia. Annual Publications.

Department of Taxation. Annual Reports. Commonwealth of Virginia. Various Issues.

Dilorenzo, T.J. "Tax Elasticity and the Growth of Local Public Expenditure." *Public Finance Quarterly* 3(1982):385-391.

Doan, Thomas A., and Robert B. Litterman. *User's Manual RATS: Version 2.6.* VAR Econometrics Minneapolis, 1987.

Erickson, Terri Ann. *Variation in the Income Elasticity of the Residential Property Tax Base.* Unpublished Ph.D. dissertation, University of Minnesota, 1981.

Edel, Mathew., and Elliot Sclar. "Taxes, Spending and Property Value: Supply Adjustment in a Tiebout-Oates Model." *Journal of Political Economy* 82(5)(1974):941-54.

Fisher, Ronald C. "Local Sales Taxes: Tax Rate Differentials, Sales Loss, and Revenue Estimation." *Public Finance Quarterly* 8(2)(1980):171-88.

Fox, William F., and C. Campbell. "Stability of the State Sales Tax Income Elasticity." *National Tax Journal* 37(2)(1984):201-12.

Friedman, M. S. "The Welfare Effects of an Income and Excise Tax." *Journal of Political Economy* 60(1952):25-30.

Frisch, R. A. "A Complete Scheme for Computing All Direct and Cross-Demand Elasticities in a Model With Many Sectors." *Econometrica* 27(1959):177-96.

Friedlander, Ann F., Gerald J. Swanson., and John F. Due. "Estimating Sales Tax Revenue Change in Response to Changes in Personal Income and Sales Tax rate." *National Tax Journal* 26(1973):103-11.

Goddard, D. "An Analysis of Canadian Aggregate Demand for Food at Home and Away From home." *Cdn. Jnl. of Agr. Econ.* 31(1983):290-317.

Goldman, C. M., and A. Uzawa. "A Note on Separability in Demand Analysis." *Econometrica* 32(3)(1964):387-98.

Goode, R. *Government Finance in Development.* Brookings Institution, Washington D.C., 1984.

Greytak, David., and Jerry Thursby. "Functional Form in State Income Elasticities." *National Tax Journal* 32(1979):195-200.

Greytak,David., and Jerry Thursby. "Elasticity of State Income Taxes: A Further Consideration." *National Tax Journal* 33(1980):497-98.

Greytak, David., and Jerry Thursby. "Functional Form in State Income Elasticities: A Further Consideration." *National Tax Journal* 33(4)(1980):497-98.

Grooves, H. M., and C.H. Khan. "The Stability of State and Local Tax Yields." *Am. Econ. Review* 42(1952):87-102.

Hahn, I. H. "Equilibrium With Transaction Costs." *Econometrica* 39(1971):417-439.

Haidacher, R. C., J.A. Craven, K.S. Huang, D.M. Smallwood, and J.R. Blaylock. *Consumer Demand for Red Meats, Poultry, and Fish.* National Economic Division, Economic Research Service Staff Report. No. AGES 820818. USDA, ERS, 1982.

Haig, R. M. *The Federal Income Tax.* Columbia University Press, New York, 1921.

Hammovitch, W. "Effects of Increase in sales of New York City." *Financing Government in New York City: Report to the Temporary Commission on City Finances.* New York University, Graduate School of Public Administration, 1966a.

Hammovitch, William. "Sales Taxation: An analysis of the Effects of Rate Increases in Two Contrasting Cases." *National Tax Journal* 19(December, 1966b):411-20.

Hanson, Alvin H. *Economic Issues of the 1960's*. New York, 1959.

Hanson, Alvin H., and H.S. Perloff. *State and Local Finances in the National Economy*. New York, 1944.

Harris, Robert. *Income and Sales Taxes. The 1970 Outlook for States and Localities*. State and Local Finance Project, Council of State Governments, 1966.

Hirsch, Werner Z. *The Economics of State and Local Government*. McGraw Hill, 1970.

Hogein, J. D. "Revenue Productivity and State Income Taxation." *National Tax Association Proceedings*. (1967):410-24.

Havlicek, Jr. Joseph. "Lecture Notes in Econometric Methods and Anaysis." Department of Agricultural Economics, Virginia Polytechnic Institute and State University, 1980.

Howe, H. "Cross-Section Application of Linear Expenditure Systems: Responses to Soc io-Demographic Effects." *Am. Jnl. Agr. Economics* 59(1977):141-48.

Jenson, Jens P. *Property Taxation in the United States*. University of Chicago Press, 1933.

Johnson, S. R., Z.A. Hassan, and R.D. Green. *Demand Systems Estimation: Methods and Applications*. The Iowa State University Press Ames, Iowa, 1984.

Johnson, Thomas G. "The Tiebout Hypothesis of Location Choice: An Empirical Model." Department of Agricultural Economics, Virginia Polytechnic Institute and State University, 1986.

Johnson, Thomas G. "Economic Theories of Infrastructure Decision-Making" in: Johnson Thomas G., B. J. Deaton, and Eduardo Segarra (ed) *Local Infrastructure Investment in Rural America*. Boulder, Colorado, Westview Press, 1988, pp.7-27.

Johnston, J. *Econometric Methods*. McGraw-Hill, Inc. New York, 1972.

Kaldor, N. *An Expenditure Tax*. Unwin University Books, London, 1955.

Klien, C. R., and H. Rubin. "A Constant Utility Index of the Cost of Living. *Review of Economic Studies* 15(1947-1948):84-87.

Klijn, N. "Expenditure, Saving, and Habit Formation: A Comment." *International Economic Review* 18(1977):771-78.

Kurnov, E. "On the Elasticity of the Real Property Tax." *Jnl. of Finance* 18(1963):56-58.

Laidler, D. W. *Tax Incentives for Owner Occupied Housing: The Taxation of Income and Capitol* Brookings Institution, Washington D. C., 1969.

Legler, J. B.,and P. Shapiro. "The Responsiveness of State Tax Revenue to Economic Growth. *National Tax Journal* 21(1968):46-56.

Lehmen, Stephens. "Relationship Between Personal Income and Taxable Income, 1947-1974." *Survey of Current Business* 56(12) (1976): U.S. Department of Commerce Washington D. C.

Lesser, C. "Family Budget data and price elasticities of demand." *Review of Economic Studies* 9(1941):40-57.

Lesser, C. "Forms of Engel Functions." *Econometrica* 31(1963):694-703.

Leuthhold, J. H. *Changing Tax Elasticities Over Time; The Case of the Ivory Coast.* University of Illinois, BEBR, Faculty Working Paper No. 1268. University of Illinois, 1986.

Levin, Henry M. *An Analysis of the Economic Effects of the New York City Sale Tax.* Brookings Washinton, D. C., 1967.

Little, I. M. D. "Direct vs Indirect Taxes." *Economic Journal* 61(1951):577-84.

Liu, B. C. "Comment on the Responsiveness of State Tax Revenue to Economic Growth." *National Tax Journal* 22(1969):294-98.

Lluch, C. "Expenditure, Saving, and Habit Formation." *International Economic Review* 15(1974):786-97.

Maddalla, C. S. *Econometrics.* McGraw-Hill Inc. New York, 1977.

Maliet, L. "A Comparative Study of the Illinois Retailer's Occupation Tax and the Iowa Retail Sales and Use Tax." Unpublished Ph.D. dissertation. University of Illinois, 1955.

May, Eleanor G. *Consumer Price Indicators for Virginia Metropolitan Areas.* University of Virginia, Tayloe Murphy Institute. Various issues.

McAllister, H. "The Border Tax Problem in Washington." *National Tax Journal* 14(1961):361-74.

Mead, J. *The Structure and of Direct Taxation.* Allen and Unwin, London, 1978.

Merz, J. ".FELES: The Functional Linear Expenditure System." *European Economic Review* 23(1983):359-94.

Mikesell, J. "Central Cities and Sales Tax Rate Differentials: The Border City Problem." *National Tax Journal* 3(1970):206-14.

Mikesell, John L. "Income Elasticities of State Sales Tax Base Components." *Quarterly Review Economics and Business* 17(1)(1977):83-94.

Mikesell, John L., and C. Kurtzorn., "Impact of the Sales Tax Rate on its Base: Evidence From a Small Town." *Public Finance Quarterly* 14(3)(1986):329-38.

Muellbauer, J. "Community Preference and the Representative Consumer." *Econometrica* 44(1976):979-99.

Muellbauer, J. "Aggregation, Income Distribution and Consumer Demand." *Review of Economic Studies* 62(1975):525-43.

Musgrave, Richard., and Peggy M. Musgrave. *Public Finance in Theory and Practice.* McGraw Hill Books Co., 1980.

Mushkin, S. J. *Comment on Financial Needs and Resources Over the Next Decade: State and Local Governments. Public Finances: Needs, Sources and Utilization.* Princeton, 1961.

Mushkin, S. J., and G.C. Lupo. "Project 70: Projecting the State and Local Sector." *Review of Economic Statistics* 42(1967):237-45.

Netzer, D. *Economics of the Property Tax.* Brookings Institution, Washington D. C., 1966.

Netzer, Dick. "The Outlook For Fiscal Needs and Resources of State Local Governments." *Amer. Econ. Review* 48(1958):317-27.

Oates, W. E. "The Effects of Property Taxes and Local Public Spending on Property Values: An Empirical Study of Tax Capitalization and Tiebout Hypothesis." *Journal of Political Economy* Nov-Dec(1969):957-71.

Orr, Larry L.. "The Incidence of Differential Property Taxes on Urban Housing." *National Tax Journal* (Sep. 1968):253-62.

Parks, R.W. "Systems od Demand Equations: An Empirical Comparison of Alternative Functional Forms" *Econometrica* 37(1969):629-50.

Pollak, R. A., and T.J. Wales. "Estimation of Complete Demand Systems From Household Budget Data: The Linear and Quadratic Expenditure Systems." *Amer. Economic Review* 68(1978):348-59.

Pechman, Joseph. A. *Federal Tax Policy.* The Brookings Institution, Washington D.C., 1987.

Phlips, Louis. *Applied Consumption Analysis.* North Holland, Amsterdam, 1963.

Pindyck, R. C. and D.C. Rubinfeld. *Econometric Models and Economic Forecasts.* McGraw-Hill Book Co., New York, 1981.

Pollak, R.A., and T.J. Wales. "Estimation of Linear Expenditure System." *Econometrica* 37(1969):629-650.

Powel, A. A. "A Complete System of Consumer Demand Equations for the Australian Economy Fitted by a Model of Additive Preferences." *Econometrica* 34(1966):661-75.

Ray, R. "Analysis of Time-Series Household Expenditure Survey for India." *Review of Economics and Statistics* 62(1980):595-602.

Ray, Ranjan. "The Testing and Estimation of Complete Demand Systems on the Household Budget Survey: An Application of AIDS." *European Economic Review* 17(1982):349-369.

Reader, R. J. *Rural Government Raising Revenues and Feeling the Pressure.* USDA, ERS, Rural Development Research Report No. 51. USDA, Economic Research Service, 1985.

Ricardo, David. *The Principles of Political Economy and Taxation* Irwin, Homewood, Illinois, 1963.

Richman, Raymond L. "The Incidence of Urban Real Estate Taxes under Conditions of Static and Dynamic Equilibrium." *Land Economics* 43(May, 1967):172-180.

Ross, William D. "State and Local Finance Policy and Economic Growth." *National Tax Journal* (1957):66-67.

Roy, Jharna. "An Econometric Model of New York City." Unpublished Ph.D. Dissertation, City University, New York, 1980.

Saligman, E. R. A. *Studies in Public Finance*. New York, 1925.

Samuelson, P.A. "Some Implications Of Linearity." *Review of Economic Studies* 15(1947-48):88-90.

Sexton, Terri Erickson., and R.J. Sexton. "Re-evaluating the Income Elasticity of Property tax Base." *Land Economics* 62(2)(1986):181-191.

Simon, H. "The Incidence of a Tax on urban Real Property." *Quarterly. Jnl. of Economics* 57(1943):398-421.

Simon, H. C. *Personal Income Taxation*. University of Chicago Press, Chicago, 1938.

Singer, M. M. "The Use of Dummy Variables in Estimating the Income-Elasticity of State Income Tax Revenues." *National Tax Journal* 21(1968):200-4.

Singer, Neil. "Estimating State Income Tax Revenue. A New Approach." *The Review of Economics and Statistics* 52(1970):427-33

Solari, L. *Theorie des Choix et Fonctions de Casommation Sem-Agreges, Models Statiques*. Droz, Geneva, 1971.

Spar, Michael A., and Julia A. Martin. "Housing Units Authorized in Virginia Counties and Cities". Center for Public Service, University of Virginia. Various Issues.

Spengler, Albert W. *The Tax Rates in Virginia's Cities, Counties and Selected Towns*. Institute of Government, University of Virginia Virginia, 1986.

Stiglitz, J. E. *Economics of the Public Sector*. W. W. Norton and Co., New York, 1986.

Stone, J. R. M. *The Measurement of Consumer's Expenditure and Behavior in the United Kingdom, 1920-1938*. Vol 1. Cambridge University Press, Cambridge, 1953.

Stone, J. R. N. *The Measurement of Consumer's Expenditure Behavior in the United Kingdom*. Cambridge University Press, 1(1954a).

Stone, R. "Linear Expenditure Systems and Demand Analysis. An Application to the Pattern of British Demand." *The Economic Journal* 64(1954b):511-27.

Strotz, R. H. "The Empirical Utilization of a Utility Tree." *Econometrica* 25(2)(1957):269-80.

Sullivan, A. A. "The General Equilibrium Effects of the Industrial Property Tax: Incidence and Tax Burden." *Regional Science and Urban Economics* 14(1984):547-563.

Tiebout, Charles M. "A Pure Theory of Local Expenditure." *Journal of Political Economy* 64(1956):416-424.

Ware, P. M. *An Outline of State and Local Taxes.* (1986): Virginia Department of Economic Development.

Wilford, W. T. "State Tax Stability Criteria and the Revenue Income Elasticity Coefficients Reconsidered." *National Tax Journal* 18(1965):304-12.

Wilford, W. T. "On the Sensitivity of State Revenue the Gross State Product: Louisiana's Revenue-Income Elasticity Coefficient." *Review of Business and Economic Research* 11(1975):1-20.

Williams, W. V., R.M. Anderson, D.O. Froehle, and K.L. Lamb "The Stability, Growth, and Stabilizing Influence of State Taxes." *National Tax Journal* 26(1973):267-74.

Working, H. "Statistical Laws of Family Expenditure." *Jnl. of the American Stat. Assoc.* 38(1943):43-56.

Wasylenka, M. "Estimating the Elasticity of State Personal Income Taxes." *National Tax Journal* 28(1)(1975):139-142.

Yoshihara, K. "Demand Functions: An Application to the Japanese Expenditure Pattern." *Econometrica* 37(1969):257-74.

Zellner, A. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." *Jnl. Amer. Statistical Association.* 57(1962):348-68.

Appendix A. STANDARD METROPOLITAN STATISTICAL AREAS (SMSA)

SMSA 1. Charlottesville: Albermarle, Fluvanna, Greene.

SMSA 2. Lynchburg: Amherst, Appomattox, Campbell.

SMSA 3. Newport News-Hampton: Gloucester, James City, York.

SMSA 4. Northern Virginia (excludes Maryland and D.C. parts of Washington metropoliton areas).: Arlington, Fairfax, Louden, Prince William.

SMSA 5.Petersburg-Colonial Heights-Hopewell: Dinwiddie, Prince George.

SMSA 6. Richmond: Chesterfield, Goochland, Hanover, Henrico, Powhatan, New Kent.

SMSA 7. Roanoke: Botetourt, Craig, Roanoke.

Appendix B. DATA USED FOR ESTIMATION

The Variable Definitions

RETR = Real estate tax rate

PPTR = Personal property tax rate

MTR = Machinary/tool tax rate

AR = Assessment/sales ratio

POP = population

HS = Housing stock

AP = Automobile price index

NTP = Non-taxed goods price index

RPP = Residential property price (Dollars)

RPF = Real price per farm (Dollars)

TP = Total price index

FVTH = Full value of real property in thousand of (dollars)

PPV = Tangible personal property value (dollars)

MTV = Value of the machinery/tool tax base (dollars)

ST = Value of the sales tax base

ACV = Assessed value of commercial/industrial property (dollars)

AAG1 = Assessed value of the Agricultural property (20-100 acres) dollar

AAG2 - assessed value of the Agricultural property (100 acres or more)

FMVR = Full market value of real property (dollars)

FMCA = Full market value of commercial/industrial + agricultural property

Table A.1. Data Used for Estimation: Tax Rates and Population.

County	Year	RETR	PPTR	MTR	AR	POP
Bath	1981	.68	3.18	3.18	44.7	5300
Bath	1982	.67	3.17	3.17	45	5200
Bath	1983	.46	3.57	3.57	89.3	5400
Bath	1984	.39	3.5	3.5	86.1	5400
Bath	1985	.39	3.5	3.5	87	5300
Bedford	1981	.61	4.4	4.4	66.7	36000
Bedford	1982	.61	4.4	4.4	65.5	36300
Bedford	1983	.48	4.4	4.4	90.7	35900
Bedford	1984	.5	4.4	4.4	86	37000
Bedford	1985	.61	4.4	4.4	84.1	38300
Campbell	1981	.45	3.15	3.15	91.1	46200
Campbell	1982	.45	3.15	3.15	90.9	45900
Campbell	1983	.45	3.15	3.15	88.4	45900
Campbell	1984	.45	3.15	3.15	89.1	46000
Campbell	1985	.45	3.15	3.15	92.8	46900
Caroline	1981	.45	3.35	3.35	83.3	17900
Caroline	1982	.45	3.35	3.35	83.3	18200
Caroline	1983	.45	3.35	3.35	83.3	18300
Caroline	1984	.5	3.35	3.35	81.1	18700
Caroline	1985	.5	4	3.35	75.9	18800
Charls Ci	1981	.91	2.33	1.05	64.4	6700
Charls Ci	1982	1.18	3.03	1.33	70.1	6700
Charls Ci	1983	1.18	3.03	1.33	64.9	6600
Charls Ci	1984	1.05	3.43	1.51	73	6700
Charls Ci	1985	1.15	3.78	1.71	71.1	6600
Culpeper	1981	.68	5	5	75	22500
Culpeper	1982	.68	5	5	73.2	22800
Culpeper	1983	.59	5	5	95	22900
Culpeper	1984	.61	5	5	92.4	23200
Culpeper	1985	.61	5	5	86	23700
Dickenson	1981	.5	14	14	67.9	20100
Dickenson	1982	.5	14	14	73	20100
Dickenson	1983	.5	14	14	66.7	20200
Dickenson	1984	.5	14	14	75.4	20100
Dickenson	1985	.5	14	14	69.8	20000
Essex	1981	.45	3.75	3.5	84.7	8700
Essex	1982	.45	3.75	3.5	82.6	8800
Essex	1983	.45	3.75	3.5	80	8700
Essex	1984	.45	3.75	3.5	71.6	8800
Essex	1985	.45	3.5	3.5	88.3	8900
Fauquier	1981	.73	3.45	3.45	73.4	36600
Fauquier	1982	.73	3.45	3.45	73.1	37400
Fauquier	1983	.59	3.45	3.45	91	38200
Fauquier	1984	.63	3.45	3.45	88.2	39300
Fauquier	1985	.63	3.45	3.45	84.9	40100

County	Year	RETR	PPTR	MTR	AR	POP
Floyd	1981	.6	4.5	4.5	58.2	12000
Floyd	1982	.6	4.5	4.5	59.1	11700
Floyd	1983	.55	4.5	4.5	81.6	11600
Floyd	1984	.55	1.25	1.25	78.2	11700
Floyd	1985	.55	1.25	1.25	77.5	11800
Fluvanna	1981	.86	3.7	3.9	73.8	10300
Fluvanna	1982	.55	3.7	3.9	99.5	10300
Fluvanna	1983	.55	3.7	3.9	95.1	10400
Fluvanna	1984	.55	3.7	3.7	92.9	10500
Fluvanna	1985	.55	3.7	3.7	91.2	10500
Franklin	1981	.52	5.4	5.4	61	35800
Franklin	1982	.52	5.4	5.4	65.7	36000
Franklin	1983	.52	5.4	5.4	59.5	36400
Franklin	1984	.45	5.4	5.4	86.6	36900
Franklin	1985	.45	6	5.4	86.7	37300
Greene	1981	.48	12	.75	83.7	7600
Greene	1982	.55	19.5	.75	95.3	8000
Greene	1983	.55	16.5	.75	89.5	8100
Greene	1984	.75	16.5	.75	95.1	8300
Greene	1985	.75	16.5	.75	87.9	8500
Greensvil	1981	.41	3.5	2.5	75.9	11100
Greensvil	1982	.41	3.5	2.5	71.2	10800
Greensvil	1983	.41	3.5	2.5	70	10800
Greensvil	1984	.4	4.5	2.5	90.7	10200
Greensvil	1985	.42	4.5	2.5	88.8	10500
Halifax	1981	.36	4.45	4.45	90	30500
Halifax	1982	.36	4.45	4.45	97.4	29900
Halifax	1983	.36	4.45	3.9	89.4	29900
Halifax	1984	.36	4.45	3.9	85.7	29800
Halifax	1985	.36	4.45	3.9	87.1	30200
James Cit	1981	.74	4	4	93.4	23600
James Cit	1982	.73	4	4	95.4	24300
James Cit	1983	.71	4	4	92.1	24500
James Cit	1984	.69	4	4	91.5	24700
James Cit	1985	.67	4	4	88.3	26100
King & Qu	1981	.83	.83	.83	62.6	10800
King & Qu	1982	.88	.88	.88	59	10700
King & Qu	1983	.88	.88	.88	68.4	10800
King & Qu	1984	.74	.74	.74	80	11100
King & Qu	1985	.79	.79	.79	71.8	11700
King Geor	1981	.97	2.9	2	77.1	5900
King Geor	1982	1.05	2.9	2	75.1	5800
King Geor	1983	1.05	2.9	2	66.3	5900
King Geor	1984	.82	2.9	2	83.7	5900
King Geor	1985	.88	2.9	2	75.7	6300

County	Year	RETR	PPTR	MTR	AR	POP
King Will	1981	.76	4.2	4.2	90.3	9600
King Will	1982	.76	4.2	4.2	88.9	9600
King Will	1983	.6	4.2	4.2	88.1	9800
King Will	1984	.76	4.2	4.2	84.7	9800
King Will	1985	.76	4.2	4.2	81	10100
Lancaster	1981	.37	3.8	3.8	69	10100
Lancaster	1982	.37	3.8	3.8	70.5	10300
Lancaster	1983	.31	3.8	3.8	96.3	10400
Lancaster	1984	.34	3.8	3.8	89	10600
Lancaster	1985	.39	3.8	3.8	86.2	11100
Loudoun	1981	1.02	5	2.55	90.9	58100
Loudoun	1982	1.13	5	2.75	87.4	59200
Loudoun	1983	1.13	4.75	2.75	85.7	60300
Loudoun	1984	1.1	4.75	2.75	90.2	62700
Loudoun	1985	1.13	4.5	2.75	86.2	63600
Nelson	1981	.52	2.25	1.25	88.3	12300
Nelson	1982	.55	2.5	1.25	87.4	12300
Nelson	1983	.55	2.5	1.25	84.5	12200
Nelson	1984	.59	2.5	1.25	80.9	12300
Nelson	1985	.59	2.5	1.25	78.3	12400
Orange	1981	.55	5.5	5.5	82.4	18200
Orange	1982	.5	5.5	5.5	98.1	18500
Orange	1983	.54	5.5	5.5	94.2	18600
Orange	1984	.54	5.5	5.5	92	18900
Orange	1985	.54	5.5	5.5	84.4	19200
Patrick	1981	.55	4	4	55.5	17500
Patrick	1982	.55	4	4	58.5	17500
Patrick	1983	.55	4	4	60.5	17600
Patrick	1984	.65	4	4	54.3	17600
Patrick	1985	.43	4	4	86.2	17700
Prince ge	1981	.69	3.5	1.5	86.4	26700
Prince ge	1982	.66	3.5	1.5	93.6	25900
Prince ge	1983	.66	3.5	1.5	88.7	25900
Prince ge	1985	.84	3.5	1.5	87.3	26800
Prince Ge	1984	.74	3.5	1.5	91.3	25900
Prince Wi	1981	1.52	4.07	1.07	83.4	152400
Prince Wi	1982	1.48	4.06	1.06	89.5	156700
Prince Wi	1983	1.45	4.5	1.5	90.1	159000
Prince Wi	1984	1.49	4.07	1.07	91.1	164300
Prince Wi	1985	1.49	4.07	1.07	92.6	169000
Pulaski	1981	.54	4.8	4.8	85.3	35100
Pulaski	1982	.54	4.8	4.8	78.9	35300
Pulaski	1983	.54	4.8	4.8	77.4	35000
Pulaski	1984	.54	4.8	4.8	77.2	35000
Pulaski	1985	.54	4.8	4.8	73.5	34500

County	Year	RETR	PPTR	MTR	AR	POP
Rappahann	1981	5.3	1.4	1.4	4.2	5900
Rappahann	1982	.32	5.6	5.6	84.5	5900
Rappahann	1983	.42	5.6	5.6	85.5	5900
Rappahann	1984	.5	5.6	0	80.7	6100
Rappahann	1985	.58	5.6	0	78.5	6100
Roanoke	1981	.94	3	3	88.6	74600
Roanoke	1982	1.08	3.5	3	87.7	73800
Roanoke	1983	1.1	3.5	3	85.7	73400
Roanoke	1984	1.15	3.5	3	83.1	73900
Roanoke	1985	1.15	3.5	3	92.2	73700
Rockingha	1981	.52	3.5	3.5	68.1	58300
Rockingha	1982	.39	3.5	3.5	93.4	53000
Rockingha	1983	.39	3.5	3.5	89	52900
Rockingha	1984	.43	1.54	1.54	90.5	52900
Rockingha	1985	.46	2.15	1.62	88.1	53600
Spotsylva	1981	.85	2	2	74.7	35800
Spotsylva	1982	.65	2	2	92.5	36100
Spotsylva	1983	.65	2.5	2.5	89.2	34700
Spotsylva	1984	.7	2.5	2.5	85.7	35200
Spotsylva	1985	.7	2.5	2.5	82	37500
Stafford	1981	1.32	3.8	.75	78.5	42300
Stafford	1982	1.56	5.7	.75	76.3	43900
Stafford	1983	1.21	5.7	.75	94.1	45300
Stafford	1984	1.21	5.35	.75	90.9	47200
Stafford	1985	1.2	4.99	.75	88.6	48300
Sussex	1981	.63	5.5	5.5	58.5	10600
Sussex	1982	.46	3	3	81.7	10500
Sussex	1983	.46	3	3	83.1	10300
Sussex	1984	.46	4.25	4.25	74.6	10300
Sussex	1985	.46	4.25	4.25	77	10200
Warren	1981	.6	2	2	77.4	21500
Warren	1982	.6	2.4	2	75.8	21400
Warren	1983	.6	2.4	2	73.7	21700
Warren	1984	.6	2.4	2	72	22100
Warren	1985	.46	2.4	2	85.7	22600
wise	1981	.285	4.6	4.6	87.6	44100
wise	1982	.285	4.6	4.6	85.7	44500
wise	1983	.285	4.6	4.6	86.6	45000
wise	1984	.285	4.6	4.6	86.5	45400
wise	1985	.285	4.6	4.6	92.9	45200
York	1981	.84	4.7	4.7	70.8	36800
York	1982	.9	4.7	4.7	67.4	36800
York	1983	.64	4.7	4.7	85.2	37600
York	1984	.66	4.5	4.5	79.5	39400
York	1985	.68	4.5	4.5	75.8	39900

Table A.2. Data Used for Estimation: Housing Stock and Price Indices.

County	Year	HS	AP	NTP	RPP	RPF
Bath	1981	2387	152.9916	130.0195	26244.82	4.22189
Bath	1982	2412	181.1466	152.5249	26470.07	3.81015
Bath	1983	2428	195.7241	164.1772	27764.52	3.93393
Bath	1984	2444	201.9020	169.1155	29223.21	3.90855
Bath	1985	2468	219.3055	183.0268	29249.99	3.84801
Bedford	1981	13571	157.9272	133.9647	38456.49	6.15011
Bedford	1982	13831	165.6283	140.1205	40018.04	6.31548
Bedford	1983	14000	180.9150	152.3398	44048.12	6.23647
Bedford	1984	14384	194.1884	162.9497	45396.62	6.23914
Bedford	1985	14681	208.3830	174.2960	48241.79	6.22792
Campbell	1981	16544	156.1145	132.5158	31154.10	4.75454
Campbell	1982	16860	161.7577	137.0266	33797.57	4.91671
Campbell	1983	17044	171.9982	145.2122	32579.92	4.95726
Campbell	1984	17279	310.8921	256.2355	32732.64	3.05658
Campbell	1985	17557	192.5277	161.6222	33661.99	5.05147
Caroline	1981	6560	137.9227	117.9743	32225.16	7.64465
Caroline	1982	6660	141.4674	120.8077	32617.43	8.00678
Caroline	1983	6769	152.7254	129.8067	32650.32	7.99665
Caroline	1984	6866	163.4960	138.4161	36313.24	8.02471
Caroline	1985	6978	176.5430	148.8450	39382.46	7.97107
Charls Ci	1981	2133	146.2575	124.6367	32116.52	8.39447
Charls Ci	1982	2156	151.0166	128.4408	29582.79	8.66896
Charls Ci	1983	2158	166.5534	140.8600	32520.65	8.42640
Charls Ci	1984	2167	179.0530	150.8514	40154.48	8.35995
Charls Ci	1985	2195	189.0896	158.8740	41665.21	8.41187
Culpeper	1981	8428	155.2350	131.8128	37848.56	8.80363
Culpeper	1982	8545	162.8156	137.8722	39498.16	9.01295
Culpeper	1983	8609	171.5033	144.8166	41167.72	9.17038
Culpeper	1984	8777	182.1273	153.3088	42565.97	9.24193
Culpeper	1985	8922	198.9090	166.7231	46191.10	9.06007
Dickenson	1981	6971	126.4009	108.7645	54917.63	6.54445
Dickenson	1982	7028	135.8433	116.3122	50944.85	6.55281
Dickenson	1983	7084	127.6236	109.7419	51735.09	7.35992
Dickenson	1984	7159	135.0863	115.7071	45191.95	7.43911
Dickenson	1985	7202	133.5734	114.4978	48744.22	7.96382
Essex	1981	3561	143.5461	122.4693	38238.77	10.2366
Essex	1982	3579	148.4431	126.3837	39577.88	10.5568
Essex	1983	3603	158.3532	134.3052	41304.64	10.5714
Essex	1984	3661	167.9649	141.9882	46496.11	10.6181
Essex	1985	3688	178.2896	150.2412	48642.58	10.6380
Fauquier	1981	12886	207.1387	173.3014	57010.42	10.3700
Fauquier	1982	13151	231.1794	192.5180	59686.76	10.0536
Fauquier	1983	13438	258.6272	214.4581	65422.94	9.69931
Fauquier	1984	13973	295.1875	243.6822	68160.03	9.15252
Fauquier	1985	14566	286.8660	237.0305	72129.24	10.0145

County	Year	HS	AP	NTP	RPP	RPF
Floyd	1981	4835	119.1141	102.9399	21724.87	6.07973
Floyd	1982	4882	125.1691	107.7799	21764.29	6.23857
Floyd	1983	4915	135.0562	115.6831	21950.21	6.23987
Floyd	1984	4975	147.8358	125.8983	23248.19	6.31753
Floyd	1985	5026	156.5655	132.8763	23847.90	6.21526
Fluvanna	1981	3890	138.5773	118.4976	40771.96	7.04590
Fluvanna	1982	3954	147.4862	125.6188	44921.94	7.15641
Fluvanna	1983	4016	156.3264	132.6852	46335.50	7.27434
Fluvanna	1984	4128	167.7659	141.8292	47849.22	7.29354
Fluvanna	1985	4250	183.0673	154.0602	49100.82	7.18502
Franklin	1981	13129	140.7948	120.2701	31552.88	5.91085
Franklin	1982	13319	145.2182	123.8060	27331.49	6.15296
Franklin	1983	13584	156.7470	133.0213	31286.39	6.13798
Franklin	1984	13916	168.1346	142.1239	36704.61	6.14129
Franklin	1985	14423	184.3513	155.0865	38281.29	6.00963
Greene	1981	2971	161.0410	136.4537	35341.08	6.20873
Greene	1982	3045	163.1130	138.1099	39189.08	6.56600
Greene	1983	3096	174.8552	147.4959	42188.36	6.58511
Greene	1984	3169	189.5061	159.2070	39985.63	6.52269
Greene	1985	3263	196.3308	164.6622	43806.58	6.71475
Greensvil	1981	3792	122.7163	105.8193	20005.56	8.00236
Greensvil	1982	3802	130.3802	111.9454	21854.21	8.12564
Greensvil	1983	3814	136.7388	117.0280	22546.25	8.32273
Greensvil	1984	3838	152.1130	129.3172	23468.21	8.07406
Greensvil	1985	3855	158.0015	134.0241	24419.25	8.30084
Halifax	1981	11370	122.0188	105.2618	17253.91	5.24674
Halifax	1982	11463	125.8849	108.3521	17035.12	5.44110
Halifax	1983	11538	130.9418	112.3943	18781.66	5.59144
Halifax	1984	11645	140.3636	119.9255	19801.59	5.58559
Halifax	1985	11769	145.4080	123.9576	19836.88	5.73779
James Cit	1981	8820	185.0740	155.6642	54645.80	14.3794
James Cit	1982	9061	194.7591	163.4059	54365.24	14.7604
James Cit	1983	9237	215.9213	180.3217	59334.72	14.4055
James Cit	1984	9748	236.1357	196.4798	60997.09	14.1914
James Cit	1985	10435	252.0220	209.1783	68432.13	14.2599
King & Qu	1981	2308	91.98533	81.25484	26336.11	9.37957
King & Qu	1982	2324	95.59885	84.14327	28458.39	9.71026
King & Qu	1983	2335	97.87232	85.96054	24976.52	10.1550
King & Qu	1984	2353	103.8989	90.77786	28751.78	10.2812
King & Qu	1985	2378	106.9261	93.19758	32211.53	10.6602
King Geor	1981	4002	279.4023	231.0645	33961.44	4.62234
King Geor	1982	4055	302.1802	249.2717	35209.61	4.57046
King Geor	1983	4124	322.4127	265.4443	39784.13	4.56725
King Geor	1984	4181	348.5429	286.3312	43469.69	4.58745
King Geor	1985	4254	360.8033	296.1314	48754.48	4.60864

County	Year	HS	AP	NTP	RPP	RPF
King Will	1981	3462	164.4630	139.1890	34371.76	6.24457
King Will	1982	3497	169.5257	143.2358	35253.79	6.49818
King Will	1983	3534	177.5569	149.6555	35755.98	6.65054
King Will	1984	3594	194.0441	162.8343	37660.12	6.53482
King Will	1985	3664	202.7710	169.8101	39836.01	6.67180
Lancaster	1981	4655	163.9289	138.7621	60568.98	7.98918
Lancaster	1982	4717	171.4243	144.7534	60208.44	8.15071
Lancaster	1983	4794	180.4987	152.0070	68269.59	8.24862
Lancaster	1984	4970	194.3073	163.0447	72845.48	8.16679
Lancaster	1985	5195	203.7964	170.6297	73755.82	8.26372
Loudoun	1981	20008	219.9837	183.5689	68875.36	12.9029
Loudoun	1982	20395	233.5728	194.4312	73244.24	13.0526
Loudoun	1983	21106	254.4261	211.1000	75291.88	12.8634
Loudoun	1984	22280	279.3909	231.0554	79720.62	12.5500
Loudoun	1985	23653	312.5159	257.5335	85768.08	12.0044
Nelson	1981	4995	129.1113	110.9311	40813.76	6.56284
Nelson	1982	5110	133.0248	114.0593	42942.01	6.87093
Nelson	1983	5263	142.6663	121.7661	46915.27	6.92682
Nelson	1984	5459	168.4827	142.4021	50722.75	6.39072
Nelson	1985	5627	168.2852	142.2443	56186.25	6.82497
Orange	1981	7442	168.9535	142.7785	37731.70	7.48835
Orange	1982	7549	173.2339	146.1999	38533.57	7.83337
Orange	1983	7638	177.8543	149.8932	40517.47	8.16616
Orange	1984	7803	191.7195	160.9762	41758.22	8.12865
Orange	1985	7971	203.5866	170.4620	46339.37	8.18307
Patrick	1981	6904	129.0391	110.8733	27460.72	6.23303
Patrick	1982	6993	131.3107	112.6891	26712.89	6.57566
Patrick	1983	7043	139.3007	119.0758	26191.28	6.67395
Patrick	1984	7125	153.9759	130.8063	29917.83	6.51559
Patrick	1985	7245	158.9048	134.7461	28504.49	6.74239
Prince ge	1981	7189	122.1067	105.3321	28207.69	8.34365
Prince ge	1982	7321	132.0122	113.2499	31300.04	8.30103
Prince ge	1983	7464	139.4546	119.1988	33474.09	8.40645
Prince ge	1985	7875	158.0185	134.0377	35411.21	7.98408
Prince Ge	1984	7660	151.4998	128.8271	33407.92	8.77427
Prince Wi	1981	47867	187.6597	157.7311	71480.92	14.0543
Prince Wi	1982	49317	197.0380	165.2275	74104.69	14.3516
Prince Wi	1983	50850	213.0735	178.0452	74799.51	14.2333
Prince Wi	1984	53415	228.7458	190.5728	77343.97	14.1763
Prince Wi	1985	56375	245.4572	203.9308	80966.58	14.0947
Pulaski	1981	13402	137.2490	117.4358	28989.08	6.31812
Pulaski	1982	13491	140.0867	119.7041	31761.21	6.61594
Pulaski	1983	13637	153.8199	130.6816	32506.19	6.48280
Pulaski	1984	13721	167.9158	141.9490	32869.62	6.36848
Pulaski	1985	13808	177.1049	149.2942	34960.29	6.43749

County	Year	HS	AP	NTP	RPP	RPF
Rappahann	1981	2659	154.4478	131.1835	42842.83	8.69292
Rappahann	1982	2696	161.6775	136.9625	38759.61	8.94513
Rappahann	1983	2751	182.3795	153.5104	38150.56	8.58437
Rappahann	1984	2807	189.0626	158.8524	40471.15	8.86515
Rappahann	1985	2836	205.2862	171.8206	42309.63	8.75774
Roanoke	1981	27142	185.6058	156.0893	48680.11	7.23753
Roanoke	1982	27545	194.1259	162.8998	50581.13	7.38370
Roanoke	1983	27818	211.7337	176.9743	52002.78	7.23673
Roanoke	1984	28426	227.7843	189.8042	53665.38	7.16753
Roanoke	1985	29097	238.0833	198.0365	56131.85	7.27710
Rockingha	1981	20861	149.0645	126.8804	37693.35	12.2973
Rockingha	1982	21129	159.3984	135.1407	38743.41	12.3988
Rockingha	1983	21389	166.5001	140.8173	36421.56	12.7323
Rockingha	1984	21612	177.9303	149.9540	36805.19	12.7805
Rockingha	1985	21833	188.3920	158.3164	38684.16	12.9067
Spotsylva	1981	12215	161.1837	136.5678	47488.12	8.83613
Spotsylva	1982	12551	173.3416	146.2861	51846.22	8.85766
Spotsylva	1983	12894	191.4489	160.7599	55221.26	8.64414
Spotsylva	1984	13525	211.0121	176.3975	55128.47	8.42689
Spotsylva	1985	14291	227.3602	189.4652	58680.52	8.36581
Stafford	1981	13625	173.4736	146.3916	54394.90	10.7972
Stafford	1982	13980	178.8451	150.6852	56569.31	11.2303
Stafford	1983	14384	189.5606	159.2505	57702.99	11.3662
Stafford	1984	14522	200.1413	167.7081	61767.52	11.5173
Stafford	1985	14659	216.0494	180.4240	65290.37	11.4114
Sussex	1981	3979	140.8614	120.3234	75198.85	6.68991
Sussex	1982	4042	145.6551	124.1552	21159.73	6.94437
Sussex	1983	4051	152.5523	129.6683	21187.52	7.11098
Sussex	1984	4115	163.6211	138.5161	23599.87	7.11287
Sussex	1985	4129	171.1493	144.5337	23311.48	7.25923
Warren	1981	2156	153.9596	130.7933	204949.1	9.25821
Warren	1982	2158	158.5278	134.4448	180982.1	9.66676
Warren	1983	2167	169.7952	143.4513	187703.5	9.72031
Warren	1984	2195	185.8210	156.2613	192303.0	9.56093
Warren	1985	2205	203.4126	170.3230	208953.1	9.37789
wise	1981	15745	147.2875	125.4600	26468.20	7.53068
wise	1982	15970	154.7132	131.3957	26930.59	7.70003
wise	1983	16094	150.1627	127.7582	26936.38	8.42584
wise	1984	16212	161.6933	136.9751	27262.63	8.39288
wise	1985	16379	161.7001	136.9805	28202.53	8.91057
York	1981	11655	161.1808	136.5655	52851.83	21.7456
York	1982	11848	170.5929	144.0889	57206.98	21.8383
York	1983	12076	180.2654	151.8205	61825.79	21.9252
York	1984	12332	187.1114	157.2928	67368.42	22.3349
York	1985	12604	198.0613	166.0455	72328.61	22.3192

Table A.3. Data Used for Estimation: Values of Tax Bases.

County	Year	TP	FVTH	PPV	MTV	ST
Bath	1981	138.0590	169906	10711512	45000	389780
Bath	1982	160.5527	170944	11335095	53000	426812
Bath	1983	172.1991	181023	14116524	46350	454688
Bath	1984	177.1348	190113	14567740	45000	444771
Bath	1985	191.0389	190649	13860295	45000	514785
Bedford	1981	142.0022	862213	36003565	4412650	417017
Bedford	1982	148.1548	902073	39467275	5031220	451338
Bedford	1983	160.3677	985084	41722050	5054190	548869
Bedford	1984	170.9722	1063303	44512070	5487560	654640
Bedford	1985	182.3126	1127796	56507900	6269300	666054
Campbell	1981	140.5540	839126	74048320	23226220	1035277
Campbell	1982	145.0625	864689	76241000	27487840	1145726
Campbell	1983	153.2439	905058	81252460	28371040	1266804
Campbell	1984	264.2097	913447	90694720	27701180	1436326
Campbell	1985	169.6454	933009	1.0140e8	30516300	1478539
Caroline	1981	126.0201	426269	16918098	820490	317225
Caroline	1982	128.8520	432873	19198815	1350800	329840
Caroline	1983	137.8463	435999	19372965	2057810	356751
Caroline	1984	146.4512	476825	22967320	1486270	384346
Caroline	1985	156.8748	517525	25641705	2040510	399329
Charls Ci	1981	132.6790	163133	12301800	1059200	34655
Charls Ci	1982	136.4811	150634	13234400	1180900	32062
Charls Ci	1983	148.8939	164039	11502600	2090800	31380
Charls Ci	1984	158.8801	189162	13160500	1756400	39811
Charls Ci	1985	166.8986	195960	14570200	1917300	44534
Culpeper	1981	139.8514	716037	21400960	6528418	879161
Culpeper	1982	145.9077	748374	23788750	6237095	890041
Culpeper	1983	152.8485	743598	24737503	8985401	1017434
Culpeper	1984	161.3363	776341	28255007	10862260	1207470
Culpeper	1985	174.7436	852268	32808919	9289831	1259857
Dickenson	1981	116.8150	539293	14741968	8514552	449272
Dickenson	1982	124.3588	544382	14782675	8557389	446431
Dickenson	1983	117.7919	566230	14812357	8645248	456798
Dickenson	1984	123.7540	500802	12564323	8953971	481544
Dickenson	1985	122.5454	548127	12546829	7910323	491545
Essex	1981	130.5128	279892	15688205	561369	483602
Essex	1982	134.4251	289191	17874123	615703	512699
Essex	1983	142.3425	301607	18487599	650516	551631
Essex	1984	150.0216	342108	20198454	673994	583606
Essex	1985	158.2703	336732	21802702	731304	599875
Fauquier	1981	181.3185	1622793	70932870	8241280	1101145
Fauquier	1982	200.5252	1659617	83869420	7402460	1152462
Fauquier	1983	222.4539	1844888	87915500	9337080	1418486
Fauquier	1984	251.6629	1954300	1.0404e8	8780400	1674960
Fauquier	1985	245.0146	2097182	1.2034e8	7529680	1836206

County	Year	TP	FVTH	PPV	MTV	ST
Floyd	1981	110.9934	299259	5363125	239443	167941
Floyd	1982	115.8309	297846	5428172	199518	175285
Floyd	1983	123.7300	288628	5189127	202407	183257
Floyd	1984	133.9399	305047	20164056	1159380	194078
Floyd	1985	140.9143	311893	22807074	1198147	203992
Fluvanna	1981	126.5431	295000	11912350	813270	120130
Fluvanna	1982	133.6606	305789	13476755	815780	143488
Fluvanna	1983	140.7233	323065	14115060	839790	157343
Fluvanna	1984	149.8626	337702	16107185	825490	155973
Fluvanna	1985	162.0872	351101	17720372	403390	168932
Franklin	1981	128.3147	794726	23765582	2139485	697556
Franklin	1982	131.8487	720691	25765374	2016596	766186
Franklin	1983	141.0593	822017	28104288	1859983	942932
Franklin	1984	150.1572	901159	33760757	2047757	979120
Franklin	1985	163.1131	949315	35522663	2144435	1088955
Greene	1981	144.4899	173698	4185546	15000	103602
Greene	1982	146.1453	209581	4546220	108000	106007
Greene	1983	155.5264	226581	4601720	115100	119322
Greene	1984	167.2314	217201	5092270	297313	135337
Greene	1985	172.6838	241250	5560680	1395959	153411
Greensvil	1981	113.8713	197716	18305785	5562758	203034
Greensvil	1982	119.9942	213618	20060339	6102634	172082
Greensvil	1983	125.0743	219067	21556710	4767880	185085
Greensvil	1984	137.3571	218136	23416150	6107230	295642
Greensvil	1985	142.0615	228089	24601221	7126520	273081
Halifax	1981	113.3141	534477	19223850	9057800	483831
Halifax	1982	116.4028	498514	20181580	10208880	512044
Halifax	1983	120.4429	547174	22679840	11828720	598074
Halifax	1984	127.9702	576231	24839400	13115840	668364
Halifax	1985	132.0003	575157	28342103	14741900	768238
James Cit	1981	163.6905	765619	40358258	52349485	1532218
James Cit	1982	171.4281	833086	50624550	53968680	1601933
James Cit	1983	188.3352	926019	57349056	56687550	2100473
James Cit	1984	204.4849	982793	56973023	64474747	2324904
James Cit	1985	217.1769	1150133	77250334	61576912	2419459
King & Qu	1981	89.31958	188465	13129920	1506360	37659
King & Qu	1982	92.20652	201777	14362300	1703960	40033
King & Qu	1983	94.02285	174673	15443470	1915340	39620
King & Qu	1984	98.83767	189845	18446690	2725200	45222
King & Qu	1985	101.2561	213208	20983080	3196490	47386
King Geor	1981	239.0517	238653	11950540	1635000	179595
King Geor	1982	257:2496	248544	17831440	1264780	182363
King Geor	1983	273.4138	286343	20155042	1138700	186220
King Geor	1984	294.2899	306747	22661960	1277440	211071
King Geor	1985	304.0850	347489	27687073	1276410	251535

County	Year	TP	FVTH	PPV	MTV	ST
King Will	1981	147.2238	284542	13093766	10307250	253533
King Will	1982	151.2685	293788	15037634	14309690	279490
King Will	1983	157.6849	299269	15735201	15392060	282071
King Will	1984	170.8569	314999	18414975	16408580	312107
King Will	1985	177.8290	334561	19565020	16622365	316869
Lancaster	1981	146.7971	393846	13224246	156200	481143
Lancaster	1982	152.7853	392326	14752928	156250	485495
Lancaster	1983	160.0352	437579	15874624	154150	529624
Lancaster	1984	171.0672	481859	17748972	147100	557679
Lancaster	1985	178.6483	511355	19924410	132400	606695
Loudoun	1981	191.5807	2534846	1.0669e8	3700873	2767800
Loudoun	1982	202.4374	2688720	1.1704e8	3886789	3120870
Loudoun	1983	219.0976	2811996	1.2662e8	3652980	3853061
Loudoun	1984	239.0426	3061686	1.5438e8	5877860	4625450
Loudoun	1985	265.5070	3510811	1.8331e8	5987905	5290336
Nelson	1981	118.9804	388959	18415918	1617290	220211
Nelson	1982	122.1071	409301	19717958	972257	228824
Nelson	1983	129.8099	445422	20655885	1508640	256260
Nelson	1984	150.4353	483697	23711360	1940880	302659
Nelson	1985	150.2775	530526	27159580	1789290	329343
Orange	1981	150.8114	536944	21010960	2332340	529048
Orange	1982	154.2311	556374	24059650	3234350	549416
Orange	1983	157.9224	586713	25666775	3456685	605742
Orange	1984	168.9997	609692	28988530	3372355	679390
Orange	1985	178.4806	674142	31860715	4410910	702421
Patrick	1981	118.9228	394418	13967287	1739836	249067
Patrick	1982	120.7376	383797	15587356	2281476	247578
Patrick	1983	127.1210	374848	16005222	2233003	278443
Patrick	1984	138.8454	425819	17988469	2230884	325907
Patrick	1985	142.7832	404782	20953585	3444591	332084
Prince ge	1981	113.3843	359570	25019660	972030	312957
Prince ge	1982	121.2981	380466	28744530	1068110	331355
Prince ge	1983	127.2439	416895	30374422	945460	346992
Prince ge	1985	142.0751	449814	45959072	1009660	425761
Prince Ge	1984	136.8672	419253	37786410	992710	399109
Prince Wi	1981	165.7562	3908470	2.0000e8	14852339	5236497
Prince Wi	1982	173.2488	4108329	2.5339e8	15297232	5539773
Prince Wi	1983	186.0599	4336974	2.8391e8	19471731	6379289
Prince Wi	1984	198.5810	4679944	3.3919e8	19164477	7786535
Prince Wi	1985	211.9321	5182836	3.9341e8	25605220	9385910
Pulaski	1981	125.4818	594275	23092020	8472370	1179889
Pulaski	1982	127.7490	654718	25461784	8201371	1240315
Pulaski	1983	138.7208	678680	26550060	9652870	1330833
Pulaski	1984	149.9824	692472	31797800	10772390	1434448
Pulaski	1985	157.3237	741037	32670510	13561280	1568074

County	Year	Tp	FVTH	PPV	MTV	ST
Rappahann	1981	139.2224	285731	7262063	321315	79466
Rappahann	1982	144.9984	292862	2271038	74000	78420
Rappahann	1983	161.5377	289327	2455560	0	94574
Rappahann	1984	166.8770	310297	2825739	0	94941
Rappahann	1985	179.8385	324013	3260494	0	104623
Roanoke	1981	164.1153	1620918	1.2321e8	16269692	2870401
Roanoke	1982	170.9223	1672022	1.3248e8	15865157	3014352
Roanoke	1983	184.9895	1741248	1.4032e8	20307890	3546037
Roanoke	1984	197.8128	1862184	1.6208e8	24694128	3944610
Roanoke	1985	206.0409	2011861	1.8535e8	27304005	3778511
Rockingha	1981	134.9215	1509421	65087310	15016540	1700534
Rockingha	1982	143.1776	1518086	69720230	17544120	1736511
Rockingha	1983	148.8513	1413077	65383040	14560840	1252279
Rockingha	1984	157.9832	1412556	1.7963e8	32462870	1348727
Rockingha	1985	166.3413	1479119	1.4927e8	40431194	1480291
Spotsylva	1981	144.6039	970701	49459987	15620915	1977896
Spotsylva	1982	154.3172	1082662	48561893	14695620	2156168
Spotsylva	1983	168.7836	1165578	57561189	14219865	2418298
Spotsylva	1984	184.4130	1175924	71251347	12879646	2655845
Spotsylva	1985	197.4740	1302700	90656330	12845343	3009850
Stafford	1981	154.4226	1043140	43126338	4332230	982239
Stafford	1982	158.7140	1121015	49587500	5184760	938166
Stafford	1983	167.2749	1133583	52264235	6115130	1048599
Stafford	1984	175.7281	1213559	60878920	7340339	1233876
Stafford	1985	188.4375	1285808	70578510	8266970	1457116
Sussex	1981	128.3679	299880	12658902	3628006	268239
Sussex	1982	132.1977	310033	17502164	6681452	266739
Sussex	1983	137.7080	302113	18822799	6530887	275135
Sussex	1984	146.5512	333508	20438302	6637192	286018
Sussex	1985	152.5657	322845	22393449	6998292	292818
Warren	1981	138.8324	544627	38506102	10050200	786807
Warren	1982	142.4821	566231	37821176	13637910	859449
Warren	1983	151.4838	586892	47397725	15504020	848740
Warren	1984	164.2873	610168	45405661	15423420	952135
Warren	1985	178.3416	669249	52609762	16885536	1035219
wise	1981	133.5019	744458	63215681	23965660	1510371
wise	1982	139.4345	753082	60052459	26221330	1592819
wise	1983	135.7989	764504	60058064	31606940	1805839
wise	1984	145.0110	779544	59515333	32911760	1983624
wise	1985	145.0164	843417	60604836	36768760	1946249
York	1981	144.6016	816109	37366280	11580630	1058652
York	1982	152.1211	896355	47110780	11571240	1172820
York	1983	159.8487	960741	52624780	12336170	1361576
York	1984	165.3182	1061470	60347200	12779810	1508133
York	1985	174.0663	1171954	71204210	14568260	1620507

Table A.4. Data Used for Estimation: Values of Tax Bases.

County	Year	ACV	AAG1	AAG2	FMVR	FMVCA
Bath	1981	20625355	7703868	19615827	1.6991e8	1.0726e8
Bath	1982	21306506	7746316	19141365	1.7094e8	1.0710e8
Bath	1983	9435600	21594290	70424500	1.8102e8	1.1361e8
Bath	1984	9585000	21762150	70846200	1.9011e8	1.1869e8
Bath	1985	9412800	22161450	71485980	1.9065e8	1.1846e8
Bedford	1981	4110590	1.1880e8	1.0409e8	8.6221e8	3.4032e8
Bedford	1982	4038270	1.2122e8	1.0306e8	9.0207e8	3.4858e8
Bedford	1983	5844200	1.8013e8	1.4817e8	9.8508e8	3.6841e8
Bedford	1984	28927200	1.7697e8	1.4697e8	1.0633e9	4.1032e8
Bedford	1985	30215165	1.7784e8	1.4479e8	1.1278e9	4.1956e8
Campbell	1981	1.1508e8	85741240	94078960	8.3913e8	3.2371e8
Campbell	1982	1.2352e8	73295125	71216430	8.6469e8	2.9486e8
Campbell	1983	1.2829e8	86909500	93991060	9.0506e8	3.4977e8
Campbell	1984	1.2835e8	87764050	93830560	9.1345e8	3.4786e8
Campbell	1985	1.4094e8	86355800	90087200	9.3301e8	3.4201e8
Caroline	1981	24756100	60723800	93508450	4.2627e8	2.1487e8
Caroline	1982	25334000	61198700	93096205	4.3287e8	2.1564e8
Caroline	1983	25579800	60963300	92542700	4.3600e8	2.1499e8
Caroline	1984	27440700	63987210	93073200	4.7683e8	2.2750e8
Caroline	1985	27700630	64301315	92218130	5.1753e8	2.4271e8
Charls Ci	1981	1189780	18480904	41270051	1.6313e8	94628470
Charls Ci	1982	1040700	18637900	41205700	1.5063e8	86853495
Charls Ci	1983	1040700	18668379	41205700	1.6404e8	93859444
Charls Ci	1984	2761760	24855830	46949903	1.8916e8	1.0215e8
Charls Ci	1985	2656600	22685300	48961060	1.9596e8	1.0450e8
Culpeper	1981	86238091	78795628	1.3275e8	7.1604e8	3.9705e8
Culpeper	1982	88259861	80324790	1.3217e8	7.4837e8	4.1086e8
Culpeper	1983	1.0813e8	1.0157e8	1.6003e8	7.4360e8	3.8919e8
Culpeper	1984	1.1099e8	1.0170e8	1.5944e8	7.7634e8	4.0274e8
Culpeper	1985	1.1654e8	1.0342e8	1.5857e8	8.5227e8	4.4015e8
Dickenson	1981	57371300	29825678	19040850	5.3929e8	1.5646e8
Dickenson	1982	75822872	29637878	30568590	5.4438e8	1.8634e8
Dickenson	1983	73158100	29554888	30512690	5.6623e8	1.9974e8
Dickenson	1984	74227906	28966508	30469290	5.0080e8	1.7727e8
Dickenson	1985	78057836	29019337	30478470	5.4813e8	1.9707e8
Essex	1981	25865000	35336100	60532900	2.7989e8	1.4372e8
Essex	1982	25995500	35388200	60485800	2.8919e8	1.4754e8
Essex	1983	26270200	35498700	60460200	3.0161e8	1.5279e8
Essex	1984	27352700	35815100	59902400	3.4211e8	1.7189e8
Essex	1985	33806300	39492800	65630500	3.3673e8	1.5734e8
Fauquier	1981	92130360	2.0145e8	3.5833e8	1.6228e9	8.8816e8
Fauquier	1982	70972700	2.0837e8	3.6004e8	1.6596e9	8.7468e8
Fauquier	1983	98306030	2.8312e8	4.9739e8	1.8449e9	9.6573e8
Fauquier	1984	1.0015e8	2.8559e8	4.9793e8	1.9543e9	1.0019e9
Fauquier	1985	1.0331e8	2.8955e8	4.9566e8	2.0972e9	1.0465e9

BLANK PAGE

County	Year	ACV	AAG1	AAG2	FMVR	FMVCA
Floyd	1981	8173580	67213230	37648800	2.9926e8	1.9422e8
Floyd	1982	8285280	67261930	37684100	2.9785e8	1.9159e8
Floyd	1983	9845700	89940980	47699360	2.8863e8	1.8074e8
Floyd	1984	9956200	90452380	47692260	3.0505e8	1.8939e8
Floyd	1985	10266600	91109530	47449810	3.1189e8	1.9203e8
Fluvanna	1981	4371890	42805840	53483310	2.95e8	1.3640e8
Fluvanna	1982	5161000	59304460	63061340	3.0579e8	1.2817e8
Fluvanna	1983	5079400	60782360	64407770	3.2307e8	1.3698e8
Fluvanna	1984	5243100	60801480	64183040	3.3770e8	1.4018e8
Fluvanna	1985	5262970	61230595	63395770	3.5110e8	1.4242e8
Franklin	1981	44431572	92506511	95147549	7.9473e8	3.8047e8
Franklin	1982	44893472	93347927	96086074	7.2069e8	3.5666e8
Franklin	1983	46210520	94981561	95036422	8.2202e8	3.9702e8
Franklin	1984	56560000	1.4234e8	1.3917e8	9.0116e8	3.9038e8
Franklin	1985	58308000	1.4631e8	1.3974e8	9.4932e8	3.9718e8
Greene	1981	4995330	22781955	29724325	1.7370e8	68699654
Greene	1982	8301150	33420770	44286560	2.0958e8	90250241
Greene	1983	8261150	33582340	44045940	2.2658e8	95965844
Greene	1984	8127450	34172285	43752960	2.1720e8	90486535
Greene	1985	8957350	33248465	44207910	2.4125e8	98309130
Greensvil	1981	21842170	25619850	45025875	1.9772e8	1.2185e8
Greensvil	1982	22510990	25688750	44736400	2.1362e8	1.3053e8
Greensvil	1983	22805140	25534380	44813390	2.1907e8	1.3308e8
Greensvil	1984	27440900	34163180	54550870	2.1814e8	1.2806e8
Greensvil	1985	30738780	34176490	54034820	2.2809e8	1.3395e8
Halifax	1981	56776200	1.1910e8	1.2860e8	5.3448e8	3.383e8
Halifax	1982	48073200	1.1918e8	1.2810e8	4.9851e8	3.0324e8
Halifax	1983	48211700	1.2004e8	1.2719e8	5.4717e8	3.3047e8
Halifax	1984	49066500	1.2019e8	1.2696e8	5.7623e8	3.4564e8
Halifax	1985	51037400	1.2114e8	1.2545e8	5.7516e8	3.4170e8
James Cit	1981	1.9931e8	22431800	43184600	7.6562e8	2.8364e8
James Cit	1982	2.2971e8	30270400	64839400	8.3309e8	3.4048e8
James Cit	1983	2.4797e8	33754200	66365600	9.2602e8	3.7794e8
James Cit	1984	2.5502e8	33764200	66409406	9.8279e8	3.8819e8
James Cit	1985	2.7803e8	36434100	70562000	1.1501e9	4.3604e8
King & Qu	1981	3182790	31527700	45217980	1.8847e8	1.2768e8
King & Qu	1982	3588690	31514760	44923970	2.0178e8	1.3564e8
King & Qu	1983	3536480	31582470	44466390	1.7467e8	1.1635e8
King & Qu	1984	4706330	38407260	54640050	1.8985e8	1.2219e8
King & Qu	1985	5116210	39235660	53733380	2.1321e8	1.3661e8
King Geor	1981	13143300	25954100	40114600	2.3865e8	1.0274e8
King Geor	1982	13018900	26315850	40097800	2.4854e8	1.0577e8
King Geor	1983	14496200	26677050	39893900	2.8634e8	1.2227e8
King Geor	1984	20101900	35970100	48553200	3.0675e8	1.2500e8
King Geor	1985	21192100	36507900	48346200	3.4749e8	1.4009e8

County	Year	ACV	AAG1	AAG2	FMVR	FMVCA
King Will	1981	33086800	30655000	85747100	2.8454e8	1.6555e8
King Will	1982	35386600	30331100	85861700	2.9379e8	1.7051e8
King Will	1983	35965500	30560700	85805200	2.9927e8	1.7291e8
King Will	1984	36211900	30553700	85396700	3.1500e8	1.7965e8
King Will	1985	37044000	30920200	84803300	3.3456e8	1.8860e8
Lancaster	1981	26155050	31948750	19105400	3.9385e8	1.1190e8
Lancaster	1982	26228750	31181150	18957650	3.9233e8	1.0832e8
Lancaster	1983	35734900	43894800	26584000	4.3758e8	1.1029e8
Lancaster	1984	36086200	43967300	26583600	4.8186e8	1.1982e8
Lancaster	1985	37022300	47176696	26303800	5.1136e8	1.2819e8
Loudoun	1981	3.8750e8	2.4587e8	4.1815e8	2.5348e9	1.1568e9
Loudoun	1982	3.8241e8	2.4922e8	4.1272e8	2.6887e9	1.1949e9
Loudoun	1983	3.9063e8	2.5203e8	4.0536e8	2.8120e9	1.2229e9
Loudoun	1984	4.5430e8	2.8485e8	4.2039e8	3.0617e9	1.2855e9
Loudoun	1985	5.6218e8	2.9267e8	4.2275e8	3.5108e9	1.4821e9
Nelson	1981	16835060	61510250	85092922	3.8896e8	1.8509e8
Nelson	1982	17481170	61917020	86545872	4.0930e8	1.8987e8
Nelson	1983	18105040	62742000	86891322	4.4542e8	1.9851e8
Nelson	1984	18574430	63518960	85209022	4.8370e8	2.0680e8
Nelson	1985	17003070	63932280	86913222	5.3053e8	2.1437e8
Orange	1981	46058600	57058800	1.0795e8	5.3694e8	2.5614e8
Orange	1982	51385450	70369600	1.3868e8	5.5637e8	2.6548e8
Orange	1983	51125900	71169100	1.3887e8	5.8671e8	2.7724e8
Orange	1984	52111600	71897200	1.3714e8	6.0969e8	2.8385e8
Orange	1985	51232500	72833000	1.3316e8	6.7414e8	3.0477e8
Patrick	1981	24029330	62431480	27219373	3.9442e8	2.0483e8
Patrick	1982	26987720	59801522	28452100	3.8380e8	1.9699e8
Patrick	1983	26767920	60223260	28190440	3.7485e8	1.9038e8
Patrick	1984	26606080	60685020	28180290	4.2582e8	2.1265e8
Patrick	1985	36348410	96986910	37570820	4.0478e8	1.9827e8
Prince ge	1981	16205700	42892960	76363520	3.5957e8	1.5678e8
Prince ge	1982	17839850	45345610	78448600	3.8047e8	1.5132e8
Prince ge	1983	17997550	52557910	77612900	4.1690e8	1.6704e8
Prince ge	1985	27586950	44214760	77438300	4.4981e8	1.7095e8
Prince Ge	1984	19847350	52079510	77210200	4.1925e8	1.6335e8
Prince Wi	1981	2.5478e8	78234600	73051100	3.9085e9	4.8689e8
Prince Wi	1982	2.5478e8	78234600	73051100	4.1083e9	4.5371e8
Prince Wi	1983	2.8700e8	1.0085e8	92759100	4.3370e9	5.3342e8
Prince Wi	1984	3.3991e8	89088600	70786300	4.6799e9	5.4862e8
Prince Wi	1985	3.8999e8	1.0312e8	79477300	5.1828e9	6.1835e8
Pulaski	1981	99668760	32127110	43720310	5.9428e8	2.0576e8
Pulaski	1982	1.0303e8	31960920	43505760	6.5472e8	2.2623e8
Pulaski	1983	1.0792e8	31165850	43108720	6.7868e8	2.3539e8
Pulaski	1984	1.1221e8	31255870	42949910	6.9247e8	2.4147e8
Pulaski	1985	1.1597e8	31369180	42517910	7.4104e8	2.5831e8

County	Year	ACV	AAG1	AAG2	FMVR	FMVCA
Rappahann	1981	570380	3184280	3461440	2.8573e8	1.7181e8
Rappahann	1982	8208150	73113190	77847999	2.9286e8	1.8837e8
Rappahann	1983	7812450	73460710	76367300	2.8933e8	1.8437e8
Rappahann	1984	7905850	74848850	75977750	3.1030e8	1.9669e8
Rappahann	1985	8236200	77260900	74660870	3.2401e8	2.0402e8
Roanoke	1981	1.9219e8	51512000	21779400	1.6209e9	2.9964e8
Roanoke	1982	1.7165e8	51304200	21517650	1.6720e9	2.7876e8
Roanoke	1983	1.8009e8	51511800	20900350	1.7412e9	2.9463e8
Roanoke	1984	2.0773e8	51528450	20530600	1.8622e9	3.3669e8
Roanoke	1985	2.6965e8	56438700	22976700	2.0119e9	3.7859e8
Rockingha	1981	1.3773e8	2.1020e8	1.4450e8	1.5094e9	7.2310e8
Rockingha	1982	1.7804e8	2.8023e8	1.9504e8	1.5181e9	6.9948e8
Rockingha	1983	88992770	2.7459e8	2.0073e8	1.4131e9	6.3406e8
Rockingha	1984	90290070	2.7671e8	1.9150e8	1.4126e9	6.1712e8
Rockingha	1985	95743740	2.8290e8	1.8037e8	1.4791e9	6.3453e8
Spotsylva	1981	1.0834e8	73195455	1.1027e8	9.7070e8	3.9063e8
Spotsylva	1982	1.4119e8	97537500	1.6082e8	1.0827e9	4.3194e8
Spotsylva	1983	1.4793e8	96998300	1.5964e8	1.1656e9	4.5356e8
Spotsylva	1984	1.2023e8	95539700	1.5301e8	1.1759e9	4.3031e8
Spotsylva	1985	1.2684e8	1.0175e8	1.5197e8	1.3027e9	4.6410e8
Stafford	1981	98009455	77128955	61939080	1.0431e9	3.0201e8
Stafford	1982	1.0254e8	78457055	70926770	1.1210e9	3.3018e8
Stafford	1983	1.1813e8	96009100	71532700	1.1336e9	3.0358e8
Stafford	1984	1.2280e8	94595800	70366300	1.2136e9	3.1657e8
Stafford	1985	1.2730e8	94490000	69454800	1.2858e9	3.2872e8
Sussex	1981	138880	67840	181580	2.9988e8	663760.7
Sussex	1982	15195320	37085220	1.3114e8	3.1003e8	2.2451e8
Sussex	1983	15254280	36586230	1.2789e8	3.0211e8	2.1628e8
Sussex	1984	15465970	36555050	1.2433e8	3.3351e8	2.3639e8
Sussex	1985	16076320	36314040	1.2209e8	3.2285e8	2.2659e8
Warren	1981	13438806	28297484	37797484	5.4463e8	1.0276e8
Warren	1982	64223406	30086297	38849320	5.6623e8	1.7567e8
Warren	1983	64988466	30082697	37690964	5.8689e8	1.8014e8
Warren	1984	66819730	32089457	36496064	6.1017e8	1.8806e8
Warren	1985	85626000	42837200	50227600	6.6925e8	2.0851e8
wise	1981	1.8666e8	54891280	45524520	7.4446e8	3.2772e8
wise	1982	2.2019e8	37108200	19517260	7.5308e8	3.2300e8
wise	1983	2.3342e8	36372430	16843800	7.6450e8	3.3099e8
wise	1984	2.3742e8	37612230	16960500	7.7954e8	3.3756e8
wise	1985	3.1535e8	33057000	5992100	8.4342e8	3.8149e8
York	1981	1.0397e8	13532845	24187522	8.1611e8	2.0012e8
York	1982	1.0808e8	13063645	26167619	8.9636e8	2.1857e8
York	1983	1.3045e8	19914175	32073100	9.6074e8	2.1413e8
York	1984	1.4071e8	18833875	23850600	1.0615e9	2.3068e8
York	1985	1.4839e8	18116500	30818500	1.1720e9	2.6032e8

The two page vita has been removed from the scanned document. Page 1 of 2

The two page vita has been removed from the scanned document. Page 2 of 2