# Segregated schools, investment in education, and property values in Maryland school districts: 1924-1955 

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Segregated schools, investment in education, and property values in Maryland school districts: 1924-1955

TenHoeve, Thomas, III, Ph.D.
Iowa State University, 1992

# Segregated schools, investment in education, and property values in Maryland school districts: 1924-1955 

by<br>Thomas TenHoeve, III<br>A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of the Requirements for the Degree of DOCTOR OF PHILOSOPHY Department: Economics

## Approved:

Signature was redacted for privacy.
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## I. GENERAL INTRODUCTION


#### Abstract

A. Purpose

The purpose of this dissertation is to investigate causal factors inducing investment in education, specifically investment in Maryland grade schools during the segregated schooling era. The period covered will be from 1924 through 1955. Many theoretical models have been developed which describe the educational investment process. Each presents causal relationships among variables. The goal of this dissertation is to derive a method to empirically test the validity of the relationships among variables as set forth in the theoretical models using the Maryland school district data, and to develop new theoretical models which help to explain the empirical results.

\section*{B. The Dissertation Layout}

Chapter II will discuss in detail the models of educational investment as presented in the literature. The chapter consists of three parts: an introduction, an in-depth literature review, and a section which summarizes the theoretical presentation of the models and presents the expected causal relationships among variables in each of the models. Chapter II builds a case for the use of the empirical approach taken in chapter III.

Chapter III delves into the vector-autoregressive approach to the investigation of the causal relationships among variables relating to the public school choice. This chapter is made up of five sections: an introduction, a presentation of the theoretical model of causality, a


[^0]To conclude the investigation, chapter VI incorporates the idea of a taste for discrimination into a more "traditional" static model. Twostage least squares regression analysis is employed to the static model. The chapter consists of five sections: an introduction, the presentation of the model, a description of the data used in the empirical analysis, the empirical findings, and a conclusion.

General conclusions from chapter III through VI are presented in chapter VII. This chapter also describes limitations to the research and future directions the research might take. Following chapter VII are the Bibliography, the Acknowledgements, and the Appendix.

## II. EDUCATIONAL INVESTMENI: MODELS FROM TRE IITERATURE

## A. Introduction

When considering the investment in educational services, there are five models economists have explored. These include the human capital investment model, the voter behavior or public choice model, the quantity/quality (fertility behavior) model, the model of Tiebout migration, and the capitalization model. The goal of these models is to explain how and why local governments or households invest in education and to pinpoint the factors affecting their decisions.

Before delving into a specific empirical example of the investment in education, it is necessary to review the relevant literature dealing with these different approaches. The next gection will cover this review. The goal of such a review is to better understand each approach and the structural differences which distinguish them. Following the literature review is a section which specifies the theoretical models and summarizes the predictions of each of these.

## B. Literature Review

## 1. Human capital investment model

The first approach is that of investment in human capital. Human capital is a concept which dates back to Adam Smith. The concept was reintroduced into the literature by Schultz [1960] and Becker [1962] and subsequently discussed in many other articles and texts. Schultz [1960] views humans as inputs in the production process and that any additional knowledge or skill gained by humans has a positive effect on labor
productivity. Early empirical tests of the investment model were usually stated in terms of rates of return or lifetime earnings. Internal rates of return were computed using measures of earnings at different educational levels, years of experience, and costs of schooling. Both Schultz and Becker have taken this approach by addressing investment in human capital in terms of social and private rates of return. Since the original studies, additional work has expanded the measured outcomes beyond rates of return or lifetime earnings. Measures of human capital invegtment have included occupational choice and fertility choice. Additionally, the inputs into human capital production were expanded to incorporate parental inputs (e.g., family income or some measure of wealth, parental educational background, and measures of school quality). Edwards [1975] derived a model for school enrollment rates. Her model includes the enrollment rate as a function of median income, educational attainment (adults), the unemployment rate (18-year olds), expenditure per pupil, the proportion of the population living in rural areas, the proportion of blacks, and a compulsory school dummy. The empirical results for combined races showed that school expenditures had a positive and significant effect on enrollment, implying that an increase in school quality would cause an increase in human capital investment. Edwards also reported positive signs on median income and male (father's) educational achievement coefficients. The coefficient on the educational attainment of females (mother) was found to be negative.

The findings for blacks, when run separately, were markedly different from the combined sample. The coefficient on the educational attainment
of females was found to be positive, while that of males had mixed signs. Median income had a negative impact on enrollment rates. However, as with the combined sample, expenditures exhibited a positive coefficient, but the coefficient was not significantly different from zero. Edwards noted that her model for nonwhites produced poor adjusted $R^{2}$ values and that the conclusions drawn from this particular analysis should therefore be considered very tentative.

Orazem [1983] developed a model of human capital investment using attendance as a measure of the intensity of investment in human capital. In a static setting, attendance was regressed on teacher experience, length of school term, value of school equipment and property per pupil, student/teacher ratio, a proxy for the opportunity cost of schooling, and a measure of average property value.

Empirical results for whites and blacks showed that the coefficient on the opportunity cost of education had a negative sign, while property value had a positive sign. For whites, the coefficient on property value was significant, while that on opportunity cost was not. The significance was reversed for blacks. Quality of education, in the form of teacher experience, had a positive effect on attendance for both blacks and whites. The coefficient on the length of the school term was negative for whites and positive for blacks. Also, the student/teacher ratio was found to significantly lower attendance for blacks, but increase it for whites.

Gustman and Pidot [1973] investigated the aimultaneity of the enrollment and expenditure decisions. They concluded that the simultaneous interaction of these two decisions is critical. An increase in expenditures per pupil leads to an increase in enrollments in their


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model. They also concluded that lower expenditures per pupil are predicted when enrollments rise. Increased expenditures caused by an increase in enrollments would be a human capital notion. However, the inverse effect of enrollments on expenditures would represent a public choice or voter behavior notion, which will be considered next. In a recent journal article, Card and Krueger [1992] modeled the effect of school quality on the rate of return to education. Their sample included males born between 1920 and 1949 in all states (except Alaska and Hawaii) and the District of Columbia. They considered quality variables such as pupil/teacher ratio, term length, teacher wage, education of parents, per capita income of parents, the percentage of male teachers, teachers' years of education, teachers' years of experience, high school grads in cohort, college grads in cohort, and the percentage enrolled in private schools. They categorized these school quality variables into the following groups: family background, teacher quality, educational attainment, and private schools. They found that pupil/teacher ratio and teacher wage had the anticipated signs and were significant. All of the remaining quality variables were found to be insignificant.


## 2. Voter behavior or public choice model

A second model of educational investment is the voter behavior model. "While economic interests play an important role in shaping the underlying demand for these services, the institutional structure of political decision-making may have significant effects on the way this demand is expressed." [Romer and Rosenthal, 1982, p. 556]

The median-voter hypothesis was first introduced by Hoteliing [1929]. The premise of this model is that communities are heterogeneous with regard to incomes, prices, and preferences and that the demand for locally-provided public services depends on the demand of the median voter.
"The standard median-voter theory applied to educational expenditures predicts that a given locality's educational expenditures per student correspond to the 'most-preferred' expenditure of the voter with the median ideal point." [Romer and Rosenthal, 1982, pp. 559-560] The model specified by Romer and Rosenthal expresses the most preferred expenditure as a function of median income, tax price (the ratio of median housing value to total assessed value of real estate times average daily membership (an enroliment meagure)), and the number of students in the median household. Their empirical results indicate a positive coefficient on income and negative coefficients on family size and tax price.

Similar results were reported by Gramlich and Rubinfeld [1982] when they modelled demand for per capita public expenditures. Their model included median income, median tax price (ratio of median residential value to total value), public wage (starting salary for teachers), population, and grants. Using macro data for 83 Michigan counties, positive coefficients were obtained for the income and population variables, while public wage and tax price exhibited negative coefficients.

To determine educational expenditures, McMahon [1970], considered a model of zero excess demand. To formulate his model, he assumed three choices: the demand for educational services, the costs of education
services, and the local tax behavior. The joint solution of these three equations results in a function for educational expenditures in reduced form. In the model, demand (expressed in terms of educational expenditures) is a function of school age children as a percent of the population, children not attending, the density of the community, and disposable personal income. Average salaries of teachers, the student/teacher ratio, and density are factors in the cost equation. Local revenues generated by assessed value of property are related to the desired educational expenditures and state and federal aid.

McMahon estimates his reduced-form expenditure model using both cross-sectional and time-series data. In the cross-sectional regressions, expenditures were found to be positively affected by the proportion of children in the population, the number of pupils in the school district, state aid, and personal income. The proportion of children not attending, the student/teacher ratio, federal aid, the density of the population, the assessed property value, and the proportion of nonwhites in the population all exerted a negative influence on expenditures. For the time-geries regression, the proportion of children, the student/teacher ratio, the number of pupils in the school district, the assessed property value, federal and state aid, and unemployment all had positive coefficients. Only the proportion of children not attending and teachers' salaries exhibited negative coefficients.

McMahon concluded that the major determinants for the cross-sectional data are the proportion of children in the population, the proportion of children not attending, and personal income. The major determinants for
the time-series data include those of the cross-sectional data as well as the student/teacher ratio and state aid.

Ladd [1975] also modeled educational expenditures in the context of a median-voter model. Her model uses expenditures per pupil as a function of median family income, residential property value per pupil, the proportion of the assessed property tax base that is residential, state aid measures, the proportion of children in public and private schools, the proportion of the population below the poverty level, and the proportion of the population holding professional or technical jobs. She estimated her model using ordinary least squares on a sample of 78 Boston communities. Income, the value of residential property per pupil, state block grants, the proportion of children in public schools, the proportion of the population below the poverty levels, and the proportion of the population holding technical or professional jobs all had a positive effect on per pupil expenditures. Negative coefficients were found on the residential portion of the tax base (tax price), and the proportion of children in private schools.

An interesting model of educational expenditures developed by Megdal [1983] demonstrates that no matter what type of agenda control exists in a community, a median-voter result will hold true. Her model consists of . median family income, residential value, tax price, grant variables, the proportion of the population below the poverty level, and the percentage increase in enrollment from the previous year. Like Ladd, Megdal's ordinary least squares empirical results for New Jersey communities found positive coefficients on residential value, median income, and the proportion of the population below the poverty level. Likewise, both


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studies agree on the inverge relationship between the tax price and educational expenditures. One additional finding of the Megdal study was that educational expenditures seem to be inversely related to increases in enrollments.


## 3. Quantity/quality model

At about the same time as his work on human capital, Becker introduced another model which draws on both human capital theory and household production theory. This model is known as the quantity/quality model. Here the demand for educational services is an outcome of parental utility maximizing behavior in which utility from children depends upon the number of children (quantity) and the quality per child. In this case, the quality per child typically refers to the extent of educational investment (such as educational expenditures) or the total number of years of education per child. Becker hypothesized that there is an important inverse relationship between quantity and quality per child.

The idea was incorporated into a household decision-making model presented by Becker and Lewis [1973] and Becker [1981]. In their model, the demand for children (quantity) and the quality of children are functions of the shadow price of the number of children, the shadow price of the quality, the prices of other goods, and income. quantity and quality are inversely related in the demand functions. The shadow price of quality depends on the number of children in that an increase in the number of children raises the shadow price of quality which, in turn, causes a decrease in the demand for quality. Also, the shadow price of the number of children is a function of quality. So, an increase in
quality increases the shadow price of the number of children: and hence, results in a decrease in the demand for children.

Although not very empirical in nature, Tan and Haines' [1984] investigation of fertility and education concluded that in developed countries there is a tradeoff between quantity and quality of children. They based their conclusion on historical evidence. Using enrollment rates as a measure of educational participation, Tan and Haines tracked the historical relationship between fertility and enrollment rates for five developed countries.

For the United States, the historical results back the inverse relationship predicted by the Becker/Lewis model. If enrollments serve as the quality variable and birth rates as the quantity variable, an increase in enrollments (quality) would increase the shadow price of quantity, and hence decrease the demand for quantity (birth rate). Likewise, an increase in the birth rate (quantity) would cause the shadow price of quality to rise and decrease enrollments (quality).

Similar results were reported by Anker [1978] in his empirical work relating birth rates to enrollments. Anker's approach was to use twostage least squares with cross-national data of developing countries. He hypothesized the birth rate to be a function of parental education, employment level of females, school enrollment, life expectancy, and the proportion of the population employed in agriculture. Enrollment rates were defined to be functions of income, birth rates, parental education, and the proportion of the population employed in agriculture.

All signs confirmed the a priori expectations. Enrollments and employment levels of females negatively affected birth rates, while


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illiteracy, the proportion of the population employed in agriculture, and life expectancy all had a positive influence. Birth rates, the proportion employed in agriculture, and illiteracy all had a negative impact on enroliments. Income had a positive effect.

A more recent study by Hanushek [1992] also investigated the tradeoffs between the number of children in a given family and their quality (scholastic performance). He assumed that a student's level of achievement at any point in time is a function of three sets of inputs. These sets include family, schools, and other exogenous factors. To test his assumptions, Hanushek used value-added models estimated in log-log form. The log-log form was used to easily measure elasticities. The achievement measures used were raw scores from the Iowa reading comprehension test and the Iowa vocabulary test. The empirical results showed that both achievement measures would decrease if more children were added to a family. Also found (from family inputs) to significantly affect achievement was parental income. Whether a mother works or not and whether or not a particular family unit has a father were found to have no significant impact on achievement. Significant from school inputs was teacher experience.


## 4. Tiebout migration model

Investment in educational services has also been viewed from the Tiebout point of view. The hypothesis set forth by Tiebout [1956] is that consumer-voters will migrate to communities best fitting their local public good preferences. He claimed that there is a difference in the way public goods are provided at the local level relative to the central
level. Central government will take the consumer-voters' preferences as a given and adjust the provision of public services to meet such preferences. Local governments basically have the level of public services set and are unable to deviate from that level. Hence, consumers seek out preferred communities or consumers are said to "vote with their feet."

Richard Cebula has done extensive empirical research on migration and the provision of local public services. He is one of few who has specifically addressed the relationship between educational expenditures and migration. [Cebula, 1977] He surmised that since educational expenditures tend to be the largest component of a local government's budget, local commitment to education might have a Tiebout-like effect and cause migration. He also felt that if the quality of education or household demand for education influenced the location of a household, it would also be of concern once a location was selected and a median-voter type effect might occur. In other words, he believed there was a possibility of reverse causality.

To investigate this possibility, Cebula developed a two-equation system. The model for in-migration consists of growth in public education spending per full-time student, per capita income, the unemployment rate, number of days with a temperature below 32 degrees, and per capita property tax level. The model for the growth rate of educational spending uses in-migration, the growth rate of per capita personal income, growth of federal education funding (per full-time student), and the inflation rate.


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To correct for simultaneity between in-migration and the growth in educational expenditures, the two-equation system was estimated using twostage least squares. It was found that the growth rate of educational expenditures and per capita income exhibited positive coefficients in the in-migration equation. Unemployment, number of days below 32 degrees, and property tax level, however, were found to have negative coefficients. All coefficients in the expenditure growth model were found to be positive.

The results indicate that in-migration and educational expenditures are highly interdependent. This backs Cebula's notion that causality could be in both directions. The results offer support for the Tiebout hypothesis, but they also add a new twist in that, "...in the case of public education, there is actually a dynamic process wherein the consumer-voter acts further to influence local government policies in this new community of residence." [Cebula, 1977, p. 120] So the Tiebout hypothesis may be relevant in getting people to a particular community, but once there, a median-voter mechanism can take effect.


## 5. Capitalization model

The empirical Tiebout literature has concentrated more on tax and expenditure capitalization than on migration. Oates [1969] was one of the first to address the potential effects of property taxes and public spending on property values. He felt that
if consumers, in their choice of locality of residence, do consider the available program of public services, we would expect to find that other things being equal (including tax rates), gross rents (actual or imputed) and therefore property values would be

> higher in a community the more attractive its package of public goods. In contrast, if local expenditure programs have no impact at all on locational decisions, we would not expect local property values to depend on spending variables... [Oates, 1969, p. 959 ]

Oates' empirical model consiats of the median home value as the dependent variable with tax rate, expenditures per pupil, a distance measure, median number of rooms per house, the percent of houses built since 1950, median income, and percent of families with income less than \$3,000 serving as explanatory variables. While tax rates and distance were found to have negative coefficients, expenditures and the remaining variables exhibited positive coefficients.

The size of the coefficients suggests that, for an increase in property taxes unaccompanied by an increase in the output of local public services, the bulk of the rise in taxes will be capitalized in the form of reduced property values. On the other hand, if a community increases its tax rates and employs the receipts to improve its school system, the coefficients indicate that the increased benefits from the expenditure side of the budget will roughly offset (or perhaps even more than offset) the depressive effect of the higher tax rates on local property values. [Oates, 1969, p. 968]

In this light, Oates concluded that his results backed the Tiebout model. With offaetting effects, the property tax is a pure benefits tax because it gerves as a user charge for services. Also, because property values were affected by expenditures, Oates concluded that consumers do tend to shop around for communities that reflect their preferences for public services. Consumers do seem to be willing to pay higher prices for housing in communities which offer higher-quality local public services.

Edel and Sclar [1974] claimed that Oates' study was one of disequilibrium, so they extended the approach taken by Oates by
considering supply adjustment. They felt that supply had not adjusted to long-run equilibrium in his model, because capitalization would have been zero if adjustment to competitive equilibrium had occurred. "Taxes cover costs simply, and there is neither a net increment in land values from the presence of the service nor a decrease from the presence of the tax."
[Edel and Sclar, 1974, p. 946-947]
The empirical results of Edel and Sclar show that the tax rate is negatively capitalized into property values, while school expenditures tend to be positively capitalized. To have a true Tiebout equilibrium, the coefficients on variables such as tax rates and expenditures should, over time, tend towards zero. They found this to be true with regard to educational spending, but not with some public services.

Hamilton [1976] also addressed disequilibrium as the reason for Oates' capitalization results. He claimed that any correlation between property values and expenditure levels could only be due to short supply. In equilibrium, no correlation should exist and expenditures and taxes should not be capitalized into property values.

Edel, Sclar, and Hamilton conclude the following:
If the property tax is a benefit tax that is equivalent to a head tax, and all households receive their preferred level of public services, then there is no advantage to residing in a high-expenditure, low-tax jurisdiction -- residents pay for what they get. Thus, variations in demand should not be a determinant of property value differences across communities, any more than the variations in expenditures on private goods across communities should affect property values. ...The capitalization of fiscal variables is an indication of disequilibrium -- that is, certain types of communities are in oversupply or undersupply in the metropolitan area relative to long-run equilibrium. [Mieszkowski and Zodrow, 1989, p. 1127]

An alternative to the property tax being viewed as a benefit tax is what is called the "new view." This "new view" is that property taxes are distortionary and redistributive taxes on capital and the burden of these taxes falls on the owners of capital. In this view, the effect of an increase in the property tax is to reduce the rate of return on capital. This view also concludes that the tax on capital is independent of any benefits received.

Brueckner [1979] abandons the Tiebout hypothesis in his study of capitalization. He employs a bid-rent model to test for the efficiency of the level of public services provided. He assumes that communities are heterogeneous and that property taxes have a distortionary effect (new view) on housing consumption. The sign on the expenditure coefficient determines the efficiency in his model. If increased expenditures do not affect property values, then the provision of public services is efficient. If, however, an increase in the expenditure level causes an increase in property values, then public services are less than the efficient level. Likewise, a negative sign on the expenditure variable would indicate overprovision.

Using cross-sectional data of residents in northeast New Jersey in 1960 who typically commuted to work in New York City, Brueckner modeled the median value of housing. He regressed the median value of housing on the consumption level of housing, median income, community expenditures on public goods, business profits, community population, commuting distance, and proxies for the percentage of older dwellings in a community and the percentage of those consumers below a certain income level. Brueckner's two-stage least squares results found positive and significant
coefficients on size of house, median income level, and business profits. Educational expenditures, commuting distance, and the percentage of older homes in the community all had a significant negative impact on the value of housing. From these empirical results, Brueckner concluded that the negative coefficient on public goods implied that there was overprovision in the communities in the sample. Further, a reduction in the level of public good provision would cause an increase in property values.

When the empirical capitalization literature is searched for a definitive answer to differentiate between the new view and the benefit view, no conclusion is reached. Both views imply that some degree of capitalization will occur. So establishing that capitalization exists is not proof as to whether the benefit view or the new view of a property tax is more correct.

Mieszkowski and zodrow [1989] suggest that one empirical test might be performed to distinguish between the two views. The test would be to determine whether the capitalization resulting from an increase in the property tax decreases land values or leaves them unchanged.

Under the benefit view, such increases would result in capitalization of the associated fiscal differentials; however, ... a central tenet of the benefit view is that such increases should not change the aggregate value of land in the community. In contrast, under the new view, the capital out-migration induced by an increase in the property tax should result in lower land values in the community. [Mieszkowski and zodrow, 1989, p. 1131]

## C. Summary and Implications of the Models

Although the models investigated in the literature all deal with the provision of educational services, each type of model has structural
differences from the next. Each is somewhat different in its objective function, its constraints, the endogenous variables, and the optimizing agent. This section will present a simple theoretical version of each model to better summarize the distinctions between the models. Each theoretical model simplifies to a derived demand for or supply of educational services. This section will also summarize the variables which seem to be used the most in each of the models and the expected relationships between the variables of interest.

## 1. Human capital investment model

In a human capital investment model it is the parents who are the maximizers of the objective function subject to the family's budget constraint. The objective function would be the utility of the family as a function of the quality of the child, other goods consumed, adult time spent in leisure, and other parameters. The quality of the child is a function of the quantity of schooling they receive and a function of exogenous factors affecting the quality of schooling. The constrained maximization model would be set up with an objective function (equation 2.1) and a budget constraint (equation 2.2).

```
U = f(Q(E, (XQ), XO,T
wT + I = P PE E + P PO
```

where:

```
Q = quality of the child
E = quantity of schooling received
XQ = exogenous factors affecting school quality
XO}= all other good
T
```

```
Z = a vector of other parameters
w = wage rate
T = total time
I = nonlabor family income
PE = price of education
po = price of all other goods
```

This model would lead to a derived demand for education (equation 2.3) that would be a function of nonlabor income, the price of education, school quality, the price of all other goods, the wage rate (the price of time), and a vector of other parameters including tastes and preferences.

$$
\begin{equation*}
E=f\left(I, P_{E}, X_{Q}, P_{O}, W ; Z\right) \tag{2.3}
\end{equation*}
$$

In addition, similar reduced-form specifications can be derived for $X_{O}$ and $\mathrm{T}_{\mathrm{L}}$.

Given that the derived for education function looks like this for the human capital investment model, it predicts that enrollments or attendance (measures of intensity of investment in education) are influenced by variables such as income (or other measures of wealth) and educational expenditures (or other measures of quality). If one is to invest in human capital, the goal is to experience a good rate of return on the investment. To do so, one must take advantage of an increase in educational expenditures, if this increase is perceived as an increase in quality, by increasing enrollments. Increases in income would also be predicted to have a positive influence on enrollments. These anticipated signs (from both theory and the empirical work discussed) are summarized in column one of Table 2.1 found at the end of this chapter.

## 2. Voter behavior or public choice model

Consumers are assumed to vote according to their preferences and independently of each other in a voter behavior or public choice type of model. Each consumer-voter has a utility function which depends on the level of private consumption and the level of a publicly-provided good (education). The consumer-voter maximizes the utility function (equation 2.4) subject to a budget constraint (equation 2.5). The demand function which results from this constrained maximization will reflect the consumer-voter's preferences for the publicly-provided goods. The following is a typical model of voter behavior where a median-voter assumption is made and the publicly-provided good is education.

```
U = U(X,E,n;Z)
\[
\begin{equation*}
Y_{m}=P_{X} X n+t W_{m} \tag{2.4}
\end{equation*}
\]
Ym}=\mp@subsup{P}{X}{}Xn+t\mp@subsup{W}{m}{
where: \(X=\) per-capita amount of private consumption \(E=\) expenditure on education \(n=\) the number of persons in the household \(\mathbf{Z}=\mathbf{a}\) vector of other parameters \(\mathrm{Ym}=\) income of median voter \(P_{X}=\) price of private consumption \(t=\) community tax rate \(W_{m}=\) locally taxable holdings of the median voter
```

The resulting derived demand for education (equation 2.6) is a function of the income of the median voter, the price of private consumption, the tax rate (the price of education), size of the household, and a vector of parameters including tastes and preferences.

$$
\begin{equation*}
E=f\left(Y_{m}, P_{X}, t, n ; Z\right) \tag{2.6}
\end{equation*}
$$


#### Abstract

The demand for education would be expressed in terms of the level of educational expenditures selected by the consumer-voters.

The voter behavior or public choice model would predict that income, property values, and population (birth rate or the number enrolled) would positively influence the level of educational expenditures in a given community. Tax price would be found to be a negative factor in the expenditure decision. These conclusions, based both on theory and previous empirical results, are summarized in column two of Table 2.1 found at the end of this chapter.


## 3. Quantity/quality model

The basis for the quantity/quality model is that when consumers maximize their utility, quantity and quality both exert a positive influence on utility. However, they appear to be substitutes in the utility function. A simple utility function relating the quantity and the quality of children is the form the objective function takes in the quantity/quality model. The objective function would further include consumption of all other goods. The household would maximize the objective function (equation 2.7) subject to the household budget constraint (equation 2.8). The model can be summarized as follows.
$U=U(n, q, X ; Z)$
$\mathrm{Y}=\mathrm{P}_{\mathrm{nq}} \mathrm{nq}+\mathrm{P}_{\mathrm{X}} \mathrm{X}$
where:

| $n=$ the number of children | $Y=$ household income |  |
| :--- | :--- | :--- |
| $q=$ the quality per child | $P_{n q}=$ price of child services |  |
| $X=$ all other goods | $P_{X}=$ price of all other goods |  |
| $Z$ | $=$ a vector of other parameters |  |

From this constrained maximization, the derived demand for quality (equation 2.9) is a function of income, the price of all other goods, the price of child services, and a vector of all other parameters which includes tastes and preferences. A similar derived demand for quantity results as well.
$q=f\left(Y, P_{X}, P_{n q} ; Z\right)$

The variables of importance in the quantity/quality models seem to be enroliments or expenditure levels (measures of intensity of investment in quality), birth rates, and income. If enrollments or expenditure levels are viewed as quality variables, then they should demonstrate inverse relationships with birth rates, the quantity variable. Other socioeconomic variables such as income, education of parents, and the employment of females may also exert an influence. Such results are summarized in Table 2.1 at the end of this chapter.

## 4. Tiebout model

Tiebout theory predicts that consumers-voters, when they maximize utility, migrate to communities offering the local public services they desire. In other words, they tend to separate themselves in or migrate to communities of like consumers. Each consumer-voter maximizes a utility function (equation 2.10) consisting of publicly-provided goods, housing, and all other goods. Consumer's are taxed by the local government to provide the publicly-provided goods they desire. This fact is taken into account in the individual consumer-voter's budget constraint (equation
2.11). The model also incorporates the local government's constraint for the provision of these publicly-provided goods (equation 2.12). A typical Tiebout model would be as follows.
$U=U(E, H, X ; Z)$
$Y=P_{H} H(1+t)+P_{X} X$ (individual)
$t N P_{H} H=N P_{E} E$ (government)

```
where: E = quantity of publicly-provided education (number enrolled)
    H = quantity of housing
    X = all other goods
    Z = a vector of other parameters
    Y = household income
    P}\mp@subsup{\textrm{H}}{}{\prime}=\mathrm{ price of housing
    P
    P}\mp@subsup{P}{E}{}=\mathrm{ price of education per child (expenditure per enrolled
        child)
        t = tax rate
        N = community population (number of households)
```

Each consumer-voter's individual vote is determined through the maximization of the above model with respect to the consumer's choice variables: E,H, and $X$. If the first-order conditions were solved from this constrained optimization, the derived demand functions for both publicly-provided educational services and housing (equations 2.13 and 2.14) would be functions of income, the price of housing, the price of the publicly-provided goods (the expenditure level per pupil enrolled), the local tax rate, and a vector of other parameters such as tastes and preferences.
$E=f\left(Y, P_{H}, P_{X}, P_{E}, t ; Z\right)$
$H=f\left(Y, P_{H}, P_{X}, P_{E}, t ; Z\right)$

Tiebout models of migration and provision of educational services would predict that the quantity of educational services demanded measured in terms of a variable such as enrollments (a measure of in-migration) would be positively influenced by educational expenditures or the cost of education per child enrolled, income, and negatively influenced by tax prices. These predictions are summarized in Table 2.1 found at the end of this chapter.

## 5. Capitalization model

Since the capitalization model assumes that a community's capital stock is or is not affected by the expenditure level of services provided to households within the community, the value of the community's capital must be the objective function. Consumers maximize their utility and select their optional level of nonpublic goods given the level of housing services, the level of public good expenditures, and their income. Local government would want to maximize the present value of the capital in its community (both household and business) subject to tax revenues raised from taxing the capital stock. The model would look much like Brueckner's [1979] bid-rent model.

$$
\begin{align*}
& V=(Y-X(H, E, Y)) /(\theta+t)=f(H, E, t, Y)  \tag{2.15}\\
& t \Sigma f\left(H_{i}, E, t, Y\right)+t \pi /(\theta+t)=C(E, n) \tag{2.16}
\end{align*}
$$

where:

```
V = present value of a house
Y = household income
X = numeraire private good
H = housing services
E = educational expenditure per household
0=1/\omega,\omega is the constant of proportionality
```

```
t = tax rate
\pi= aggregate business profit gross of rent
C = cost function for education
n = number of households
```

From equation 2.16 a function for the property tax rate can be derived (equation 2.17).
$t=f(H, E, Y, n, \pi)$

This equation gives the tax rates which would allow for the provision of educational services at the level $E$, given the value of the remainder of the variables. Going one step further, if equations 2.15 and 2.16 are combined, equation 2.18 results.
$V_{i}=f\left(H_{i}, E, t(H, E, Y, n, \pi), Y\right)$

Equation 2.18 can then be used to determine how a change in any one variable will affect the property value when the community maintains a balanced budget. From this model it can be concluded that a change in either gross business profits or housing services would cause property values to change in the same direction. Increasing the tax rate would cause property values to fall. A change in income or a change in educational expenditures would be found to have an ambiguous effect. Tiebout theory, in the context of a capitalization model, would conclude that there should be no relationship between educational expenditures and property values. Increased educational expenditures may


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cause rises in property values, but simultaneous increase in property taxes will cause decreases in property values. With the benefit view of taxes, these changes in property values would be predicted to be offsetting. In other words, no changes in property values should be evident. This result is show in Table 2.1 found at the end of this chapter.

If, however, a capitalization model were considered in light of the new view of property taxes, the predicted relationship between expenditures and property values may not be zero and may be hard to predict. Some literature indicates that if there is a direct relationship between the two, there may be underprovision of services. Likewise, an inverse relationship would predict an overprovision. However, it is possible to conclude that an increase in property taxes alone would have a negative effect on property values. These results are summarized in Table 2.1 at the end of this chapter.


## D. Conclusions

After searching relevant literature dealing with the five different approaches that try to explain reasons why consumers invest in education or cause educational expenditures, one can conclude that each model may contribute some particular insight. However, one can also conclude that no one model, when considered alone, ever best describes the investment in educational services.

From the five models, certain variables seem to be used routinely. The human capital models tend to use enrollments or attendance. Voter behavior models concentrate their attentions on educational expenditures.

Fertility behavior models use birth rates and enrollments or expenditures. The Tiebout models employ expenditures, enrollments, and tax rates. Capitalization models focus on educational expenditures, tax rates, and property values. The Table 2.1 summarizes some of the anticipated signs of the variables in each of the models.

Many other variables have been included in educational investment models. However, educational expenditures, attendance or enrollments, birth rates, and property values seem to prevail. For this reason, these four variables will be used in the empirical work to follow in chapter III.

Table 2.1. Expected relationships between variables

III. CAUSAL RELATIONSEIPS: THE PUBLIC SCHOOL CHOICE

## A. Introduction

As outlined above, several models have been advanced to analyze investment in education. A common criticism of these models is that they do not allow for the possibility of "feedback effects." In response, several authors have used two-stage least squares in their empirical work. Although two-stage least squares may correct for feedback among any two variables, problems may still exist if more than two variables are endogenous. In addition, two-stage estimation may miss the full impact if long-run responses differ from short-run responses.

The goal of this investigation is to let the data speak for themselves with no a priori restrictions imposed by a single model. The previous discussion showed that models of educational investment have suggested certain causal relationships among variables. This investigation will test whether or not these relationships hold true.

If there are feedback effects or if reverse causality exists among variables, one way to capture these effects would be to employ a simple vector autoregressive (VAR) model to the data. The VAR model could then be used to test for Granger-Sims type causality among the variables. This model would also allow for the generation of impulse responses which would give a feel for the dynamic response of variables to changes or "shocks" in the system. Both Winegarden [1988] and Macunovich and Easterlin [1988] employed VAR in their analyses and found Granger causality beneficial in explaining economic phenomena.
B. The Theoretical Model of Causality

Granger [1969] defines causality as follows. If
$\sigma^{2}(X \mid \bar{U})<\sigma^{2}(X \mid \bar{U}-\bar{Y})$,
then $Y$ is gaid to cause $X$, because we can better predict $X$ when all information is used ( $\bar{U}$ ), rather than when all information except $Y$ is used. Granger also says that feedback exists if

$$
\begin{align*}
& \sigma^{2}(\mathrm{X} \mid \overline{\mathrm{U}})<\sigma^{2}(\mathrm{X} \mid \overline{\mathrm{U}}-\overline{\mathrm{Y}})  \tag{3.2}\\
& \sigma^{2}(\mathrm{Y} \mid \overline{\mathrm{U}})<\sigma^{2}(\mathrm{X} \mid \overline{\mathrm{U}}-\overline{\mathrm{X}}) . \tag{3.3}
\end{align*}
$$

He then defines a simple causal model based on these definitions. His model is defined for $X_{t}$ and $Y_{t}$, two stationary time series having mean zero.
$x_{t}=\sum_{j=1}^{m} a_{j} x_{t-j}+\sum_{j=1}^{m} b_{j} y_{t-j}+e_{t}$
$Y_{t}=\sum_{j=1}^{m} c_{j} x_{t-j}+\sum_{j=1}^{m} d_{j} Y_{t-j}+\mu_{t}$

In these equations, $\varepsilon_{t}$ and $\mu_{t}$ are assumed to be two uncorrelated whitenoise series. $Y_{t}$ is said to cause $X_{t}$ if $b_{j}$ is not zero. Likewise, $X_{t}$ is said to cause $Y_{t}$ if $c_{j}$ is not zero. If both $b_{j}$ and $c_{j}$ are not zero, then feedback or reverse causality is said to exist between $X_{t}$ and $Y_{t}$.

## C. The Data

## 1. General description

Maryland school district data are employed for the period 1924 to 1955, a period in which segregated schooling existed. Maryland provides a good choice for data usage since each county in the state of Maryland is a distinct school district. For most states, the differentiation between counties and school districts would be unclear. With each county being a school district, many problems are avoided in that the demographic data for any given county apply to that school district.

The data set used is a cross-sectional time series with 32 years of data for 23 white school systems and 22 black school systems. The data concentrate on elementary schools, covering grades 1 through 8. Elementary school data were chosen because parents are the primary decision makers for their children during these years and because all counties provided both black and white grade schools. During this time period some counties did not have their own high schools for black children. Due to this fact, Maryland high school enrollment and attendance figures were thought to reflect choices from more than one county and, therefore, inappropriate for this analysis.

The variables selected for use in this analysis are variables which seem to take a prominent role in the literature. These variables include real expenditures per pupil attending, average daily attendance per thousand in the population (county), birth rate per thousand in the population (county), and real assessable property per thousand in the population (county). The data (with the exception of the birth rate) were taken from the Annual Reports of the State of Maryland Board of Education.

The birth rate data were taken from an unpublished vital statistics table received from officials of the State of Maryland Board of Education. The variables are defined in Table 3.1 and sample statistics (sample means and standard deviations) are shown in Table 3.2.

## 2. Stationarity

The asymptotic properties of the VAR require that the data be stationary. So, before starting any modeling, it is important to ensure that the data are stationary. Stationarity implies that the mean and variance of a variable remain constant over time. Prior to testing, plots were made for each of the four variables being investigated for various counties. The plots showed that both real expenditures and attendance had definite trends (positive and negative respectively). The birth rate fell during the Depression and then increased during the post-war period, mimicking national trends. Real assets rose from 1924 through 1934, then fell until 1947 when they began to rise again. From visual inspection, it was decided that the data needed to be transformed before stationarity could be maintained. Autocorrelation functions for a few counties were also calculated for the relevant variables. The autocorrelation functions confirmed the need for transformations in the data.

For ease of interpretation, the data were first transformed by taking the natural log. Then, because all of the data sets showed some type of trend or cycle to them, correction for trend was incorporated. Also, to take into account any time-invariant county influence on the variables, correction was made for the county-specific means. To make these corrections, oLS regressions were run for each of the variables. The

Table 3.1. Variable definitions ${ }^{\text {a }}$

| Variable | Definition |
| :--- | :--- |
| REXPPA (REXD) | total current expenses (in real terms) per pupil <br> attending (as measured by average daily attendance) |
| ATTPTH (ATTD) | average daily attendance per thousand in the <br> population (county) |
| RPT (RPTD) | live births per thousand in the population (county) <br> ASSETPTH (ASSD)total assessment taxable at full rate (in real terms) <br> per thousand in the population (county) |

aVariable names in parentheses refer to the transformed variables.

Table 3.2. Sample statistics

| Variable | Mean | Standard deviation |
| :--- | ---: | ---: |
| White sample: |  |  |
|  |  |  |
| REXPPA | 110.79 | 34.69 |
| ATTPTH | 114.32 | 23.37 |
| RPT | 20.55 | 4.11 |
| ASSETPTH | 1440.14 | 470.41 |
|  |  |  |
| Black sample: |  |  |
|  |  |  |
| REXPPA | 82.19 | 43.58 |
| ATTPTH | 139.55 | 22.82 |
| RPT | 25.80 | 6.29 |
| ASSETPTH | 1446.12 | 477.68 |
|  |  |  |
| COMbined sample: |  |  |
|  |  |  |
| REXPPA | 126.81 | 41.81 |
| ATTPTH | 23.11 | 26.32 |
| RPT | 1443.06 | 5.91 |
| ASSETPTH |  | 473.98 |

explanatory variables in each of the regressions were a constant, year (trend), and county dummies (22 for white samples and 21 for black samples). The residuals from each of the regressions were saved to be used in the vector autoregressions because they would have constant mean and variance. These new variables were named REXD, ATTD, RPTD, and ASSD. Variable definitions are included in Table 3.1.

To ensure that the mean and variance of each of the newly created series were constant, autocorrelation functions (acf's) were calculated and plotted for these residuals. "Stationary autoregressive (AR) processes have theoretical acf'a that decay or 'damp out' toward zero." [Pankratz, p. 55] The plots confirmed that the data were now stationary the acf's died down towards zero.

## 3. The causal model

To test four variables for causality, a model with four time series was constructed much like that of Granger. The general unrestricted model is as follows:

$$
\begin{align*}
& \operatorname{REXD}_{t}=\sum_{s=1}^{\infty} a_{s} R E X D_{t-s}+\sum_{s=1}^{\infty} b_{s} A T T D_{t-s}+\sum_{s=1}^{\infty} c_{s} R P T D_{t-s}+\sum_{s=1}^{\infty} d_{s} A S S D_{t-s}+\varepsilon_{t}  \tag{3.6}\\
& A T T D_{t}=\sum_{s=1}^{\infty} e_{s} R E X D_{t-s}+\sum_{s=1}^{\infty} f_{s} A T T D_{t-s}+\sum_{s=1}^{\infty} g_{s} R P T D_{t-s}+\sum_{s=1}^{\infty} h_{s} A S S D_{t-s}+\mu_{t}  \tag{3.7}\\
& R P T D_{t}=\sum_{s=1}^{\infty} i_{s} R E X D_{t-s}+\sum_{s=1}^{\infty} j_{s} A T T D_{t-s}+\sum_{s=1}^{\infty} k_{s} R P T D_{t-s}+\sum_{s=1}^{\infty} 1_{s} A S S D_{t-s}+v_{t}  \tag{3.8}\\
& \text { ASSD }_{t}=\sum_{s=1}^{\infty} m_{s} R E X D_{t-s}+\sum_{s=1}^{\infty} n_{s} A T T D_{t-s}+\sum_{s=1}^{\infty} o_{s} R P T D_{t-s}+\sum_{s=1}^{\infty} p_{s} A S S D_{t-s}+\omega_{t} \tag{3.9}
\end{align*}
$$

or more generally,
$Y_{t}=\sum_{s=1}^{\infty} A_{s} Y_{t-s}+U_{t}$
where $Y_{t}$ is an ( $n \times 1$ ) vector, $Y_{t-s}$ is an ( $n *$ lags $x$ 1) matrix of lagged variables, $A_{s}$ is an ( $n \times n$ *lags) matrix of constants, and $U_{t}$ is an ( $n \times 1$ ) uncorrelated innovation vector. The number of endogenous variables is $n$.

If, in any of the equations, any of the sets of coefficients (other than the one on the lagged dependent variable) are significantly different from zero, then there is causality from those variables to the dependent variable. For example, if the $b_{g}$ coefficients are jointly found to be significantly different from zero, then attendance is said to cause real expenditures. Also, if both the $b_{s}$ and $e_{s}$ coefficients are significantly different from zero, it can be concluded that there is a feedback effect between real expenditures and attendance.

## 4. Laq length tests

The theoretical model involves infinite lags which are not empirically tractable, so some truncation level of the lags must be found (i.e., the order of the VAR). To determine the optimal lag length for the VAR, lag length tests were performed. A procedure suggested by Sims [1980] was followed. He used a chi-square statistic which compares a VAR of a particular order to a VAR of higher order. The former is viewed as a restricted version of the latter. The statistic generated is as follows.


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$T$ is the number of observations, $C$ is the number of variables in each unrestricted equation, $C V R$ and $C V U$ are the two covariance matrices of residuals, and $n$ is the degrees of freedom (the total number of restrictions).


Lag length tests were performed on the combined sample using consecutive lags. The results are reported in Table 3.2. Unfortunately, these results were not conclusive. They did reveal a $\chi^{2}$ of lowest value (and a marginal significance level of 0.023 ) when the 8 th lag was added. It was therefore decided that a lag length of 7 was appropriate. This determination was not based on the lag length test exclusively, but on other criteria as well. A lag length of 7 has some intuitive appeal in that most children start elementary school between the ages of 6 and 7, so the impact on the educational system of people having children would be felt 6 to 7 years after the child's birth. For most of the sample period, child labor laws allowed children to work at age fourteen so that the seven-year period also spans the bulk of the period for which parents would make schooling choices for their children.

Even though the statistical and intuitive choice for the lag length may be open to criticism, the results of the model, when run for various lag lengths, gave consistent relationships among the relevant variables. For simplicity, all results reported from this point forward are for the vector autoregressive model of order 7.

Table 3.2. Testing lag length for the vector autoregressive system ${ }^{\text {a }}$

| lage | T | T-C | $q$ | log det. CVR | $10 g$ det. CVU | $\chi^{2}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 vs. 2 | 690 | 682 | 16 | -21.8123 | -21.5725 | 163.58 |
| 2 vs. 3 | 667 | 655 | 16 | -21.9223 | -21.7525 | 111.27 |
| $3 \mathrm{vs}$. | 644 | 628 | 16 | -21.9339 | -21.8396 | 59.25 |
| 4 ve. 5 | 621 | 601 | 16 | -22.0737 | -21.8714 | 121.60 |
| 5 vs. 6 | 598 | 574 | 16 | -22.3095 | -22.1393 | 97.67 |
| 6 vs. 7 | 575 | 547 | 16 | -22.4746 | -22.2870 | 102.60 |
| 7 va. 8 | 552 | 520 | 16 | -22.4489 | -22.3929 | 29.15 |
| 8 va. 9 | 529 | 493 | 16 | -22.5759 | -22.4138 | - 79.95 |
| 9 vs. 10 | 506 | 466 | 16 | -22.6003 | -22.4964 | 48.41 |
| 10 vs. 11 | 483 | 439 | 16 | -23.1443 | -23.0132 | 57.53 |
| 11 vs. 12 | 460 | 412 | 16 | -24.0350 | -23.6348 | 164.87 |

[^1]
## D. Empirical Results

## 1. Regression procedure

Using the cross-sectional, time series data corrected for the mean, trend, and county fixed effects, the model described above was run using RATS (Regression Analysis for Time Series). This statistical package allows for easy calculation of impulse responses and variance decomposition which will be discussed later. The system of four equations can be regressed equation by equation using ordinary least squares. If all of the equations of the model have the same right-hand side variables, ordinary least squares, when applied equation by equation, provides consistent and asymptotically efficient estimates. The estimates are equivalent to Zellner's seemingly unrelated regression method. [Theil, p. 302 ]

The model was run three times: once for the white sample, once for the black sample, and once for the combined sample. Since the data used were from an era of segregation, one question to address would be whether there is any information gained by looking at the samples separately or whether there is no statistical significance between the separate samples and the combined sample. One would anticipate that there would be differences between the separate black and white samples versus looking exclusively at the combined sample. To test each variable for. significance between the separate samples versus the combined sample, F statistics were calculated. For real expenditures, attendance, and birth rates, the F-statistics ( $2.42,2.37,2.24$ respectively) were significant at the . 01 level implying that the separate samples were significantly different from the combined samples for these variables. The F-statistics
for real assets was equal to 1.15 implying that there was no statistical significance between samples. This is consistent with the fact that the real assets variable was calculated on a per capita basis, but not distinguished by race. Even though the F-statistics proved that there was information to be gained by considering separate samples, results for the separate samples as well as the combined sample are reported in this analysis.

## 2. Direction of causality

The regression package reports coefficients and their t-ratios for each of the lagged variables. However, these individual coefficients do not have much importance in this particular type of model since colinearity among the lagged variables makes it difficult to interpret any one coefficient in isolation. To get the overall interrelationships among the variables, F-tests were used. The F-tests determine whether the coefficients on the lagged values of a particular variable (as a whole) are significantly different from zero. The F-test is of the form:
$\frac{\left(r_{c}^{\prime} r_{c}-r_{u}^{\prime} r_{u}\right) / p}{\left(r_{u}^{\prime} r_{u}\right) /(N-4 p)} \sim F_{p, N-4 p}$
where $r_{c}$ is the ( $N \times 1$ ) vector of residuals from the constrained model (the first term in the numerator is the $S S R$ of the constrained model), $r_{u}$ is the ( $N \times 1$ ) vector of residuals from the unconstrained model (the second term in the numerator is the SSR of the unconstrained model), $p$ is the order of the vector autoregression (the lag length), $4 p$ is the number


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of regressors in the unconstrained model, and $N$ is the number of observations.

If the F-statistic is significant, that variable has an influence in determining, or is said to cause, the left-hand side variable of that equation. If the F-test for some variable $A$ in an equation with left-hand side variable $B$ is significant and the similar F-test shows $B$ significant in the equation for $A$, then causality runs in both directions or a "feedback effect" between $A$ and $B$ is said to occur.

The results of the F-testa are reported in Table 3.3. The white sample showed all four variables to be aignificant (at the . 05 level) in determining each other. For the black sample, all variables were significant (at the . 05 level) in determining real expenditures, attendance, and real assets. However, real expenditures and attendance were not gignificant in the determination of the birth rate. In the combined sample everything was gignificant with the exception of attendance being insignificant in the birth rate equation.

From these F-tests, it can be concluded that causality runs in both directions among most variables, or that a feedback effects are present. The only exception to this for the combined sample would be that birth rate causes attendance, but attendance does not cause the birth rate. Also, in the black sample, birth rate causes real expenditures and attendance, but real expenditures and attendance do not cause birth rate.


## 3. Impulse responses and sign of causality

With the direction of causality determined, it is appropriate to determine the sign of causality when causality exists. signing can be

Table 3.3. F-Statistics for white, black, and combined samplesa

| Independent variable | Dependent variable |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | REXD | ATTD | RPTD | ASSD |
| white sample: |  |  |  |  |
| REXD | $\begin{aligned} & 28.86 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 6.37 \\ & (.3696 \mathrm{E}-06) \end{aligned}$ | $\begin{aligned} & 3.76 \\ & (.5432 \mathrm{E}-03) \end{aligned}$ | $\begin{aligned} & 4.03 \\ & (.2568 \mathrm{E}-03) \end{aligned}$ |
| ATTD | $\begin{aligned} & 5.10 \\ & (.1260 E-04) \end{aligned}$ | $\begin{aligned} & 239.87 \\ & \quad(.4034 E-07) \end{aligned}$ | $\begin{aligned} & 4.75 \\ & (.3382 \mathrm{E}-04) \end{aligned}$ | $\begin{aligned} & 10.25 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ |
| RPTD | $\begin{aligned} & 5.26 \\ & (.7866 \mathrm{E}-05) \end{aligned}$ | $\begin{aligned} & 16.26 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 46.52 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 5.72 \\ & (.2178 \mathrm{E}-05) \end{aligned}$ |
| ASSD | $\begin{aligned} & 3.17 \\ & (.2727 E-02) \end{aligned}$ | $\begin{aligned} & 4.30 \\ & (.1207 \mathrm{E}-03) \end{aligned}$ | $\begin{aligned} & 6.52 \\ & (.2533 \mathrm{E}-06) \end{aligned}$ | $\begin{aligned} & 160.82 \\ & \quad(.4034 \mathrm{E}-07) \end{aligned}$ |
| Black sample: |  |  |  |  |
| REXD | $\begin{aligned} & 85.17 \\ & (0.00) \end{aligned}$ | $\begin{aligned} & 3.29 \\ & (.1960 \mathrm{E}-02) \end{aligned}$ | $\begin{aligned} & 0.76 \\ & (.6218) \end{aligned}$ | $\begin{aligned} & 4.66 \\ & (.4497 E-04) \end{aligned}$ |
| ATTD | $\begin{aligned} & 3.24 \\ & (.2232 \mathrm{E}-02) \end{aligned}$ | $\begin{aligned} & 201.98 \\ & \quad(.1110 \mathrm{E}-15) \end{aligned}$ | $\begin{aligned} & 0.91 \\ & (.5018) \end{aligned}$ | $\begin{aligned} & 4.16 \\ & (.1829 \mathrm{E}-03) \end{aligned}$ |
| RPTD | $\begin{aligned} & 2.76 \\ & (.7904 \mathrm{E}-02) \end{aligned}$ | $\begin{aligned} & 6.30 \\ & (.4093 \mathrm{E}-06) \end{aligned}$ | $\begin{aligned} & 18.62 \\ & (.1110 \mathrm{E}-15) \end{aligned}$ | $\begin{aligned} & 2.13 \\ & (.3945 E-01) \end{aligned}$ |
| ASSD | $\begin{aligned} & 5.83 \\ & (.1597 E-05) \end{aligned}$ | $\begin{aligned} & 2.60 \\ & (.1209 \mathrm{E}-01) \end{aligned}$ | $\begin{aligned} & 4.92 \\ & (.2112 E-04) \end{aligned}$ | $\begin{aligned} & 234.76 \\ & (.2220 \mathrm{E}-15) \end{aligned}$ |
| Combined sample: |  |  |  |  |
| REXD | $\begin{aligned} & 122.06 \\ & \quad(.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 7.23 \\ & (.5757 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 2.51 \\ & (.1468 \mathrm{E}-01) \end{aligned}$ | $\begin{aligned} & 8.36 \\ & (.4090 \mathrm{E}-07) \end{aligned}$ |
| ATTD | $\begin{aligned} & 5.41 \\ & (.4124 \mathrm{E}-05) \end{aligned}$ | $\begin{aligned} & 452.85 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 1.75 \\ & (.9409 \mathrm{E}-01) \end{aligned}$ | $\begin{aligned} & 12.48 \\ & (.4934 \mathrm{E}-07) \end{aligned}$ |
| RPTD | $\begin{aligned} & 4.76 \\ & (.2790 \mathrm{E}-04) \end{aligned}$ | $\begin{aligned} & 18.96 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 60.69 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 5.99 \\ & (.7658 \mathrm{E}-06) \end{aligned}$ |
| ASSD | $\begin{aligned} & 11.51 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 6.51 \\ & (.1912 \mathrm{E}-06) \end{aligned}$ | $\begin{aligned} & 9.96 \\ & (.4035 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 426.97 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ |

[^2]accomplished by simulating the system's response to one-time shocks in each of the variables. To simulate the system's responses, impulse response functions were generated. These functions generate dynamic responses to shocks in each of the variables. Since the possibility of the residuals being correlated across equations exists, sims [1980] suggests that it is best to orthogonalize them. The procedure described below was followed.

If $\Sigma$ is the positive definite symmetric covariance matrix of the residuals, $U_{t}$, then it can be factorized, using Choleski decomposition, into $S S^{\prime}$ such that $S$ is lower triangular. This matrix $S$ will depend on the ordering of the rows in $\Sigma$ (i.e., the ordering of the variables). A new matrix of orthogonalized innovations, $V_{t}$, can be created such that $V_{t}=s^{-1} U_{t}$ where $V_{t}$ is $\operatorname{NID}(0,1)$ since $E\left(V_{t}\right)=0$ and $\operatorname{Var}\left(V_{t}\right)=I$. If both sides are premultiplied by $S$, then $s V_{t}=U_{t}$. If $U_{t}$ is then plugged into the general expression (equation 3.10) it yields

$$
\begin{equation*}
Y_{t}=\sum_{\mathbf{g}=1}^{\infty} A_{s} Y_{t-s}+s V_{t} . \tag{3.13}
\end{equation*}
$$

This equation can then be used to simulate responses to one-time, unit shocks in any one of the variables, since the orthogonalized innovations are found in the $V_{t}$ vector and have unit variance. If the real expenditures variable is first in the $Y_{t}$ vector, a shock to some component of real expenditures that exclusively affects real expenditures would be the first element in $V_{t}$ (the first element in the vector would be a one, all else zeros). This one-time, unit shock combined with the s matrix generates a shock in real expenditures. So even though the elements of
the $V_{t}$ vector are unitless, elements of the $s V_{t}$ vector would have units. In this case the units would be real dollars.

As mentioned above, the ordering of the variables can make a difference in the dynamic response of the system to any one shock. A shock in the first variable is assumed to have an immediate impact on the remaining variables in the system. The size of the impact depends on the strength of the correlation among the variables. A shock in the last variable impacts only itself immediately.

Since the ordering of the variables could be significant in the impulse responses, the ordering was done from what was considered to be the most important variable to the variable with the least importance (i.e., what was thought to have the most immediate impact on the system to what was thought to have the least impact). Real expenditures and attendance were thought to be the most important, so the following ordering used was: real expenditures, attendance, the birth rate, and real assets. A second ordering was tried (e.g., attendance, real expenditures, the birth rate, and real assets) and the qualitative and quantitative results were not altered substantially. It was anticipated that such a second ordering would not make much difference in the reaults because the correlation between residuals was quite small. The impact of a one standard deviation shock in each of the variables on the other variables, as well as on themselves, were plotted for the white, black, and combined samples. These plots can be found in the Appendix, Figures 1 - 12.

Because the responses to shocks may exhibit cycles that lead to positive and negative values for different time periods, it is difficult
to sign the responses. For this reason, it is useful to sum the impulse responses of a given variable over time. This gives an overall dynamic impact (sign and magnitude) of a shock. Summing the impulse responses over time would be equivalent to summing the area under the impulse response curve of a particular variable over time. For instance:

$$
\begin{equation*}
\sum_{t=1}^{T} a_{t} \tag{3.14}
\end{equation*}
$$

gives the impact of a one standard deviation shock in real expenditures on the birth rate over time periods 1 through $T$ when $a_{1}, \ldots, a_{T}$ are the impulse values of the birth rate generated by a shock in real expenditures for years 1 through T.

During the time period investigated, truancy laws required children to attend school up to the age 14. Because children would typically enter school (grade 1) at age 6 and could possibly drop out after age 14 (grade 8), it would seem appropriate to calculate the impact of any shock over time periods 1 through 5 and also over time periods 1 through 14. In addition, this study only incorporates grades 1 through 8 . These results are reported in Table 3.4 and are discussed in Section 5 in conjunction with the results of the dynamic elasticity measures derived in the next section.

## 4. Elasticities of responseg

From the summation of the impulse responses another useful calculation can be made, namely that of a dynamic elasticity measure. Although no other VAR literature has employed such an idea, in this

Table 3.4. Summation of the impulse responses, $T=14$, for white, black, and combined samples ${ }^{\text {a }}$

| shock variable | Sum of the impulaes |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | REXD | ATTD | RPTD | ASSD |
| White sample: |  |  |  |  |
| REXD | 0.1055 | -0.0763 | -0.1142 | 0.1638 |
|  | (0.1360) | (-0.0328) | (-0.0829) | (0.1001) |
| ATTD | -0.0461 | 0.1292 | -0.0101 | 0.1133 |
|  | (0.0045) | (0.1745) | (0.0224) | (0.1412) |
| RPTD | 0.0615 | 0.0479 | 0.2585 | -0.0639 |
|  | (-0.0133) | (0.0144) | (0.2023) | (-0.0220) |
| ASSD | -0.0972 | -0.0459 | 0.0185 | 0.2330 |
|  | (-0.0385) | (-0.0065) | (-0.0126) | (0.2227) |
| Black sample: |  |  |  |  |
| REXD | 0.2955 | 0.0070 | -0.0552 | 0.0912 |
|  | (0.2143) | (-0.0361) | (-0.0395) | (0.0650) |
| ATTD | 0.0500 | 0.3279 | -0.0319 | 0.1477 |
|  | (0.0318) | (0.2035) | (0.0265) | (0.1068) |
| RPTD | -0.0051 | 0.0777 | 0.2495 | 0.0489 |
|  | (0.0169) | (0.0128) | (0.2442) | (0.0019) |
| ASSD | -0.2478 | -0.1222 | -0.1303 | 0.2511 |
|  | (-0.0722) | (-0.0035) | $(-0.0356)$ | (0.2695) |
| Combined sample: |  |  |  |  |
| REXD | 0.2006 | -0.0265 | -0.0834 | 0.1359 |
|  | (0.1868) | (-0.0330) | $(-0.0639)$ | (0.0845) |
| ATTD | -0.0034 | 0.2323 | -0.0244 | 0.1322 |
|  | (0.0155) | (0.1998) | (0.0273) | (0.1215) |
| RPTD | 0.0508 | 0.0892 | 0.2752 | -0.0025 |
|  | (0.0102) | (0.0135) | (0.2350) | (-0.0136) |
| ASSD | -0.2153 | -0.1161 | -0.0744 | 0.2444 |
|  | (-0.0670) | (-0.0065) | (-0.0265) | (0.2538) |

$a_{T}=5$ in parentheses.
particular situation such a measure is very useful and appropriate. This measure is useful in the sense that it indicates how responsive any one of the variables is to an initial shock in any one of the variables over time.

By definition, an elasticity measure is the percent change in one variable relative to a percent change in some other variable (unless the own elasticity is of importance). Given that the data are in natural logs, a change in any one variable (i.e., a change in the natural log) relative to a change in any other variable would, by definition, be an elasticity measure as laid out in equation 3.15.

$$
\begin{equation*}
\frac{\Delta \ln y}{\Delta \ln x}=\frac{\ln Y_{1}-\ln Y_{0}}{\ln x_{1}-\ln x_{0}}=\frac{q \Delta y}{q \Delta x} \tag{3.15}
\end{equation*}
$$

The shock in any one variable would be the denominator of the elasticity formula. The value of this shock would be the initial value of the impulse response function for that variable. Since the value is assumed to be zero before the shock, the change in the natural log of that variable goes from zero ( $\ln x_{0}$ ) to the initial value of the impulse response function $\left(\ln x_{1}\right)$ and hence, a percentage change ( $\% \Delta x$ ). In other words, the denominator of the above expression is $\ln x_{1}$.

The numerator for the dynamic elasticity measure would be obtained by summing over time the impulse responses of the variable responding to the initial shock. Again, the initial value of this variable is assumed to be zero, so the numerator becomes the sum of the impulse responses over the time period desired.

The final form the dynamic elasticity formula takes is expressed in equation 3.16.
$\frac{\Delta \ln y}{\Delta \ln x}=\frac{\Sigma \ln y_{t}}{\ln x_{1}}$

Using this formula, dynamic elasticities were calculated for shocks in all of the variables and the resulting responsiveness in the variable itself and in the other variables. Thege results are reported in Table 3.5. Notice that the initial shocks in each of the variables (in percentage terms) are not the same. (The values of these shocks are shown in parentheses beside the shock variables in the table). For example, a typical random shock in say real expenditures for the white sample is 7.4\%, while a typical random shock in attendance in the same sample is only 3.9\%.

From the dynamic elasticity measures some interesting things can be found. The magnitude and signs on the cross-elasticities provide useful information about the relationships among the four variables of interest. These findings are discussed in the next section.

## 5. Empirical findings vs. theoretical predictions

This section compares and contrasts this study's empirical findings to the predications based on theory and based on previous empirical work. Although separate sections could be devoted to the empirical results of the impulse responses and the dynamic elasticity measures, it seems more appropriate to discuss these topics fointly. The signs of the impulse response values (reported in Table 3.4) and the dynamic elasticity values

Table 3.5. Dynamic elasticities due to typical random shocks for white, black, and combined samples, $T=14^{\text {a }}$

| Shock variable (value) | Dynamic elasticities |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | REXD | ATTD | RPTD | ASSD |
| White sample: |  |  |  |  |
| REXD (.074) | $\begin{gathered} 1.43 \\ (1.84) \end{gathered}$ | $\begin{gathered} -1.03 \\ (-0.44) \end{gathered}$ | $\begin{gathered} -1.55 \\ (-1.12) \end{gathered}$ | $\begin{gathered} 2.22 \\ (1.36) \end{gathered}$ |
| ATTD (.039) | $\begin{aligned} & -1.17 \\ & (0.12) \end{aligned}$ | $\begin{gathered} 3.29 \\ (4.44) \end{gathered}$ | $\begin{aligned} & -0.26 \\ & (0.57) \end{aligned}$ | $\begin{gathered} 2.88 \\ (3.59) \end{gathered}$ |
| RPTD (.083) | $\begin{gathered} 0.74 \\ (-0.16) \end{gathered}$ | $\begin{gathered} 0.58 \\ (0.17) \end{gathered}$ | $\begin{gathered} 3.13 \\ (2.45) \end{gathered}$ | $\begin{gathered} -0.77 \\ (-0.27) \end{gathered}$ |
| ASSD (.055) | $\begin{gathered} -1.77 \\ (-0.70) \end{gathered}$ | $\begin{gathered} -0.84 \\ (-0.12) \end{gathered}$ | $\begin{gathered} 0.34 \\ (-0.23) \end{gathered}$ | $\begin{gathered} 4.24 \\ (4.06) \end{gathered}$ |
| Black sample: <br> REXD (.084) | $\begin{gathered} 3.52 \\ (2.55) \end{gathered}$ | $\begin{gathered} 0.08 \\ (-0.43) \end{gathered}$ | $\begin{gathered} -0.66^{b} \\ (-0.47) \end{gathered}$ | $\begin{gathered} 1.09 \\ (0.77) \end{gathered}$ |
| ATTD (.049) | $\begin{gathered} 1.03 \\ (0.65) \end{gathered}$ | $\begin{gathered} 6.75 \\ (4.19) \end{gathered}$ | $\begin{aligned} & -0.66^{b} \\ & (0.54) \end{aligned}$ | $\begin{gathered} 3.04 \\ (2.20) \end{gathered}$ |
| RPTD (.121) | $\begin{aligned} & -0.04 \\ & (0.14) \end{aligned}$ | $\begin{gathered} 0.64 \\ (0.11) \end{gathered}$ | $\begin{gathered} 2.06 \\ (2.01) \end{gathered}$ | $\begin{gathered} 0.40 \\ (0.02) \end{gathered}$ |
| ASSD (.066) | $\begin{gathered} -3.77 \\ (-1.10) \end{gathered}$ | $\begin{gathered} -1.86 \\ (-0.05) \end{gathered}$ | $\begin{gathered} -1.98 \\ (-0.54) \end{gathered}$ | $\begin{gathered} 3.82 \\ (4.10) \end{gathered}$ |
| Combined sample: REXD (.081) | $\begin{gathered} 2.46 \\ (2.29) \end{gathered}$ | $\begin{gathered} -0.33 \\ (-0.40) \end{gathered}$ | $\begin{gathered} -1.02 \\ (-0.78) \end{gathered}$ | $\begin{gathered} 1.67 \\ (1.04) \end{gathered}$ |
| ATTD (.045) | $\begin{aligned} & -0.07 \\ & (0.34) \end{aligned}$ | $\begin{gathered} 5.12 \\ (4.40) \end{gathered}$ | $\begin{aligned} & -0.54^{b} \\ & (2.08) \end{aligned}$ | $\begin{gathered} 2.91 \\ (2.76) \end{gathered}$ |
| RPTD (.106) | $\begin{gathered} 0.48 \\ (0.10) \end{gathered}$ | $\begin{gathered} 0.84 \\ (0.13) \end{gathered}$ | $\begin{gathered} 2.59 \\ (2.21) \end{gathered}$ | $\begin{gathered} -0.24 \\ (-0.13) \end{gathered}$ |
| ASSD (.062) | $\begin{gathered} -3.48 \\ (-1.08) \end{gathered}$ | $\begin{gathered} -1.87 \\ (-0.11) \end{gathered}$ | $\begin{gathered} -1.20 \\ (-0.43) \end{gathered}$ | $\begin{gathered} 3.95 \\ (4.10) \end{gathered}$ |

$\mathrm{a}_{\mathrm{T}=5}$ in parentheses.
$b_{\text {Not }}$ jointly significantly different from zero at the .05 level in Table 3.3.
(reported in Table 3.5) will be the same. The difference in these values is that the impulse response values are reported in "levels" (the amount by which the variable changed) and the elasticity values are reported in relative percentages. Both tables demonstrate the exact same conclusions. It is, however, easier to discuss and interpret the empirical findings in terms of the dynamic elasticity values. The elasticity results are discussed in terms of a dynamic impact of the shock variables over 14 years. The values for $T=5$ are also reported (in parentheses).

A shock in real expenditures would be expected to cause attendance to rise due to increased returns to human capital investment or because of Tiebout migration. The median-voter model would predict that real expenditures would rise due to a shock in attendance. The two crosselasticity measures for the attendance variable and the real expenditure variable are both negative and very close to one in value in the white sample ( -1.03 and -1.17 respectively). This would imply that a typical shock in either variable would cause an opposite and almost equal response in the other variable (in percentage terms). In that sense, real expenditures and attendance are almost perfect substitutes for one another in the white sample. This may be true in that greater expenditures (better quality) could give students more knowledge per day and they could obtain the same overall amount of knowledge by attending fewer days.

The same was not true in the black sample. Response of attendance to a real expenditure shock was positive, but very inelastic (0.08). Also, the response of real expenditures to an attendance shock was almost unitary elastic and positive (1.03) rather than negative as in the white
sample. In this case, the idea of real expenditures and attendance being substitutes for one another does not hold true.

In the combined sample, both cross-elasticity measures for attendance and real expenditures were negative, but inelastic ( $\mathbf{- 0 . 3}$ and $\mathbf{- 0 . 0 7}$ respectively). Again, the idea of expenditures and attendance being perfect substitutes for one another would not hold as in the white sample.

The Becker-Lewis theory implied that there was a trade-off between the quantity and the quality of children. This idea is most clearly supported in the white sample in that a positive shock in real expenditures caused an elastic negative response in the birth rate (1.55). The birth rate did not, however, have a like impact on real expenditures. Real expenditures rose as a result of a shock in the birth rate, but the response was inelastic (0.74). Although this result is somewhat inelastic, the median-voter model would have predicted that the birth rate would have a positive impact on real expenditures. In the black sample the birth rate responded negatively to a shock in real expenditures, but the response was inelastic ( -0.60 ). As in the white sample, the birth rate had little impact on real expenditures ( -0.04 ). In the combined sample the birth rate showed a negative unitary elastic response to the real expenditure shock ( -1.02 ) and real expenditures showed a positive inelastic response to the birth rate (0.48). These results back the predictions of both the median-voter model and the Becker-Lewis quantity/quality model.

A shock in real assets caused elastic negative responses in real expenditures (black: -3.77 , combined: -3.48 ), attendance (black: -1.86 , combined: -1.87 ), and the birth rate (black: -1.98 , combined: -1.20 ) in
both the black and the combined samples. An elastic negative response was also seen in the white real expenditures ( -1.77 ), but white attendance and the white birth rate had inelastic responses with values that were negative and positive respectively ( -0.84 and 0.34 ). One explanation for the negative sign on real expenditures might be that persons perceive the increase in property values as an increase in the tax price and a medianvoter type response results.

The most intriguing result of the cross-elasticity measures was the response of real assets to shocks in attendance. In all samples, real assets showed very elastic positive responses to increases in attendance. Although not quite as dramatic in value, real assets did show positive elastic responses to real expenditures in all samples as well.

These results are intriguing in that real assets or property values do appear to increase when there is more spending on education in a community or when more children are attending school in the community. There could be many possible reasons for property values increasing due to a better-educated community. Among these reasons could be the fact that better quality education or more education could cause the future labor force to be better educated and therefore enhance the value of capital in that community. Give that both the white and the black samples demonstrated that education did affect real assets, incentive did exist to invest in the education of both blacks and whites, even in an era of segregation. The idea that incentive did exist to invest in education of blacks and whites alike will be further addressed in chapter $V$.

## 6. Decomposition of variance

With causality, the sign of causality, and the elasticity of the responses investigated, decomposition of variance was performed. Variance decomposition gives the percent of the variance of a particular variable due to own innovations and the innovations in other variables.

The extent of exogeneity or endogeneity can also be determined from the variance decomposition. A variable tends to be exogenous if its variance is due to, or can be explained almost exclusively by, its own shocks.

Given the assumptions used to generate the impulse responses, the attendance component of the variance decomposition for the birth rate (the proportion of the variance in the birth rate which can be explained by attendance) would be calculated as indicated in equation 3.17.

$$
\sum_{t=1}^{T} b^{2}
$$

$$
\begin{equation*}
\sum_{t=1}^{T} a^{2}+\sum_{t=1}^{T} b_{t}^{2}+\sum_{t=1}^{T} c_{t}^{2}+\sum_{t=1}^{T} d_{t}^{2} \tag{3.17}
\end{equation*}
$$

This is the sum of the squared birth rate impulse responses due to a one standard deviation shock in attendance $\left(b_{t}\right)$ relative to the sum of the squared birth rate impulse responses due to one standard deviation shocks in each of the variables $\left(a_{t}, b_{t}, c_{t}\right.$, and $d_{t}$ ). Likewise, similar calculations could be made for any of the variables.

As with the impulse responses, the periods of interest would be 5 years and 14 years. The variance decomposition for each variable after 5 years and after 14 years is reported in Table 3.6. These results are

Table 3.6. Variance decomposition after 14 years for white, black, and combined samplesa

| Percentage due to | Variable |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | REXD | ATTD | RPTD | ASSD |
| White sample: |  |  |  |  |
| REXD | 73.65 | 6.60 | 12.00 | 17.33 |
|  | (88.96) | (3.83) | (11.54) | (16.14) |
| ATTD | 6.50 | 75.30 | 4.28 | 24.23 |
|  | (4.10) | (93.66) | (1.95) | (24.80) |
| RPTD | 11.57 | 12.40 | 75.31 | 9.08 |
|  | (1.91) | (1.90) | (86.11) | (0.93) |
| ASSD | 8.28 | 5.71 | 8.41 | 49.36 |
|  | (5.03) | (0.61) | (0.40) | (58.12) |
| Black sample: |  |  |  |  |
| REXD | 69.26 | 4.15 | 3.35 | 7.55 |
|  | (85.47) | (3.29) | (2.11) | (9.26) |
| ATTD | 2.50 | 77.75 | 4.72 | 15.20 |
|  | (2.67) | (95.27) | (2.93) | (13.04) |
| RPTD | 2.05 | 6.03 | 81.89 | 3.23 |
|  | (2.12) | $(0.76)$ | (93.07) | (0.39) |
| ASSD | 26.20 | 12.07 | 10.04 | 74.01 |
|  | (9.75) | (0.68) | (1.89) | (77.32) |
| Combined sample: |  |  |  |  |
| REXD | 69.70 | 2.59 | 6.21 | 11.11 |
|  | (86.53) | (2.78) | (5.05) | (12.02) |
| ATtD | 1.80 | 75.66 | 4.17 | 19.28 |
|  | (1.77) | (95.57) | (1.96) | (18.02) |
| RPTD | 3.19 | 10.43 | 82.20 | 4.65 |
|  | (1.54) | (0.93) | (91.86) | (0.39) |
| ASSD | 25.31 | 11.32 | 7.42 | 64.96 |
|  | (10.16) | (0.72) | (1.13) | (69.57) |

$a_{\text {After }} 5$ years in parentheses.
reported having used the impulse responses with ordering real expenditures, attendance, birth rate, and real assets. Again, the ordering should be insignificant if there is little correlation among the residuals.

For the white sample, real expenditures, attendance, and the birth rate exhibited some degree of exogeneity. They explained between 73 to 75 percent of their own variance even after 14 years. Real assets for the white sample were found to be quite endogenous. After 14 years, only 49 percent of the variance could be explained by itself. Real expenditures and attendance were found to contribute approximately 17 and 24 percent respectively to the variance in real assets. This result would imply that investment in education, either through expenditures or through attendance would have a significant impact on the property values in a given community.

For the black sample, real assets appeared to be most highly influenced by other variables. Even though attendance and real expenditures did explain some of the variance in real asseta, 74 percent was still due to itself even after 14 years. Real assets explained 26 percent of the real expenditure variance. This was significantly higher than the 8 percent in the white sample. Both attendance and the birth rate were found to be quite exogenous for the black sample.

When the samples were combined, attendance and the birth rate remained quite exogenous. Even though real expenditures explained approximately 69 percent of their own variance, 25 percent was due to real assets. Also, real assets were influenced by both real expenditures and attendance as was demonstrated in the white sample.

From the variance decomposition, if one were to rank the variables from the most exogenous to the least exogenous, the following would result. For both the white sample and the combined sample the most exogenous (after 14 years) would be the birth rate followed by attendance, real expenditures, and then real assets. The ordering for the black sample would be similar except for the fact that real assets and real expenditures would be switched in position.

## E. Conclusions

This chapter sought to empirically test the theoretical models addressing consumers' investment in education as laid out in the literature. The vector autoregressive approach proved to be very beneficial in that it allowed the data to tell the researcher the types of relationships that existed among the variables of interest without assuming any type of relationship among these variables a priori. Although this type of approach had not been previously used to investigate the educational investment process, it was an approach found to be quite useful.

It was anticipated at the onset that many of the theoretical models would each have some relevance when it came to causal relationships among the variables. This was found to be true. The empirical findings showed that each model had some relevance and that none could be eliminated from the list of models that tell the story of educational investment. Further, the empirical findings demonstrated that no one model better described the educational investment process better than any other.

The most intriguing finding from this chapter's empirical investigation was the fact that a shock in public school attendance caused property values to rise. It has long been a paradox as to why, in an era of segregation, whites had any incentive to invest in black school systems. The answer to this paradox may lie in the results of this chapter's empirical work. If local governments, which were almost exclusively controlled by whites during the time period this study covers, could see some economic benefit from investing in blacks schools, it seems logical that they would not totally discriminate against black with regard to education and see to it that some of the county tax money went to black schools as well as white schools. Increased property values resulting from a better-educated labor force could be the economic incentive which existed. This paradox is more fully addressed in a theoretical setting in chapter V. Before moving to a theoretical presentation concerning this paradox, the private school choice is investigated in the next chapter.

## IV. CAUSAL RELATIONSHIPS: THE PUBLIC-PRIVATE SCHOOL CHOICE

## A. Introduction

Whenever the investment in public education is discussed, the picture can only be completed by discussing the investment in private education. The reason for this being that investment in private schools is a substitute for investment in public schools. This chapter will investigate the causal relationships among variables relevant to both the public and private school choice. In particular, one goal of this chapter is to empirically determine whether investment in private schools in an era of segregation had the same effect on property values that investment in public schools had.

Before looking at the empirical investigation of the private-public school choice, it is important to look at relevant literature on investment in private schools and how such investment affects the public school systems. The literature review is covered in the following section. Following the literature review are sections discussing the predicted causal relationships, the empirical procedure, and the findings from the empirical investigation.

As was the goal in chapter III, the goal here is to let the data speak for themselves with no a priori assumption as to model type. The literature has suggested various causal relationships among relevant variables. This investigation will test whether or not these relationships hold true. To capture any feedback effects or reverse causality which may exist among variables, the empirical analysis will employ a simple vector autoregressive (VAR) model. This is the exact
approach used in the previous chapter about the public school choice. Such a model allows for the generation of impulse responses which give a feel for the dynamic response of variables to changes or "shocks" in the system.

## B. Literature Review

Long and Toma [1988] investigated the public-private school choice. They found that household income, homeownerghip, educational background of the parents, the race of the parents, the level of expenditures per student in public schools, the relative number of private schools, the cost of private education, and the percentage of the population that was Catholic influenced households' decisions to send their children to private schools. As a dependent variable they used school choice. They measured school choice as a 0,1 , or 2 according to whether the child attended a public school, a parochial school, or a nonparochial private school.

They found that the coefficient on income was positive. This finding backed the a priori assumption that as income rises, parents would be more likely to consider private schools as an alternative to public education. The coefficient on the white (race) was also positive as expected. They found that the probability of white households sending their elementary school age children to private schools was $6.3 \%$ higher than nonwhites.

Age and educational background of the parents were also found to positively influence the private school choice, as did home ownership. As was expected, public school expenditures and the cost of private education had a negative impact on the private school choice. However, Long and

Toma could not prove these to be statistically significant. The relative number of private schools and the percentage of Catholics in the population were both found to be highly gignificant with positive coefficients.

Long and Toma also investigated the income elasticities of private schooling. Their findings indicated that the income elasticities were larger among nonwhites than whites.

Martinez-Vasquez and Seaman [1985] looked at the Tiebout hypothesis and private school choice. They considered three options that households have. "In an area with several school districts, the options available to the household include remaining within the present school district and attending public schools, remaining in the present school district and attending private schools, and moving to another school district and attending public school." [Martinez-Vasquez and Seaman, 1985, p. 296]

They developed a decision rule for some taxpayer, i. "If the marginal valuation of education summed over the additional education that i can consume privately compared to what was available publicly (a measure of frustration with publicly supplied education) exceeds the expenditure (net of moving costs) on the amount of private education for all public school districts $j$, then $i$ will choice private schooling." [MartinezVasquez and Seaman, 1985, p. 297]

This decision rule then provided them with determinants of the private school choice. They considered income, private school costs, religious beliefs, racial content of a community, educational background of the parents, and expenditures in the public schools (quality).

To test their expectations, they used crose-sectional data from 75 large areas across the country. Because they predicted some simultaneity between expenditures per student and enrollment figures they used ols and two-stage least squares as regression techniques. When considering private schools, they like many others, separated parochial schools enrollments from nonparochial private schools encollments.

In both the parochial and nonparochial private school equations, the percentage of Catholics in the population was found to be positive and significant. Also positive and significant in both equations was the percentage of nonwhites in the community. Catholic school tuition had the anticipated negative sign for Catholic school enrollment, but had a positive sign in the nonparochial private school equation. Such opposite signs in the two equations would be expected if the two are thought to be gross substitutes for one another.

Also of interest were public school expenditures per pupil. In both equations expenditures were found to have negative coefficients, implying that expenditures are a measure of quality and increasing quality of public schools would shift enrollments from private to public schools. However, the coefficients in both equations were not statistically gignificant.

Akin and Lea [1982] included the percentage of children in private schools in their regression estimating educational expenditures per pupil in a given region. They also included property value, the cost of providing education, income level, the number of school aged children in a household, the education of the parents, the percentage of the population who are minority, and the age of the parenta. Their empirical results
demonstrated a significant negative relationship between the percentage of children in private schools and the educational expenditures per pupil in the public schools.

Using cross-sectional data from all states, West and Palsson [1988] tested a model for the probability of attending a private school relative to a public school. As explanatory variables they used the proportion of Catholics in the population, the pupil/teacher ratio, the proportion of whites in the population, the income level, the cost of private schools, and a few others. It was found that parents tended to place their children into private schools when public school class sizes were quite large. "Significant and positive independent variables turned out to be the Catholic proportion of the population, the pupil/teacher ratio, the number and length of strikes, and per capita income. Significant and negative independent variables included the proportion of administrative expense to total expenditure, the proportion in all school districts who are NEA members, and the average tuition..." [West and Palsson, 1988, p. 737 ]

West and Palsson also measured price elasticities for private education. To do so they used opinion surveys in an attempt to estimate people's reactions to hypothetical subsidization of private schools by the government. Their surveys showed very elastic responses to the hypothetical subsidization scheme suggested.

The assumption that private school encollment depends on the public school racial composition is the basis for Clotfelter's [1976] analysis of the private-public school decision. For explanatory variables in his model, Clotfelter used the proportion of whites who were Catholic (a taste
component), white median income, and the average number of children per white family. Also included were variables for desegregation policy.

Cross-sectional data (U.S. metropolitan areas) from 1960 and 1970 were used. The analysis found the percent Catholic to be positively related to private school enrollments. Family size was negatively related as expected, but insignificant. Racial composition (percent nonwhites) was found to have a significant impact on private enrollments. From the results Clotfelter concluded that in the case of desegregation, there was "white flight." The increase in the proportion of nonwhites in public schools caused white parents to enroll their children in private schools. "White flight" was found not to be significant in areas where public schools were predominately white.

Education reaction functions were the analysis approach taken by Erekson [1982] when he investigated consumer responses to state aid programs. His claim was that very little attention is ever given to what happens to per pupil expenditures when state aid programs are designed. He felt that those who did not benefit from such programs would either move to another school district or enroll their children in private schools. These two choices he termed "exit choices." The purpose of his paper was to investigate what happens to per pupil expenditures in the public school system when parents switch their children to or from the private schools.

Prior to empirical investigation, Erekson decided that private school enrollment would have an ambiguous effect on per pupil expenditures in the public schools due to counteracting effects. The two counteracting effects are termed the scaling effect and the support effect. The scaling
effect would be a situation in which the public school expenditures increased when private school enrollments increased, holding revenues constant. The support effect would be a situation in which increased private school enroliment leads to a decrease in support for the public schools, which in turn leads to decreased revenues and decreased per pupil expenditures. He expected that the support effect would dominate the scaling effect. He further expected that if public school expenditures per pupil were increased, private school enrollments would decrease. In other words, he believed that some reverse causality existed.

The empirical work that Erekson did involved data from New York school districts from 1970 to 1971. He employed these data in his twoequation reaction curve model. The dependent variable in the first equation was public school expenditures per pupil. Included as exogenous variables were family income, the percentage of persons holding white collar jobs (a taste for education variable), tax price, a migration variable, and the proportion of students enrolled in private schools. The second equation modeled enrollment in private schools. Both parochial and nonparochial private schools were studied. Tuition was used as an exogenous variable as well as expenditures per pupil in the private schools (a measure of quality), household income, the percentage of persons below the poverty level (a taste for private education variable), migration, and the proportion of students enrolled in public schools.

To estimate his model, Erekson used two-stage least squares. This method was employed to avoid simultaneous equations bias. The empirical work showed coefficients with anticipated signs. Income had a positive coefficient in the public school enrollment equation, but negative in the
private school equation. Although increases in income would be conducive to better affording private education, it might also increase expenditures per pupil in the public schools, which in turn might cause private enrollments to decrease. This was the explanation for the negative coefficient on income in the private school enrollment equation. Tax price had a negative effect on public school enrollments as expected. Also exerting a negative influence on public school enrollments was migration. The percentage of persons who were white collar workers did demonstrate a strong preference for education.

The price of tuition was expected to have a negative impact on private school enrollments. The impact was negative for nonparochial private schools, but positive for parochial schools. Erekson explained this unexpected result for parochial schools as being due to parochial school tuition serving as an indicator of school quality because it is thought that parochial school enrollment is very price inelastic.

Migration also had differing signs on its coefficients for parochial and nonparochial private school enrollments. Migration had the anticipated negative sign for parochial schools. However, it was found to gignificantly increase enrollments in nonparochial private schools. Out migration would typically cause a decrease in public school demand. Erekson's explanation for the positive coefficient was that nonparochial private school enrollment could serve as an alternative to migration for those persons dissatisfied with the public schools.

Also significant in the empirical work was the fact that increases in nonparochial private school enrollments caused increases in public school per pupil expenditures. This fact implies that the scaling effect
dominated in Erekson's model. This was just the opposite of what he had expected. Increases in public school expenditures did not significantly affect parochial school enrollments, but did significantly increase nonparochial school enrollments.

Increases in the nonwhite population were found to significantly increase parochial school enrollments, but not nonparochial private school enrollments. Urbanization was also found to increase parochial school enrollments, but not nonparochial school enrollments. The percentage of the population below the poverty level exhibited negative coefficients for parochial and nonparochial school enrollments.

Elasticities were also calculated between various variables in the model. Among the interesting results was the fact that public school expenditures and enrollments in parochial schools had zero elasticity values. The elasticity values between nonparochial private school enrollments and public school expenditures were positive.

## C. Conclusions from the Literature

The primary variables in the literature used to study the investment in private schools are pretty consistent across studies. These variables are household income, race (or percentage in the population), expenditures per student in the public schools, the number of private schools, the cost of private schools, and the percentage of Catholics in the population. From the literature and from economic theory one would predict that if a regression were run with private school enrollments as the dependent variable, the coefficients on household income, the number of private schools, the percentage of nonwhites in a community, and the percentage of

Catholics in a community would be positive. The cost of private education and the expenditures per student in public schools would be predicted to have negative coefficients.

## D. The Data

## 1. General description

The data set used for this particular investigation was similar to the Maryland school district data set utilized for the public school choice investigation in the last chapter. To maintain consistency with the previous investigation, elementary school data were chosen. The cross-sectional time series in this case consisted of 28 years of data (1928 to 1955) for 23 white school syatems and 22 black school systems. Private school data for the state of Maryland were not reported prior to 1928, so maintaining the 32 -year length of the time series was not possible for this analysis.

The variables used in the empirical analysis were variables which were used in the public school empirical analysis REXPPA, ATTPTH, ASSETPTH (real expenditures per pupil attending (public schools), average daily attendance per thousand in the population (county), total assessment taxable at full rate (in real terms) per thousand in the population (county)), but further include the numbers of pupils enrolled in Maryland nonpublic elementary schools (all private schools) per thousand in the population (county), TPRIVPTH. (See chapter III, section $C$ for a further description of REXPPA, ATTPTH, and ASSETPTH.) The data on private school enrollments were taken from the Annual Reports of the State of Maryland Board of Education. Since the birth rate per thousand in the population
(county) had relatively inelastic dynamic elasticity values and was extremely exogenous, this variable was not considered in this analysis. Sample means and standard deviations are shown in Table 4.1.

## 2. Stationarity

To ensure stationarity, a correction for trend and a correction for county-specific means were incorporated. To make these corrections, oLS regressions were run for each of the variables with a constant, year (trend), and county dummies (22 for white samples and 21 for black samples) serving as the explanatory variables. The residuals from these regressions were then saved for use in the vector autoregressions. These new variables were named REXD, ATTD, ASSD, and TPRD. Unlike the previous analysis, the existence of zeroes in the data made it impossible to use the natural logarithms. Although it would have made the interpretation of the empirical results much nicer, the natural logarithm transformation was not a necessity to meet the stationarity conditions of constant mean and constant variance.

## 3. The causal model and lag lengths

The model of causality used for this analysis was identical to that used in chapter III (section B) with the exception of the birth rate variable (RPTD) being replaced by the enrollment in private schools variable (TPRD). For the same reasons as in the previous analysis, a lag length of 7 was maintained for this analysis.

Table 4.1. Sample statistics
Variable Mean $\quad$ Standard deviation

White sample:

| REXPPA | 116.55 | 33.16 |
| :--- | ---: | ---: |
| ATTPTH | 111.36 | 22.88 |
| TPRIVPTH | 13.82 | 20.70 |
| ASSETPTH | 1484.37 | 475.92 |

Black sample:

| REXPPA | 88.51 | 42.79 |
| :--- | ---: | ---: |
| ATTPTH | 138.11 | 22.55 |
| TPRIVPTH | 4.47 | 12.69 |
| ASSETPTH | 1491.69 | 482.72 |

Combined sample:

| REXPPA | 102.84 | 40.65 |
| :--- | ---: | ---: |
| ATTPTH | 124.44 | 26.36 |
| TPRIVPTH | 9.25 |  |
| ASSETPTH | 1487.69 | 479.08 |

## E. Empirical Results

## 1. Reqression procedure

The procedure followed for the empirical analysis was identical to that of the previous investigation. A full description of this procedure can be found in chapter III, section $D$. The model was run three times: once for the white sample, once for the black sample, and once for the combined sample. All regressions results are reported accordingly.

## 2. Direction of causality

To determine the interrelationships among the variables, F-tests were used. These results are reported in Table 4.2. From thege F-tests it can be concluded that causality runs in both directions, or that a feedback effect is present among the real expenditures, attendance, and real assets variables. These variables also showed similar causality in the public school VAR (Table 3.3). Real expenditures, attendance, and real assets had insignificant F-statistics when used in the equation with private school enrollment as the dependent variable. The one exception to this was the impact of public school attendance on private school enrollment in the combined sample. Although not significant at the . 05 level, public school attendance could also be considered to cause enrollments in private schools in the black sample at a . 10 significance level. Private school enrollments demonstrated a significant impact in determining real expenditures per pupil in the public schools in white and in the combined samples. Private school enrollments were further found to be significant in causing real assets in the white sample.

Table 4.2. F-Statistics for white, black, and combined samples ${ }^{\text {a }}$

| Independent variable | Dependent variable |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | REXD | ATTD | TPRD | ASSD |
| White sample: |  |  |  |  |
| REXD | $\begin{aligned} & 44.85 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 6.59 \\ & (.2370 \mathrm{E}-06) \end{aligned}$ | $\begin{aligned} & 1.50 \\ & (.1639) \end{aligned}$ | $\begin{aligned} & 7.58 \\ & (.5193 \mathrm{E}-07) \end{aligned}$ |
| ATTD | $\begin{aligned} & 13.00 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 182.43 \\ & \quad(.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 1.23 \\ & (.2862) \end{aligned}$ | $\begin{aligned} & 15.94 \\ & \quad(.4034 \mathrm{E}-07) \end{aligned}$ |
| TPRD | $\begin{aligned} & 4.21 \\ & (.1640 \mathrm{E}-03) \end{aligned}$ | $\begin{aligned} & 1.54 \\ & (.1524) \end{aligned}$ | $\begin{aligned} & 493.16 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 2.85 \\ & (.6477 \mathrm{E}-02) \end{aligned}$ |
| ASSD | $\begin{aligned} & 8.33 \\ & (.4171 E-07) \end{aligned}$ | $\begin{aligned} & 5.00 \\ & (.1786 \mathrm{E}-04) \end{aligned}$ | $\begin{aligned} & 1.12 \\ & (.3513) \end{aligned}$ | $\begin{aligned} & 90.35 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ |
| Black sample: |  |  |  |  |
| REXD | $\begin{aligned} & 46.37 \\ & (.1110 \mathrm{E}-15) \end{aligned}$ | $\begin{aligned} & 3.01 \\ & (.4273 E-02) \end{aligned}$ | $\begin{aligned} & 0.93 \\ & (.4813) \end{aligned}$ | $\begin{aligned} & 11.39 \\ & (.2705 \mathrm{E}-12) \end{aligned}$ |
| ATTD | $\begin{aligned} & 3.07 \\ & (.3596 \mathrm{E}-02) \end{aligned}$ | $\begin{aligned} & 162.08 \\ & \quad(.1110 \mathrm{E}-15) \end{aligned}$ | $\begin{aligned} & 1.76 \\ & (.9296 \mathrm{E}-01) \end{aligned}$ | $\begin{aligned} & 8.02 \\ & (.3544 \mathrm{E}-08) \end{aligned}$ |
| TPRD | $\begin{aligned} & 0.91 \\ & (.4954) \end{aligned}$ | $\begin{aligned} & 1.71 \\ & (.1052) \end{aligned}$ | $\begin{aligned} & 415.36 \\ & (.2220 \mathrm{E}-15) \end{aligned}$ | $\begin{aligned} & 0.38 \\ & (.9116) \end{aligned}$ |
| ASSD | $\begin{aligned} & 3.08 \\ & (.3521 E-02) \end{aligned}$ | $\begin{aligned} & 2.27 \\ & (.2830 \mathrm{E}-01) \end{aligned}$ | $\begin{aligned} & 0.48 \\ & (.8507) \end{aligned}$ | $\begin{aligned} & 96.68 \\ & (.4441 \mathrm{E}-15) \end{aligned}$ |
| Combined sample: |  |  |  |  |
| REXD | $\begin{aligned} & 84.53 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 7.13 \\ & (.4105 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 1.57 \\ & (.1419) \end{aligned}$ | $\begin{aligned} & 18.03 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ |
| ATTD | $\begin{aligned} & 8.32 \\ & (.4105 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 374.25 \\ & \quad(.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 2.02 \\ & (.4980 \mathrm{E}-01) \end{aligned}$ | $\begin{aligned} & 21.90 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ |
| TPRD | $\begin{aligned} & 3.26 \\ & (.1987 \mathrm{E}-02) \end{aligned}$ | $\begin{aligned} & 1.49 \\ & (.1686) \end{aligned}$ | $\begin{aligned} & 880.41 \\ & (.4034 \mathrm{E}-07) \end{aligned}$ | $\begin{aligned} & 1.58 \\ & (.1388) \end{aligned}$ |
| ASSD | $\begin{aligned} & 9.32 \\ & (.4037 E-07) \end{aligned}$ | $\begin{aligned} & 4.59 \\ & (.4656 \mathrm{E}-04) \end{aligned}$ | $\begin{aligned} & 0.62 \\ & (.7438) \end{aligned}$ | $\begin{aligned} & 183.34 \\ & \quad(.4034 \mathrm{E}-07) \end{aligned}$ |

[^3]
## 3. Impulse responses and sign of causality

With the direction of causality determined among the relevant variables through the use of F-tests, the sign of causality was determined. To accomplish this, impulse response functions were generated to simulate the system's dynamic response to shocks in each of the variables. (Refer to chapter III, section D, part 3 for a full description of the procedure.) The impulse responses of a given variable were summed over time (time periods 1 through 5 and time periods 1 through 14). Such a summation gives the overall impact (both sign and magnitude) of a shock. The summations of the impulse responses are reported in Table 4.3. On closer inspection, one will note that the magnitude of the values reported in Table 4.3 is much different from the magnitude of the values found in Table 3.4. This is due to the fact that these second set of impulse responses are not in natural logarithm form as was the case with those reported in the previous table.

## 4. Elasticities of responses

To be able to compare and contrast the results from this chapter with the results from chapter III, it was again appropriate to calculate dynamic elasticities for each of the variables. Dynamic elasticities are useful in interpreting results because they are unitless and because they indicate how responsive any of the variables are to a shock in any one of the variablea.

The calculation of the dynamic elasticity values was done somewhat differently in this analysis than was done in the previous analysis. (See chapter III, part $D$, section 5.) In the previous analysis the calculation

Table 4.3. Summation of the impulse responses, $T=14$, for white, black, and combined samplea ${ }^{\text {a }}$

| shock <br> variable | Sum of the impulses |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | REXD | ATTD | TPRD | ASSD |
| White sample: |  |  |  |  |
| REXD | 20.4765 | 2.5737 | -5.8202 | 275.8226 |
|  | (21.3820) | (-0.8586) | (-1.4145) | (54.8108) |
| ATTD | -12.9508 | 3.0542 | -2.4443 | 66.9827 |
|  | (1.0213) | (16.8741) | (0.1985) | (162.0880) |
| TPRD | 0.2145 | -0.1781 | 13.9818 | 242.8024 |
|  | (4.1784) | (1.8925) | (8.4644) | (92.4858) |
| ASSD | -12.3615 | -12.1521 | -0.4361 | 194.8234 |
|  | (-8.5189) | (-2.6049) | (-0.1818) | (209.9264) |

Black sample:

| REXD | 14.5257 | 9.0635 | -0.4306 | 448.8671 |
| :--- | :---: | :---: | :---: | :---: |
|  | $(27.0247)$ | $(1.4527)$ | $(0.2424)$ | $(126.3242)$ |
| ATTD | 2.9889 | 40.5097 | -3.3980 | 351.0626 |
|  | $(4.9609)$ | $(27.7345)$ | $(-0.4177)$ | $(142.3055)$ |
|  |  |  |  |  |
| TPRD | 13.2930 | 1.3398 | 12.4266 | -1.4731 |
|  | $(1.0786)$ | $(-3.5240)$ | $(7.8752)$ | $(-7.5309)$ |
|  |  |  |  |  |
| ASSD | -20.8412 | -7.9019 | 0.9805 | 301.8054 |
|  | $(-4.6335)$ | $(-1.5182)$ | $(0.0150)$ | $(280.2458)$ |

Combined sample:

| REXD | 17.8063 | 2.7524 | -4.2978 | 350.4249 |
| :--- | :---: | :---: | :---: | :---: |
|  | $(25.4237)$ | $(0.8025)$ | $(-0.8029)$ | $(100.8657)$ |
| ATTD | -5.8344 | 24.4410 | -2.7550 | 250.6979 |
|  | $(2.8526)$ | $(24.2372)$ | $(0.2571)$ | $(167.0170)$ |
| TPRD | 2.2678 | -2.1017 | 15.4906 | 119.2509 |
|  | $(2.6696)$ | $(-1.0095)$ | $(8.6143)$ | $(45.3201)$ |
|  |  |  |  |  |
| ASSD | -17.7620 | -12.0500 | 0.0342 | 224.7265 |
|  | $(-7.1486)$ | $(-2.2591)$ | $(-0.1036)$ | $(247.5866)$ |

$a_{T}=5$ in parentheses.
of the dynamic elasticity values was made easy by the fact that the impulse responses were reported in natural logarithm form. That was not the case in this analysis. To get a percent change in the response variable relative to a percent change in the shock variable, equation 4.1 was used.

$$
\begin{equation*}
\frac{\% \Delta y}{\% \Delta x}=\frac{\left(\sum y_{t} / \bar{y}\right)}{\left(x_{1} / \bar{x}\right)} \tag{4.1}
\end{equation*}
$$

The numerator for the dynamic elasticity measure would be calculated by summing the impulse responses of the variable responding to the initial shock over the appropriate time period ( $T=5$ or $T=14$ ) and dividing this sum by the mean of that variable. The denominator would be the value of the shock, which is the initial value of the impulse response function for the variable relative to its mean.

Using this formula, dynamic elasticities were calculated for shocks in all of the variables and the resulting responsiveness in each of the variables. These results are reported in Table 4.4. The values of the shocks in each of the variables (in percentage terms) are shown in parentheses beside the shock variables in the table. It is interesting to note that the values of the shocks which were calculated in this analysis are consistent with those found in Table 3.5. The fact that the values are so close demonstrates that equation 4.1 is an appropriate method of calculating dynamic elasticities when the data are not in natural logarithm form.

Table 4.4. Dynamic elasticities due to typical random shocks for white, black, and combined samples, $T=14^{\text {a }}$

| Shock variable (value) | Dynamic elasticities |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | REXD | ATTD | TPRD | ASSD |
| White sample: |  |  |  |  |
| REXD (.077) | 2.29 | 0.30 | -5.49 ${ }^{\text {b }}$ | 2.42 |
|  | (2.39) | (-0.10) | (-1.33) | (0.48) |
| ATTD (.038) | -2.95 | 0.73 | -4.69 ${ }^{\text {b }}$ | 1.20 |
|  | (0.23) | (4.02) | (0.38) | (2.90) |
| TPRD (.116) | 0.16 | $-0.01{ }^{\text {b }}$ | 8.75 | 1.41 |
|  | (0.31) | (0.15) | (5.29) | (0.54) |
| ASSD (.061) | -1.73 | -1.78 | $-0.51{ }^{\text {b }}$ | 2.14 |
|  | (1.19) | (-0.38) | (-0.21) | (2.30) |
| Black sample: |  |  |  |  |
| REXD (.106) | 1.54 | 0.62 | $-0.90{ }^{\text {b }}$ | 2.83 |
|  | (2.87) | (0.01) | (0.51) | (0.80) |
| ATTD (.046) | 0.74 | 6.41 | -16.60 | 5.15 |
|  | (1.23) | (4.39) | (-2.04) | (2.09) |
| TPRD (.329) | $0.46{ }^{\text {b }}$ | $0.03{ }^{\text {b }}$ | 8.44 | $0.00{ }^{\text {b }}$ |
|  | (0.04) | (-0.08) | (5.35) | (-0.02) |
| ASSD (.069) | -3.40 | -0.83 | $3.16^{\text {b }}$ | 2.92 |
|  | (-0.76) | (-0.16) | (0.05) | (2.71) |
| Combined sample: |  |  |  |  |
| REXD (.095) | 1.82 | 0.23 | $-4.90{ }^{\text {b }}$ | 2.48 |
|  | (2.61) | (0.07) | (-0.91) | (0.71) |
| ATTD (.044) | -1.28 | 4.44 | -6.73 | 3.81 |
|  | (0.63) | (4.40) | (0.63) | (2.54) |
| TPRD (.179) | 0.12 | -0.09 ${ }^{\text {b }}$ | 9.33 | $0.45{ }^{\text {b }}$ |
|  | (0.14) | (-0.05) | (5.19) | (0.17) |
| ASSD (.066) | -2.59 | -1.45 | $0.06^{\text {b }}$ | 2.26 |
|  | (-1.04) | (-0.27) | (-0.17) | (2.49) |

$\mathrm{a}_{\mathrm{T}=5}$ in parentheges.
$\mathrm{b}_{\text {Not }}$ jointly significantly different from zero at the .05 level of significance in Table 4.2.
5. Empirical findings vs, theoretical predictions

The dynamic elasticity results are reported for both $T=5$ and $T=14$. The discussion that follows refers to the $T=14$ elasticity values, unless otherwise noted.

Both real expenditures and real assets had a positive elastic response to a shock in real expenditures in all three samples. This result was consistent with the findings in the previous analysis. Tiebout theory or human capital investment theory would predict that public school attendance would rise due to an increase in real expenditures per pupil. In the previous analysis, this was not found to be true. However, in this analysis the dynamic elasticity measure for public school attendance showed a positive sign for all samples, but was inelastic in all cases. The total private school enrollment variable showed a very elastic negative response to an increase in real expenditures in both the white and the combined samples ( -5.49 and -4.90 respectively). An increase in real expenditures was found to have a negative impact on black total private school enrollments as well. The value was inelastic ( -0.90 ), however. These results demonstrate that real expenditures per pupil were viewed by parents as a measure of school quality in the public school system. If the school quality were increased, then parents would tend not to send their children to private schools.

A shock in public school attendance caused responses in real expenditures and real assets similar to those in the first analysis. In the combined sample, the previous dynamic elasticity value for real expenditures was negative and very inelastic (-0.07). For this analysis the result was negative, but elastic (-1.28). As predicted, increased
public school attendance caused a positive elastic response in real assets in all three samples.

An increase in total private school enrollments had very little impact on real expenditures and public school attendance. The elasticity measures for real expenditures were all positive, but inelastic $(0.16$, 0.46 , and 0.12 respectively). The impact on public school attendance was negative in both the white and the combined samples and positive in the black sample. All of these measures were very inelastic, however. As one would predict, an increase in private school enrollments had an impact on real assets similar to that of an increase in public school attendance. The white sample demonstrated this best. The dynamic elasticity measure for real assets was positive and elastic (1.41). Given how few private black school existed, it was not surprising to see the 0.00 elasticity measure for real assets in the black sample. While the value was positive in the combined sample, it was inelastic (0.45).

The real expenditure dynamic elasticity measures resulting from a shock in real assets were almost identical to those in the previous analysis. The impact of a real asset shock on attendance were very similar to those of the previous analysis as well. Total private school enrollments showed a negative inelastic response to a shock in real assets in the white sample ( -0.51 ), but a positive elastic response in the black sample $(3.16)$. For the combined sample, the elasticity measure was positive, but very inelastic (0.06). The positive responses would be consistent with theory in that greater wealth would tend to causes private school enrollments to rise.


#### Abstract

The results found in this analysis, as in the previous analysis, support the idea that increased expenditures or increased attendance (in either public schools or in private schools) do appear to cause real assets in the community to rise. As was stated in the previous chapter, there could be many possible reasons for property values or real assets increasing due to a better-educated community. The best explanation thus far is that better quality education or more education cause the future labor force to be better educated and therefore enhance the value of capital in that community. The results of this analysis further demonstrate that there was incentive to invest in the education of both black and whites in an era of segregation.


## 6. Decomposition of variance

To complete the empirical investigation and to keep it consistent with the empirical work performed in chapter III, decomposition of variance was performed. Variance decomposition gives the percent of the variance of a particular variable due to own innovations and innovations in other variables. The method of calculation is explained in chapter III, section D, part 6 (equation 3.17). The variance decomposition for each variable over 5 years and over 14 years is reported in Table 4.5. The results are reported using the impulse responses with ordering real expenditures, public school attendance, total private school enrollment, and real assets.

After five years, public school attendance and private school attendance seem to be influenced very little by other variables. The percent of variation in these variables was explained by between 94 and 99

Table 4.5. Variance decomposition after 14 years for white, black, and combined samples ${ }^{\text {a }}$

| Variable | Percentage due to |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | REXD | ATtD | TPRD | ASSD |
| White sample: |  |  |  |  |
| REXD | 62.50 | 21.99 | 4.32 | 11.20 |
|  | (79.13) | (4.64) | (4.35) | (11.88) |
| ATTD | 7.43 | 75.44 | 4.82 | 12.30 |
|  | (0.73) | (94.08) | (1.54) | (3.64) |
| TPRD | 10.53 | 4.42 | 84.87 | 0.17 |
|  | (3.20) | (0.14) | (96.54) | (0.12) |
| ASSD | 21.69 | 29.91 | 13.48 | 34.92 |
|  | (3.62) | (27.50) | (8.98) | (59.90) |
| Black sample: |  |  |  |  |
| REXD | 76.84 | 6.14 | 5.88 | 11.14 |
|  | (92.34) | (3.68) | (0.37) | (3.60) |
| ATTD | 7.78 | 86.12 | 3.44 | 2.67 |
|  | (0.73) | (96.31) | (2.05) | (0.91) |
| TPRD | 0.79 | 5.32 | 93.26 | 0.63 |
|  | (0.20) | (0.87) | (98.89) | (0.04) |
| ASSD | 39.28 | 20.86 | 1.66 | 38.20 |
|  | (12.03) | (16.25) | (0.24) | (71.48) |
| Combined sample: |  |  |  |  |
| REXD | 77.59 | 9.34 | 1.18 | 11.89 |
|  | (88.58) | (2.19) | (1.54) | (7.69) |
| ATTD | 6.79 | 85.07 | 0.71 | 7.42 |
|  | (0.42) | (97.59) | (0.22) | (1.77) |
| TPRD | 5.93 | 4.98 | 88.97 | 0.12 |
|  | (0.98) | (0.33) | (98.67) | (0.02) |
| ASSD | 31.58 | 25.20 | 2.73 | 40.49 |
|  | (8.26) | (23.99) | (1.80) | (65.96) |

after 5 years in parentheses.
percent of their own innovations. Real expenditures in the black sample also showed very little variation being explained by other variables after five years. The white sample showed 20.87 percent of the variation in real expenditures coming from innovations other than own innovations after five years. The most interesting result when considering variance decomposition after five years is that of real assets. Public school attendance and total private school enrollment were able to explain 36.48 percent of the variation in real assets in the white sample after only five years. In the black sample and combined sample, these variables were able to explain 16.49 and 25.79 percent respectively of real assets variation.

After 14 years, real expenditures and real assets were found to explain 19.73 percent of the variation in public school attendance in the white sample. Although real assets did not explain much variation in public school attendance in the black sample, real expenditures were found to explain 7.78 percent after 14 years. Variation in real expenditures was influenced by the other three variables such that 62.50 percent, 76.84 percent, and 77.59 percent was due to own innovations in the white, black, and combined samples respectively. Variation in total private school enrollments was due mostly to own innovations, but 10.53 percent was attributable to real expenditures in the white sample. In the black sample, variation in total private school enrollments was again due mostly to own innovations, but 5.32 percent was attributable to public school attendance. Real assets were most highly influenced by the other variables. Only $34.92,38.20$, and 40.49 percent of variation in real assets was due to own innovations in the white, black, and combined
samples respectively. Real expenditures explained the greatest percent of the variation in real assets in both the black and the combined samples (39.28 and 31.58 respectively). In the white sample, public school attendance (29.91 percent) explained even more than real expenditures (21.69 percent).

From the variance decomposition it is possible to rank the variables from most exogenous (least influenced by the other variables) to the most endogenous (most influenced by the other variables). In this analysis, total private school enrollment was the most exogenous for all three samples. One would expect real expenditures in the public school system to influence private school enrollments, but one would further expect other variables not considered in this analysis to have a significant effect as well. Variables which would tend to influence private school enrollments are the ones addressed by the literature. These would be the percent Catholic in the population (a religious preference or taste variable), the number of private schools available, the cost of private schooling (a price variable), and the percent white or black in the population (a taste for discrimination variable). With these variables absent from this analysis, it is not surprising that total private school enrollments is quite exogenous in nature. These variables are left for the more traditional empirical analysis of chapter VI.

Of the remaining variables considered here, attendance in the public schools was the next most exogenous variable in all three samples followed by real expenditures. The least exogenous or, in other words, the most endogenous variable in all of the samples was real assets.

## F. Conclusions


#### Abstract

As was true with the public school choice investigation, using a vector autoregressive methodology to investigate causal relationships among variables affecting both private and public school investment provided some interesting empirical results. One goal of this chapter was to test whether private school enrollment had the same effect on property values that public school attendance did. For the white sample, it did. This was not true for the black sample, however. Private school enrollment by blacks had no effect on property values at all. This was probably attributable to the fact that the percent of black children attending private schools in any given county was quite negligible. It was interesting to note that most of the variables showed very inelastic responses to changes in private school enrollments. The causal relationships among the other three variables (REXD, ATTD, and ASSD) did not change significantly from the previous investigation.

Before a more traditional approach empirical approach is applied to the public-private school choice in chapter VI, a theoretical approach is taken to investigate the interaction between investment in education and property values. A theoretical model will be derived in the next chapter that will encompass the empirical findings of chapters III and IV as well as characteristics from various models found in the literature.


## V. BDUCATIONAL INVESINENT: A LOOK AI MYRDAL'S PARADOX

## A. An Introduction

Thus far in this study educational investment has been addressed primarily without regard to race. An interesting extension of the discussion in chapters III and IV is to specifically examine the interaction between educational investment and property values in the segregated era. In particular, this interaction may provide leverage toward explaining why there was an incentive for white-dominated school systems to invest in education for white and black children alike.

This paradox was first addressed by Myrdal [1944]. Various explanations have been put forth in attempts to solve this paradox. However, the explanation to be concentrated upon in this section is one given by Richard Freeman [1973]. Freeman suggested that whites may have been willing to invest in black schools with the hopes of reaping the benefits of a better-educated labor force. His explanation backs the empirical findings of chapter III and chapter IV. The empirical analysis of these chapters showed that positive shocks in educational investment, in the form of either educational expenditures or attendance, would cause property values to rise. This chapter will investigate the theoretical underpinnings of this empirical finding.

The firgt goal of this chapter is to review the literature and summarize what has been studied to date with regard to educational investment, provision of educational services, segregated schools, and the relationship educational investment might have to property values. This chapter will take the literature one step further and develop a


#### Abstract

theoretical model which backs the idea that there is a positive relationship between property values and educational investment. This model is a two-period model which includes a representative profitmaximizing firm and a representative utility-maximizing household.


## B. Literature Review

The literature on educational investment is quite limited when it comes to the investigation of segregated schools and the racial differences which existed in the educational services provided. Margo has concentrated much effort in this area of study. Kousser, Pritchett, Freeman, and Fishback have also addressed this area. Their work will be discussed in this chapter. Orazem, Edwards, and Cebula have made contributions as well. Their contributions have already been discussed in chapter II.

Margo [1990] took a human capital approach when he modeled school attendance of southern children in 1900. For explanatory variables, he used household characteristics such as literacy of parents, home ownership, and occupational status. Other independent variables included the child's age, age squared, the gender of the child, the number of children under 5, school density, length of the school year, the teacherpupil ratio, and average teacher salary (quality variable).

Tobit models were used to run the regressions of school attendance for both blacks and whites because the dependent variable was often zero. Home ownership and occupational status had the anticipated positive signs for both samples. Iiteracy also had a positive effect on attendance for both black and white children. The child's age exhibited a positive but
decreasing effect on attendance. The nonlinearity in age is attributed to the fact that most children left school by the age of 15 or 16 . Gender had no significant effect on attendance. If there were children under 5 at home, attendance of older children was significantly decreased in black families.

The school characteristics attempt to capture both quantity and quality measures. School density and length of school term are both measures of quantity. It would be anticipated that as the number of schools in an area increased, attendance would rise. A positive response in attendance would also be expected if the length of the school term were increased. However, school density did not affect attendance for either blacks or whites. Longer school terms encouraged greater attendance, the effect being much more significant for blacks than whites.

The teacher-student ratio and average salary of teachers were used as proxies for the quality of education. Both variables had the anticipated positive effect on attendance for both blacks and whites. The teacherstudent ratio was significant for both races. The average salary was marginally gignificant for black attendance and insignificant for whites. Margo concluded that:

Racial differences in school characteristics account for 40-77 percent of the racial attendance gap, depending on how the effect of separate-but-equal is calculated. Had the equal part of separate-but-equal been enforced, the racial attendance gap would have been much smaller. But even if it had been enforced, black children still would have attended less frequently than white children, because of racial differences in family background. Inadequate educational opportunities were not the sole, or even quantitatively the most important reason for the racial attendance gap. Racial differences in adult literacy, occupational status, and homeownership
account for 74-83 percent of the racial attendance gap; adult literacy, by itself, explains over, half of the gap. [Margo, 1990, pp. 78-79]

Margo also investigated why there was any incentive, in an era of segregation, for whites to invest in black schools. Margo has found that the quality of black schools improved in most states from the early 1900's through the 1950's. [Margo, 1988, p. 2]

Margo developed a model of local government discrimination/mobility. [Margo, 1988] He showed that local public goods are always provided and that the amount supplied to nonwhites is less than the desired level in that their taxes exceed the expenditures on local public goods. This degree of discrimination decreases as nonwhites become more mobile and their labor services are desired by other locations.

From his local government discrimination model Margo concluded that, with no collusion of local governments and geographic mobility of nonwhites, local public goods will be provided to nonwhites. He also concluded that since perfect mobility is implausible, there must be other factors affecting the decision to provide local public goods and services, one of these being the economic benefits of having black workers who are better-educated.

To look at these issues further, Margo examined black mobility and the quality of schooling. [Margo, 1988] The model he developed uses changes in the proportion of the black population and changes in geographic concentration of blacks (competition for black labor) to explain changes in the school year length. Empirical results of pooled cross-sectional, time-series data showed the anticipated signs. A
decrease in the proportion of blacks caused an increase in the school year length, as did an increase in the competition for black laborers.

Next, Margo considered the tax burden of black schools and black mobility. [Margo, 1988] Margo's mobility model suggests that blacks would be taxed more than the level of local public goods they received would call for. The only time this would not be true would be if blacks were perfectly mobile. If they were perfectly mobile, such excessive taxing would drive black labor from that community.

Many have theorized that blacks were subsidizing white schools. "...Early twentieth century writers, such as Charles Coon and w.E.B. DuBois, claimed that black schools were not a burden to white taxpayers and that blacks were subsidizing whites in some states." [Margo, 1988, p. 24] More recently, Richard Smith [1974] measured racial burden of school taxes. He concluded that in most states, blacks were subsidizing white education.

Margo [1988] finds problems with the way Smith derived his range of tax burdens. Margo claims that "...if his [Smith's] lower bound estimates are used, blacks were subsidizing whites in only three states in 1910..." [Margo, 1988, p. 26] However, like Margo's claim, empirical studies have shown that blacks did not subsidize white schools. They show that just the opposite was true.

Kousser [1980], using a "black balance of payments" measure, found the whites to be subsidizing black education. The "black balance of payments" was the difference between black educational expenditures and black educational taxes. He found the "black balance of payments" to be positive, even after disfranchisement.

Pritchett [1989] also investigated the issue of who subsidized whom in a segregated school setting. He delved into the incidence of the property tax. His conclusion was that the more elastic the supply of property (landowners) relative to the demand for property (laborers), the more chance there was of blacks paying entirely for theix own education. Such a result hinged on the fact that the tax burden could be shifted from landowners back to the workers in the form of higher rents. Pritchett does not provide any empirical evidence, but rather only sets up the conditions under which blacks may have paid for their own education. Considering that labor was probably relatively more mobile than was capital and land (usually assumed fixed), Pritchett's model would back Kousser's results.

So, if the expenditures on black schools exceeded the revenues from black taxes, and given that perfect mobility was implausible, another explanation was needed to explain why whites tended to subsidize black schools. Margo explains that since school expenditures were derived from property taxes, whites would have a large share of the tax burden. However, such an explanation still does not answer the question as to why there was investment in black schools at all.

Even though blacks had the right to vote in the period from the 1920's through the 1950 's, it is common knowledge that most governing bodies, including school boards, were almost exclusively white. With the power governing the provision of public services predominantly in the hands of the whites, it's a wonder that black public schools existed at all. This issue has become known as Myrdal's paradox. [Myrdal, 1944]

Since blacks would support their own private schools, public schools are the only issue here.

Various explanations have been advanced to resolve this paradox. A few seem to predominate. The first explanation came from Myrdal himgelf. He perceived that Americans felt they had a moral responsibility to educate all. He states that, "The American Creed showed itself strong enough not to allow the sacred principle of public education (for blacks) to succumb in the South." [Myrdal, 1944, p. 889]

A second explanation would be the "separate-but-equal" provision of the law established by the Plessy vg. Ferguson Case of 1896. Such a provision in the law was said to cause some school boards and local authorities to worry about legal action which might occur if public education were not provided to both blacks and whites alike. However, it appears that there was a lot of slack in the way the separate-but-equal doctrine was interpreted. So, whether the threat of legal action was large or not is debatable.

A third explanation, and one which may have the most merit, was advanced originally by Richard Freeman [1973] and further by Margo [1990]. They suggested that whites may have been willing to subsidize black schools with the hope of reaping the economic benefits of a bettereducated black labor force. A better education for blacks would, in turn, cause the productivity of capital owned by whites to increase.

Fishback [1989] also addressed the issue as to why whites would be willing to invest in black education. His study investigated coal companies and segregated schools in West Virginia in the early 1900's. The reason he used coal companies is because they were the major employers
in West Virginia at that time and they often faced very tight labor markets.


#### Abstract

With tight competitive labor markets, the coal companies had to give some incentive for workers to locate in their particular community. These incentives came in the form of higher wages and improved local public goods, such as education.


In addition to attracting a greater number of miners, the coal companies felt that improving education would attract more productive and more stable workers with families. With labor at a premium, low spending on the education of black children was also costly to the coal employer because it limited his ability to attract black workers, potentially leaving the company short of its optimal work force. Further the company could reap more benefits by extra spending on black education than on white education. Expenditures per pupil on white school greatly exceeded those on black schools elsewhere. Given diminishing marginal utility for education, another dollar spent on their child's education was likely to attract more black than white workers. [Fishback, 1989, pp. 314-315]

There is much literary support of Freeman's idea, but little empirical work dealing with this idea is evident in the literature. The statistical analyses done in chapters III and IV showed positive shocks in either expenditures or attendance (i.e., increases in educational inputs) would have significant positive effects on the value of assets (capital and property). This fact can be seen in the dynamic elasticity values for random shocks in either variable, but especially attendance. positive shocks to attendance caused large positive responses in asset values. This was found to be true in all three samples (white, black, and combined). However, the most significant result was with black attendance causing a dynamic elastic response in real assets of 3.04 .

The goal of this chapter is to provide a theoretical model which explains why there was an incentive (on the part of a white-dominated school system) to invest in blacks schools during an era of segregation and why increases in attendance would cause increases in property values. The next section develops a model which would support the empirical results obtained in chapter III and chapter IV.

## C. Theoretical Model

The framework for model building begins by employing Freeman's idea that white capitalists would be willing to invest in black education, provided that they benefitted economically. Freeman's idea can be formulated in a simple profit-maximizing model for a representative firm and a utility-maximizing model for a representative household, both of whom were involved in educational investment. The firm's investment would be through dollars spent on education. The household's investment would be through attendance. Such models would incorporate the idea of investing in human capital in the current period, with an expected return on the investment in a future time period.

The investigation will involve looking at the profit-maximizing firm's and utility-maximizing household's decisions in period one. firstorder conditions will be derived and then interpreted. Period two will be investigated in a similar manner.

## 1. Period one

a. The profit-maximizing firm The model selected for the firm is a two-period, profit-maximizing model in which the firm invests in
schooling in the first period. The firm then employs the educated workers and reaps the economic benefits of a better-educated labor force in the second period.

The empirical work done in chapters III and IV demonstrated that a one-time shock in human capital invegtment would increase property values. In this model, profits are investigated. The reason for investigating profits, rather than property values, is that firms are assumed to be the primary holders of land and capital. If their profits increase, they would be capitalized into property values because current land prices, $P_{L, 1,}$ will equal the present value of current and expected dividends from holding land.
$P_{L, 1}=\sum_{t}^{\infty}\left[\frac{1}{(1+r)}\right]^{t} \pi_{t}$

So, if skills acquired from education are firm-specific or locationspecific, an increment in human capital in one location would not be valued by other firms or other locations. If the increment is not observable to other firms or other locations, the market would not incorporate it into the market wage. The firm would appropriate the return on the human capital by paying wages below the marginal product. In turn, these profits would be capitalized into property values in the relevant county.

It is also likely that some of the private investment in education is determined by parental tastes. Nonpecuniary returns from, for example, more able or cultured children, will also influence how many years of schooling children receive or how many days per year children attend. If
parents' taste for education differ across counties, this will cause differences in attendance and human capital production across counties, even if children are receiving the same years of education. Unanticipated changes in parental tastes will cause unanticipated changes in human capital production in a given county that may not be observable in other counties. If labor markets clear at expected and not actual marginal products, firms in the counties with unexpectedly high attendance will be paying wages below realized marginal product.

In the first period, a firm would face the typical decisions of how much capital, $K$, to employ and how much uneducated labor, $H_{1}$, to employ. Capital and labor are the sole components in a constant-returns production function. The firm would also face competitive factor prices of $r$ and $w$ respectively. If a firm considers educational expenditures, the model gets a bit more complicated. A firm must add the per capita cost of education to its expenses and considers the future (period two) return on such expenses.

To incorporate educational expenditures into a profit-maximizing framework; the firm must consider the discounted returns to investing in education today relative to the dollar expenditure today. As with period one, a constant-returns production function is used for period two production and the production would include a human capital component reaulting from the education received in period one, as well as capital (assumed to be fixed from period one), and uneducated labor.

It was often said that an education made blacks even more mobile. Without an education, they remained where they were. However, an education opened up many more career opportunities within a given
community as well as in other communities. Margo [1990, pp. 110-111] found that in 1900, about $12.3 \%$ of educated adult males tended to migrate. Whereas, only about $3.9 \%$ of uneducated adult males did. The numbers were quite comparable for 1940. The percentage of adult males who migrated with 0 to 1 year of education was 8.7. Adult males with 9 to 12 years of education migrated approximately 29.8 percent of the time. Therefore, it would not be unrealistic to assume imperfect mobility of labor for this model, especially since the target group is grade school educated labor. The idea that labor was not perfectly mobile would back the assumption that labor markets would clear at the expected marginal product rather than actual marginal product.

Migration theory gtates that a person would only migrate to another area if the economic benefits from doing so exceeded the economic costs. [Sjaastad, 1962] Black migration was often due to higher wage incentives. Margo presented evidence to support such a migration theory. He showed that black males in 1939 who migrated received approximately 42.5 (0-4 years of schooling) to 46.4 (5-8 years of schooling) percent higher annual earnings than did those who did not migrate. Also, those with 5 to 8 years of schooling had a higher migration rate than did those with 0 to 4 years. [Margo, 1990, pp. 11.8-119]

Even though imperfect mobility is assumed, some incentive from the community (firms) had to be offered to the educated blacks to keep them from exercising any newly found mobility due to the education they received. This incentive is incorporated into the model in the form of a second-period "educational wage." This is a competitive market wage for
educated labor, which is higher than the market wage paid to uneducated laborers.

So, the model for period one profit maximization incorporates the idea of a firm maximizing profits in period one with a constant-returns production function having inputs of capital and uneducated labor, expenses due to capital and labor usage, and expenses due to educational investment. Also included in the period one profit maximization would be the discounted expected returns to education in period two. The discounted expected returns part of the model uses a constant-returns production function, incorporating a human capital component. The model further includes expenses due to capital and uneducated labor, and a special wage paid to educated labor.

The firm must determine the optimal level of capital in period one, the optimal amounts of uneducated labor in period one and period two, and the educational investment they are willing to make as well as the number of educated laborers they are willing to hire in period two (or the total number for whom they are willing to pay out educational expenditures in period one). The firm asaumes that attendance is independent from their decision and that the number of children to be educated in period one will be the number of educated laborers employed in period 2. The rental rate of capital and the uneducated wage are determined by the competitive market.

In the second period, the decision for the firm is more simplistic. The firm needs only to determine the optimal level of uneducated labor to hire. The firm assumes that attendance, their investment in education, the number of educated laborers, the educational wage, the rental rate of
capital, and the uneducated wage are predetermined or given by the market. No inflation is assumed between periods one and two.
b. The firm model The firm will maximize profits in period one according to the model laid out in equation 5.2. The variables used in the equation are described in Table 5.1.
$\pi_{1}=p f\left(K, H_{1}\right)-r K-w H_{1}-E_{F} N+\beta\left(p g\left(K, H_{2}, h\left(A, E_{F}\right) N\right)-r K\right.$

$$
\begin{equation*}
\left.-w_{2}-w_{e} h N\right] \tag{5.2}
\end{equation*}
$$

The production functions ( $f$ and $g$ ) consist of capital and labor components. Capital, once selected in period one, is assumed to remain constant through period two. In $g$, the second-period production function, educated labor is taken into account in the form of $h N$. $N$ is the number of educated laborers and $h$ is the amount of human capital per laborer. Variable $h$ depends on both the attendance level and the firm's per capita educational expenditure level. hN gives the total amount of human capital which can be added into the production function due to a better-educated labor force.
$E_{F}$ is the per capita educational expenditure by the firm. $E_{F} N$ is the total cost of education that the firm pays out. Both $E_{F}$ and $N$ are choice variables for the firm.

The first part of the equation deals with the total revenues and total costs faced by the firm in period one. The second part of the equation is the present value of expected profits in period two, when the educational component of the labor force takes effect.

Table 5.1. Variable definitions

| Variable | Definition |
| :---: | :---: |
| $\pi_{1}$ | firm's discounted profits (period one and period two) in period one |
| $\pi_{2}$ | firm's profits in period two |
| p | price of output |
| f | production function in period one |
| $g$ | production function in period two |
| $r$ | rental rate of capital in periods one and two |
| w | market wage in periods one and two (no inflation) |
| $w_{e}$ | educational wage |
| $\bar{w}_{e}$ | expected educational wage |
| K | amount of capital used in periods one and two |
| $\mathrm{H}_{1}$ | amount of uneducated labor used in period one |
| $\mathrm{H}_{2}$ | amount of uneducated labor used in period two |
| h | amount of human capital per educated person |
| $E_{F}$ | firm's educational expenditures |
| A | level of attendance |
| $A^{e}$ | expected level of attendance |
| N | number educated in period one, number of educated workers hired in period two (first model presented); number educated in period one (second model presented) |
| $\mathrm{N}_{2}$ | number of educated workers hired in period two |
| $\beta$ | discount factor |

Firms will only invest in education now if they perceive economic benefits resulting from such educational expenditures in the future. This is the purpose of the second term. The firm expects to pay out the value of the marginal product of human capital due to people attending school, $w_{e}$, times the amount of human capital per educated laborer, $h$, times the number educated in period one, $N$.

The wage going to educated laborers (equation 5.2) is equal to the value of the marginal product of human capital times the percentage of human capital due to people attending school.
$w_{e}=\frac{h_{A} A}{h} \mathrm{pg}_{\mathrm{h}}$

It is the $w_{e}$ term which is the pre-contracted wage that the firm agrees to pay to educational returns per unit of human capital. People know before period two that this is the wage educated laborers will receive. In the model, both $w_{e}$ and $w$ are assumed to equalize across counties.

The production functions, $f$ and $g$, are assumed to be linearly homogeneous and twice differentiable with $f_{K}, f_{H_{1}}, g_{K} ; g_{H_{2}}, g_{h}>0$ and $\mathrm{f}_{\mathrm{KK}}, \mathrm{f}_{\mathrm{H}_{1} \mathrm{H}_{1}}, \mathrm{~g}_{\mathrm{KK}}, \mathrm{g}_{\mathrm{H}_{2} \mathrm{H}_{2}}, \mathrm{~g}_{\mathrm{hh}}<0$. The function $\mathrm{h}\left(\mathrm{A}, \mathrm{E}_{\mathrm{F}}\right)$ is also assumed to be linearly homogeneous.
c. The firm's first-order conditions In the first period, $p, r$, $W$ and $B$ are assumed to be exogenous. Therefore, the first-order conditions are taken with respect to $K, H_{1}, H_{2}, E_{F}$, and $N$. In optimizing it is assumed that there is no inflation across time periods. The profitmaximizing firm would have the following first-order conditions for period one.

$$
\begin{align*}
& \frac{\partial \pi_{1}}{\partial K}=p f_{K}-r+B\left(p g_{K}-r\right)=0  \tag{5.4}\\
& \frac{\partial \pi_{1}}{\partial \mathrm{H}_{1}}=\mathrm{pf}_{\mathrm{H}_{1}}-\mathrm{w}=0  \tag{5.5}\\
& \frac{\partial \pi_{1}}{\partial \mathrm{H}_{2}}=B\left(\mathrm{pg}_{\mathrm{H}_{2}}-w\right)=0  \tag{5.6}\\
& \frac{\partial \pi_{1}}{\partial E_{F}}=-N+\beta p g_{h} h_{E_{F}} N-\beta p h_{A E_{F}} A g_{h} N-\beta p h_{A} A g_{h h^{\prime}} \mathrm{E}_{F} N^{2}=0  \tag{5.7}\\
& \frac{\partial \pi_{1}}{\partial N}=-E_{F}+\beta \mathrm{pg}_{\mathrm{h}} \mathrm{~h}-\beta \mathrm{ph}_{\mathrm{A}} \mathrm{Ag}_{\mathrm{h}} \mathrm{hN}-\beta \mathrm{ph}_{\mathrm{A}} A g_{\mathrm{h}}=0 \tag{5.8}
\end{align*}
$$

d. Interpretation of the first-order conditions The first-order conditions can be summarized in the following ways. Condition 1 (equation 5.4) states that the sum of the values of the marginal product of capital, both present (period one) and discounted future (period two), equals the present rental rate of capital (period one) plus the discounted future rental rate of capital (period two). This is expressed in equation 5.9.

$$
\begin{equation*}
p\left(f_{K}+B g_{K}\right)=r(1+\beta) \tag{5.8}
\end{equation*}
$$

Condition 2 (equation 5.5) implies that the value of the marginal product of uneducated labor in period one equals the uneducated wage in period one. In other words, the firm should continue to hire labor up to the point at which the value of the marginal product due to labor is equal to the competitive market wage.
$p f_{H_{1}}=w$

Condition 3 (equation 5.6) is similar to condition 2 in that the value of the marginal product of uneducated labor in period two is equal to the uneducated wage. Given the model's assumption of no inflation, the uneducated wage across periods is the same across periods.
$\mathrm{pg}_{\mathrm{H}_{2}}=\mathrm{w}$

The fourth first order condition (equation 5.7) states that a firm would want to increase $E_{F}$ up to the point at which the last dollar of educational expenditures is equal to the discounted net value of the marginal product of educational expenditures.

$$
\begin{equation*}
1=\beta p\left[g_{h} h_{E_{F}}-\left(h_{A E_{F}} A g_{h}+N h_{A} A g_{h h^{\prime}} h_{E_{F}}\right)\right] \tag{5.12}
\end{equation*}
$$

From the final first-order condition it is concluded that it is beneficial to allow atudents to enroll up to the point at which the cost per student $\left(E_{F}\right)$ is equal to the discounted value of the marginal product of educated labor net of cost.

$$
\begin{equation*}
E_{F}=\beta p\left(g_{h} h-h_{A} A g_{h h} h N-h_{A} A g_{h}\right) \tag{5.13}
\end{equation*}
$$

With all of these first-order conditions considered, a reduced form for $E_{F}$ can be defined. This reduced form demonstrates that the expenditures per pupil are a function of prices, uneducated as well as the
expected educated wage, the expected level of attendance (the household's investment in education), and the discount factor.

$$
\begin{equation*}
E_{F}=E_{F}\left\langle D, w, \bar{w}_{e}, A^{e}, B\right\rangle \tag{5.14}
\end{equation*}
$$

e. A second firm model A slightly modified version of the above model is useful to derive more explicit predictions. The above model assumed that the number of children educated in period one would be exactly to the number of educated laborers hired in period two. This model makes the more reasonable assumption that the number educated in period one, $N$, is exogenous to the firm and may differ from the number hired in the second period, $N_{2}$. A fixed educational wage is also assumed in this model. The $w_{e}$ variable is now the wage to educated labor, rather than the wage to a unit of human capital as was previously the case. Attendance is still treated as a decision made by households and therefore exogenous to the firm.
$\pi_{1}=\mathrm{pf}\left(\mathrm{K}, \mathrm{H}_{1}\right)-\mathrm{rK}-\mathrm{wH}_{1}-\mathrm{E}_{\mathrm{F}} \mathrm{N}+\mathrm{B}\left(\mathrm{pg}\left(\mathrm{K}, \mathrm{H}_{2}, \mathrm{~h}\left(\mathrm{~A}, \mathrm{E}_{\mathrm{F}}\right) \mathrm{N}_{2}\right)-\mathrm{rK}\right.$

$$
\begin{equation*}
\left.-\mathrm{wH}_{2}-\mathrm{w}_{\mathrm{e}} \mathrm{~N}_{2}\right\} \tag{5.15}
\end{equation*}
$$

f. First-order conditions for the second firm model The
following first order conditions result when profits are maximized.

$$
\begin{equation*}
\frac{\partial \pi_{1}}{\partial \mathrm{~K}}=\mathrm{p} f_{\mathrm{K}}-\mathbf{r}+\beta\left(\mathrm{pg} g_{K}-r\right)=0 \tag{5.16}
\end{equation*}
$$

$$
\begin{align*}
& \frac{\partial \pi_{1}}{\partial \mathrm{H}_{1}}=\mathrm{pf} \mathrm{H}_{1}-\mathrm{w}=0  \tag{5.17}\\
& \frac{\partial \pi_{1}}{\partial \mathrm{H}_{2}}=\beta\left(\mathrm{pg}_{\mathrm{H}_{2}}-\mathrm{w}\right)=0  \tag{5.18}\\
& \frac{\partial \pi_{1}}{\partial \mathrm{E}_{\mathrm{F}}}=-\mathrm{N}+\beta \mathrm{pg} \mathrm{~h}_{\mathrm{E}_{\mathrm{F}}} \mathrm{~N}_{2}=0  \tag{5.19}\\
& \frac{\partial \pi_{1}}{\partial \mathrm{~N}_{2}}=\beta \mathrm{pg}_{\mathrm{h}} \mathrm{~h}-\beta{w_{e}}=0 \tag{5.20}
\end{align*}
$$

The first three first-order conditions retain the same interpretation as before. Equation 5.19 would state that the cost of increasing school quality should be set equal to the discounted value of the marginal product to the firm due to increased educational expenditures times the number who will be hired in period two. The last first-order conditions states that the educational wage should be set equal to the value of the marginal product of human capital times the amount of human capital per laborer.

In this model it is of interest to determine the relationship between expenditures per pupil and the educational wage, between the number of children attending school and the expenditures per pupil, and between the educational wage and the number of educated workers the firm is willing to hire in period two. If one were to take the total derivative of equation 5.19, one could derive the following comparative static result.

$$
\begin{equation*}
\frac{d E_{F}}{d N}=\frac{1}{\beta p\left[g_{h h^{N}}{ }^{2} h_{E_{F}}+g_{h} N_{2} h_{E_{F} E_{F}}\right]}<0 \tag{5.21}
\end{equation*}
$$

This says that if the current number of children attending school were to rise, the firm would respond by decreasing its educational expenditure per pupil. This is consistent with the quantity/quality model of human capital investment. For school districts, the cost of increasing school inputs by one dollar per pupil is the number of pupils in the district.

Taking the total derivative of equation 5.20 , yields a comparative static for the relationship between the educational wage and the firm's expenditures per pupil.
$\frac{d E_{F}}{d w_{e}}=\frac{1}{p g_{h h^{\prime}} h_{E_{F}} N_{2} h+p g_{h} h_{E_{F}}} \ll 0$

The first term in the denominator is negative and the second term is positive. Therefore, increasing the educational wage has an ambiguous effect on educational expenditures per pupil. This means that the extent of wage discrimination against blacks has an uncertain effect on the incentive for firms to invest in black human capital.

The total derivative of equation 5.20 , would also yield the following.
$\frac{d N_{2}}{d w_{e}}=\frac{1}{h^{2} p g_{h h}}<0$

This states that if the educated wage were increased, the firm would unambiguously decrease the number of educated workers it would be willing to hire in period two.
e. The utility-maximizing household At the same time the firm is investing in education in order to maximize profits, the household is
investing in education to maximize utility. As with the firm, a household would have to consider two distinct time periods. A representative household, in a given community, is assumed to consist of one adult laborer who works full time, earning income $Y_{1}$ in period one and $Y_{2}$ in period two. Further, the household has a child who's time can be divided between working or attending school. It is assumed that each child who attends school in period one expects to receive the educational wage, wer in period two upon completion of schooling.

The cost of education to the household takes the form of the foregone wages the child could have earned working at the competitive unskilled or uneducated market wage. The household knows that the child will receive the pre-contracted wage in period two if its child attends school in period one.

The household maximizes utility with three components entering its utility function. These components are consumption in period one, $C_{1}$, consumption in period two, $C_{2}$, and the amount of human capital per child, h. As with the typical constrained utility maximization problem, the household faces a budget constraint. The budget constraint is such that the incomes earned by the adult and the child in period one plus the discounted earnings of both in period two must equal the spending in period one plus the discounted spending in period two.
f. The household model The household's constrained utility maximization problem in period one would be as follows. The variable descriptions are listed in Table 5.2.

$$
\begin{equation*}
\mathscr{L}_{1}=U\left(C_{1}, C_{2}, h\left(A, E_{F}\right) ; \tau\right)+\lambda\left(Y_{1}+w(1-A)-p C_{1}+B\left(Y_{2}+w_{e} h-p C_{2}\right)\right) \tag{5.24}
\end{equation*}
$$

Table 5.2. Variable definitions for the household model

| Variable | Variable definition |
| :---: | :---: |
| $\mathbb{L}_{1}$ | household's constrained utility-maximization in period one |
| $\mathscr{L}_{2}$ | household's constrained utility-maximization in period two |
| U | household's utility function (homogeneous of degree zerol |
| $C_{1}$ | consumption in period one |
| $\mathrm{C}_{2}$ | consumption in period two |
| h | human capital per capita due to education |
| A | attendance level |
| $E_{F}$ | educational expenditures per pupil by firm |
| $\mathrm{EFF}_{F}{ }^{\text {e }}$ | expected educational expenditures per pupil by firm |
| $\mathrm{Y}_{1}$ | adult income in period one |
| $Y_{2}$ | adult income in period two |
| w | wage for uneducated laborers |
| $p$ | price of consumption in periods one and two (no inflation) |
| ${ }^{W} e$ | educational wage |
| $\bar{\omega}_{e}$ | expected educational wage |
| $\tau$ | tastes |
| $\lambda$ | marginal utility of income |
| B | discount factor |

g. The household's first-order conditions Equations 5.25 through 5.28 are the resulting first-order conditions which result from the household's constrained utility maximization.

$$
\begin{align*}
& \frac{\partial \mathscr{L}_{1}}{\partial C_{1}}=U_{C_{1}}-\lambda p=0  \tag{5.25}\\
& \frac{\partial \mathscr{Q}_{1}}{\partial C_{2}}=U_{C_{2}}-\lambda B p=0  \tag{5.26}\\
& \frac{\partial \mathscr{Q}_{1}}{\partial A}=U_{h} h_{A}-\lambda w+\lambda B p h_{A} A g_{h h^{\prime}} h_{A}+\lambda B p_{A} g_{h}+\lambda B p h_{A A} A g_{h}=0  \tag{5.27}\\
& \frac{\partial \mathscr{L}_{1}}{\partial \lambda}=Y_{1}+w(1-A)-p C_{1}+B\left(Y_{2}+w_{e} h-p C_{2}\right)=0 \tag{5.28}
\end{align*}
$$

h. Interpretation of the first-order conditions Combining equations 5.25 and 5.26 , a typical result can be obtained. Consumption will be allocated across periods such that the ratio of the marginal utilities, $U_{C_{1}} / U_{C_{2}}$, is equal to the inverse of the discount rate, $1 / \beta$. The third first-order condition (equation 5.27), states that households should have their children attend school up to the point at which the marginal utility associated with attendance is equal to the net value of the marginal product due to attending school. The following reduced-form expression for attendance can be derived from the first-order conditions.
$A=A\left(p, w, Y_{1}, Y_{2}, E_{F}^{e}, \bar{w}_{e}, B, \tau\right)$

## 2. Period Two

Period two is the time horizon in which the children who were educated in period one enter the labor force as educated laborers. Therefore, they must be incorporated into the production function. Educated laborers receive an educational wage as a reward for their attendance. The educational wage was pre-contracted in period one and is considered to be exogenous in period two.
a. The firm's profit-maximizing model The firm's profit maximization is quite simple in period two. This model for period two would be consistent with either of the period-one firm models presented earlier. If the first model is assumed, the only choice variable is the amount of uneducated labor to hire. Capital, $K$, is assumed to be fixed at the optimal level selected in period one. The level of human capital, the market wages, and the rental rate of capital are also assumed to be exogenous. If the second model is assumed, the number of educated workers to hire also becomes a decision for the firm in period two.

The firm's profit-maximization model for period two is expressed in equation 5.30.

$$
\begin{equation*}
\pi_{2}=\operatorname{pg}\left(K, h\left(A, E_{F}\right) N, H_{2}\right)-w_{e} h N-r K-w H_{2} \tag{5.30}
\end{equation*}
$$

The variables used in the profit equation are the same as those in period one. For the second model, $N$ would be replaced with $N_{2}$ in equation 5.30. A description of the variables used can be found in Table 5.1. Further explanation of the terms can also be found under the period one section dealing with the firm.

Because all else is assumed to be exogenous, the firm's only decision variable in period two is the amount of uneducated labor, $H_{2}$, to hire (for the firat model). When the firm optimizes with regard to $H_{2}$, the following first-order condition results.

$$
\begin{equation*}
\frac{\partial \pi_{2}}{\partial \mathrm{H}_{2}}=\mathrm{pg}_{\mathrm{H}_{2}}-\mathrm{w}=0 \tag{5.31}
\end{equation*}
$$

This condition implies that uneducated workers will be hired up to the point at which the value of the marginal product is equal to the market wage in period two for uneducated labor.

If the second model is considered another first-order condition becomes relevant.

$$
\begin{equation*}
\frac{\partial \pi_{2}}{\partial N_{2}}=p g_{h} h-w_{e}=0 \tag{5.32}
\end{equation*}
$$

This condition states that educated labor should be hired in period two up to the point at which the value of the marginal product of human capital is equal to the educational wage.
b. The household's utility maximizing model In period two, the household's decision is quite trivial. The only choice the household has to make in the second period is how much to consume given the budget constraint. The household's model for period two is expressed in equation 5.33.

$$
\begin{equation*}
\mathscr{L}_{2}=U\left(C_{2}\right)+\lambda\left(Y_{2}+w_{e} h-p C_{2}\right) \tag{5.33}
\end{equation*}
$$

Optimization would occur with regard to $C_{2}$ and $\lambda$ only. All else is assumed to be constant in period two. The resulting first-order conditions when optimizing are expressed in equations 5.34 and 5.35 .

$$
\begin{align*}
& \frac{\partial \mathscr{L}_{2}}{\partial \mathrm{C}_{2}}=\mathrm{U}_{\mathrm{C}_{2}}-\mathrm{p}=0  \tag{5.34}\\
& \frac{\partial \mathscr{L}_{2}}{\partial \lambda}=\mathrm{Y}_{2}+\mathrm{w}_{\mathrm{e}} \mathrm{~h}-\mathrm{pC}_{2}=0 \tag{5.35}
\end{align*}
$$

For utility maximization, the marginal utility of consumption in the second period must be equal to the price of consumption in that period. Also, the income from the parents and the educated child must equal the total amount of consumption.
D. The Incentive to Invest in Education

Part of the goal of this chapter was to prove theoretically that incentive did exist to invest in both black and white schools alike. The answer to this question lies in the idea that firms must have benefitted economically for such investment. The fact that the first-order conditions for the firm show that $E_{F}$ must be positive for profit maximization demonstrates that economic benefit did exist to investing in educational expenditures. The pecuniary returns to a better-educated labor force were incentive enough to invest in both black and white schools.

The other part of the goal of this chapter was to answer the question as to why investment in education would cause property values to rise. If the actual level of human capital in period two exceeded the expected
level, then firms should reap the benefits of the better-educated labor force in that their profits would rise. If their profits rise, these profits would then be capitalized into property values. This was the possible argument laid out in words at the beginning of this chapter. However, to this point, this issue has not been addressed in any type of formal proof. A theoretical demonstration of this possibility follows.

## 1. A one-time shock in attendance

A situation such as stated above could arise if there were a onetime, unanticipated unit shock in attendance, all else constant. Given that today's attendance would be correlated with past attendance plus an error term, an unanticipated shock in attendance could result only from a one-time unit shock in a component of attendance which is exclusive to attendance. Of all the factors affecting attendance, the household's taste for education would be the only factor exclusive to it. A change in a household's taste pattern for education could generate such an unanticipated shock.

This type of unanticipated shock would not be capable of being captured by the market. Therefore, wages could not reflect the shock and would leave firms reaping the full economic benefit in terms of increased profits. Tiebout would say that property values should not change due to investment in public goods; the market should incorporate it all and property values should be unchanged. However, if there is private investment (unanticipated attendance) in a public good which the market cannot observe, the profits would then be capitalized into property values.

## 2. A theoretical proof

The theoretical proof that such a result would occur is as follows. This theoretical proof uses the first version of the firm's model. If the production function exhibits constant returns to scale, then using Euler's Theorem, the following can be said to be true.
$g=g_{K} K+g_{h}\left(h_{A} A+h_{E_{F}} E_{F}\right) N+g_{H_{2}} H_{2}$

Rearranging and solving for $g_{\mathrm{H}_{2}}$ equation 5.37 results.
$g_{H_{2}}=\frac{g-g_{K} K-g_{h}\left(h_{A} A+h_{E_{F}}{ }^{\mathrm{E}}{ }^{\mathrm{F}}\right) \mathrm{N}}{\mathrm{H}_{2}}$

Plugging $g_{H_{2}}$ into the first-order condition, a reduced-form expression for optimal level of $\mathrm{H}_{2}, \mathrm{H}_{2}{ }^{*}$, can be found.
$H_{2}{ }^{*}=f\left(A, E_{F}, K, N, w\right)$

If $\mathrm{H}_{2}{ }^{*}$ were'plugged back into the equation for $\pi_{2}$, the optimal level of profits could be calculated.

The question now is what if the actual level of attendance exceeds the level which was expected, all else constant? Such a condition would arise if there were a shock in the attendance level. Do the profits in period two rise? The answer to this is yes. Again, this can be shown with a few mathematical steps.

Plugging $\mathrm{H}_{2}{ }^{*}$ into the $\pi_{2}$ equation, the model becomes equation 5.39.

$$
\begin{equation*}
\pi_{2}=p g\left(K, H_{2}^{*}, h\left(A, E_{F}\right) N\right)-w_{e} h N-r K-\omega_{2}{ }^{*} \tag{5.39}
\end{equation*}
$$

Taking the derivative of $\pi_{2}$ with respect to $A$ will determine whether profite rise, fall, or remain unchanged due to the actual level of attendance exceeding the expected level. Taking the derivative, the following is obtained.
$\frac{\partial \pi_{2}}{\partial \mathrm{~A}}=\mathrm{pg}_{\mathrm{H}_{2}} \frac{\partial \mathrm{H}_{2}{ }^{*}}{\partial \mathrm{~A}}+\mathrm{pg}_{\mathrm{h}} \mathrm{h}_{\mathrm{A}} \mathrm{N}-\mathrm{w}-\frac{\partial \mathrm{H}_{2}{ }^{*}}{\partial \mathrm{~A}}$

To simplify the right-hand side, one can use the first-order condition (equation 5.11), $\omega=\mathrm{pg}_{\mathrm{H}_{2}}$. When this is plugged into the derivative, the result is that profits in period two would unambiguously rise due to an unanticipated shock in attendance. Equation 5.41 shows this result.

$$
\begin{equation*}
\frac{\partial \pi_{2}^{*}}{\partial A}=\operatorname{pg}_{h} h_{A} N>0 \tag{5.41}
\end{equation*}
$$

This result proves that if households take advantage of the education provided more than was anticipated by firms, the firm reaps pure economic profits. This result has some intuitive appeal in that the only place a shock in human capital would come into play in the profit-maximizing problem would be the production function. The level of human capital determines the educational wage, but the educational wage is precontracted and would not change in the event of a shock in attendance. Therefore, the firm reaps the rewards in terms of additional revenues collected and pays no more in wages than was pre-contracted.

## E. Conclusions

The goal of this chapter was to present a theoretical model encompassing causal relationships among variables used in the VAR analysis. In particular, the theoretical model was to demonstrate why their was incentive by whites to invest in both black and white education alike and why property values might rise due to investment in education. The goal was accomplished, such a theoretical model was presented. The model demonstrated that there was incentive to invest. Profit maximization showed that expenditures per pupil should be positive. Pecuniary returns to a better-educated labor force were the motivating factor. Further it was shown that if there were unanticipated investments in education due to consumer tastes, then firms reaped the economic profits and the fact that these profits would be capitalized into property values.

The next chapter uses the findings of the VAR and the reduced forms for educational expenditures and attendance derived in this chapter to formulate a model of investment in education. This model is then tested using more "traditional" techniques of regression analysis.

## VI. EDUCATIONAL INVESTMENT: A FINAL EMPIRICAL ANALYSIS

A. Introduction

To this point, the issue of discrimination has not been addressed explicitly. Taste for discrimination is very hard to quantify into a variable which can be used in regression analysis. This chapter attempts to incorporate characteristics of the public school system and the private school system which have already been addressed, and to further incorporate a taste for discrimination into one final empirical analysis of the Maryland school districts to better explain why there was investment in education during an era of segregation. By incorporating a taste for discrimination into the analysis, the picture is completed.

The literature has already been reviewed for both investment in public schools (chapter II) and investment in private schools (chapter IV) and reviewed for the issue of race and how race affects the invegtment in education (chapter V). From work discussed in these literature reviews and from the theoretical derivations in chapter $V$ a model is developed which incorporates the desired components mentioned above. The next section explains the components to be included in the analysis. The third section discusses the empirical approach that was taken. The empirical findings are presented in the fourth section and the last section offers conclusions.

## B. The Model

For the this empirical investigation, the model used to capture public and private school characteristics as well as a taste for
discrimination is a static model which leads to a reduced form for real educational expenditures per pupil much like that derived in chapter $V$. Such a reduced form describes the "firm'g" investment in education. From chapter III it was determined that attendance in the public schools, the birth rate per thousand in the population, and real assets were significant in determining real expenditures per pupil. The analysis in chapter IV confirmed the significance of attendance in the public schools and real assets in determining real expenditures per pupil. It further indicated that total private school enrollment was significant in causing real expenditures (with the exception of the black sample).

To quantify taste for discrimination a change in private school enrollment variable was used. This variable was created by employing the idea of revealed preference. If a taste for discrimination did exist during an era of segregated schooling, it would be hard to pinpoint this taste. However, such a taste for discrimination might become more revealed after schools were forced to become integrated in that those possessing a taste for discrimination might send their children to private schools. Measuring the change in private school enrollments from 1955 to 1960 in a given county relative to the populations of the counties at those particular times seemed a logical way to quantify a taste for discrimination. If a taste for discrimination existed during the segregated era, it would be revealed in terms of "white flight" to private schools when public schools became integrated.

Therefore, combining the theory of chapter $V$ and the empirical results of chapters III and IV, the following reduced form for educational investment was derived. Most studies found in the literature dealing with
the public-private school choice and discrimination include a percentage of blacks in the community variable (or a percentage of whites variable). Inclusion of such a variable did not seem appropriate for this investigation given that the time period being studied involved segregated schools. (The studies where such a variable was included involved time periods where integrated schools existed.) Table 6.1 describes the variables in the reduced-form expression.

REXPP $=f($ RASSPP, TPRIVTCH, NCHTPOP, MDWAGE, ENR5560, TREND)

$$
\begin{array}{r}
\operatorname{REXPP}_{i, t}=\alpha+\beta_{1} \operatorname{RASSPP}_{i, t}+\beta_{2} \mathrm{TPRIVTCH}_{i, t}+\beta_{3} \mathrm{NCHTPOP}_{i, t}+ \\
\beta_{4} \text { MDWAGE }_{i, t}+\beta_{5}{\mathrm{ENR} 5560_{i, t}}+\beta_{6} \text { TREND }_{i, t}+\epsilon_{i, t} \\
i=1, \ldots, n ; t=1, \ldots, T \tag{6.2}
\end{array}
$$

An increase in the total number of children enrolled in private schools relative to the total number of children in the population would be expected to cause an increase in real expenditures in the public school. This expectation is based on the VAR results in chapter IV and the fact that previous empirical work shows that communities tend to increase school quality (in terms of expenditures per pupil) when they are losing their enrollments to private schools. By increasing the per pupil expenditure level, a community attempts to gain its enrollments back. Another explanation for this kind of result was put forth by Erekson [1982]. He claimed that the scaling effect might dominate the support effect when there are low levels of private school enrollment. There will
be less students in the public schools, but with almost the same amount of tax support.

Real assets, if considered a measure of wealth would be expected to have a positive coefficient. A positive sign on this coefficient would indicate that the more wealth consumers have, the more they are willing to invest in education. As with the private school enrollments regression, the predicted sign on MDWAGE was uncertain.

With any type of demand function, the regression should include a price variable. However, because expenditures are used as the endogenous variable, it is not appropriate to use measures such as teachers' salaries as measures of the price of education. These measures would be too highly correlated to educational expenditures to give consistent results. Therefore, the quantity-quality model was drawn upon for an answer to this problem. This model states that there is a trade-off between the quantity of children and the quality per child. In this light, the number of children in the population relative to the total population can be thought of as a "price" variable. The price of raising expenditures per pupil by one dollar is the number of children in the system. Such an expectation is also consistent with the theory derived in the previous chapter.

If a taste for discrimination were in existence during the segregated era, one would anticipate that there would be "white flight" when educational segregation ended. In other words, one would expect that private school enrollments would increase significantly upon the end of segregation. One would anticipate the coefficient on this variable, ENR5560, to enter the equation for the black sample with a negative sign. The negative sign would indicate that a taste for discrimination did exist
and this taste for discrimination would cause the expenditures per pupil in the black school systems to decrease.

The empirical analysis in chapter IV showed that private school enrollments were quite exogenous in nature relative to the other variables being considered in that particular analysis. However, because the empirical work discussed in the literature review (chapter IV) indicated that there were other factors affecting private school enrollments, the model for this investigation was expanded to further include a reduced form for private school enrollments. Private school enrollments can be expressed as a function of income, the cost of attending a private school, tastes, and a measure of wealth. This reduced form is expressed in equations 6.3 and 6.4 and the variable definitions can be found in Table 6.1.

```
TPRIVTCH = f(RASSPP, NPRIV, PCTCATH, MDWAGE, TREND)
```

$$
\begin{align*}
\text { TPRIVTCH }_{i, t}=\gamma & \gamma \delta_{1} \text { RASSPP }_{i, t}+\delta_{2} \text { NPRIV }_{i, t}+\delta_{3} \text { PCTCATH }_{i, t}+ \\
& \delta_{4} \text { MDWAGE }_{i, t}+\delta_{5} \text { PREND }_{i, t}+\mu_{i, t} \quad i=1, \ldots, N ; \quad t=1, \ldots, T \tag{6.4}
\end{align*}
$$

It would be anticipated that total private school enrollments would rise if a person's wealth were to increase or if the availability of private schools would increase. Great density or availability of schools should respond like a decrease in the price of private schools and cause enrollments to rise. Further one would predict that the greater the Catholic population in any given county, the greater would be the enrollment in private schools. The proxy for Maryland manufacturing wages

Table 6.1. Variable definitions

| Variable | Definition |
| :--- | :--- |
| REXPP |  |
| RASSPP | $\begin{array}{l}\text { total current expenses (in real terms) per pupil belonging }\end{array}$ |
| total assessment taxable at full rate (in real terms) per |  |
| person in the total population (county) |  |$]$| total number of children (both black and white) in the |
| :--- |
| population (county) enrolled in private schools relative to |
| the total number of children (both black and white) in the |
| population (county) |

was the variable where there was some uncertainty as to what sign the coefficient should have. If the wage acted like income in the equation, private school enrollment would rise if it were increased. However, if the wage was considered to be the cost of education (foregone opportunity), then the coefficient would be negative.

If real assets are a basis for taxation in a given community, and the primary purpose of taxation is for the provision of educational services, then real assets may function as a cost in the private school enrollment equation rather than a wealth variable. The idea of opportunity cost is involved again. If a consumer's real assets were to rise, one would expect that real expenditures on public schools would rise as a result. The opportunity cost of sending children to a private school would rise if the quality of the public schools increased (greater real expenditures) and decrease private school enrollments as a result.

## C. The Data

The data set used is a cross-sectional time series with 28 years of data for 23 white school systems and 22 black school systems. The data concentrate on elementary schools, covering grades 1 through 8 . The real expenditures (REXPPA), real assets (RASSPP)., total number of children enrolled in private schools (TPRIVTCH), total number of private schools (TPRIV), and the change in enrollment from 1955 to 1966 (ENR5560) data were all taken from the Annual Reports of the State of Maryland Board of Education. The population figures used to calculate the number of children relative to the population (NCHTPOP) and the denominators of the RASSPP and the TPRIVTCH variables were taken from an unpublished vital


#### Abstract

statistics table received from officials of the State of Maryland Board of Education. The employment and payroll index numbers of Maryland manufacturing industries used to calculate the wage proxy, MDWAGE, were taken from the Reports of the Commissioner of Labor and Statistics of Maryland. The percentage of Catholics in the population, PCTCATH, data was taken from the U.S. Department of Commerce, Bureau of the Census. Religious Bodies, Summary and Detailed Tables (1926 and 1936), and from Churches and Church Membership in the United States: an Enumeration and Analysis by Counties, States, and Regions, 1956-1958. Sample statistics are presented in Table 6.2. TREND, a time trend variable, was also included to capture any unmeasured characteristics of the county that change over time.


## D. Empirical Results

## 1. Regression procedure

A two-stage least squares approach was applied to reduced-form equations. Such an approach was taken because of the use of total private school enrollments in the real expenditure equation. If oLS were applied to the reduced form for real expenditures, inconsistent estimates of the coefficients on the variables would result due to the fact that all of the regressors are not exogenous variables. Problems arise because total private school enrollment is too highly correlated with the error term in the real expenditure equation, $\epsilon$. Two-stage least squares is a solution to this type of problem.

With two-stage least squares, an estimate for total private school enrollment is derived by regresaing total private school enrollment on

Table 6.2. Sample statistics

| Variable | Mean | Standard deviation |
| :---: | :---: | :---: |
| White sample: |  |  |
| REXPP | 106.6946 | 31.4125 |
| RASSPP | 1.4844 | 0.4759 |
| TPRIVTCH | 0.0819 | 0.1055 |
| NCHTPOP | 0.1094 | 0.0281 |
| MDWAGE | 1.4365 | 0.4544 |
| ENR5560 | 0.0199 | 0.0268 |
| NPRIV | 6.3820 | 9.7170 |
| PCTCATH | 0.0949 | 0.1354 |
| Black sample: |  |  |
| REXPP | 78.8544 | 40.5243 |
| RASSPP | 1.4917 | 0.4827 |
| TPRIVTCH | 0.0833 | 0.1063 |
| NCHTPOP | 0.0349 | 0.0253 |
| MDWAGE | 1.4365 | 0.4544 |
| ENR5560 | 0.0204 | 0.0273 |
| NPRIV | 6.6153 | 9.8720 |
| PCTCATH | 0.0977 | 0.1378 |

real assets, number of private schools, percent of the population who are Catholic, the Maryland manufacturing wage, and trend. Since these variables are assumed exogenous, they will be uncorrelated with the error term in the real expenditure equation, $\varepsilon$. Therefore, the estimate of total private school enrollment will be uncorrelated with $\epsilon$ as well. If the estimates for private school enrollment are then used in the real expenditures regression, the estimates of the coefficients on the variables will no longer be inconsistent.

Using two-stage least squares techniques, equation 6.2 was initially estimated over the 23 counties (white sample) and 22 counties (black sample) with no transformation of the data. It was assumed that the error term, $\epsilon_{i, t}$, had an expected value of zero $\left(E\left(\epsilon_{i, t}\right)=0\right)$, had a constant variance, and $E\left(\epsilon_{i, t} \epsilon_{i, t+g}\right)=0$ for $s \neq 0$. The very low values of the Durbin-Watson statistics resulting from these estimations demonstrated that the assumption of the error terms being independent was violated. Even though the $R^{2}$ values obtained were quite high, low Durbin-Watson statistics implied that the data needed some type of transformation to eliminate the autocorrelation existing. To correct for the autocorrelation the Durbin two-step procedure was employed. [Maddala, 1977, pp. 277-279]

## 2. Durbin two-step procedure

The presence of autocorrelation in time series data is quite common. The autocorrelation simply implies that the error term for a particular county at time $t$ is functionally related to the error term for that county at time t-1. In the model for real expenditures this implies that:

$$
\begin{equation*}
\epsilon_{i, t}=\rho \epsilon_{i, t-1}+e_{i, t} \tag{6.5}
\end{equation*}
$$

where $0<\rho<1$. The $e_{t}$ are serially independent, have a constant variance, $\sigma_{e}^{2}$, and $E\left(e_{t}\right)=0$.

If equation 6.2 is lagged by one time period, each term is multiplied by $\rho$, and then the lagged equation is subtracted from the original using equation 6.5, the following results.

$$
\begin{align*}
& \operatorname{REXPP}_{i, t}= \alpha(1-\rho)+\rho \text { REXPP }_{i, t-1}+\beta_{1} \text { RASSPP }_{i, t}+\beta_{1} \rho^{\prime} \text { RASSPP }_{i, t-1}+ \\
& \beta_{2} \text { TPRIVTCH }_{i, t}+\beta_{2} \rho \text { TPRIVTCH }_{i, t-1}+\beta_{3} \text { NCHTPOP }_{i, t}+ \\
& \beta_{3} \rho N C H T P O P_{i, t-1}+\beta_{4} \text { MDWAGE }_{i, t}+\beta_{4} \rho \text { PDWAGE }_{i, t-1}+ \\
& \beta_{5} \text { ENR5560 }_{i, t}+\beta_{5} \rho E N R 5560_{i, t-1}+\beta_{6} \text { TREND }_{i, t}+e_{i, t} \\
& i=1, \ldots, n ; t=2, \ldots, T \tag{6.6}
\end{align*}
$$

When equation 6.6 is estimated using ordinary least squares, the coefficient on the lagged real expenditure term can be used as an estimate of $p$. Prior to the estimation process, the 1928 observation for each county was omitted. This modification was necessary due to the nature of the data (cross-sectional, pooled over time). Failure to make such a modification would imply that the error term for an observation in some county A in 1928 would be functionally related to the error term of an observation in some county $B$ in 1955. Such a functional relationship is not statistically justifiable.

Obtaining the estimate for $p$ is the first step of the two-step procedure. With this estimate determined, all of the original variables were transformed according to equation 6.7.
$\hat{x}_{i, t}=x_{i, t}-\left(\hat{\rho} x_{i, t-1}\right)$

This transformation of the data is the second step in Durbin's two-step procedure. Again, the 1928 observation was omitted for each variable in each county for the reasons stated above. The transformed data were then used in the two-stage least squares estimation of real expenditures for public schools. A statistical summary of these transformed data can be found in Table 6.3.

## 3. Empirical findings va, theoretical predications

With the transformed data the model was run three times: once for the white sample, once for the black sample, and once for the combined sample (pooled sample). The combined sample was run to see if there was any information gained by looking at the samples separately or whether there were statistically significance differences in the way decisionmakers responded to exogenous influences in funding black and white schools. To test whether the coefficients vary across races, an F-test was performed. The result was an F-statistic equal to 94.95 (significance level 0.00). The F-statistic demonstrated that there was information to be gained by running the samples separately. The coefficients across samples could not be assumed to be the same. Therefore, the remainder of the empirical results are reported for the black and white samples only.

The empirical results of the two-stage least squares regressions are reported in Tables 6.4 and 6.5 . Table 6.4 reports the variable coefficients which are used in the equation which estimated total private

Table 6.3. Sample statistics for the transformed data

| Variable | Mean | Standard deviation |
| :---: | :---: | :---: |
| White sample: |  |  |
| REXPP | 22.3694 | 21.2064 |
| RASSPP | 0.3095 | 0.1980 |
| TPRIVTCH | 0.0046 | 0.0054 |
| NCHTPOP | 0.0226 | 0.0099 |
| MDWAGE | 0.3004 | 0.2362 |
| ENR5560 | 0.0041 | 0.0085 |
| NPRIV | 0.1937 | 3.8783 |
| PCTCATH | 0.0028 | 0.0358 |
| Black sample: |  |  |
| REXPP | 6.8428 | 26.7626 |
| RASSPP | 0.1274 | 0.1913 |
| TPRIVTCH | 0.0051 | 0.0058 |
| NCHTPOP | 0.0030 | 0.0078 |
| MDWAGE | 0.1237 | 0.2356 |
| ENR5560 | 0.0106 | 0.0168 |
| NPRIV | 0.2309 | 3.9559 |
| PCTCATH | 0.0033 | 0.0366 |

Table 6.4. First stage regression results, TPRIVTCHa, 1928-1955

| Independent <br> variable | White <br> sample | Black <br> sampleb |
| :--- | :---: | :---: |
| INTERCEPT | $-0.1206 \mathrm{E}-02$ | $-0.1481 \mathrm{E}-02$ <br> $(-0.62)$ |
| TREND | $0.1041 \mathrm{E}-03$ |  |

$a_{t-s t a t i s t i c s ~ i n ~ p a r e n t h e s e s . ~}^{\text {in }}$
$b_{\text {Dependent }}$ variable is total (both black and white) children enrolled in private schools. The only difference in the regression run for the black sample would be the number of counties included. (Garrett county is excluded from the black sample.)

Table 6.5. Second stage regression results, REXPPA ${ }^{\text {a }}$, 1928-1955

$a_{t-s t a t i s t i c s ~ i n ~ p a r e n t h e s e s . ~}^{\text {in }}$
school enrollment. The estimates from this regression were then used in the second stage of the two-stage least squares procedure to estimate real expenditures. Table 6.5 reports the variable coefficients for the real expenditures equation. In both sets of results, the Durbin-Watson statistics indicate that the data transformation has eliminated the autocorrelation that existed in the data.

The two-stage least squares regression procedure worked well with this particular data set. Most of the variables selected for use in this model had the anticipated signs and possessed significant t-statistics. In particular, almost all of the regressors in the total private enrollment regression were predicted to have positive coefficients.

In both the black and the white samples the number of private schools, NPRIV, and the percentage of the population who are Catholic, PCTCATH, had coefficients which were statistically significant with the anticipated positive signs. Real assets, RASSPP, and the proxy for the Maryland manufacturing wage, MDWAGE, had negative coefficients in both samples. The coefficients were significant in both samples as well. The coefficient on the MDWAGE variable demonstrated that the wage was considered to be a measure of the cost of education.

The second stage of the two-stage least squares procedure also produced statistically significant results. The regressions for the real expenditures showed coefficients with most of the anticipated signs. In both regressions, real assets, RASSPP, and private school enrollments, TPRIVTCH, had positive coefficients which were significant. Using the quantity/quality idea that the number of children and a percent of the total population should act as a price for education proved to be a good
choice. The coefficient on this variable, NCHTPOP, was negative and significant in both the black and the white equations proving NCHTPOP a good proxy for the price of public education. The wage variable, MDWAGE, had a positive coefficient for the black sample and a negative coefficient for the white sample. The coefficient was not statistically significant in the white regression and only marginally significant ( $t=1.69$ ) in black regression.

The taste for discrimination variable, ENR5560, did work as anticipated in the black sample. A taste for discrimination on the part of whites in a community (revealed in the "white flight" after the segregated era ended) was expected to be negatively related to expenditures on black public schools. Such a negative relationship did exist. It was not statistically significant, however. The expected positive sign on the coefficient of the same variable in the white sample did not result. The coefficient was negative and significant. In other words, counties experiencing the largest increases in proportional private school enrollments following the Brown vs. Topeka Board of Education decision had low levels of per-pupil expenditures in both the black and the white schools systems over the 1928 - 1955 period.

## 4. Elasticities

The results from the two-stage least squares regressions were used to calculate elasticities among the variables. Although the data were not in logarithm form when the regressions were run, simple elasticity calculations were possible. The values were calculated at the mean value of the variables according to the following formula.
$\frac{8 \Delta y}{\% \Delta x}=\frac{(\Delta y / \bar{y})}{(\Delta x / \bar{x})}=\frac{\Delta y}{\Delta x} \cdot \frac{\bar{x}}{\bar{y}}=\beta_{x} \cdot(\bar{x} / \bar{y})$
$\beta_{x}$ is the coefficient on the $x$ term in the regression for variable $y$. Using this formula the elasticity values found in Table 6.6 and Table 6.7 were calculated.

All of the elasticity estimates that were calculated were found to be inelastic. The fact that they are inelastic may seem strange given that many of the elasticity values calculated in previous chapters were elastic. However, the previous measures were dynamic in nature, meaning that they measured the percentage change in a variable over time rather than at a point in time. The measures found here are not dynamic in nature, so these results are by no means inconsistent with the previous measures.

From the elasticity values it can be seen that the percentage of Catholic persons in the population had the greatest impact on the total number of students enrolled in private schools relative to the county population. The availability of private schools had the next greatest impact. The Maryland wage was followed by real assets per person. These results would seem to imply that enrollment in private schools is more an issue of taste than it is a fiscal issue. (Elasticity values for total private school enrollments would not differ significantly for the black and the white samples. See footnote b, Table 6.4.)

The findings differed somewhat for the black and white samples with regard to the elasticity calculations for real expenditures per pupil belonging. In both samples, real assets had the highest elasticity value.

Table 6.6. Estimates of elasticities for total private school enrollments relative to the total population, (TPRIVTCH)

| Variable | Black and White <br> sample |
| :--- | :---: |
| RASSPP | -0.09 |
| NPRIV | 0.22 |
| PCTCATH | 0.38 |
| MDWAGE | -0.15 |

Table 6.7. Estimates of elasticities for real expenditures on public schools per pupil belonging, (REXPP)

| Variable | White <br> sample | Black <br> sample |
| :--- | :---: | :---: |
| RASSPP | 0.36 | 0.37 |
| NCHTPOP | -0.20 | -0.14 |
| TPRIVTCH | 0.04 | 0.19 |
| MDWAGE | -0.02 | 0.07 |
| ENR5560 | -0.07 | -0.06 |


#### Abstract

For whites, the number of white children relative to the county population had the next greatest impact on real expenditures. This was followed by the change in private school enrollment from 1955 to 1960, the total number of children enrolled in private schools relative to the total number of children in the county, and the Maryland wage in the white sample. For the black sample, real assets were followed by the total number of children enrolled in private schools relative to the total number of children in the county, the total number of black children relative to the county population, the Maryland wage, and then the change in private school enrollment from 1955 to 1960.


## E. Conclusions

The approach taken to investigate the public-private school choice with a taste for discrimination included was a more traditional one. Although the model used was static rather than dynamic, the results were not much different than what was anticipated from previous empirical work.

A little different approach had to be taken in terms of transforming the data, but the Durbin two-step corrected the autocorrelation problems that existed. The transformed data produced some nice results which were statistically sound.

The taste for discrimination variable derived using the idea of revealed preference did not have the impact anticipated. To test whether it was the specific time period being used (1928-1955) which affected the results, a sample of only years 1945 to 1955 (a time period nearer to Brown vs. Topeka Board of Education) was used. The same regressions were run, but the results were very much the same for the "nearer" time period
than the entire time span. These results are reported in Tables 6.8 and 6.9. The coefficients on the ENR5560 did behave a little more as expected with these regressions. Although the sign on the ENR5560 coefficient was still negative in the white regression, it was not significant. The regression for the black sample showed the anticipated negative sign on the ENR5560 coefficient and it was significant which was not true in the previous regressions. The Maryland wage variable took on a positive, significant coefficient in the white regression for REXPPA. RASSPP, the real assets variable kept the positive coefficient, but lost its significance in the REXPPA regressions. Overall, many of the coefficients had t-statistics which decreased in value.

The elasticity estimates that were calculated (for the first set of regressions) were found to be inelastic. At first glance, this would appear to be inconsistent with the previous estimates calculated from the VAR models. However, given that the estimates from the VAR were calculated by summing over either 5 or 14 years, these results are not inconsistent in the least. To test whether there was inconsistency, the VAR data were used to approximate static elasticity measures. To accomplish this the initial impulse response due to a particular shock was used as in the numerator component of the elasticity measure (rather than the summation of impulse responses over time). The shock value was used in the denominator component. These static approximations from VAR data were quite consistent with the estimates in this chapter.

Table 6.8. First stage regression results, TPRIVTCH ${ }^{\text {a }}$, 1945-1955

$a_{t-s t a t i s t i c s ~ i n ~ p a r e n t h e s e s . ~}^{\text {in }}$
bDependent variable is total (both black and white) children enrolled in private schools. The only difference in the regression run for the black sample would be the number of counties included. (Garrett county is excluded from the black sample.)

Table 6.9. Second stage regression results, REXPPA, 1945-1955

$a_{t-s t a t i s t i c s ~ i n ~ p a r e n t h e s e s . ~}^{\text {in }}$

## VII. SUMMARY

## A. Overview of the Empirical Results

Chapter III was successful in estimating the causal relationships among real expenditures per pupil in public schools, average daily attendance in the public schools, the rate of births per thousand in the population, and real assets per person in the population. F-statistics showed that in the white sample all four variables were significant in determining each other. For the black sample, all variables were significant in determining real expenditures, attendance, and real assets. Real expenditures and attendance were found not to be significant in determining the birth rate. In the combined sample, only attendance was ingignificant in the birth rate equation. Significant F-statistics implied that causality ran in both direction for most variables or that a feedback effect was present.

Impulse responses were then generated to simulate the system's response to shocks in each of the variables. From these impulse responses it was possible to create dynamic elasticity measures. These elasticity measures showed characteristics of the Tiebout migration model, the median-voter model, the quantity/quality model, the human capital investment model, and the capitalization model. No one model seemed to be predominate. Given that no one particular model has been decided upon by the literature as the "best" model to describe the educational investment process, this finding was expected.

The most intriguing result of the dynamic elasticity measures was the response of real assets to shocks in school attendance. In each of the
samples, real assets demonstrated a very elastic positive dynamic response to increases in attendance (for both $T=5$ and $T=14$ ). This result supported the claim that there was incentive to invest in the education of both blacks and white, even in an era of segregation. More education implied that the value of a community's assets increased.

Chapter IV examined the public-private school decision and tested whether various causal relationships presented in the literature held true. This investigation was an extension of the investigation in chapter III and was performed using the same methodology found in that chapter. The empirical findings indicated that real expenditures and real assets were not significant in causing private school enrollments in all samples. Although attendance in public schools was found to be insignificant in causing total private school enrollments in both the white and the black, samples, it was significant in the combined sample. Private school enrollments were found to cause real expenditures in the white and combined samples, but not in the black sample. Private school enrollments were also found to be significant in causing real assets in the white sample, marginally significant in the combined sample, and insignificant in the black sample. In all three samples, private school enrollments were insignificant in causing public school attendance. The remainder of the variables demonstrated the same type of causal relationships as presented in chapter III.

Impulse responses and dynamic elasticity measures were also calculated in this chapter. Real assets in the white sample showed a positive elastic response to increases in private school enrollments. Real assets also showed a positive elastic response to increases in public
school attendance in all three sample. Cross-elasticity values among the other variables were comparable to the values in chapter III.

The causal relationships determined in chapters III and IV along with the theory developed in chapter $V$ were used to formulate a reduced-form equations model which was empirically tested in chapter VI. This model incorporated variables used in the previous empirical analyses, but further included the number of children in the population, a proxy for the Maryland manufacturing wage, the percentage of the population who are Catholic, the number of private schools, and a taste for discrimination variable.

A two-stage least squares approach was applied to the reduced-form equations. The regression results for total private school enrollments gave the anticipated positive coefficients on the number of private schools variable and on the percent Catholic variable. The negative coefficient on the Maryland wage variable was somewhat expected, but not on the real assets variable. All of the coefficients in the private school enrollments regression were significant.

The second stage was to estimate real expenditures in the public school systems. Most of the coefficients had the anticipated signs and were significant. The Maryland wage variable had a negative coefficient in the white sample and a positive one in the black sample. These coefficients were, however, insignificant. The coefficient on the discrimination variable had the anticipated negative sign in the black sample, but the coefficient was not significant. In the white sample the coefficient was expected to be positive, but the results were negative and significant.

## B. An Overview of the Theoretical Model

A theoretical model which explaing the educational investment decision from both a firm's perspective and a household's perspective was derived in chapter $V$. The goal of the model was twofold. First, the model was to explain why there was an incentive for white-dominated school systems to invest in education for white and black children alike, and hence provide a possible explanation for Myrdal's paradox. second, the model was to explain why property values would rise if there were increases in attendance. A two-period model was developed which included a representative profit-maximizing firm and a representative utilitymaximizing household.

The model demonstrated that there were pecuniary benefits to the firm by investing in education. The model further demonstrated that if there were an unanticipated shock in attendance due to unanticipated investment by a household (a change in a household's taste pattern for education), wages would be unable to incorporate the unanticipated investment and firms would reap the economic benefits in terms of increased profits. These increased profits would then be capitalized into property values.
C. General Conclusions and Future Research

Although the approach taken to study investment in education was not "traditional" in nature, the main goal of the dissertation has been met. Causal relationships among educational investment variables have been estimated and then compared and contrasted to the findinga of the literature and the predictions of theory. Even after all the empirical was performed, the final conclusion is still that no one model best
describes the educational investment process. Characteristics of each of the models have merit.

The causal relationship between school attendance and property values shown in the empirical results as well as in the theoretical derivations, present one explanation for Myrdal's paradox. This explanation was originally suggested by Freeman, but no one to date had presented economic theory in support of such an explanation or had empirically tested such a possible solution to the paradox.

The results of this study suggest that there are several areas for possible future research. While this study did incorporate discrimination into the investigation of educational investment, an extension to this study would be to find a better method of incorporating it into the theoretical and empirical models. An extension for further study would be to locate and incorporate additional variables such as actual consumer income, state and federal aid to school districts, tuition of private schools as well as other variables which might help to better explain the educational investment process.

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Fulfilling the requirements for this degree has been a long and persevering process. My father stated it best when he said, "A Ph.D. is not necessarily a degree indicating how much one knows, but rather a degree indicating how well one perseveres."

The number of people who have helped me make it through the persevering process is too great to mention. To each one my heartfelt thanks goes out. I could not have made it without their encouragement at each stage of the process.

I would, however, like to give special thanks to my wife and my daughter who have probably had to endure more than I have. With this process completed, I look forward to being a family man and devoting the time and love to them that they deserve. Further, I would like to thank my parents who raised me to understand the challenges in life and how to approach these challenges. Their love, encouragement, and belief in me could never go unnoted.

Finally, I would like to thank my committee members, Dr. Barry Falk, Dr. William Meeker, Dr. Charles Meyer, Dr. Dan Otto, Dr. Todd Sandler, and especially my major professor, Dr. Peter Orazem. Peter stepped in at a point in my Ph.D. program where I definitely needed encouragement and guidance. As a result of his incredible patience $I$ was able $: 0$ put together what I consider to be a good piece of research. His confidence in my abilities kept: my spirits up and made me persevere. In him, not only did I find a mentor, but a friend.

To all these people I say thanks.

## APPENDIX



Figure 1. Responses to one standard deviation shock in REXD (white)


Figure 2. Responses to one standard deviation shock in ATTD (white)


Figure 3. Responses to one standard deviation shock in RPTD (white)


Figure 4. Responses to one standard deviation in ASSD (whites)


Figure 5. Responses to one standard deviation shock in REXD (black)


Figure 6. Responses to one standard deviation shock in ATTD (black)


Figure 7. Responses to one standard deviation shock in RPTD (black)


Figure 8. Responses to one standard deviation shock in ASSD (black)


Figure 9. Responses to one standard deviation shock in REXD (combined)


Figure 10. Responses to one standard deviation shock in ATTD (combined)


Figure 11. Responses to one standard deviation shock in RPTD (combined)


Figure 12. Responses to one standard deviation shock in ASSD (combined)


[^0]:    section on the data and data transformations, a comparison of the empirical results and the theoretical predictions, and conclusions. The empirical results from chapter III support the idea that whites may have been willing, in an era of segregated schooling, to invest in black schools with the hope of reaping future benefits to a better-educated black labor force.

    Anytime investment in public schools is discussed, a discussion about private school investment should also be included. This is a necessity because investment in private schools can be thought of as a substitute for investment in public schools.

    Chapter IV investigates the causal relationships among all relevant variables in the public-private school choice. This chapter consists of four sections. Along with a general introduction, an in-depth review of the literature on the public-private school investment choice is included. A third section presents an empirical look at this choice using the same methodology as chapter III. The final section summarizes the findings of this chapter.

    Chapter $V$ investigates Myrdal's paradox, a paradox which has not been formally addressed in an empirical or theoretical setting before. The first section of this chapter gives a general introduction to Myrdal's paradox. The second section explores the literature which deal with segregated schools and the racial differences which exist in the educational services provided. Theoretical models supporting the empirical findings in chapter III are presented and discussed in the third section. Chapter $V$ ends with conclusions about the theoretical approach to solving Myrdal's paradox.

[^1]:    $a_{\text {The }}$ critical value of the chi-square test with 16 degrees of freedom is 32.0 at the .01 level of significance and 26.3 at the .05 level of significance.

[^2]:    ${ }^{a_{S i g n i f i c a n c e ~}}$ level in parentheses. The critical value of $F(7, \pi)$ at the .05 significance level where $n=547,522,1097$ respectively for the white, black, and combined samples, would lie somewhere between 2.09 ( $F(7,120)$ ) and $2.01(F(7, \infty))$.

[^3]:    $a_{\text {Significance }}$ level in parentheses. The critical value of $F(7, n)$ at the .05 significance level where $n=455,434,917$ respectively for the white, black, and combined samples, would lie somewhere between 2.09 ( $F(7,120)$ ) and $2.01(F(7, \infty))$.

