The Supply of Public School Teachers in the United States: A Study in Human Capital Theory

Andrew W. Bacdayan

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THE SUPPLY OF PUBLIC SCHOOL TEACHERS IN
THE UNITED STATES: A STUDY IN
HUMAN CAPITAL THEORY

by

Andrew W. Bacdayan

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Economics
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relatives who have on numerous occasions made contributions to my earlier education, I give my final thanks.

Andrew W. Bacdayan
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ABSTRACT

The Supply of Public School Teachers in the United States: A Study in Human Capital Theory

by

Andrew W. Bacdayan, Doctor of Philosophy

Utah State University, 1973

Major Professor: Dr. Kenneth S. Lyon
Department: Economics

This study uses the principles of human capital theory to develop and test a theory of a supply of a class of educated manpower services with special reference to school teachers.

In the theory formulation, the determinants of the existing stock of teacher education capital are first identified. These are: (a) the price per man-year of teaching service, $W_{TS}$, (b) the rate of interest, $r$, (c) the price of the human capital already embodied in the individual working for a college degree in teacher education, $W_{CS}$, and (d) private costs of education such as foregone earnings and tuition fees, $F_{RTN}$.

The stock function is then expressed in terms of a partial adjustment model and then finally transformed into a supply function for a flow of teacher services by assuming a constant rate of flow of services from each unit of education stock. Finally, the model is made logically complete by specifying a demand function for teachers by the nation's public school systems. This function which is derived by the application of traditional factor demand theory to the production of public
education states that the demand for teachers depends on the price per man-year of teaching services, \( WTS \), the prices of other educational inputs such as the services of supporting instructional personnel, the services of custodial workers, the services of physical facilities, and the exogenously determined level of output which is assumed here as being measured by the average daily attendance or ADA.

To test the model its parameters are estimated by using the methods of ordinary least squares (OLS) and the two-stage least squares (2SLS). The use of the OLS method yields acceptable results for the supply equation only. On the other hand the use of the 2SLS method results in estimates that agree with all theoretical considerations in both the supply and demand functions. In view of the superiority of 2SLS in a simultaneous equation context, it is concluded that the estimates of the parameters resulting from it are more reliable. On the basis of these improved estimates the following observations and/or conclusions are made:

(a) A human capital approach to the study of the factors affecting the supply of a special class of educated manpower services is capable of explaining the realities of the school teacher market,

(b) Of the four determinants identified, only the price of teacher services, \( WTS \), and the private cost of education consisting of foregone earnings and tuition fees, \( FERTN \), seem to be significant, and

(c) The supply of teachers is relatively elastic with respect to the price of its services.
These findings provide strong support for existing or planned policies possessing the following features:

(a) A highly competitive salary structure,
(b) A flexible teacher education grants program, and
(c) Measures designed to ease the teacher supply-demand adjustment process. During shortages, these measures may include among others reconsideration of teacher credential requirements and better use of manpower. Up-to-date information on current and prospective teacher market situations, career counselling and voluntary limitations on student admissions by teacher education institutions would also help prevent the development of teacher manpower surpluses.

The first two features should help assure a sufficient supply of the desired quality and quantity of teachers and the last one is expected to speed up the attainment of supply-demand equilibrium.

(85 pages)
CHAPTER I
INTRODUCTION

Most economists now recognize that education is a special form of human capital which is acquired not entirely for its own sake but for the future income stream that it generates. This most recent revolution in economic thinking suggests that it is no longer sufficient to study the supply of any particular class of skilled or educated labor services in terms of the traditional income- or work-leisure indifference curve analysis. Rather, it suggests that the study of the market for skilled manpower services is more properly conducted within the framework of a stock-flow analysis which directly links the flow of a class of labor services to the corresponding stock of human capital. This study is an attempt to do just that.

1 The treatment of education as a form of capital, i.e., human capital, is considered to be a revolutionary economic thought in the 1960's. Although some 18th and 19th century economists occasionally referred to it as such, it was only in the past decade that the idea gained wide acceptance with the consequence that an explosive torrent of articles and books started being written on the subject matter. The person primarily responsible for generating this torrent is T. W. Schultz of the University of Chicago. Among his earlier writings are "Investment in Man: An Economist's View," Social Service Review, June 1959, pp. 109-117; "Capital Formation by Education," Journal of Political Economy (December 1960), pp. 571-83; "Investment in Human Capital," The American Economic Review (March, 1961), pp. 1-17; and the Economic Value of Education (New York: Columbia University Press, 1963), 92 pp.

2 As an example of a study that uses the traditional framework in the study of a specialized class of labor, see Mario F. Bognano, An Economic Study of the Hours of Labor Offered by the Registered Nurse, Unpublished Ph.D. dissertation, University of Iowa, 1969, 129 pp.
There are thus two main objectives of this dissertation. They are: (1) to formulate a theory of the supply of a special class of manpower services based on stock-flow considerations, and (2) to estimate the parameters of the econometric model which the theory implies. Although attention is primarily focused on the teaching profession throughout the study, the principles involved are just as applicable to other specialized professions.

To pursue the foregoing objectives the next chapter attempts to clarify some of the thornier assumptions that make up the foundation of the study. Chapter III then develops the theory which makes up the basis of the empirical model in Chapter IV. Also included in Chapter IV is a discussion of the measures of the variables and the sources of data used to test the model. Chapter V discusses the test results and the inevitable summary and conclusions are the tasks reserved for Chapter VI.
CHAPTER II
THE ASSUMPTIONS

The traditional assumption for the type of study under consideration is that of a competitive market. For the factor market which the teacher market is, this standard assumption requires the approximate existence of the following conditions: (1) infinity of buyers and sellers, (2) perfect mobility of factors, (3) possession of perfect knowledge, and (4) factor homogeneity. Insofar as the first three are concerned, there seems to be no serious violations in the real world of the teacher market. The number of teachers and school districts is not infinite, but there are so many of them that except for isolated instances in which one school system or one regional education association may dominate the market, there is generally no single district or education association that can set a nationwide salary level for teachers. One can also reasonably assume that teachers generally know what is happening in the market for their services, i.e., they generally know where the high-paying jobs are. This reasonable assumption stems

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3 A model which requires only an approximation of these conditions is called workable competition.

4 Whether or not teacher unions really affect the level of teacher salaries is still a matter of conjecture. One study which purports to show that teacher unions do not seem to affect salaries is Hischel Kasper's "The Effects of Collective Bargaining on Public School Teachers' Salaries," Industrial and Labor Relations Review (October, 1970), pp. 57-71.
from the fact that just like other groups, teachers have professional journals and other publications as well as national and regional or local meetings where all sorts of information, especially job market information, are exchanged. Older members of the profession may not be as mobile in the sense that they may have established "roots" in certain localities and are, therefore, not easily lured into accepting more attractive positions elsewhere. However, the same thing cannot be said of the young, new teacher education graduate. Thus, as long as a marginal portion of the total teacher population is free to move about, regional differences in teacher salaries tend to be eliminated save for the cost and inconvenience of moving.

While it is possible to justify that the first three conditions for competition to exist are sufficiently approximated in the real world, it is a little difficult to provide a similar justification in regard to factor homogeneity. In the first place, the educational capital embodied by the teacher may vary both in space and time. That is, one could reasonably argue that a teacher education obtained from a prestigious, well-financed ivy-league college such as Columbia, Yale, and the like, is qualitatively much better than the same amount of education obtained from a struggling university in the "sticks." Or, one could also argue that a teacher education received thirty years ago is much inferior to an education acquired in the present age of technology and space. And even assuming that a teacher education is truly homogeneous both in time and space, the warm body with which it must be welded to be of any use may not be as homogeneous. That is to say, some bodies are endowed with plenty of talent and others are
not as fortunate. All the foregoing indicate that there are diverse sources of variation in teacher quality such that the notion of teacher homogeneity is rather thoroughly destroyed. Failing to see a way out, this study shall follow the practice, set by other researchers,\(^5\) of accepting the judgment of the market. This practice rests on the assumption that if one unit of a factor is priced higher than another unit of the same class, then that unit commanding a higher price must represent more than one of the other unit. That is, if unit \#1 sells for \$1.50 while unit \#2 sells for only \$0.50, then unit \#1 must be equivalent to three units of \#2. For this particular study, the standard unit by which all other units are measured shall be the new teacher education graduate. If one teacher receives an annual salary higher than this standard unit, the ratio of the higher salary to the standard unit's annual salary shall measure the number of standard units which the higher-priced teacher represents.

Obviously, the chief participants in the market for public school teachers are the teachers themselves and the public school districts. Therefore, in addition to the assumption of a purely competitive market, assumptions must also be made about the behavior of the participants. In this regard, it shall be assumed that on the average, teachers and school districts or school boards are economically motivated, i.e., they are utility maximizers. For the individual teacher, this assumption means that he allocates his limited resources (time)

in a manner that will maximize his utility or satisfaction. On the other hand, the citizens of any given community or school district at any time usually have a predetermined level and quality of education which they desire their children to have. Given fixed levels of educational output which itself represents a given level of utility, the assumption of utility-maximizing behavior implies that the district will attempt to minimize the cost of obtaining that desired level of output and thereby maximize utility per dollar of expenditure. The community or district can do this either through the group acting as a whole or through its properly designated representatives such as the district superintendent or the local board of education.
CHAPTER III

THE STOCK OF TEACHING CAPITAL AND THE SUPPLY OF TEACHER SERVICES: A THEORETICAL MODEL

Before the model is actually formulated, it is important to firmly distinguish two separate but interdependent markets involved. The first one is the market for the sources of teaching services. A unit of this source will alternatively be referred to as an education degree, teaching certificate or teaching capital. In this market students or prospective teachers are the demanders while the teacher education institutions are the suppliers. The commodity involved is essentially a stock of human capital. The second one is the market where teacher services are bought and sold. In this market, the demanders are the nation's elementary and secondary schools that are engaged in the production of public education and the suppliers of the human capital input are the teachers who are holders of education diplomas. In contrast to the other market, this one involves a flow.

This study is essentially an attempt to understand the flow market for teacher services. As far as the demand side is concerned, no particular difficulty is encountered since it simply involves a direct application of traditional factor demand theory. The supply side is a different matter, however. Before an individual can provide a flow of teaching services, he or she must first acquire the source—an education degree. For society as a whole, the supply of teaching services depends upon the stock of education diplomas that already exists.
This means that before the factors affecting the supply of teacher services are isolated, the determinants of the existing stock of teaching certificates are first examined.

This chapter, therefore, first outlines the factors affecting the equilibrium level of education degrees for society as a whole. In the stock demand analysis, it is shown that the equilibrium stock demanded is an inverse function of the present value of the stream of services expected from a unit of the teacher capital. Similarly, the equilibrium stock supply is shown to be a direct function of the cost price associated with the acquisition of a degree. With this foundation, the chapter then examines the factors that determine the supply and demand for man-years of teaching services. Assuming a constant rate of flow of services from a unit of the source per unit of time, the supply of teacher man-years by the holders of education degrees is seen to be affected by the price per unit of the human capital input, or teaching service, the rate of interest, the price of the services of an individual with an equivalent high school education, the foregone earnings of the college student and tuition and other incidental expenses. It is also shown that the demand for teacher services by the nation's elementary and secondary schools is affected by the price per unit of a teaching service, the price of other public education inputs and the exogenously-determined level of enrollment. In the final section, the theory formulation is concluded by bringing together the supply and the demand functions and the market-clearing condition. These three constitute the complete model.
The long run equilibrium stock of education degrees

The market for education degrees is analyzed in this section. Since an education degree (any academic degree for that matter) represents a source of a stream of services, it is no different from a piece of non-human capital. This section's analysis will, therefore, draw largely from capital theory. More specifically, it follows Friedman's analysis of stock demand and stock supply curves. In this connection, the stock demand for education degrees will be discussed first. This is followed by a stock supply analysis. The section is then capped by showing how the long run stationary equilibrium stock of education degrees is determined by both supply and demand. Before these are done, however, a few assumptions that are specially important for this particular section must be made explicit. First, it will be assumed that all those who plan on pursuing a college education (i.e., all those who plan to acquire human capital or a college diploma) are homogeneous in their intellectual attributes. This assumption means that the individual with at least a high school education who desires to become an engineer or a lawyer has basically the same intellectual capacity as the individual who plans on becoming a teacher. Another assumption is that the rate of interest is determined outside the model and is equal for all individuals. Also, current and expected prices per unit of the flow of services are equal. Finally, it is also assumed that

6 This approach actually originated from Frank H. Knight's, "Interest," The Encyclopedia of Social Sciences (New York: Macmillan, 1932), Vol. VIII, pp. 131-144. The idea has been elaborated by Milton Friedman in his "The Theory of Capital and the Interest Rate." Price Theory: A Provisional Text (Chicago: Aldine Publishing Company, 1962), pp. 244-263.
the nonpecuniary returns of an education degree to all its holders are the same.

The long run stock demand. Given the above assumptions, it is hypothesized that the amount of education degrees demanded by society depends on the price or the present value of the expected stream of services from a degree, non-human sources of income such as stocks, bonds and other forms of non-human assets, and tastes and preferences. Since teaching is a salaried profession, it is probably safe to assume that non-human assets do not significantly affect teacher's decisions to acquire human capital. Also, tastes and preferences tend to change in imperceptible degrees. These suggest that society's stock demand for education degrees is primarily a function of its price.

One requirement for stock demand equilibrium is that the present value of the flow of services from a unit of teaching capital be equal to the cost per unit of the stock. Denote the present value of teaching capital as \( VTK \) and follow Jorgensen\(^7\) by denoting the cost price per unit of stock as \( q \). If \( VTK > q \), a dollar invested in an education degree yields a higher return than a dollar invested in the acquisition of some other degrees. As a consequence, more prospective and actual college students change their plans and shift to the acquisition of an education degree instead of pursuing other educational programs. If \( VTK < q \), the reverse situation holds. That is, a dollar invested in an

\(^7\) This definition is discussed in more detail in D.W. Jorgensen, "The Theory of Investment Behavior" in Determinants of Investment Behavior, Robert Ferber (ed), (New York: National Bureau of Economic Research, 1967) pp. 129-155. For this study, the specific definition is discussed later in the section on stock supply.
education degree will yield less than what it would if it were used in
the acquisition of some other degree. Of course, if $VTK = q$, then
everybody is satisfied with their educational plans and no changes
occur.

Given the simplification which reduces the stock demand for edu-
cation degrees as a sole function of price and the foregoing condition
for equilibrium, we now define a long run stock demand curve (see
Figure 3.1) as the locus of all points representing combinations of
stock prices, $q$, and quantity of education degrees, $TK$, where there
are no forces from the demand side to cause changes. This definition
implies that the long run stock demand is a stationary market demand
curve and therefore the time rate of change, denoted as $dTK$, is equal to
zero. Also, it means that the current and future prices of a unit of
teaching service are equal.

![Figure 3.1. Long-run stationary stock demand curve.](image-url)
Although the long run stock demand curve as shown in Figure 3.1 is downward sloping, we shall nevertheless show why this must be so. To do this, first assume that there is no change in the demand for the flow of teaching services. Also, define the present value of a unit of teaching capital as:

\[ VTK = \int_{t=0}^{R} e^{-r(t-s)} (WTS) e^{-\delta(t-s)} dt \] (3.1)

where \( WTS \) = the price per unit of service from the education degree, \( r \) = the rate of interest, \( t \) = time period which is usually equated to 0, \( s \) = time of completion of the degree and start of employment, \( R \) = the end of the income flow which should correspond to the age at retirement or withdrawal from the teaching profession, and \( \delta \) is the rate of depreciation or appreciation of the education degree. Note that

\[ e^{-(t-s)}(WTS) \]

is the discounted value of the price of a unit of service from an education degree where this service has been rendered at time \( t \). Also, the expression

\[ e^{-\delta(t-s)} dt \]

gives the flow of services over an interval of length \( dt \) beginning at time \( t \) from a unit of education degree completed at time \( s \). Note that when an education degree is acquired and used in service at the time period \( s = t_0 = 0 \) Eq. (3.1) becomes

\[ VTK = \int_{s}^{R} e^{-rt}(WTS) e^{-\delta t} dt \] (3.2)
Moreover, if an education degree is permanent and indestructible, Eq (3.2) reduces to

\[ VTK = \int_{s=0}^{R} e^{-rt(WT)} dt \]  

(3.3)

Finally, if \( WTS_1 = WTS_2 = \ldots = WTS_n \), then Eq. (3.3) ultimately becomes

\[ VTK = (WTS)/r \]  

(3.4)

which is the familiar capitalization formula.

Now, at some point such as A in Figure 3.1 where \( dTK = 0 \), education stock is \( TK_2 \) and the price per unit of teaching service is \( WTS_2 \), equilibrium will exist if the present value implied by \( WTS_2 \) and denoted by \( VTK_2 \) is equal to the stock price, \( q_2 \). At A this is exactly the situation and the point is therefore on the long run stock demand curve. Consider another point such as B where the time rate of change of stock is also equal to zero, the existing stock is \( TK_1 < TK_2 \) and the price per unit of services is \( WTS_1 > WTS_2 \). For this to be an equilibrium position, \( VTK_1 \) or the present value of the stream of services from a unit of the existing stock, \( TK_1 \), must be equal to the stock price, \( q_1 \). Since this is the case at B, it is also a point on the long run stock demand curve. Given that the stock represented by \( TK_2 > TK_1 \), then \( WTS_2 < WTS_1 \) and therefore \( VTK_1 = q_1 > VTK_2 = q_2 \). That is, the demand curve is downward sloping.

To demonstrate further that points A and B are on the downward sloping demand curve, assume that \( q \neq VTK \) at some stock, \( TK \). At B'
where $q_1 > VTK_2$ and stock is $TK_2$, the utility-maximizing individual will increase his economic well-being by investing his time and money in the acquisition or some other types of human capital. This means that prospective teachers will change their plans and take on some other degrees instead. The stock of teacher certificates will thus decrease. At point $A'$, the opposite situation holds. That is, $q_2 < VTK_1$ at a stock of $TK_1$. This time the individual will be adding to his welfare by going in for an education degree instead of some alternative form of human capital. The result is an increase in the stock.

In Eq. (3.1), $s$ and $R$ are all given parameters. For non-human capital, the absolute value of $\delta$ is generally assumed to be negative since we ordinarily think of physical capital as being used up in service. For human capital embodied by an individual, no clear-cut presumption can be made. It may be negative or positive, but whatever its absolute value, the important question is whether it is a constant or not. If it is a constant, then it, too, becomes a parameter like $s$ and $R$. If it is not, then it is important to identify what factors affect its value. To do this, let us theorize that it is a function of obsolescence, absence from the classroom and experience. That is,

$$\delta = h(OBS, LV, EXPR) \quad (3.5)$$

where $\delta$ = the rate of depreciation of the individual's human capital, $OBS$ = obsolescence, $LV$ = absence from the classroom and $EXPR$ = experience. Although not necessary for our purposes, let us assume the following properties for Eq. (3.5)
The first two state that $\delta$ is inversely related to both obsolescence and absence from the classroom, and the third property states that the human capital embodied appreciates with experience. Since both obsolescence and experience are functions of time and since absence from the classroom is determined by the relative price of teacher services, Eq. (3.5) may be rewritten as:

$$\delta = f(t, WTS) \quad (3.7)$$

where $t = \text{time}$ and $WTS$ is as defined earlier. Moreover, since educational technology is notoriously tradition-oriented and since individuals gain experience gradually and evenly, it is reasonable to assume the effect of $t$ on $\delta$ in Eq. (3.7) as a constant. This means that the rate of depreciation of teacher capital is a sole function of $WTS$. Referring back to Eq. (3.1), we, therefore, see $VTK$ as a function only of $WTS$ and $r$. Therefore, the long run stock demand is a function of the price of a unit of teacher services and the rate of interest.

The long run stock supply. At any given point in time, the total stock of education degrees held by all members of society is given. Also given are the cost condition of the teacher education industry and the rate of depreciation of the total human capital stock. In this
study, it will be assumed that the teacher education industry is subject to increasing cost. This assumption is illustrated as Panel $b$ in Figure 3.2 which shows the supply of new teacher capital as an increasing function of the stock price, $q$. For society as a whole, the rate of attrition of the existing stock of education degrees at any given period of time is a function of the number of deaths and retirements. Since these forces are determined by external forces whose rate of incidence does not vary much over time, it is reasonable to assume the rate as a constant. For the stock supply to be in equilibrium, the flow output of new education degrees must be equal to the amount of attrition. Algebraically, this condition is given by:

$$\delta TK = dTK$$  \hspace{1cm} (3.8)

where $\delta TK =$ the amount of attrition and $dTK =$ the number of new education diplomas produced by the nation's colleges and universities.

Panel $c$ graphically illustrates the condition given in Eq. (3.8), i.e., the amount of attrition is equal to the amount of new output of education degrees at any given time period. Panel $d$ illustrates the assumed constancy of the rate of attrition, $\theta$. Finally, panel $a$ shows the long run stock supply curve. This curve shall also be defined here as those combinations of price and quantity such that there are no forces from the supply side to change the stock of teacher capital. For any price-quantity combination to satisfy the definition, Eq. (3.8) 

---

Figure 3.2. Stock supply determination.
must hold, i.e., the rate of flow of new teaching certificates must be equal to the rate of attrition. In the diagram, three such points satisfy the definition. These are C, G and M. At point C, the stock price is \( q_1 \) when the stock supplied is \( TK_1 \) and when \( \theta TK_1 = dTK_1 \).

At G, \( q = q_2 \) when \( \theta TK_2 = dTK_2 \). Similarly, at M, \( q = q_3 \) when \( TK = TK_3 \) and \( \theta TK_3 = dTK_3 \).

To show even further that points C, G, and M are, in fact, on an equilibrium stock supply curve, it must be established that forces exist to move the stock away from positions not on the curve to positions that lie on it. Consider first point F below the curve in Panel a. This is consistent with a present value or price of \( VTK_1 \) and a stock of \( TK_2 \). For this to be a position of equilibrium, \( \theta TK_1 = dTK_1 \). In Panel b, this equilibrium condition is consistent with the production of new education degrees in the amount of \( dTK_1 \). In Panel d, however, the depreciation that is consistent with a stock of \( TK_2 \) is \( \theta TK_2 \) which is greater than \( dTK_1 \). Since the flow of new education degrees is not sufficient to replace the amount of depreciation, the existing stock decreases. In this case, the stock moves away from F to a point on the stock supply curve to the left.

Now consider point B. This, too, is consistent with a stock of \( TK_2 \) and a price of \( q_3 \). For this point to be an equilibrium position, \( \theta TK_3 = dTK_3 \). In Panel b, this specific condition implies an output of new education degrees given by \( dTK_3 \). But it is to be noted in Panel d that the stock given by \( TK_2 \) is consistent with a depreciation
of $\theta TK_2$. Since $dTK_3$ is greater than $\theta TK_2$, as is evident in Panel 2, the total stock must increase. Again, the stock moves away from B to the long run stock supply curve to the right. That the curve along which points C, G, and M lie is truly a long run stationary supply curve is thus demonstrated. Similarly, we may label it as $S_{TK}^8 (dTK = 0)$ to indicate that as long as the technology of diploma production and the rate of depreciation remain constant, no change in the stock will occur.

The conclusion of this section's discussion is that the stock supply of teacher education diplomas is a function of stock price, $q$. Although society spends considerably more to educate an individual teacher, only certain portions of the total social cost are relevant in the prospective teacher's decision-making process. Therefore, to the individual, the relevant cost price of a unit of teacher capital consists of the earnings that he or she must forego in order to attend college, and tuition fees, books and other incidentals. In a sense, the human capital embodied at the start of the degree-acquisition process (which at least must be equal to a high school education) is also an imput. This means that the cost price of an education degree must, therefore, include an imputed value of the human capital already embodied in the prospective teacher. This imputed value may be measured by the discounted value of the flow of services expected from an unskilled occupation. In the same manner that the present value of an education degree has been shown to depend on the price of a unit of teaching service and the rate of interest, it can also be shown that
the total discounted value of the stream of services from the warm-bodied input in the degree-production process is a function of the price per unit of service from an unskilled worker and the rate of interest. It is thus concluded that the stock supply of education degrees is a function of foregone earnings, tuition and other fees, the price per unit of service from an unskilled worker and the rate of interest. All these are components of the stock price denoted as $q$.

The long run stationary equilibrium stock. To demonstrate how this stock is determined, we bring together the stock supply of and the stock demand for education degrees. This is done in Figure 3.3 where we superimpose the long run stationary stock demand curve in Figure 3.1 to the long run stationary stock supply curve in Panel a, Figure 3.2.

![Figure 3.3 Society's long-run equilibrium stock of education degrees.](image-url)
In the diagram, E is a long run equilibrium position and TK* is the associated stock. At this level, the number of education degrees that society wants to hold is equal to the actual number of diplomas in existence. In addition, the number of degrees produced by the nation's colleges and universities per unit of time is just sufficient to replace the sum total of education degree holders who die, retire or permanently withdraw from the teaching force. At any point other than E, forces exist to move the level of stock toward E. For example, suppose that the stock of education degrees is given by TK_1 which is the level of stock at E'. At that point, the holders of the TK_1 education degrees are satisfied and relative to holders of other degrees, they are receiving a higher return. If colleges and universities were profit-motivated just like business firms, they would try to induce more people to acquire an education degree since they realize that they can produce human capital at a much lower cost than what society is willing to pay for it. Specifically, when the number of education degrees consists only of TK_1 units, an education degree can be produced at a cost of q_2 but individual holders are willing to pay a price equal to VTK_1 which is greater than q_2. As more degrees are produced, the stock increases, but as the stock quantity increases, the cost of maintaining the stock also increases. Eventually, the equilibrium level is attained. At this new level, the amount of attrition is just equal to the amount of new degree production and the number of education degrees desired is just equal to the number actually held. Similarly, other points not coincident with E can be shown to contain forces which tend to drive the stock towards TK*.
As long as no changes occur in the flow of new demand for education
degrees, in the technology of education degree production, in society's
tastes and preferences, and in individual holdings of non-human capital
assets, TK will continue to be maintained. It is, thus, a long run
stationary equilibrium stock.  

Of course, colleges and universities do not produce education for
profit. Nevertheless, when they realize that society has a demand
for certain skills, they feel it their social obligation to increase
their production of graduates with training in these skills. In this
case, the motivation is not to earn more profits for its stockholders,
but rather to contribute to social welfare. In a sense, profits exist
but they are socialized. That this is a realistic representation of
what is actually happening in the real world is attested to by what has
happened during the 1950's and the 1960's. During those decades, the
demand for teachers was rising, i.e., the present value of the flow
of services expected from a teaching certificate was going up. In
response, colleges and universities expanded their output of new
education degrees. Now that the equilibrium has finally been reached,
the same institutions are now adjusting their outputs to a level that
is consistent with the maintenance of the existing stock.  

From this point on the theory can be extended to show the
difference between temporary and long run stationary equilibrium
and the path leading from one to the other. For this study, it is
felt that these extensions are not crucial.

In recapitulation, the stock theory just developed yields the following determinants of the equilibrium stock of teacher capital held by society: (1) the price per unit of teacher service, (2) the rate of interest, (3) foregone earnings plus tuition fees and other incidentals, and (4) the price per unit of the services of an unskilled worker. This conclusion may be expressed mathematically by:

\[ TK^* = G(WTS, WCS, r, FERTN) \]  

where \( TK^* \) = the equilibrium stock of teacher capital, \( WTS \) = the price per unit of teacher service, \( WCS \) = the price of the services of an unskilled worker, \( r \) = the rate of interest, and \( FERTN \) = the sum of foregone earnings and tuition and other incidental fees.

In equilibrium, the stock of teacher capital desired by society is equal to the existing stock of education diplomas. But implicit in the discussion accompanying Figure 3.3 some lag may occur between actual and desired stock. If we assume that these two stock concepts are related in accordance with a partial adjustment model, then we can write:

\[ TK_t - TK_{t-1} = \gamma(TK^*_t - TK_{t-1}) \]  

where \( TK_t \) = the actual stock during the current period, \( TK^*_t \) = the desired stock in the same time period, \( TK_{t-1} \) = the actual stock in the previous time period and \( \gamma \) = the coefficient of adjustment which shall be assumed to have a value between 0 and 1 to insure the stability.

of the model. Solving Eq. (3.10) for the actual stock in the current period, we obtain

$$TK_t = \gamma TK^*_t + (1 - \gamma)TK_{t-1}$$

(3.11)

If the righthand side of Eq. (3.9) is substituted for $TK^*_t$ in Eq. (3.11) the supply equation becomes

$$TK_t = \gamma G(WTS_t, WC_t, r_t, FERTN_t) + (1-\gamma)TK_{t-1}$$

(3.12)

Eq. (3.12) essentially states that the actual stock of teacher education degrees is a function of the determinants affecting the desired or equilibrium stock, and the actual stock in the preceding time period.

**The supply of teachers or teacher services**

At any given point in time, the supply of teacher man-years forthcoming from society as a whole depends upon the actual stock of teacher capital or number of education degree holders. By definition, the total flow of teacher man-years supplied per unit of time is given as the product of the stock and the rate of flow of services, i.e.,

$$TS = TK \times V$$

(3.13)

where $TS =$ the flow of services from education degree holders, $TK =$ the number of education degree holders and $V =$ the rate of flow from a unit of teacher capital or education degree per unit of time. For ordinary labor paid on an hourly basis, $V$ would vary depending upon the relative wage. However, since teaching is a salaried occupation
in which teachers are contracted to provide a fixed amount of service per year, the value of V is equal to a constant which may be less or equal to unity. Therefore, the flow of teacher services becomes solely dependent on the actual stock of education degrees.

By substituting the right hand side of Eq. (3.12) for TK in Eq. (3.13), the following expression for the supply of teacher services is obtained:

\[ TS_t = \gamma G(WTS_t, WCS_t, r_t, FERTN_t) + (1-\gamma)TS_{t-1} \]  

(3.14)

where TK_{t-1} is now written as TS_{t-1} and where the dependent variable is now subscripted with a t to make it conformable with the independent variables. Also, the term V now disappears since it has been assumed constant.

In accordance with the usual properties accorded supply functions, it is expected that WTS or the price per man-year of teaching service is directly related to the flow of teacher man-years. This is expected because when the price of teacher services increases, the present value of an education degree goes up. As this happens, more of it is acquired and the number of education degree holders also increases. This ultimately means that more people are in a position to provide teaching services.

Whereas TS and WTS are positively related, it is expected that an inverse relation exists between TS and both WCS and FERTN. This is because when the price per man-year of the unskilled labor increases, the present value of a unit of unskilled laborer also increases. This, in turn, increases the cost of acquiring an education degree.
As it becomes costly, less of it is acquired. Its ultimate effect is, therefore, to cause both the stock of education degrees and the flow of teacher services to decrease. The same logic may be used to show the negative relationship between TS and FERTN.

In contrast to WTS, FERTN and WCS, the nature of the relationship between the flow of teacher services and the rate of interest cannot be ascertained definitely. Whereas its effect as a factor in the determination of both the present value of a unit of teaching capital and the present value of an unskilled laborer is inverse these two present values exert opposite effects on the stock of education degrees. Thus, depending upon which of the two present values exert the greater effect on the stock of degrees the relationship between TS and r may be negative or positive, or it may even be zero.

In view of the assumed value of \( \gamma \) it is also expected that \((1-\gamma)\) is between 0 and 1.

All of the foregoing dictate that the following properties be specified for Eq. (3.14)

\[
\begin{align*}
(a) \ & \frac{\partial (TS)}{\partial (G)} \cdot \frac{\partial (G)}{\partial (WTS)} > 0 \\
(b) \ & \frac{\partial (TS)}{\partial (G)} \cdot \frac{\partial (G)}{\partial (WCS)} < 0 \\
(c) \ & \frac{\partial (TS)}{\partial (G)} \cdot \frac{\partial (G)}{\partial (r)} > 0 \\
(d) \ & \frac{\partial (TS)}{\partial (G)} \cdot \frac{\partial (G)}{\partial (FERTN)} < 0 \\
(e) \ & 0 < \frac{\partial (TS)}{\partial (TS)} < 1
\end{align*}
\]
The demand for teachers or their services

Although this study is primarily concerned with the supply relation, we shall make our model logically complete by next specifying the determinants of the demand for teachers or their services. This demand comes from the nation's elementary and secondary schools which are in the business of producing public education. Since the commodity involved is distinctly an input flow, this section's analysis is strictly an application of traditional factor demand theory.

In Chapter II, a unit of public education output was defined as the knowledge and information gained by a school age person from a day of attendance in school. This being the case, the level of public education output is seen as a direct function of the average daily attendance which, in turn, is directly proportional to the level of enrollment or the school age population. Since this segment of society is exogenously determined, the level of output for any school district is predetermined. Given a predetermined level of output, the assumption of utility-maximizing behavior postulated for the school district implies that it minimizes its operating costs subject to the exogenously determined output level. This further implies that the school district's demand for teacher inputs is a function of the price per unit of a teacher's services, the prices of other inputs and the exogenously determined level of output. 12 On the assumption that the

12 For the derivation of input demand curves for firms whose output levels are predetermined, see Henderson and Quandt, op.cit., in the chapter, "The Theory of the Firm."
various individual school district's input demand functions are independent from each other, then one can easily obtain an aggregate demand function for teacher services by the familiar process of summation. Since about 84 percent of the average school district's expenditures are allocated to teacher salaries, salaries of supporting professional and administrative personnel, services of physical facilities, and salaries of custodial workers, such an aggregate demand function may be shown as:

\[ T_{ST} = f(W_{TS}^t, W_{CS}^t, A_{DA}^t, P_{SPF}^t) \] (3.16)

where \( T_{ST} \) = the number of teacher man-years, \( W_{TS} \) = the price per man-year of teaching service as originally defined, \( W_{CS} \) = the price of a man-year of custodial services, \( W_{SP} \) = the price per man-year of the services of a supporting non-education degree instructional personnel, \( A_{DA} \) = average daily attendance per year, \( P_{SPF} \) = price of the services of a unit of physical facility per year and \( t \) = time period.

As is customary in demand analysis, it is assumed that the number of teachers hired by the public schools is inversely related to the price per man-year of teacher service and positively or inversely-related to the prices of the services of other inputs depending on whether these other inputs are substitutes or complements. It is further assumed that the quantity of teachers is directly related to

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13 See Cost of Education Index (CEI) published annually in School Management. The 84 percent may be broken down as follows: (a) teacher salaries, 64 percent; (b) salaries of supporting professional and administrative personnel, 7 percent; (c) services of physical facilities, 7 percent; and (d) salaries of custodial workers, 5 percent. The remaining 15 percent of total expenditures are distributed to some 20 or more other expenditure classifications.
the exogeneously-determined level of output. Mathematically, these properties are given as:

\[
\begin{align*}
(a) \frac{\partial (TS)_t}{\partial (WTS)_t} &< 0 \\
(b) \frac{\partial (TS)_t}{\partial (WCS)_t} &> 0 \\
(c) \frac{\partial (TS)_t}{\partial (WSP)_t} &> 0 \quad (3.17) \\
(d) \frac{\partial (TS)_t}{\partial (ADA)_t} &> 0 \\
(e) \frac{\partial (TS)_t}{\partial (PSPF)_t} &< 0
\end{align*}
\]

The market for teachers

For equilibrium to exist in this market, we argue that the supply of teachers or man-years of teaching services from the nation's holders of teaching certificates must be equal to the whole public school system's demand for these same services. A complete representation of this market must, therefore, consist of the supply relation given in Eq. (3.14), the demand function given in Eq. (3.16) and a market-clearing condition. For convenience, we bring all these components together:

\[
\begin{align*}
S: &\quad TS_t = \gamma G(WTS_t, WCS_t, r_t, FERTN_t) + (1-\gamma)TS_{t-1} \\
D: &\quad TS_t = F(WTS_t, WCS_t, WSP_t, ADA_t, PSPF) \\
EQ: &\quad TS_t = TS_t
\end{align*}
\]
where Eq. (3.18) is the market-clearing or equilibrium condition.\textsuperscript{14}

\textsuperscript{14}Up to this point, we have maintained the assumption that the current levels of the present values of a unit of teacher capital and an unskilled laborer and the interest rate are no different from their future levels. When this assumption is relaxed, then WTS, WCS and \( r \) in the supply relation must be redefined in terms of their expected or future levels. See Appendix I for the details of this modified model and for reasons why the attempt to estimate its parameters was discontinued.
CHAPTER IV

THE EMPIRICAL MODEL AND THE DATA

This chapter reformulates the mathematical model of Chapter III so that it may be empirically tested. It also discusses the data used in the estimation process.

The econometric model and the statistical hypotheses

To provide a test of the theory the first two behavioral components of the model must be transformed. First, assume the supply relation in Eq. (3.14) to be stochastic, that is:

\[ TS = \gamma G(WTS_t, WCS_t, r_t, \text{FERTN}_t) + (1-\gamma)TS_{t-1} + u_{lt} \]  

(4.1)

where \( u_{lt} \) is an error term. Also, assume the desired stock supply function, \( G \), to be linear:

\[ TS^* = a_{10} + a_{12}(WTS_t) + a_{13}(WCS_t) + a_{14}(r_t) + a_{15}(\text{FERTN}_t) \]  

(4.2)

where the \( a_{1j} \)'s are the parameters. By substituting the right hand side of Eq. (4.2) for \( G \) in Eq. (4.1) a linear stochastic supply relation is obtained:

\[ TS_t = \gamma a_{10} + \gamma a_{12}(WTS_t) + \gamma a_{13}(WCS_t) + \gamma a_{14}(r_t) + \gamma a_{15}(\text{FERTN}_t) + (1-\gamma)(TS_{t-1}) + u_{lt} \]  

(4.3)
If the same assumptions are made for the demand function given in Eq. (3.16) and the estimated coefficients of the whole system written in terms of $b_{ij}$'s, a new statistically testable proposition emerges:

(a) Supply: $TS_t = b_{10} + b_{12}(WTS_t) + b_{13}(WCS_t) + b_{14}(r_t) + b_{15}(FERTN_t) + b_{16}(TS_{t-1}) + u_{1t}$

(b) Demand: $TS_t = b_{20} + b_{22}(WTS_t) + b_{23}(WCS_t) + b_{27}(WSP_t) + b_{28}(ADA_t) + b_{29}(PSPF_t) + u_{2t}$

where $b_{10} = \gamma a_{10}$, $b_{12} = \gamma a_{12}$, $b_{13} = \gamma a_{13}$, $b_{14} = \gamma a_{14}$, $b_{15} = \gamma a_{15}$, $b_{16} = (1-\gamma)$, the $b_{2j}$'s ($j = 0, 2, 3, 7, 8, 9$) are parameters of the demand equation and $u_{2t}$ is another error term.

Since the theory assumes the dependent variable TS and the explanatory variable WTS to be simultaneously determined, it is no longer possible to make the assumption that the error terms possess all the properties generally attributed to them in single equation models. In particular, both error terms are no longer independent from WTS which appears as an independent variable in both the supply and demand equations. The violation of this standard assumption means that it is not appropriate to estimate the parameters of the system using the method of ordinarily least squares (OLS). Application of this method yields not only biased but also inconsistent estimates. 

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16 Most standard textbooks in econometrics provide a mathematical proof of this bias and inconsistency.
As alternative methods for estimating the parameters of systems with a simultaneous equation bias, several procedures have been devised depending upon the identifiability of the model. If the model is just identified, the indirect least squares method is very convenient to use. If it is overidentified, then it is more appropriate to use one of the limited information methods.

A look at Eq. [4.4(a)] immediately suggests that it is overidentified. Given the two endogeneous variables TS and WTS, the order condition of identifiability requires that the number of predetermined variables excluded from each relation must be at least equal to 1. In addition, the rank condition requires that it must be possible to construct at least one nonzero determinant of order 1 from the coefficients of the variables excluded from one equation but included in the other behavioral equation. In Eq. (4.4), more than one predetermined variable is excluded from each relation. For instance, there are three variables excluded from the supply equation but included in the demand equation. The same number of variables are included in the demand equation but not in the supply. Both of these satisfy the order condition for overidentification. Further, the rank conditions are satisfied since there are three determinants of order 1 which can be constructed from the coefficients in the variables excluded in one equation but contained in the other. In view of the overidentified nature of both equations, the structural parameters may therefore be estimated by any one of the limited information methods.

\[\text{See Johnston, Chapter 9.}\]
such as the two-stage least squares (2SLS) or generalized classical linear regression. Since this is the only method for which a computer program is available on campus, it is used in this study's empirical analysis.

In estimating the parameters of the foregoing structural equations it is important to note that the theoretical considerations specified in Eq. (3.15) for the supply and Eq. (3.17) for the demand imply the following statistical hypotheses:

For the supply, these are:

(a) $b_{12} > 0$

(b) $b_{13} < 0$

(c) $b_{14} < 0$ \hspace{1cm} (4.5)

(d) $b_{15} < 0$

(e) $0 < b_{16} < 1$

For the demand, these are:

(a) $b_{22} < 0$

(b) $b_{23} < 0$ \hspace{1cm} (4.6)

(c) $b_{27} > 0$

(d) $b_{28} > 0$

(e) $b_{29} < 0$
Measuring the variables and constructing the data

Researchers in economics are often beset by the lack of data that is conceptually consistent with the variables involved in their models. This study is no exception and an attempt shall therefore be made to construct admissible data from other existing but related measures, or to select proxies or stand-ins for any of the variables where this difficulty is encountered. Before this is done, be it noted that all the data series are converted to a school-year basis and where appropriate deflated to a constant dollar using the 1957-1959 = 100 base. Also, the data collection has been limited to the 22-year period covering the school years 1948-1949 to 1969-1970. It is this author's judgment that the data for the variables in the model are defensible only for this period. Also, the variations for the same variables have occurred largely during these two decades which the period encompasses. A complete listing of the data used is found in Appendix II.

TS: the number of teachers. This is the dependent variable the variations of which the study seeks to explain. The basic data which measure it is given in surveys conducted by the United States Office of Education of the Department of Health, Education and Welfare, and in estimates made by the National Education Association, heretofore

referred to as simply NEA. The former provides figures for the even-numbered years and the latter completes the data by providing estimates for the intervening or odd-numbered years. In both cases, the figures refer to actual bodies in front of classrooms or their full-time equivalents. But as pointed out in Chapter II where the study's assumptions are discussed, teachers are a heterogeneous group and one must express their number in terms of homogeneous units. The way to do this as detailed therein is to obtain the ratio of the average annual salary of teachers to the average starting salary of the new beginning teacher and multiply this ratio by the actual number of teachers as given in the two sources just cited.

Note that data for average starting salaries are assumed to exist. Actually, the data series for this is incomplete. There are estimates for the public school system as a whole provided by surveys conducted by the NEA from the school year, 1962-1963, to the school year, 1970-1971. Prior to the 1962-1963 school year, however, the existing estimates are for big school districts with enrollments of 100,000 or more only. There is thus a need to estimate the average starting salary for the whole public school system for the rest of the study period, i.e., from the school year 1948-1949 to 1961-1962. To do this it was assumed that the average ratio of the average starting salaries

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for all school systems to the average starting salaries in big districts for the period from 1962-1963 to 1969-1970 also holds for the earlier period, i.e., the period from the school year 1948-1949 to 1961-1962. Given this assumption, the average starting salaries for all districts from 1948-1949 to 1961-1962 are obtained by multiplying the average ratio for the period 1962-1970 by the existing estimated average starting salaries for big school districts. The actual process and results of this construction are given in Appendix III, part A.

**WTS: the price of the services of teachers.** Since the dependent variable has been expressed in terms of the new beginning teacher, it may seem at first blush that the logical measure of this price variable is the average starting salary. However, if it is recognized that education is a long-term asset, then it would seem just as appropriate to measure WTS by the average price or salary. The reason why the average salary is more appropriate is that if teacher education is a long-term asset, then the price that the purchaser of the asset must consider is that which takes into consideration the possible prices throughout the lifetime of the asset. Since the teacher population is represented by a cross-section of individuals who are at various stages of their careers, the average of all their salaries even if taken at one point in time would be a better gauge of the average income that one might expect to obtain from his educational investment. In view of this, WTS is measured by the annual mean salary for all teachers. Fortunately, a complete and highly reliable estimate of this series is also given in the same sources cited in connection with the discussion of TS in the preceding section.
WCS: the price of the services of unskilled labor. A good measure of the earnings of an individual with only a high school education is given by the average annual earnings of workers in the service industries which are alternatively classed as unskilled workers by the Department of Labor. These figures are available in the supplements and various issues of the Survey of Current Business. Since the figures are on the basis of calendar years, it was necessary to convert them into a school year basis. Moreover, since the current school term includes four months of the preceding calendar year and 8 months of the current year, the formula used to make the necessary transformation is:

\[
WCS_t = \frac{4}{12} \times ER_{t-1} + \frac{8}{12} \times ER_t
\]

where \(WCS_t\) is the annual earnings in the school year ending in year \(t\), \(ER_{t-1}\) is the annual earnings in the preceding calendar year and \(ER_t\) is the annual earnings for the current calendar year. Thus, for the school year ending in 1970, the value of WCS is obtained by:

\[
WCS_{1970} = \frac{4}{12} \times ER_{1969} + \frac{8}{12} \times ER_{1970}
\]

Note that this is also used as a measure of the price of the services of custodial workers which enters as an explanatory variable in the demand equation. This is done because the schools do not provide information which could lead to the actual derivation of the series. In the absence of this information, it is assumed that school janitors would most likely find alternative jobs in the service industries, and, therefore, a measure of the price of custodial services would be given by the average earnings in that sector.
r: the rate of interest. In the model this is seen as that rate of discount which would make the present value of the stream of earnings flowing from the possession of an education degree equal to the cost of its acquisition. It is felt that despite of the recent employment situation which may have revised people's opinions about the generally accepted riskless nature of an educational investment, a college education is, in the long run, a good investment. Thus, it is considered that the percent yield of risk-free high grade municipal bonds would be a sufficient measure of this variable. The time series on this rate is published in many sources including the annual Economic Report of the President where the data used in this study were taken. Since the data on this variable is available on a calendar year basis, it also had to be converted on a school year basis using the same procedure in estimating WCS.

FERTN: foregone earnings and tuition fees. Professor T. W. Schultz estimates foregone earnings of college students to be about 25 times the average weekly earnings in manufacturing. \(^{22}\) Since the United States Department of Labor has widely publicized data on earnings in manufacturing that date as far back as the 1900's, no difficulty has been encountered in this estimation.

Figures on tuition fees are available on an aggregate basis and for even-numbered years that date back beyond the time period relevant

\(^{22}\) T. W. Schultz, 1963
for this study. It was thus necessary to convert the aggregate figures to a per-student basis and to interpolate to obtain estimates for the odd-numbered years. For details of the construction, see Appendix III, part B.

WSP: the price of the services of supporting non-education degree instructional personnel. The National Education Association in cooperation with the U.S. Office of Education provides two separate estimates of salaries for public school personnel. One estimates the average annual salaries of all instructional staff and another the average annual salaries of classroom teachers only. Since the instructional staff consists of classroom teachers, supervisory personnel, teaching aides, guidance counselors, librarians and other non-education degree professional personnel, it is possible to make a separate estimate for the rest of the staff who are not primarily classroom teachers. This derivation is made on the basis of the formula:

\[
W_{ST_t} = \frac{(INSS_t \times W_{IS_t} - TS_t \times W_{TS_t})}{(INSS_t - TS_t)}
\]

where \(INSS_t\) = the total number of instructional staff, \(W_{IS_t}\) = the average instructional staff salary, \(t\) = time period and \(W_{TS}\) and \(TS\) are as defined earlier. Just like \(W_{TS}\) and \(TS\), data on \(INSS\) and \(W_{IS}\) are also directly available from the same annual publications of the NEA and the U.S.O.E. as already cited. See Appendix III, part C for details.

\[23\] See Sections on higher education in the Statistical Abstracts of the U.S. for various years. For periods prior to 1962, see U.S. Historical Statistics.
PSPF: the price of the services of physical facilities. The most important physical facility which provides a service that is a major input in the production of public education is the classroom. A good measure of this price would thus be the actual or imputed rental for the average classroom owned by the school districts. However, data on this series or on other sources from which it may be derived are either nonexistent or very spotty. For instance, there are no dependable estimates on the number of classrooms. Whereas interest expenditures for the whole school system is available for a number of years, it does not indicate how much is for classrooms and how much is for other facilities. In view of these difficulties, it is felt that whereas a bad estimate may sometimes turn out to be better than no estimates at all, there is simply no way by which even bad estimates may be made. Thus, no observations have been made for this variable. In the empirical test, therefore, it has been dropped as an explanatory variable in the demand equation.

ADA: the level of public education output. In the section on the demand for public school teachers in Chapter III, a public education output was defined as the knowledge and information gained from a day's attendance in school. While it is recognized that there is an infinite number of ways in which variations in this output may occur, it is also realized that there is simply no feasible way in which to take account of these variations. Thus, it is just hoped that the plain number of average daily attendance will provide a rough measure of the variable.24

24 Data on ADA are easily available from NEA's annual Estimates of School Statistics, various years.
CHAPTER V

THE EMPIRICAL RESULTS

An empirical test of the hypotheses is undertaken in this chapter. Although the 2SLS method is for this model more appropriate than the OLS both are used to estimate the structural parameters. This is done in order to provide a basis for comparison. Moreover, even as the primary focus is on the supply equation estimates of the demand relation are also presented.

The OLS estimates

In view of the explosive increase in public school enrollment that was sustained from the late 1950's to the end of the 1960's it is reasonable to assume that demand for teachers has varied much more than the supply. In the language of supply-demand analysis this means that demand has been shifting faster than supply. It also means that observations on TS and WTS actually trace a line that more approximates a supply rather than a demand curve. Given this supposition, an application of OLS is therefore expected to yield estimates of the supply parameters that may be biased and inconsistent but yet possess the usual properties. This is confirmed by the OLS regression equations presented in Eq. (5.1):
(a) S: $TS = 0.07813 + 0.27890(\text{WTS}) - 0.06961(\text{WCS}) - 0.00761(r)$

\[
\begin{array}{c@{\;\;\;\;}c@{\;\;\;\;}c@{\;\;\;\;}c@{\;\;\;\;\;}c}
(\text{.1672}) & (\text{.08588}) & (\text{.16840}) & (\text{.01545}) \\
(\text{.4673}) & (3.24800) & (-4.1340) & (-4.9220) \\
\end{array}
\]

\[-0.30160(\text{FERTN}) + 0.79700(TS_{t-1})
\]

\[
\begin{array}{c@{\;\;\;\;}c@{\;\;\;\;}c@{\;\;\;\;\;\;}c}
(\text{.16110}) & (\text{.12350}) \\
(-1.87200) & (6.45400) \\
\end{array}
\]

\[R^2 = 0.9976 \quad \text{D.W.T.} = 2.083\] (5.1)

(b) D: $TS = -1.01500 + 0.33560(\text{WTS}) + 0.36020(\text{WCS})$

\[
\begin{array}{c@{\;\;\;\;}c@{\;\;\;\;}c@{\;\;\;\;\;}c@{\;\;\;\;\;}c}
(\text{.13910}) & (\text{.22720}) & (\text{.25780}) \\
(-7.29800) & (1.47700) & (1.39700) \\
\end{array}
\]

\[+0.05488(\text{WSP}) -1.47400(\text{ADA})
\]

\[
\begin{array}{c@{\;\;\;\;}c@{\;\;\;\;}c@{\;\;\;\;\;\;}c@{\;\;\;\;\;\;}c}
(\text{.02625}) & (2.42600) \\
(2.09100) & (-.60770) \\
\end{array}
\]

\[R^2 = 0.9900 \quad \text{D.W.T.} = 1.079\]

A brief look at the estimated equations immediately shows that it is, indeed, only the supply estimates that bear the correct signs. In the demand equation the signs preceding the coefficients of WTS and ADA are in conflict with \textit{a priori} considerations. This, of course, is what is expected when the method used is OLS.

Judged by all the test statistics and the signs of the coefficients the OLS method performs very well only insofar as the supply equation is concerned. The high $R^2$ value of .9976 certainly indicate that the data fits the supply model very well. The Durbin-Watson statistic (D.W.T.) of 2.083\footnote{For 22 observations and 5 explanatory variables at the .01 level of significance the Durbin-Watson statistic must be greater than 1.69 but less than 2.31.} also indicates that there is no need to worry about the
problem of autocorrelation. 26 Among other things this favorable statistic implies that the supply function is properly specified.

On the assumption that the presence of the lagged endogenous variable on the right hand side of the supply equation does not affect the normal distribution of the parameters, an examination of the t-values (the first figure in parenthesis under each regression coefficient is the standard error and the second is the t-value) shows that both the estimated parameters of WTS and TS\textsubscript{t-1} are significant at the very high level of .005 while the coefficient of FERTN is significant at the lower but nonetheless highly acceptable level of .05. The t-value for the coefficient of the rate of interest, r, is too low to be significant at an acceptable level but it possesses a sign which is one of the theoretical possibilities. Specifically, its negative sign indicates that its increase tends to decrease the present value of an education capital and therefore discourages people from acquiring a teaching diploma, i.e., its increase causes TS to decrease. Conversely, its decrease tends to increase the present value of a teaching capital and therefore encourages people to seek a diploma in education. Although the coefficient of WCS is also significant at a low level, its sign likewise confirms the theoretical expectation that it is inversely related to TS.

26 One other problem in this study is the existence of high values of r evident from the matrix of correlation coefficients in Appendix I. This is the problem of multicollinearity. Its extreme consequence is to cause the variances and therefore the standard errors of the estimates to be inordinately high, the t-values to be underestimated and for the null hypothesis to be accepted instead of being rejected. Since this does not happen in the supply estimates, it is concluded that the problem is probably not too serious. Hence, it is ignored as it usually is in most quantitative studies.
The 2SLS estimates

Inspite of the seemingly excellent performance of the OLS estimates of the supply parameters the previously noted interdependence between TS and WTS and therefore the correlation of WTS and the error terms makes the estimates as presented in Eq. (5.1) biased and inconsistent. To remove this inconsistency, the method of 2SLS was used on the same data. The estimated equations follow:

(a) S: \[ TS = 0.04310 + 0.17700(WTS) - 0.00354(WCS) - 0.00516(r) - 0.16650(FERTN) + 0.82470(TS_{t-1}) \]  

(b) D: \[ TS = -1.1920 - 0.18470(WTS) + 0.80640(WCS) + 0.01613(WSP) + 3.0870(ADA) \]

A comparison of the coefficients of Eq. (5.1) and Eq. (5.2) in Table 5.1 shows that there is at least one important improvement—all the signs of the coefficients of the demand equation are now acceptable. In the OLS estimates, \( b_{22} \) and \( b_{28} \) were positive and negative, respectively. In Eq. (5.2) which is obtained by the method of 2SLS, \( b_{22} \) is now negative and \( b_{28} \) positive. Both are, of course, in conformity with theory. This observation is an empirical support of the conclusion

\[ b_{22} \]

In contrast to the OLS estimates presented earlier the following 2SLS results do not include figures on the standard errors, t-values and the statistics, \( R^2 \) and D.W.T. The primary reason for this is that it is not yet conclusively shown that the application of these test statistics within a simultaneous equation context is valid. For an example of several recent attempts to examine whether or not it is appropriate to apply the t-values in testing the significance of the structural parameters in a simultaneous equation model see Richardson & Rohr, "Distribution of a Structural t-Statistic for the Case of Two Included Endogeneous Variables" Journal of the American Statistical Association (June, 1971), pp. 375-382. One special note that needs emphasis in this and similar studies is that lagged values of the endogenous variables are expressly excluded as explanatory variables. The model tested here includes this lagged value.
Table 5.1. A comparison of the OLS and 2SLS estimates.

<table>
<thead>
<tr>
<th>Independent variables*</th>
<th>Supply</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>2SLS</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0781</td>
<td>-0.0431</td>
</tr>
<tr>
<td>WTS</td>
<td>0.2789</td>
<td>0.1770</td>
</tr>
<tr>
<td>WCS</td>
<td>-0.0696</td>
<td>-0.0035</td>
</tr>
<tr>
<td>r</td>
<td>-0.0076</td>
<td>-0.0052</td>
</tr>
<tr>
<td>FERTN</td>
<td>-0.3016</td>
<td>-0.1665</td>
</tr>
<tr>
<td>TS&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.7970</td>
<td>0.8247</td>
</tr>
<tr>
<td>WSP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*TS is the dependent variable in all four equations

that the use of 2SLS yields more reliable results in a simultaneous equation context. In subsequent discussions, therefore, we will consider the results given in Eq. (5.2) more reliable than those presented in Eq. (5.1). Moreover, the primary emphasis will now be on the supply component of the model.

**Deriving the estimates of the true supply parameters**

What has been done so far is to estimate the parameters of the statistical supply relation in Eq. (4.4). Since these estimates do not directly yield the estimated parameters of the theoretical supply as
linearized in Eq. (4.2), the latter may be obtained by equating the \( y_{a_{1j}} \)'s \((j = 0, 2, 3, 4, 5, 6)\) in Eq. (4.3) to the \( b_{1j} \)'s for the same values of \( j \) in Eq. (4.4). Thus:

(a) \( b_{10} = y_{a_{10}}, \) therefore, \( a_{10} = \frac{b_{10}}{y} \)

(b) \( b_{12} = y_{a_{12}}, \) therefore, \( a_{12} = \frac{b_{12}}{y} \)

(c) \( b_{13} = y_{a_{13}}, \) therefore, \( a_{13} = \frac{b_{13}}{y} \)

(d) \( b_{14} = y_{a_{14}}, \) therefore, \( a_{14} = \frac{b_{14}}{y} \)

(e) \( b_{15} = y_{a_{15}}, \) therefore, \( a_{15} = \frac{b_{15}}{y} \)

(f) \( b_{16} = (1 - y), \) therefore, \( y = (1 - b_{16}) \)

By substituting the appropriate values of \( y \) and the \( b_{1j} \)'s from Eq. (5.2) to those in Eq. (5.3), the following estimates of the true supply parameters are obtained:

(a) \( a_{10} = -0.2456 \)

(b) \( a_{12} = 1.0097 \)

(c) \( a_{13} = -0.0202 \)

(d) \( a_{14} = -0.0294 \)

(e) \( a_{15} = -0.9498 \)

---


29 Although this practice is common in the literature there is evidence that except for \( y \) which is a linear combination of \( b_{16} \) it may not be valid to make inference about the significance of the \( a \)'s on the basis of the significance of the \( b \)'s. See T. P. Lianos and G. C. Rausser, "Approximate Distribution of Parameters in a Distributed Lag Model," *Journal of the American Statistical Association* (March, 1972), pp. 64-67.
The supply elasticities

Now that we know the estimated parameters of the true supply equation, it is now possible to compute the elasticities associated with each of the supply determinants. They are:

(a) \( E_{WTS} = 2.7789 \)
(b) \( E_{WCS} = -0.0391 \)
(c) \( E_r = -0.0563 \)
(d) \( E_{FERTN} = -1.3416 \)

A more direct method of estimating the same elasticities is to estimate the parameters of the supply function using the natural log of the variables. Suppose the desired supply function is of the form:

\[
TS^* = A^{a_{10}} WTS^{a_{12}} WCS^{a_{13}} r^{a_{14}} FERTN^{a_{15}} \quad (5.4)
\]

where \( TS^* \) = the desired supply of teaching services, \( A^{a_{10}} \) = constant, WTS, WCS, r, FERTN are as defined earlier and \( a_{12}, a_{13}, a_{14}, a_{15} \) are the associated elasticities, respectively. Suppose it is further assumed that the adjustment process is described by:

\[
\frac{TS_t}{TS_{t-1}} = \left( \frac{TS^*_t}{TS^*_{t-1}} \right)^{\gamma} \quad (5.5)
\]

where all the symbols are defined in Eq. (3.10). Solving for \( TS_t \) in Eq. (5.5) and then substituting the right hand side of Eq. (5.4) for \( TS^*_t \) yields the relation:

30 The coefficients of elasticity are computed using the general formula:

\[
E = (\partial Y/\partial X) (X_t/Y_t)
\]

where \( Y \) is the quantity supplied and the \( X_t \)'s are the supply determinants and \( E \) = the coefficient of elasticity.
If the natural log of Eq. (5.6) is now obtained, a new relation emerges:

\[
\ln(TS_t) = a_{10} \ln(A) + a_{12} \ln(WTS_t) + a_{13} \ln(WCSt) + a_{14} \ln(rt) + a_{15} \ln(FERTN_t) + (1-\gamma) \ln(TSt-1) \tag{5.7}
\]

If an error term is now added to Eq. (5.7) and the coefficients are expressed in terms of b's, we obtain the new testable expression:

\[
\ln(TS_t) = b_{10} + b_{12} \ln(WTS_t) + b_{13} \ln(WCSt) + b_{14} \ln(rt) + b_{15} \ln(FERTN_t) + b_{16} \ln(TSt-1) + e_t \tag{5.8}
\]

where \(b_{10} = a_{10} \ln A\), \(b_{12} = a_{12}\), \(b_{13} = a_{13}\), \(b_{14} = a_{14}\), \(b_{15} = a_{15}\) and \(b_{16} = (1-\gamma)\). From these relationships it is easy to deduce the supply elasticities. If the demand equation is likewise assumed to be nonlinear, and then transformed into its natural logs a new testable model emerges. Such a model is similar to Eq. (4.4) except that the variables are now expressed in terms of their natural logs and the elasticities may now be directly deduced from the parameter estimates.

If the method of 2SLS is now used on Eq. (5.8) the estimated supply equation becomes:

\[
\ln(TS_t) = 0.6183 + 0.5382 \ln(WTS) + 0.1854 \ln(WCSt) - 0.0320 \ln(rt) - 0.2117 \ln(FERTN) + 0.6419 \ln(TSt-1) \tag{5.9}
\]

It may be observed from Eq. (5.9) that \((1-\gamma) = 0.6419\) which implies that \(\gamma = 0.3581\). Given this and the value of \(b_{12}, b_{14}\) and \(b_{15}\), we deduce the following elasticities:

\[31\] In Eq. (5.9), \(b_{13} > 0\) which is contrary to expectations. Therefore, it is meaningless to deduce the associated elasticity, \(a_{13}\).
\[
E_{WTS} = a_{12} = 1.5029 \\
E_r = a_{14} = -0.0894 \\
E_{FERTN} = a_{15} = -0.5912 
\]

Table 5.2. A comparison of supply elasticities using two different approaches.

<table>
<thead>
<tr>
<th>Value of E</th>
<th>Computed from Eq. (5.2)</th>
<th>Deduced from Eq. (5.9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(E_{WTS})</td>
<td>2.7789</td>
<td>1.5029</td>
</tr>
<tr>
<td>(E_{WCS})</td>
<td>-0.0391</td>
<td></td>
</tr>
<tr>
<td>(E_r)</td>
<td>-0.0563</td>
<td>-0.0894</td>
</tr>
<tr>
<td>(E_{FERTN})</td>
<td>-1.3416</td>
<td>-0.5912</td>
</tr>
</tbody>
</table>

In Table 5.2, the various supply elasticities (a) computed by applying the elasticity formula on the results from Eq. (5.2), and (b) directly deduced from the results given in Eq. (5.9) are compared. A few significant observations may be made from this comparison. One is that both approaches indicate that supply price elasticity substantially exceeds unity. This means that a one percent change in teacher salaries is accompanied by more than one percent change in the number of teaching services supplied. Secondly, the relative positions of \(E_{WTS}\) and \(E_{FERTN}\) do not change.
In both, $E_{WTS}$ yields the highest elasticity coefficient while $E_{FERTN}$ comes next. This may be interpreted to mean that the supply of teachers is most sensitive to changes in average annual salaries, followed by changes in foregone earnings and tuition fees. Finally, both approaches would also seem to indicate that teacher supply is relatively insensitive to changes in both $WCS$ and $r$.

**The coefficient of adjustment**

In addition to the manner in which the supply determinants are identified, the human capital approach that this study uses is further reflected by the use of a partial adjustment model which includes the coefficient of adjustment, $\gamma$. This coefficient measures the rate at which the actual stock of teachers catches up with the desired stock. If it approaches unity which means that $(1-\gamma) = 0$, then the desired stock and the actual stock are identical at the time of observation. On the other hand, if it approaches 0, then no such identity exists at the time of observation. From the alternative estimates of $b_{16}$ given in Eq. (5.1(a)), Eq. (5.2(a)) and Eq. (5.9), we deduce that $\gamma$ is equal to .2030, .1753 and .3581, respectively. Although widely divergent from each other, all are closer to zero than to unity. This result, of course, confirms the obvious, i.e., for an asset that takes some years to acquire only a very small portion of the desired stock at any given time period is actually realized for that same period.
Reality and the estimates

Earlier in this chapter the OLS estimation method was justified on the grounds that the demand curve probably shifted more than the supply. Since the supply shift is more likely to be towards the left\(^ {32}\)

![Diagram of supply and demand shifts](image)

**Figure 5.1.** Presumed extent of supply and demand shifts for the study period.

one would then expect that the OLS estimates would more appropriately reflect properties of the line labelled as \(s_s\) in Figure 5.1. Likewise the 2SLS method would yield results that more appropriately reflect the less steeply sloped but true supply line such as \(S_1 S_1\). Since the

\(^{32}\)This is supported by the fact that during the late 1950's and throughout the 1960's complaints about teachers moving in droves to private industry were very common. For a more detailed analysis of this see J. Kershaw and R. McKea, Teacher Shortages and Salary Schedules (New York: McGraw-Hill Book Company, 1962), 203 pp.
OLS results yield a value of 1.3246 for $a_{12}$ and the 2SLS yield an estimated value of 1.0097 for the same parameter, it is here concluded that on the basis of at least this difference in slopes, the results reflect reality.
Summary

Education is now widely accepted, at least among economists, as a special form of investment in human capital. One implication of this revolutionary economic thought is that it is not sufficient to derive the theory of labor supply via the traditional income-leisure indifference curve analysis but rather through an approach that takes into explicit account both education stocks and labor flows. This study is an attempt to use the latter approach to the study of the supply of educated or highly skilled manpower services with special reference to the public school teacher. The objectives of this study therefore includes the formulation of a theory of the supply of teachers or their services and the estimation of the parameters associated with it.

In formulating the theory it is important to note two separate but inter-dependent markets. The first is the market for sources of teaching services (degrees, diplomas or teaching certificates) where the demanders are the prospective teachers and the suppliers are the colleges and universities. The second one is the market for a flow of teaching services where the demanders are the nation's elementary and secondary schools and the suppliers are the holders of education degrees.
This study is essentially an attempt to understand the flow market in which man-years of teaching services are bought and sold. As far as the demand side of this market is concerned, no particular difficulty is encountered since it simply involves a direct application of traditional factor demand theory. Specifically, the demand by the schools for man-years of teaching services is shown to be a function of the price per man-year of teaching services, the prices of other educational inputs and the level of enrollment. However, the supply side is a different matter. Before an individual can provide a flow of teaching services he must acquire the necessary education. For society as a whole, the supply of teaching services depends upon the stock of education degrees that already exists. This means that before the factors affecting the supply of teacher services are isolated, the determinants of the existing stock of degrees are first examined. In this connection, it is hypothesized that society's stock of teaching capital is a function of the unit price of teaching services, the rate of interest, the cost of the human capital input that is at least equivalent to a high school education, the earnings foregone while attending college and tuition and other incidentals. Assuming that the rate of flow is proportional to the stock and that there is a time lag between actual and desired stock, the supply of man-years of teaching services is, therefore, seen as a function of the very same factors that influence the stock as well as the previous level of the stock. In view of these considerations, the market for teacher services is then summarized by the following functions:
where $\gamma$ is the coefficient of adjustment with a value between 0 and 1, 
$TS$ = man-years of teaching services, $WTS$ = price per units of the service, $WCS$ = the price of a man-year of service rendered by an unskilled worker with only a high school education, $r$ = the rate of interest, $FERTN$ = the sum of foregone earnings and tuition and other incidental fees, $TS_{t-1}$ = the number of teachers in the previous time period, 
$WSP$ = the price of a man-year of administrative and other professional services used as inputs in the public educational process, $PSPF$ = the price of the services of classrooms and other facilities and $ADA$ = the level of enrollment expressed in terms of average daily attendance. 
In the empirical model the demand variable, $PSPF$, is excluded from the analysis due to data problems. 

To test the model the behavioral equations are first transformed into statistically testable propositions and then estimated by OLS and 2SLS methods.

Observations and conclusions

On the basis of the estimation results, the following observations and/or conclusions may be made:

First, a human capital approach to the study of the factors affecting the supply of educated manpower services as reflected in the manner in which the supply determinants are identified and the adoption
of a partial adjustment model performs quite well in explaining recent events in the school teacher market. In this respect, the results of this study can help lend credibility to the new but fast growing field of human capital theory.

Second, as expected the use of the method of 2SLS yields results that are an improvement over that of the OLS estimates. This improvement primarily consists of the correct signs of all the model's parameters when the former method is used. As already noted the OLS method yields correct signs for the supply but not for the demand equation.

Third, of the four determinants identified only the price of teacher services, WTS, and the private cost of education made up by foregone earnings and tuition fees and denoted FERTN would seem to exert any effects on teacher supply.

Finally, it is concluded that the supply of teachers is relatively elastic with respect to the price of its services.

**Implications for policy**

The foregoing conclusions and observations lend support to existing or contemplated policies embodying the following features:

(a) Competitive teacher salary schedules. This feature which has also been recognized by many students of the public school teacher market as an effective tool for teacher recruitment is supported by the conclusion that teacher supply is relatively elastic with respect to the price variable.

33Among the more recent ones are J. Kershaw and R. N. McKean who are cited in footnote 31 and Werner J. Hirsch in his "Demand and Supply of Teachers in California" *California Management Review* 10(1): 27–34, 1967.
(b) The finding that the private cost of education such as foregone earnings and tuition fees are significant negative factors affecting teacher supply also suggests that competitive salary levels can be supplemented by a flexible grants program to prospective teachers.

(c) Note, however, that human capital formation is a slow process as the low coefficient of adjustment certainly attests. This means that any present attempt to change the competitiveness of teacher salaries and/or the level of private cost of education will produce the desired effects at a later time. Since this is liable to create a state of disequilibrium such as a shortage or a surplus it would seem that a sound teacher recruitment policy should also include measures to speed up the supply-demand adjustment process. When the disequilibrium results in a shortage, these measures may assume the form of reconsidering state teacher credential requirements with the aim and view of including more talent, and better use of manpower through technology and curriculum improvements. 34 On the other hand, when the disequilibrium results in a surplus the adjustment process may be eased by such measures as up-to-date information on current and prospective teacher market situations, career counselling for prospective teachers and possibly voluntary limitations on teacher school admissions. 35

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34 For more detailed discussion of these measures, see W. J. Hirsch, op. cit.

35 Many states including Utah are now doing this.
LITERATURE CITED


Appendix I
The Model with Expectations

One assumption that lies behind the supply relation given in Eq. (3.14) is that current values of WTS, WCS and r are no different from their future values. One alternative is to assume there is a difference between these values. If this is made, Eq. (3.14) needs to be rewritten to become:

$$TS_t = \gamma G(WTS_t), E(WCS_t), E(r_t), FERTN_t] + (1-\gamma)TS_{t-1} \quad (I.1)$$

where $E(WTS_t), E(WCS_t)$ and $E(r_t)$ are the expected values in time period $t$ of WTS, WCS and $r$, respectively.

Normally, it is not possible to observe the future values of expected variables. This means that to be able to estimate the parameters of the new model, some assumptions must be made concerning the manner in which the values of the variables involved are formed. In this connection, assume that the formation of the values of WTS, WCS and $r$ is in accordance with the adaptive expectations model:¹

(a) $E(WTS_t) = (1-\eta)[(WTS_t) + \eta(WTS_{t-1}) + \eta^2(WTS_{t-2}) + \ldots]$  
(b) $E(WCS_t) = (1-\lambda)[(WCS_t) + \lambda(WCS_{t-1}) + \lambda^2(WCS_{t-2}) + \ldots] \quad (I.2)$  
(c) $E(r_t) = (1-\rho)[(r_t) + \rho(r_{t-1}) + \rho^2(r_{t-2}) + \ldots]$  

where $\eta$, $\lambda$ and $\rho$ are assumed to have values between 0 and 1 for stability reasons.

The next step in estimating the parameters associated with Eq. (I.1) is to assume that it is linear and stochastic. That is:

\[
TSt = \gamma a_1 + \gamma a_2 E(TS_t) + \gamma a_3 E(WCS_t) + \gamma a_4 E(r_t) + \\
+ \gamma a_5 (FERTN)_t + (1-\gamma)(TS)_{t-1} + u_{1t}
\]  

(I.3)

where the \( a \)'s are the true supply parameters and \( u_{1t} \) is the error term.

Now substitute the right hand sides of Eq. (I.2) for the appropriate expectations variables in Eq. (I.3) and then apply the Koyck transformation\(^2\) thrice in succession to the result. This two-step procedure should then yield the following supply equation:

\[
TSt = c_0 + c_{20}(WTS)_t + c_{21}(WTS)_{t-1} + c_{22}(WTS)_{t-2} + \\
+ c_{30}(WCS)_t + c_{31}(WCS)_{t-1} + c_{32}(WCS)_{t-2} + \\
+ c_{40}(r_t) + c_{41}(r)_{t-1} + c_{42}(r)_{t-2} + \\
+ c_{50}(FERTN)_t + c_{51}(FERTN)_{t-1} + c_{52}(FERTN)_{t-2} + \\
+ c_{53}(FERTN)_{t-\lambda} + c_{11}(TS)_{t-1} + c_{12}(TS)_{t-2} + \\
+ c_{13}(TS)_{t-3} + c_{14}(TS)_{t-4} + e_t
\]  

(I.4)

where the \( c \)'s are appropriate combinations of the true supply parameters of Eq. (I.3) and the constants \( \eta, \lambda \) and \( \rho \) from Eq. (I.2). Likewise \( e_t \) is a combination of the same constants and \( u_{1t} \).

While Eq. (I.4) is much more elegant than Eq. [4.4(a)] the attempt to estimate its parameters was discontinued primarily because of data problems which is particularly severe for the lagged values of \( TS_t \).

Note that while the expectation variables (WTS, WCS, r) and FERTN\textsubscript{t} need to be lagged only two and three time periods, respectively, TS\textsubscript{t} has to be lagged four times. This means that for TS\textsubscript{t}, data as far back as the school year, 1944-1945, must be available. Unfortunately, the data which make it possible to construct estimates of TS do not go that far back in time. This is clearly evident in Appendix III, A.

One way to go around this problem is to make the last observation on TS fall on the school year 1952-1953 such that when it is lagged four time periods the first observation on TS\textsubscript{t-4} would fall on the 1948-1949 school year. But this means there will only be 18 observations. Since the model given in Eq. (1.4) contains 18 explanatory variables the number of degrees of freedom goes to zero. It is thus not possible to use this alternative either.
Appendix II

The Complete Data Series, Its Sources

and Statistical Properties

The data series

<table>
<thead>
<tr>
<th>School Year</th>
<th>TS</th>
<th>WTS</th>
<th>WCS</th>
<th>r</th>
<th>FERTN</th>
<th>TS</th>
<th>WSP</th>
<th>ADA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948-49</td>
<td>1.0301</td>
<td>3.079</td>
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<td>2.27</td>
<td>1.780</td>
<td>1.0733</td>
<td>7.839</td>
<td>0.2169</td>
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<tr>
<td>1949-50</td>
<td>1.1044</td>
<td>3.411</td>
<td>2.618</td>
<td>2.06</td>
<td>1.910</td>
<td>1.0301</td>
<td>7.155</td>
<td>0.2216</td>
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<td>1950-51</td>
<td>1.1375</td>
<td>3.413</td>
<td>2.568</td>
<td>1.99</td>
<td>1.942</td>
<td>1.1044</td>
<td>5.107</td>
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<td>2.642</td>
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<td>2.020</td>
<td>1.1375</td>
<td>6.141</td>
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<td>1952-53</td>
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<td>2.772</td>
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<td>2.107</td>
<td>1.2397</td>
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<td>2.257</td>
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<td>2.357</td>
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<td>1.5577</td>
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<td>1959-60</td>
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<td>2.513</td>
<td>1.6391</td>
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<td>2.618</td>
<td>1.8789</td>
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<td>5.566</td>
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<td>2.0020</td>
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<td>0.3741</td>
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<td>1964-65</td>
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<td>5.673</td>
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<td>2.853</td>
<td>2.0592</td>
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<td>1965-66</td>
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<td>3.64</td>
<td>2.909</td>
<td>2.1542</td>
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<td>1966-67</td>
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<td>5.929</td>
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<td>2.2515</td>
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<tr>
<td>1967-68</td>
<td>2.5040</td>
<td>6.217</td>
<td>4.129</td>
<td>4.33</td>
<td>2.955</td>
<td>2.3731</td>
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<tr>
<td>1968-69</td>
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<td>2.983</td>
<td>2.5040</td>
<td>9.332</td>
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<td>1969-70</td>
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<td>4.486</td>
<td>6.60</td>
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<td>0.342</td>
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<td>0.136</td>
<td>0.2325</td>
<td>1.407</td>
<td>0.0045</td>
</tr>
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</table>

1 All money variables including WTS, WCS, FERTN and WSP are deflated to a constant dollar using the 1957-1959 = 100 base. For such an index converted to a school year basis see NEA, Economic Status of the Teaching Profession, 1969-1970, Research Report 1970-R3, p. 62. All four are also expressed in thousand dollars.
Sources

TS, the number of teachers in standard units, is from column 7 in part A, Appendix III. It is expressed in millions.

WTS, the price of a year of teaching service or the average annual salaries of teachers, is directly taken from the section on Instructional Staff of the NEA's annual Estimates of School Statistics.

WCS is the cost of the human capital embodied in a new beginning teacher education student which is assumed to be approximated by the average annual earnings of full time workers in the service industries. It was taken from Table 6.5 which shows the average annual earnings per full time employee by industry in The National Income and Product Accounts of the United States, 1929-1965. This is a supplement to the Survey of Current Business and published by the United States Department of Commerce, Office of Business Economics in 1966. For the period from 1966 to 1970, the figures were obtained from the individual issues of the Survey.

r, the rate of interest, was taken from Table C-55 of the 1970 Economic Report of the President. It is expressed in percentages and is converted to a school-year basis.

FERTN, the sum of foregone earnings and tuition fees is from column 8 of part B, Appendix III.

$TS_{t-1}$ is the lagged value of $TS_t$ and is therefore directly derived from that column.

WSP, the average annual earnings of instructional personnel other than regular classroom teachers comes from column 7, part C, Appendix III.
ADA, average daily attendance which is assumed to be a measure of public educational output comes directly from the annual Estimates of School Statistics, Enrollment Section. It is expressed in hundred millions.

The correlation matrix

<table>
<thead>
<tr>
<th></th>
<th>TS</th>
<th>WTS</th>
<th>r</th>
<th>WCS</th>
<th>FERTN</th>
<th>TS</th>
<th>WSP</th>
<th>ADA</th>
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</thead>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
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<td></td>
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</tr>
<tr>
<td>r</td>
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<td></td>
</tr>
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<td></td>
</tr>
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<td>0.9891</td>
<td>0.9843</td>
<td>0.8252</td>
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</tbody>
</table>
## Appendix III

### Construction of Data for TS, FERTN and WSP

#### A. TS: The number of teachers in standard units

<table>
<thead>
<tr>
<th>School year</th>
<th>Number of teachers in all big school districts as a whole (millions)</th>
<th>Unadjusted starting salaries ($1,000)</th>
<th>Average starting salaries ($1,000)</th>
<th>Average annual teacher salary (dollars)</th>
<th>Adjusted annual teacher salary factor</th>
<th>Number of teachers in standard units (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947-48</td>
<td>0.8521</td>
<td>2.123</td>
<td>2.011</td>
<td>2.532</td>
<td>1.259</td>
<td>1.0733</td>
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<td>1948-49</td>
<td>0.8652</td>
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<td>2.162</td>
<td>2.574</td>
<td>1.191</td>
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<td>1949-50</td>
<td>0.9044</td>
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<td>2.313</td>
<td>2.824</td>
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<td>1950-51</td>
<td>0.9276</td>
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<td>2.562</td>
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<td>3.080</td>
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<td>3.273</td>
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<td>4.571</td>
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<td>1.5577</td>
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<td>1958-59</td>
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<td>1960-61</td>
<td>1.4033</td>
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<td>5.275</td>
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<td>1962-63</td>
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<td>1.344</td>
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</table>

Column 2, the unadjusted number of school teachers in millions, comes from various issues of the Estimates of School Statistics. It is
a simple body count of all teachers in the nation's public elementary and secondary schools.

Column 3, the average starting salaries in all big districts (districts with more than 100,000 enrollment) is from pp. 83-86 of the October 1970 issue of the Research Bulletin, another regular publication of the NEA.

Column 4, average starting salaries for the nation as a whole, comes from two sources. The boxed figures which represent the period from 1962-1963 to 1970-1971 are available from various issues of the NEA's annual Salary Schedules for Teachers. No estimates have been made by the NEA for the previous period, i.e., from the school year 1947-1948 to 1961-1962.

To provide estimates for each of the 15 years included in this missing period, two steps were undertaken. First, it was assumed that the average ratio of column 4 to column 3 for the 9-year, 1962-1971 period also holds for the 15-year period from 1947 to 1962. This average ratio which has been determined to be .9472 is then multiplied into each entry in column 3 to obtain the corresponding entries in column 4.

Column 5 also comes from various issues of the Estimates of School Statistics.

Column 6 is the ratio of column 5 to column 4.

Column 7 is the product of column 6 and column 1.
### B. FERTN: Foregone earnings plus tuition fees

<table>
<thead>
<tr>
<th>School Year</th>
<th>Average weekly earnings in manufacturing 1957-59=100</th>
<th>Consumer price index</th>
<th>Real value of foregone earnings</th>
<th>Real value of tuition cost of private college education per student per year</th>
<th>Total tuition charge</th>
<th>Total college enrollment</th>
<th>Real value of total income, all enrollment</th>
<th>Real value of total tuition charge</th>
<th>(1) ($)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
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<td>1.614</td>
<td>360</td>
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<tr>
<td>1949-50</td>
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<td>2.390</td>
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<td>1950-51</td>
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<tr>
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<tr>
<td>1952-53</td>
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Column 3 comes directly from various issues of the NEA's annual Economic Status of the Teaching Profession.

Column 4 is obtained by multiplying column 2 by 25 and deflating the resulting product by the consumer price index given in column 3.

Columns 5 and 6 come from the sections on higher education in the United States Historical Statistics and the annual Statistical Abstracts of the U.S., both of which are publications of the U. S. Department of Commerce Bureau of the Census. Figures from 1948 to 1962 were taken from the first one and those for 1964 to 1970 were taken from the second. In both cases, figures are available only for the even-numbered years. Estimates for the intervening or odd-numbered years were obtained by interpolation.

Column 7 is obtained by dividing column 6 into column 5 and then deflating by the index in column 3.

Column 8 is the sum of columns 4 and 7. Discrepancies occur due to rounding.
C. WSP: Average annual salaries of instructional staff members who are not primarily classroom teachers

<table>
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<tr>
<th>School Year</th>
<th>Number of instructional staff (millions)</th>
<th>Average annual salary, instructional staff ($1,000)</th>
<th>Number of classroom teachers (millions)</th>
<th>Average annual salary, classroom teachers ($1,000)</th>
<th>Consumer price index 1957-59=100</th>
<th>Real average annual salary, supporting staff ($1,000)</th>
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Columns 2, 3, 4 and 5 are from Instructional Staff Section, Estimates of School Statistics, various years.

Column 6 is from Economic Status of the Teaching Profession, various years.
Column 7 is obtained by using the formula:

\[
\left( \frac{(\text{Col. 2} \times \text{Col. 3}) - (\text{Col. 4} \times \text{Col. 5})}{\text{Col. 2} - \text{Col. 4}} \right) \times \left( \frac{1}{\text{Col. 6}} \right)
\]

(Col. 2 x Col. 3) gives the total salary expenditures for all the instructional staff in the nation's public schools. (Col. 4 x Col. 5) yields the total salary expenditures for that part of the instructional staff constituted by all classroom teachers. The difference between Col. 2 and Col. 4 gives that part of the total instructional staff which are not primarily classroom teachers. The first part of the formula therefore gives the average annual nominal salary per supporting or non-teacher member of the instructional staff. The second part of the formula converts the nominal figure into its real value.
VITA

Andrew W. Bacdayan

Candidate for the Degree of

Doctor of Philosophy

Dissertation: The Supply of Public School Teachers in the United States: A Study in Human Capital Theory

Major Field: Economics

Biographical Information:

Personal Data: Born February 4, 1973 in Bangaan, Sagada, Mountain Province, Philippines; son of Maria Luisa Somebang and Paul Bacdayan; married Virtud R. Covar of Majayjay, Laguna, Philippines; two children—Wangdali and Maquiling.

Education: Attended primary, intermediate and secondary schools of the Episcopal Mission in Sagada, Mountain Province, Philippines up to 1955; received Bachelor of Science in Forestry degree from the University of the Philippines in 1959; obtained M.S. degree in forestry and resource development at Michigan State University, East Lansing, Michigan in 1962 under a grant from the United States Agency for International Development and the Philippine National Economic Council.

Professional Experience: Instructor then Assistant Professor at the University of the Philippines, 1959-1961, 1962-1965; research assistant at Utah State University, 1966-1969; Assistant Professor of business administration and economics at Wartburg College, Waverly, Iowa, 1969-1972.