AN ECONOMIC ANALYSIS OF SMALL RURAL COMMUNITY COLLEGES

by

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Dissertation submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

in

Community College Education

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December 1984

Blacksburg, Virginia

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(ABSTRACT)

The purpose of this study was to investigate the relationship between educational costs and educational output in two-year public community colleges. The research hypothesis was that small rural community colleges cannot produce the same educational output at either the same average or the same marginal cost as do those community colleges that operate on a relatively larger scale. The dependent variable was IEG (Instructional Educational and General) expenditures as reported to NCES (National Center for Educational Statistics). The independent variables were: (1) FTE enrollment, (2) MARKET (proportion of headcount enrollment to target population), and (3) DIVERSITY (proportion of the number of different curricula in which degrees, diplomas or certificates were awarded to the total number (70) of different HEGIS (Higher Education General Information Survey) curricula. A control variable, ADJAVSAL, was used to control for salary differences.

Using the 1980-81 HEGIS information as the primary data base, both linear and nonlinear total, average, and marginal cost functions were derived for seven institutional types of

two-year public colleges and three composites.

Findings from the study lead to the conclusion that although economies of scale (defined as the excess of average over marginal cost) were achievable by all two-year public colleges, how these economies were spent was dependent on institutional size. For example, 194 small rural community colleges were found to add or delete educational programs having the same (not different) marginal cost @ $2,668/FTE. If comprehensiveness is equated with programs having different (not the same) costs, the findings indicate that small rural colleges were unable to convert their achieveable economies of scale into increased comprehensiveness. In contrast, all other two-year public colleges (other than medium large colleges) were found to have nonconstant marginal costs per FTE student.

The principal recommendation is that differential funding is needed to compensate for differences in achievable economies of scale between small rural community colleges and their larger counterparts. The continued denial of nearly half the states to compensate for economy of scale differentials of the magnitude confirmed by the present study may be equated to a denial of access to equality of educational opportunity for those served by small rural community colleges.

ACKNOWLEDGEMENTS

Anyone who has ever written a doctoral dissertation knows what a lonely effort it is. The nights, the weekends, the frustrations with the computer--they all add up to a total commitment on the part of the researcher. Yet, awareness of one's "silent partners" is ever present. It was Albert Einstein who humbly said, "I stand on the shoulders of giants."

As for my own silent partners, one in particular was truly a giant--Sir Isaac Newton--for it was Newton who invented calculus. Prior to Newton's contribution, scientists--particularly astronomers--were at a loss as to how to measure the rate of change between two or more variables. Although most academic disciplines make use of calculus today, my own study would not have been possible without the historical development of two such calculus-based disciplines--statistics and economics.

Within a more contemporary frame of reference, I also had a great number of other silent partners, without whose support and encouragement this study could never have been completed. Whereas I initially came to Virginia Tech intending to write a dissertation within a discipline in which I was familiar--accounting--I wound up writing a dissertation on a subject in which I had neither knowledge nor experience--community college education. Quite apart from any contribution this dissertation may make to the field of community college education, this dissertation also makes a statement about my own silent partners--the faculty of the Community College Program Area of the College of Education at Virginia Tech. The reader of this dissertation will not find the words "community college" anywhere in my vita, for I can count on one hand the number of times I have even been inside a community college. Whatever knowledge of community college education I now posses, I have learned over these past three years at Virginia Tech. Although, as author, I assume full responsibility for the dissertation that follows, I would like to take this opportunity to thank all of my silent partners at Virginia Tech, and especially:

1) Dr. Charles Atwell, for his guiding hand as Chairman of my dissertation committee.
2) Dr. W. Robert Sullins, for serving as a member of my dissertation committee and for his seemingly endless support in terms of computer funding for this project.
3) Drs. Darrel Clowes, Gerald McLaughlin, and Dennis Hinkle, for serving as members of my dissertation committee.
4) for serving as an examiner at my dissertation defense.
5) for serving as examiners in connection with my Prospectus exam.

6) , Assistant Chairman of Student Affairs, Mathematics Department, VPI&SU, for helping me to understand calculus in a multi-variate environment.

7) , formerly Systems Analyst, User Services Department, VPI&SU, for teaching SAS to me.

8) , graduate student, Statistics Department, VPI&SU, for helping me to understand the innumerable statistics put forth by SAS.

9) , AES Division secretary, VPI&SU, for giving up untold hours of personal time, not only to type this dissertation, but to do so in such a timely manner.

Finally, the isolation associated with completing such a project as this has also been felt by my family, to whom this work is dedicated. I wish to extend my heartfelt appreciation to my wife, , who alone knows what personal sacrifices had to be made in coming to Blacksburg so that I might pursue a doctorate degree. I also extend my personal appreciation to my sons, , and who have been so supportive of my efforts. Finally, the real beginning for this study can be traced to my mother and to the memory of my father, for whom education was a value to be placed above all others.

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CHAPTER I

INTRODUCTION, STATEMENT OF THE PROBLEM, AND LITERATURE REVIEW

Introduction

The two-year college is an educational innovation of the twentieth century. The first public two-year college opened in 1901 as the Joliet Junior College (Vaughan, 1982, p. 13) and operated for a number of years out of the basement of a public high school in Joliet, Illinois. Such humble beginnings relate to the not-so-humble educational philosophies of William Rainey Harper, Chancellor of the then newly formed University of Chicago. Harper suggested that the first two years of college were more preparatory than university in nature, and, as such, more properly belonged within the province of the two-year or junior college. Harper's ideas were too radical a departure from accepted practice, and the four-year baccalaureate programs of study within university systems have continued even unto the present day.

Yet, the two-year public college did eventually assume a key role in the American system of higher education. Its placement within this system became secure as a response to a number of searching educational concerns, including in more recent decades:

1. The Truman Commission's Report on Education (1947).
2. The Federal government's offer to match state funds committed to building two-year higher educational facilities as expressed in the Higher Education Facilities Act (1963).
3. The Federal government's financial commitment to post-secondary vocational/technical education as expressed in the Vocational Education Act (1963 and subsequent amendments thereto).

But the more proximate cause of the post-1960 growth in state wide systems of community colleges was not a commitment to an educational philosophy, but rather a historical circumstance--the post-war baby boom--and a renewed pledge to a typically American social ideal--equality of opportunity. Because education in this country has always been linked with the democratic ideal of opportunity, the same principle that orchestrated the Civil Rights Movement of the late 1950's and early 1960's also opened the doors of higher education to those who had previously been denied an opportunity to participate. Accordingly, one of the evolving missions of the community college has been to provide comprehensive educational programs, many of which are career oriented, to all those who would otherwise be denied access to higher education at more traditional institutions--and to do so at a relatively modest cost to those seeking such an opportunity.

The social commitment to the egalitarian right to higher educational opportunities at a relatively low personal cost translates into a substantial financial commitment on the part of society. Once the social commitment had been made, the financial commitment became acceptable; and once the financial commitment was accepted, the growth of the two-year public college became assured. Breneman and Nelson (1981), citing Grant and Eiden (1980), document the historical record of both the assurance and the financial commitment that made this growth possible:

> In 1960, 315 public two-year colleges enrolled 392,000 students, 11 percent of total higher education enrollment; by 1979, 926 public two-year colleges enrolled 4,057,000 students, 35 percent of the total. The increase in public community college enrollments from 1960 to 1979 was a striking 930 percent, compared with 220 percent for all of higher education. Since 1975 approximately half of all first-time college students have enrolled in community colleges, which are also serving increasing numbers of older part-time students. These institutions employ more than 87,800 full-time and 115,400 part-time faculty members during 1979, and received roughly $6.3 billion from public and private sources. By these measures, community colleges have clearly become a large and important part of U.S. higher education. (p. 1)

Statement of the Problem

Since the time of the ancient Greek philosophers, the goal of education has been the pursuit of excellence. However, since excellence is a relative term, its attainment can never be measured absolutely. Thus, individual students may attain relative, but never absolute, success in their endeavors; so too may faculties and their institutions. Consequently, no two students, no two faculties, and no two educational institutions can be said to be absolutely equal in terms of their respective achievements. Quite the contrary, differences (rather than similarities) between students, between faculties, and between institutions are used as measures along the continuum of excellence. It is inequality and not equality that abounds throughout education. Students are different, programs are different, costs are different, and state support is different. Within such a context, education typically sets minimum standards of excellence for its students, its faculties, and its institutions, to establish some absolute floor below which performance is deemed unacceptable. Regional accrediting agencies provide rigid guidelines as to what these minimum standards of excellence must be to ensure acceptable levels of performance by educational institutions. Moreover, state determined, minimum levels of funding available to each two-year public college within every state system ensures that these defined levels of acceptable performance will be financially attainable. Despite the assurance of this minimum level of funding, however, most educators would argue that these minimums are woefully inadequate to provide educational programs of uniform quality. Nevertheless, the state's minimum funding level, together with the accrediting agency's minimum standards, serve to provide every community with the same, absolute base of educational opportunity.

As previously noted, one of the most revered goals of American society has always been that of equality of opportunity, including (since the Emancipation Proclamation) educational opportunity. While the educational pursuit of excellence is a relative concept, the social pursuit of equality of opportunity is an absolute concept. Thus, every student is entitled to the same educational opportunity as every other student. When measuring our society's success in achieving such a social goal, similarities and not differences are the desired results. For example, <u>within</u> any given two-year public college, different student clientele call for different, not the same, curricular offerings to satisfy different student and community needs. Yet, <u>between</u> community colleges within the boundaries of the same state wide system, equality of opportunity demands that equivalent, not different, comprehensive programs be offered at similar, not different, costs to similar, not different, students. When programs are different, when costs are different, when funding is different, and when students are different, then community colleges within the same state wide system will also be different, providing different, not equivalent, educational opportunities. Moreover, if the mere size of an individual institution within the same state wide system of community colleges contributes to the existence of such differences, then in terms of society's own minimum standards of educational opportunity, such a performance is unacceptable per se.

If the social commitment to educational opportunity is to be universally met, then it must be met equally by the small, as well as by the large, community college. "Equally" as used here is not intended to mean "identical." Curriculums are designed to meet student and/or community needs, and student/community needs <u>are</u> different. But student needs are not different because of size differences that may exist between their communities or their educational institutions, i.e., student needs are independent of institutional size. While student/community needs of rural America may have been different from those of urban America as recently as twenty years ago, the recent dawn of the age of high technology may have changed different educational needs into similar educational needs. Thus, there is no reason to believe that the needs of students served by small rural community colleges are intrinsically any different than those served by larger community colleges. For example, should a student interested in computer programming, but attending a small rural community college, be limited to learning only basic programming languages, while his/her counterpart, attending a larger community college, is given an opportunity to learn higher-order computer languages ? Similarly, should a student interested in nursing, but attending a small rural community college, be restricted to a practical nursing program, while a similar student with similar needs, attending a larger community college, is given an opportunity to become a registered nurse ? While all computer languages are similar, they are not all equivalent; and while practical nursing programs are similar to registered nursing programs, they too are not equivalent educational programs. To the extent that state funding formulas may not compensate the smaller institution for the hypothesized inherent disadvantages associated with economies of scale, then size alone may also preclude the small rural community college from deciding for which student needs it will provide equal educational opportunities, and which it will not. Under these conditions, the small rural community college may only partially satisfy its student needs by, for example, purchasing less expensive microcomputers instead of mini-computers or much larger main frames capable of running far more sophisticated software; and/or by, for example, offering a practical nursing program because it cannot afford to run a more costly associate degree nursing program. In contrast, the hypothesized economies of scale associated with bigness may allow those institutions with larger overall enrollments to purchase larger, more sophisticated computer equipment, and yet simultaneously offer an associate degree nursing program, neither of which could have otherwise been considered were it not "big."

To permit the mere size of an institution to dictate which students in which communities will have the opportunity to become computer programmers or registered nurses and which will not, when the needs of their students and/or their communities are identical, is "tracking" on an even grander scale than perhaps anyone has yet considered. Accordingly, as a matter of public policy, there must be an ever-present commitment to the pursuit of uniformity in educational opportunity, irrespective of the relative sizes of our educational institutions responsible for implementing such a commitment. Yet, it is hypothesized that the small rural community college, merely because it <u>is</u> small, cannot provide the same educational opportunity at either the same average cost or the same marginal cost per student as can the larger community college. If those providing and allocating the funds, principally the states and their legislators (supplemented in some states by their localities), do not compensate small rural community colleges for their inability to achieve the hypothesized economies of scale that are achievable by their larger counterparts, then parity of educational opportunity becomes an unachievable objective. And if access to equality of educational opportunity is denied to certain students because they live in certain communities, then the American promise of equality of opportunity becomes broken in half--a social goal available to some, yet denied to others.

Looking to the record, many states do not adjust their funding formulas for economy of scale differentials. In a 1981 survey of the 50 states, only "28 replied that small size was compensated for or given consideration in their state funding formula or appropriation...[and] only four states apparently recognized rural environment in their funding formulas" (TenHoeve, 1981, p. 17). Even among the 28 states that give some recognition to economy of scale differentials in their funding formulas, an inspection of the responses to the TenHoeve survey indicates that they do not do so in any uniform manner. Moreover, because "AACJC [American Association of Community and Junior Colleges] statistics indicate approximately one-half of all membership institutions classify themselves as...small/rural community colleges" (TenHoeve, 1981, p. 17), the hypothesized economy of scale problem is quite widespread and, accordingly, is deserving of further investigation and analysis on a nationwide scale.

Purpose

The purpose of the present study was to investigate the relationship between educational costs (the dependent construct) and educational output (the independent construct) in two-year public colleges, with particular emphasis on the meaning of this relationship for the small rural community college. This study used total instructional educational and general expenditures (IEG) to represent educational costs, and FTE, MARKET, and DIVERSITY to represent educational output.[1] The research hypothesis was that small rural community colleges, by virtue of their relatively smaller scale of operations, not only <u>do not</u>, but more importantly, <u>can not</u> produce the same educational output at either the same average or the same marginal cost as do those community colleges that operate on a relatively larger scale. If relevant data were to confirm this hypothesis, then public policy responsible for creating such a situation will have failed to achieve one of its own pre-defined educational objectives. For if, as an objective, society is to achieve equality of educational opportunity, then educational output, no matter how defined, must be independent of institutional size, and state funding formulas must be adjusted differentially to compensate small

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[1] The terms, IEG, FTE, MARKET, and DIVERSITY, are subsequently defined in the section, "DESCRIPTION OF THE VARIABLES".

rural community colleges for those cost differentials that are attributable to economies of larger scaled operations. So long as these cost differentials remain either undetected (or worse yet, ignored), public policy will have unwittingly (or worse yet, wittingly) contributed to the inability of small rural community colleges to achieve parity in educational opportunity by failing to provide parity in the cost of producing educational output relative to their larger counterparts. Finally, any such disparities that continue to persist become evidence of this society's failure to provide equality of opportunity to all who seek it through higher education at the two-year public college level.

Need for the Study

One of the missions of the community college is to provide equality of educational opportunity. One of the ways the community college fulfills this mission is by offering diverse curricula in response to the equally diverse needs of the community it serves. While needs differ among students, there is no reason to believe that these needs differ between large and small communities, i.e., student needs are independent of institutional size. Yet, if economies of scale do exist for the large community college, then the larger institutions are inherently in a better financial position to meet the diverse needs of their community by offering greater curricular diversity than are the smaller institutions. And, if equality of educational opportunity really does mean equality of curricular diversity, then those states that continue to ignore differential funding may be effectively denying equality of educational opportunity to those served by the small community college.

These contentions form the basis of the present study. A thorough review of these contentions is justified on the following grounds:

1. The fact that nearly half the states fail to make any adjustments in their funding formulas for economy of scale differentials (TenHoeve, 1981).
2. The fact that more than half of AACJC's membership consider themselves as being small rural community colleges[2] (TenHoeve, 1981).

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[2] Upon inquiry, the AACJC supplied the present investigator with a current listing of 571 community, junior, and technical colleges which had identified themselves as being rural, out of a total 1983 membership roll of 855 two-year public institutions located in the continental United States (AACJC, 1983, p. 73). Of these 571 rural institutions, an analysis of the responses to the 1980-81 Higher Education General Information Surveys (HEGIS) indicated that only 248 rural two-year public community colleges were also both (1) small, and (2) AACJC members (Table 1). Nevertheless, 248 out of a total 1980-81 HEGIS universe of 886 two-year public colleges (Table 1) is a significant enough segment of the population to merit the present research effort.

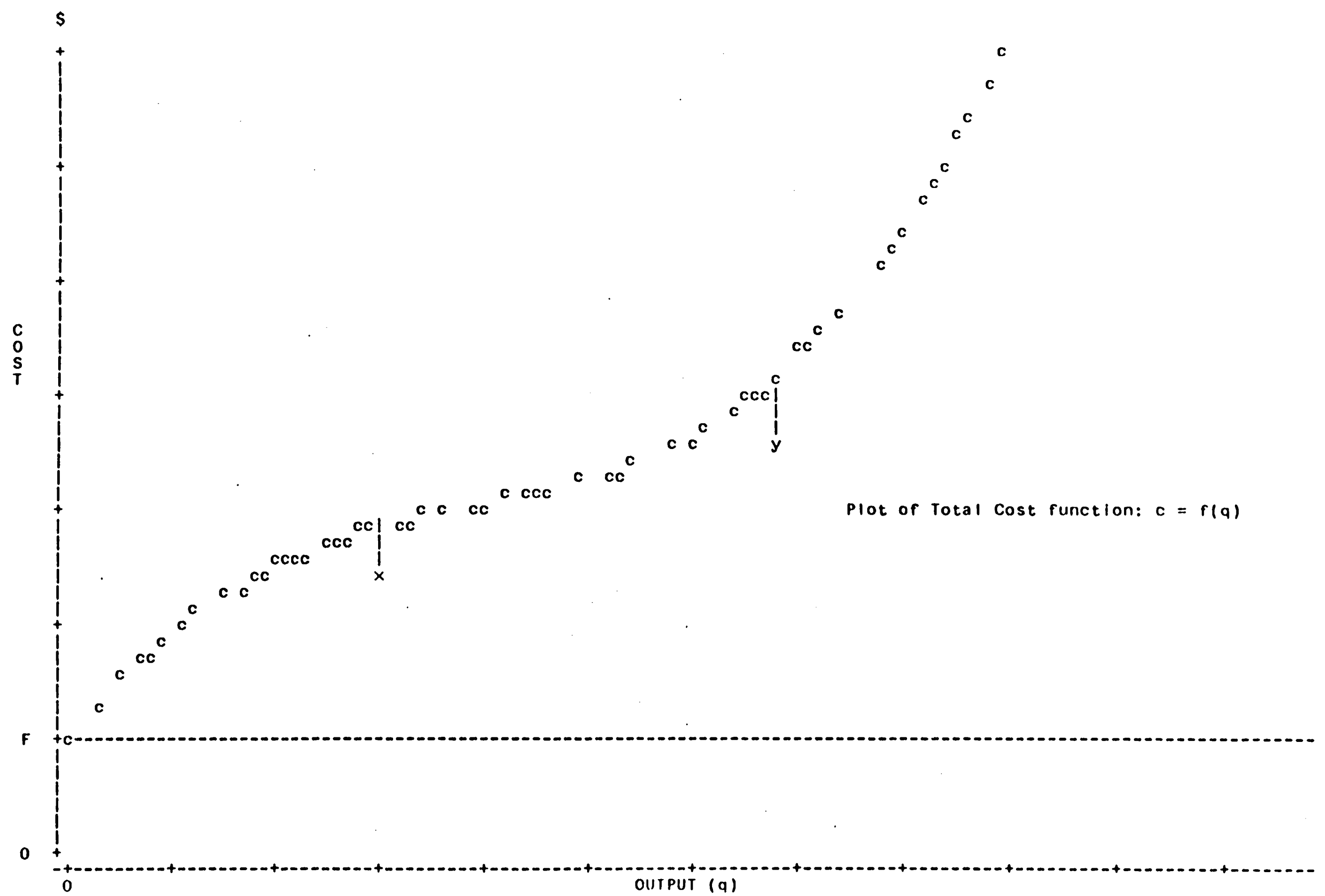
3. The assumption that economies of scale exist for institutions of higher education, just as they do for noneducational economic entities.

While the first two reasons cited as justification for the present study are factually supportable. the third reason, being an assumption, is deserving of further explanation in understanding the context of the problem.

Economic Context of the Problem

Total Cost Function

As previously stated, the purpose of this study was to investigate the relationship between educational costs and educational output in two-year public colleges. This statement of purpose has conceptually followed conventional micro-economic analysis where costs (c) are considered to be dependent upon output (q), or $c = f(q)$. Such a function is referred to as a cost function. According to Allen and Brinkman (1983), "a cost function yields a set of values that represent the minimum cost of production at each level of output" (p. 10). Although it is doubtful that educational output is ever attempted at minimum cost (except perhaps in the case of proprietary schools), the construction of a cost function serves as a useful and a powerful analytical tool even in an educational setting. The cost function, $c = f(q)$, is typically presented graphically as in Figure 1.



Note. Adapted from Price Theory and Applications (2nd ed., p. 275) by J. Hirshleifer, 1980, Englewood Cliffs, N.J.: Prentice-Hall, Inc. Copyright 1980 by Prentice-Hall, Inc.

Figure 1. Illustration of a hypothetical total cost function.

The generally accepted interpretation of the cost function, c = f(q), (Figure 1), is as follows:

1. The cost function represented here is at the micro or economic agent level.
2. All costs from O to F are fixed, indicating that at zero output, the economic agent will still incur some costs.
3. All costs above point F are variable costs, indicating that as output increases, costs will also increase.
4. The cost function, c = f(q), reflects all costs, both fixed and variable, and is represented by the curved line extending from point F.
5. Points (x) and (y) on the curved line are "inflection points." Inflection points occur whenever the cost function stalls and either changes direction or continues in the same direction. Inflection points have unique meanings, not only for the total cost function, but also for the average and marginal cost functions which are derivable from the total cost function. Figure 1 is a representation of the total cost function, whereas Figure 2 (following) shows the average and marginal cost functions derived from such a total cost function.

6. Cost is always portrayed on the vertical axis, and output is always portrayed on the horizontal axis, indicating that a cause/effect relationship exists between output (cause) and cost (effect). Similarly, cost (c) is always presented mathematically as a function of output (q) and never the other way around.

In addition to the cost minimization assumption, or optimization assumption as it is referred to by Hirshleifer (1980), a second assumption of micro-economic theory is that the cost function is itself derivable from yet another function referred to as the production function. In other words, if c = f(q), of what is (q) a function ? The micro-economic answer is the production function, which defines output (q), the dependent construct, in terms of input factors (i), the independent construct, or q = f(i). Hirshleifer (1980) indicates that "the production function shows, as a matter of technology, how output produced depends upon the amounts of input factors employed" (p. 270). Allen and Brinkman (1983), citing Varian (1978), describe the production function much more vividly as the <u>production frontier</u>: "A production function is similar to a completely efficient plan in which it is not possible to provide more output with the same input, or to produce the same output with fewer inputs" (p. 9). Because of a genuine lack of interest or perhaps because the production process in an educational setting is seldom very efficient, few, if indeed any, researchers attempt to define a production function. Allen and Brinkman (1983) offer two other reasons--complexity and lack of understanding--as to why production functions remain unknown to educational researchers (p. 14-15). Accordingly, Allen and Brinkman conclude that "discovery of a comprehensive, meaningful production function, as economists use the term, is simply out of the question" (p. 15).

For the lack of any meaningful production function, educational researchers have little choice but to define their cost function in terms of cost, (c), and output, (q), and proceed to use curve-fitting techniques (regression analysis). As an example, Brinkman (1981) proceeded to define both linear and nonlinear cost functions, identifying total instructional cost, (c), as the dependent variable and six different enrollment data as independent variables which he labeled as "output" variables (p. 48). In addition, Brinkman's regression equation contained no less than two price-related control variables (average faculty compensation and a state price index), six general technological control variables, and 12 program-related technological control variables (p. 48).

As for the present research study, there has been no attempt to break new ground by defining a production function within an educational setting. Hence, no attempt has been made to equate output, (q), as being dependent upon input factors, (i). However, following the lead of other educational researchers--Brinkman (1981), Mullen (1981) and Bowen (1980)-- the present study has defined a cost function, wherein total cost (TC) is dependent upon output (q). After considering output (q) from both an educational and economic perspective, three independent variables (FTE, MARKET, AND DIVERSITY)[3] were selected to represent educational output. And, after considering TC from both an accounting and an economic perspective, total instructional education and general expenditures (IEG)[4] was selected as the dependent variable to represent educational cost.

Average and Marginal Cost Functions

Once a total cost function has been defined, the related average and marginal cost functions become derivable. Since average cost (AC) is simply total cost (TC) divided by output (q), or TC/q, the average cost function with respect to any one of the output or independent variables is simply the total cost function

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[3] FTE, MARKET AND DIVERSITY are subsequently defined in the section entitled, "DESCRIPTION OF THE VARIABLES."

[4] IEG is also a defined term in the section entitled, "DESCRIPTION OF THE VARIABLES."

expressed in terms of that same output variable. Using the variable names of the present study, the average cost function with respect to FTE, for example, becomes:

If predicted IEG = f(FTE,MARKET,DIVERSITY)

Then predicted AC (expressed in terms of FTE) = predicted IEG / FTE

Or: AC = predicted IEG / FTE

Since the total cost function can be easily converted to an average cost function, the researcher must decide whether to express the dependent variable in terms of either total cost (TC) or average cost (AC) before proceeding with the regression equation. If the dependent variable is to be average cost, the subsequent prediction of average cost will result directly from the regression process itself, e.g., Mullen (1981). However, as will be shown below, the behavior of predicted marginal cost cannot be derived directly if the dependent variable had been expressed initially as an average cost. If the predicted behavior of marginal cost is of direct interest to the researcher (i.e., without resorting to mathematical transformations of predicted AC, first into predicted TC and subsequently into predicted MC), then the dependent variable must be total (not average) cost, e.g., Brinkman (1981). Here's why. Marginal cost, (MC), is defined as the change in total cost (delta TC) that is associated with a change in one unit of output (delta q). Mathematically, MC is represented by the slope of the total cost function, or MC = delta TC/delta q, that is, MC is a function of the change in total cost relative to the change in output. Since MC is the slope of the total (not the average) cost function, it can be derived by taking the first derivative of the total cost function (Haeussler and Paul, 1980, p. 265). If the researcher defines the total cost function using a linear regression model, then the parameter estimate (also sometimes referred to as the regression coefficient or even more loosely as the beta value) of an output variable "can be read directly as the estimated marginal cost [of that variable type]. In nonlinear models, the marginal cost estimate must be calculated [derived] from the estimated coefficient(s)" (Brinkman, 1981, p. 72).[5]

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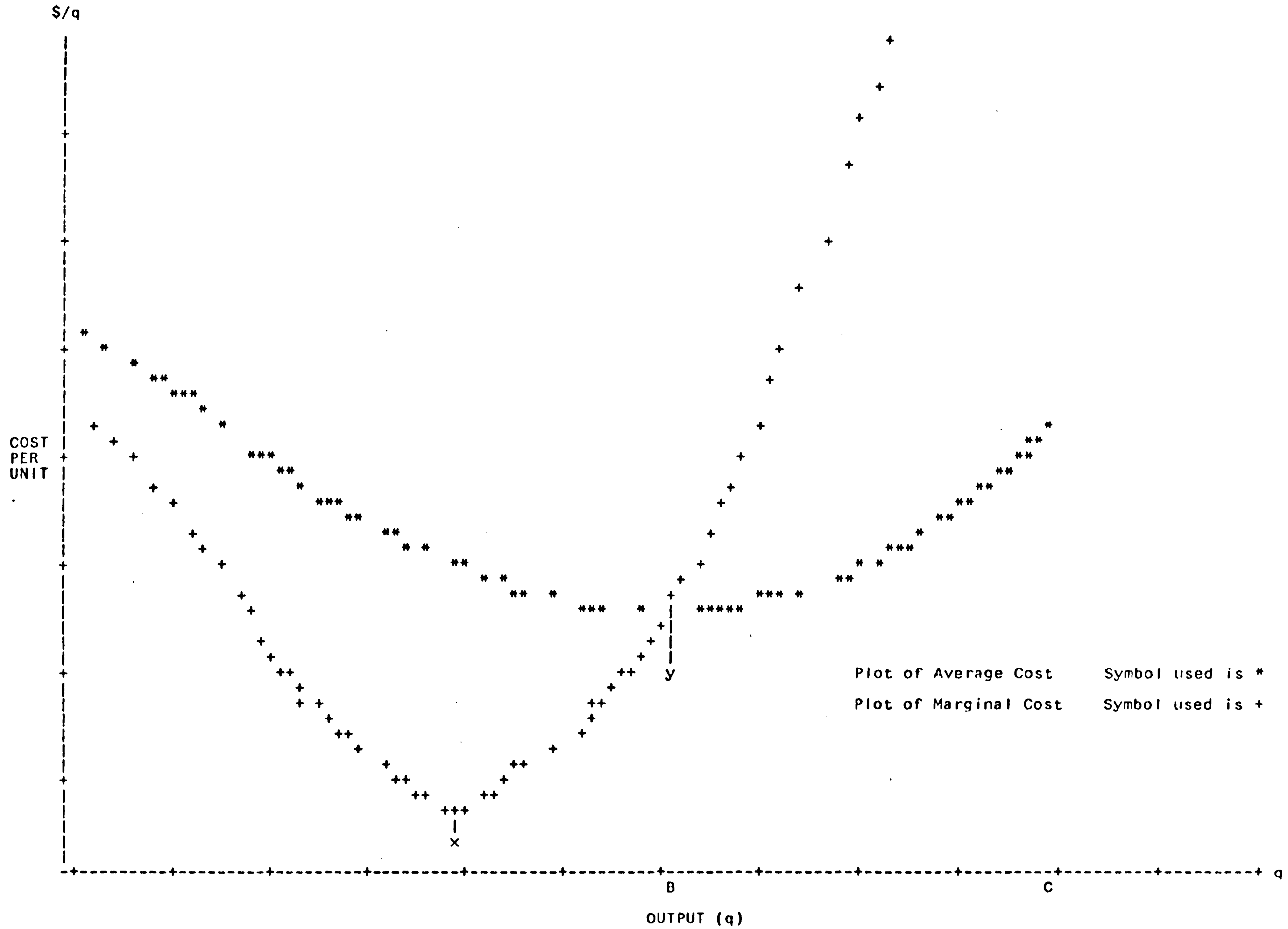
[5] Actually, Brinkman (and Haeussler and Paul), in defining the first derivative of the total cost function as equivalent to marginal cost, are correct only if the total cost function is defined in terms of a single independent or output variable. If total cost functions are defined in terms of more than one independent variable, the first derivative of such multi-variate cost functions can only be a partial derivative with respect to but one independent variable of interest. In taking partial derivatives, the remaining independent variables are treated as constants, and the slope of a constant is always zero. Consequently, reliance upon a partial derivative as equivalent to marginal cost is a gross oversimplification in the multi-variate case, and as such, can only lead the researcher to erroneous marginal cost values and equally erroneous marginal cost analysis. This point is expanded upon in Chapter II.

Because the direct determination of marginal cost was of particular interest to the present researcher, total cost (and not average cost) was used as the dependent variable, in which case both average and marginal cost functions were subsequently derived, analyzed, and interpreted. If the relationship between IEG and FTE, MARKET, and DIVERSITY in the present study can be shown to be significant, that is, other than by chance, then the derived average and marginal cost functions will be equally significant, thereby establishing a meaningful context for their subsequent interpretation.

Graphically, Figure 2 is a representation of the average and marginal cost functions as derived from the hypothetical total cost function portrayed earlier in Figure 1.

<u>Returns to Scale</u>

To investigate whether the activity of any economic agent demonstrates increasing, decreasing or constant returns to scale, the researcher need only to look at the behavior of the marginal cost (MC) curve in relation to the average cost (AC) curve over any output interval of interest. Economies of scale exist whenever MC < AC or



Note. Adapted from Price Theory and Applications (2nd ed., p. 275) by J. Hirshleifer, 1980, Englewood Cliffs, N.J.: Prentice-Hall, Inc. Copyright 1980 by Prentice-Hall, Inc.

Figure 2. Illustration of hypothetical average and marginal cost functions.

whenever (MC/AC) < 1. For example, in an educational setting, if enrollment (as a proxy for output)[6] increases proportionately by a greater amount than does the additional or marginal cost of educating that increased enrollment, then the average cost of producing all enrollment through that output level must necessarily be falling, in which case increasing returns (savings) are realizable merely by operating on a larger scale than before.

For example, the hypothetical data reflected in Figure 2 indicate that increasing returns to scale exist as output, i.e., enrollment, approaches level "B" , or as long as MC/AC < 1, whereas decreasing returns to scale become evident as enrollment moves from level "B" to level "C", or when MC/AC > 1.

To illustrate, suppose that a two-year public college receives $2,300 per FTE student as the state's contribution toward the education of an enrollment of, say, 1,000 FTE students. Suppose further that each FTE student also pays $500 tuition which is added to the state appropriation. Total revenue (TR) is, therefore, $2.8 million [1,000 @

[6] Enrollment, as used in educational finance studies, is both an input and an output variable (Brinkman, 1981 and Bowen, 1980)--not by design, but by default. As Bowen (1980) puts it, "our knowledge of [educational] outcomes [learning, personal development, the advancement of culture, and economic growth] is so feeble, and even if we had the knowledge, our ability to quantify outcomes would be so limited...[that] we resort to the expedient of using adjusted number of students e.g., FTE] as a proxy for the true outcomes" (p. 6).

($2,300 + $500)]. Finally, suppose that the average cost of educating all students at this scale of operations (i.e., 1,000 students) is also $2,800 per FTE, in which case total cost (TC) is also $2.8 million. As a result, a state of economic equilibrium is said to exist.

Now suppose an additional 200 FTE students enroll, and the state, disregarding economy of scale issues, continues to fund its community college system at the rate of $2,300 per FTE student. Assume further that tuition also remains at $500. As a result, TR increases to $3.36 million [1,200 @ ($2,300 + $500)]. Suppose, however, that the MC of educating the additional 200 students is <u>not</u> the average cost of educating the first 1,000 students, but rather, is something proportionally less--say, only $2,000. Such a condition could conceivably result, for example, by administrative decisions to absorb the increase in enrollment by adding only the variable cost associated with that enrollment, thereby utilizing existing plant and facilities over the expanded enrollment base. As a result, total cost becomes:

TC = (1,000 @ $2,800) + (200 @ $2,000)
= $3.2 million

In this hypothetical example, the achievable economies or savings due solely to having increased the scale of operations at a marginal cost that is less than the average cost, is represented by the excess of TR ($3.36 million) over TC ($3.2 million) or $160,000. Such a return or savings represents a temporary disequilibrium. In this event, such an educational institution has the opportunity to convert these savings into additional costs by increasing the quality (not the quantity) of its educational output--reduced faculty teaching loads, purchase of bigger and better computers, more computer terminals per FTE student, more student services, more counselors, expanding the number of different degree programs offered, increasing the numbers of full-time versus part-time faculty, upgrading faculty, providing more faculty training and development, more community service programs, and so forth. The result is that economies of scale may in fact <u>not</u> show up in the form of declining AC curves after all, as larger educational institutions convert their achieved economies of scale into educational output of a higher quality, thereby putting small rural community colleges, their students and their communities, at a distinct disadvantage in terms of achieving parity of educational opportunity relative to their larger constituents. To achieve parity, the state funding formulas must be adjusted differentially to compensate the small rural community college for the hypothesized diseconomies associated with smallness. It is to this end that the present study has been dedicated.

Do economies of scale exist for institutions of higher education ? According to Bowen (1980) "there can be little doubt that potential and substantial economies of scale in higher education actually exist. They are especially evident in very small institutions having enrollments of less than 1,000 students" (p. 192). Bowen's conclusions apparently support Reicherd's review of pre-1971 cost studies, which "indicate that very small institutions, relative to their purported mission, tend to have disproportionately high unit costs" (Brinkman, 1981, citing Reicherd, 1971, p. 25).

Although, as indicated previously, Brinkman's (1981) primary purpose was to determine marginal cost, he also reported average cost and then proceeded to compare the behavior of both cost functions over a range of FTE enrollment. With respect to his cost analysis of two-year institutions, Brinkman (1981) used the NCHEMS (National Center for Higher Education Management Systems) classification scheme, distinguishing between purely technical schools, schools offering primarily transfer programs (which Brinkman referred to as "academic"), and comprehensive community or junior colleges.[7] Brinkman's (1981) cost analysis confirmed constant returns to scale for

[7] The NCHEMS classification scheme has not been used in the present study. See the section entitled "DESCRIPTION OF THE INSTITUTIONS" of Chapter I for the reasons why a different classification scheme was selected.

technical schools and increasing returns to scale for both academic (or transfer) institutions and, to a lesser extent, comprehensive institutions. Relating these findings to state funding formulas, which Brinkman argued as being based more on average costs than on marginal costs-- enrollment driven state funding formulas tend to be stated in terms of constant (or average) and not variable (or marginal) rates per FTE--Brinkman (1981) concluded:

> The meaning of these ratios [i.e., the ratio of MC/AC] with respect to the formula funding issue is straightforward. The academic institution has the most to gain or lose financially by a gain or loss in enrollment [MC/AC = .5966], assuming funding on a given average cost basis. Technical institutions, on average, will not be affected financially by a change in enrollment [MC/AC = 1.00875], because average cost funding will match the [projected] actual changes in an institution's cost structure. Comprehensive institutions, on average, will be affected [MC/AC = .9065], but considerably less so than academic institutions. (p. 160)

The Carnegie Commission on Higher Education (1972) also confirmed the existence of economies of scale in higher education:

> Among all groups of institutions, exceptionally small colleges and universities tend to have relatively high costs. The cost per FTE student declines quite sharply as institutions increase in size from very small levels to moderate levels, after which the decline occurs at a diminishing rate or levels off. (p. 164)

McLaughlin, Montgomery, Smith, Mahan, and Broomall (1980) conducted a cost study of 1,347 public four-year colleges and universities based on data collected by the

U.S. Office of Education's Higher Education General Information Survey (HEGIS) reports for 1975-76. They discovered that while size, as measured by enrollment, did deliver the expected economies of scale "between 2,500 and 4,500 students", consistent with the Carnegie report noted above, "size of an institution explains [only] about 2.6 percent of the variation in its cost per student" (p. 57). Changes in staffing ratio (FTE faculty/FTE enrollment) and changes in curricula complexity (ratio of the number of different HEGIS curricula in which degrees were awarded to the total maximum possible HEGIS curricula) accounted for far more significant effects (R = .816), prompting the following advice for future researchers: "Therefore, while economy of scale influences student costs, complexity, as measured by curricula offerings, should be considered when investigating how costs per student might relate to size" (McLaughlin et al., 1980, p. 60).

An earlier cost study by Broomall, Mahan, McLaughlin and Patton (1978) of 22 public senior institutions on six categories of educational expenditures concluded that economies of scale in expenditures per FTE did <u>not</u> exist. It was this finding that convinced McLaughlin et al. (1980) that something other than enrollment was responsible for explaining cost variations. They suspected that as enrollment increased, so too did organizational and curricula complexity--hence the need for their own follow-up study in 1980 using a nation-wide data base.

Whereas McLaughlin et al. (1980) ignored two-year community and junior colleges, Millett (1971) confirmed that economies of scale also existed for these types of institutions:

> The smaller the enrollment of a college, the higher tends to be the costs per student...With one exception, all of the community colleges with enrollments above 1,000 full-time equivalent students had expenditures under 2,000 dollars per student, while all of the community colleges with enrollments under 1,000 students with one exception had expenditures of more than 2,000 dollars per student. (Millett, 1971, p. 14 as cited by Mullen, 1981, p. 70)

Millett's work was consistent with that of McLaughlin et al. (1980) regarding the significance of curricula complexity: "Millett also indicated that program mix was important to cost per student, especially in the health-related and science-dependent programs" (Mullen, 1981, p.70 citing Millett, 1971).

As for Mullen's (1981) own cost study, he concluded that "economies of scale do exist, especially up to enrollment levels as high as 5,000 FTE students, but are most striking below 1,000 or 1,500 FTE student levels" (p. 234). Mullen (1981) also found that "the observed total cost function for educational and general [expenditures] is linear"...and that "the existence of a linear total cost function indicates that marginal cost will be fixed [constant] or linear for most observable values of enrollment"...but that marginal cost declines dramatically "if a nonlinear function (Hoerl's) is applied" (p. 232-233).

Description of the Variables

As previously stated, the present study was concerned with the relationship between two constructs--educational costs and educational output. A general description and definition of the proxies selected to represent these two constructs follows.

Educational Output: An Educational Perspective

Educational output ultimately must be a qualitatively and not a quantitatively defined variable. The strongest statement an institution of higher education can make about itself, its mission, and its success in achieving that mission, is in terms of the quality (not the quantity) of its curriculum, the quality (not the quantity) of its faculty, and the quality (not the quantity) of its students. Consider, for example, the qualitative statement of objectives for the college curriculum as defined by The Carnegie Foundation for the Advancement of Teaching (1977):

> Since it is impossible for any college or university to expose its students to all available knowledge, perhaps the basic objectives of the curriculum will be to provide students with skills for lifelong learning. These will include the ability to analyze written and spoken ideas and exposition, to use computational tools properly,

> to integrate information gathered from more than one source to produce new conclusions or observations, and to use knowledge to solve problems. (p. 120)

This qualitative emphasis on developing skills for lifelong learning as a definition of educational output is perhaps nowhere more pronounced than in the statements of educational missions of the two-year public college. Whereas meritocratic values adopted by other delivery systems of higher education traditionally have established barriers to opportunities for lifelong learning, the educational missions of the two-year public community college reflect egalitarian values that serve to abolish these same barriers. For those who would otherwise be denied these opportunities for lifelong learning, the two-year public college is symbolic of America's promise to provide equal educational opportunity for all who seek it.

Consider, for example, the community college's responses to but a few of the traditional barriers to lifelong learning opportunities:

1. For those who cannot afford higher education, the community college offers low tuition.
2. For those who have learning deficiencies, community colleges offer remedial education.
3. For those who do not seek the traditional academic curriculum, community colleges offer both occupational/technical and continuing education programs of study.

4. For those who already hold a full-time job and therefore can't go away to college, community colleges offer evening and weekend programs of study to part-time students. Community colleges, by their very presence within the same community in which their clientele both live and work, reduce the geographic barriers to higher education.
5. Finally, the community college's "open door" admissions policy serves to reduce barriers relating to past academic deficiencies caused by either the past failure of the individual or by the past failure of the preparatory educational system imposed on the individual.

The recurring theme in each of the various missions of the community college is expressed in but a single word--diversity. The open door policy of admissions brings together a diverse student body with diverse interests, goals and expectations, as well as diverse academic and/or technical aptitudes and equally as diverse academic records of achievement (or nonachievement). Moreover, the educational missions of the community college are very much demand-driven, and not supply-determined. Hence, the community college offers diverse curricula and programs of study leading to equally diverse degrees, certificates and diplomas in recognition of academic achievement and the completion of academic programs.

How successful the community college has been in translating these missions of diversity into service to its students and its community is a reflection of how successful that community college has been in matching its own expectations of educational output with those demanded by society. Having defined these expectations qualitatively in terms of educational missions, what remains is to define the degree of their achievement quantitatively, i.e., in operational terms as used throughout the present study.

Because achievements have relevance only when compared to objectives, educational achievements can be evaluated only in terms of initially defined educational goals, assuming that such goals meet or exceed some minimum standard of excellence. How well the community college subsequently achieves its assigned missions is, therefore, an appropriate evaluative measure of its educational output. And how well the community college subsequently satisfies the diversity of educational needs existing throughout the community it serves, is, for purposes of the present study, represented by three operational proxies for educational output: 1) enrollment--in the sense that without enrollment, there can be no educational output, 2) market penetration-- the degree to which the community college serves its geographic market area in terms of population served, and 3) curricular diversity-- the number of different curriculum areas in which formal awards are both offered and earned.

The enrollment and curriculum data used in the present study were those submitted by two-year public colleges in response to the following HEGIS surveys conducted by the National Center for Education Statistics (NCES):

1. 1980-81: Fall Enrollment in Institutions of Higher Education, 1980 (HEGIS XV).
2. 1980-81: Degrees and Other Formal Awards Conferred Between July 1, 1980 and June 30, 1981 (HEGIS XVI).

One of the first researchers to have been concerned with market penetration was Wattenbarger, et al. (1970, pp. 31-50). Wattenbarger's research on the community colleges' "target population", principally within the state of Florida, formed the basis of the present investigator's interest in updating such market penetration data on a nationwide scale. Accordingly, responses from a current nationwide survey of curricular comprehensiveness in two-year public community and technical colleges conducted by Atwell and Sullins (1984) was used to form a data base representing the potential service area population of all those surveyed. For a more complete description of the usable universe of all two-year public community and technical colleges included in the present study, see the section entitled, "DESCRIPTION OF THE INSTITUTIONS."

Definition of the independent variables.

The specific definition of each of the three operational proxies for educational output used throughout the present study is as follows:

1. Enrollment: Enrollment refers to either full-time equivalent enrollment (FTE) or headcount enrollment (HEAD). Whenever enrollment is referenced, its specific meaning (i.e., FTE or HEAD) has also been referenced. HEAD = (full-time enrollment) + (part-time enrollment). FTE = (full-time enrollment) + (1/3 part-time enrollment).[8]

2. Market penetration (MARKET): Market penetration is defined as the ratio of headcount enrollment to target population (HEAD/TARGET) within each reporting institution's market or service area. Although Wattenbarger, Cage and Arney (1970) identified the 15-34 age group as being uniquely relevant to community colleges, for purposes of the present study the target population (TARGET) is the total service area population as reported by those institutions responding to the Atwell and Sullins (1984) survey

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[8] Brinkman (1981) indicates that because "part-time students often play an especially important role in a two-year college,...their impact on instructional costs may not be assessed adequately if enrollment is calculated only in composite, FTE terms" (p. 42). Accordingly, Brinkman used all three--FTE, full-time, and part-time--enrollments as output variables within the same regression equation.

previously mentioned. The total service area population, with the exception of those under the age of, say, 15 years old, is consistent with the concept of lifelong learning. Moreover, the impact of those under 15 years-old should not affect any relative comparisons between institutions, since the total service area population for every institution is presumed to be proportionately overstated by the same relative amount.

3. Curricular diversity (DIVERSITY):[9] Curricular diversity refers to the number of different HEGIS curriculum areas in which formal academic awards (e.g., A.S. and A.A.S. degrees, certificates, and diplomas) are offered and earned.[10] Specifically, DIVERSITY is defined as the ratio of the number of different HEGIS curricula in which degrees, certificates or diplomas were awarded to the total maximum possible HEGIS curricula for every reporting

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[9] The present study used a statistical software package called SAS (Statistical Analysis System), wherein variable names are limited to no more than eight characters. Accordingly, curricular diversity was represented on the present researcher's data base by the variable name, DIVERSTY--see Appendix D. However, in the interest of clarity, the variable name used to represent curricular diversity throughout the present text is DIVERSITY--a nine character variable name.

[10] Based on the HEGIS XVI data base, there was a maximum of 70 different curriculum areas (excluding "other" classifications) in which degrees or other formal awards were awarded by two-year public colleges during 1980-81.

institution, or:

DIVERSITY = NUMBER / 70

While it is true that many of those enrolling in community college programs may never intend to complete a program of study leading to the awarding of a specific degree, certificate, or diploma, nevertheless, in the absence of any nationwide data as to the nature and extent of the curricula offered, DIVERSITY *is* readily available, and the present study has considered DIVERSITY to be representative of the comprehensiveness of this curricula.[11] In other words, although DIVERSITY is a measurement of degrees, certificates, and diplomas awarded rather than a measurement of the breadth of the curricula being offered, for purposes of the present study, DIVERSITY was considered to be a proxy for curricular comprehensiveness.

DIVERSITY, therefore, together with FTE and MARKET, has been hypothesized by the present study to be a significant predictor of total educational costs. More specifically, the following hypothesis has been tested statistically:

> After controlling for salary differences, is there a significant relationship between the dependent variable (IEG) and the three independent variables (FTE, MARKET, and DIVERSITY/INDEXCOMP) ? The

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[11] A more complex index of comprehensiveness, INDEXCOMP, was also considered (and in some cases used) as an alternative to DIVERSITY--see Chapters II and III.

associated null hypothesis is that R = 0, i.e., no such relationship exists other than by chance.

Educational Output: An Economic Perspective

Higher education results in both public and private benefits. In economic terms, the distinction between public and private benefits hinges on the ability to exclude. A public good is a good, the consumption of which does not also exclude others from its consumption. In addition to being nonexclusive, a public good is also nondivisible; everyone has the same opportunity to consume the same amount of a purely public good. A private good, on the other hand, carries with it certain exclusive and divisible benefits attributable solely to the individual who pays for them. The consumption of a purely private good excludes others who do not pay privately for the right to receive such a good. In a world of scarcity, the consumption of a purely private good reduces the amount available for consumption by others who either cannot or do not pay.

In a free society, the economic distinction between a public versus a private good is particularly applicable to an educational setting. Because education yields both public and private benefits, public financial support for higher education has often been defended on both efficiency and equity grounds. For example, Breneman and Nelson (1981) first defined the economic concepts of efficiency and equity, and then later applied these concepts to the public versus private dichotomy as support for the public subsidy of education:

> An efficient allocation of resources is said to occur when the total benefits from the production of some good or service exceed by as much as possible the total costs of producing it. Beyond this point, additional production will cost more than it is worth, but to produce less would leave unrealized some potential net benefit. Equity is a more subjective concept than efficiency, so not surprisingly it has received numerous interpretations. In general, though, it reflects a concern with the distribution of income in society. (p. 41)

Using these concepts as economic justification for the public subsidy of education, Breneman and Nelson continue:

> The efficiency argument for subsidy is based on the external, or public benefits that are thought to accompany education and that extend beyond those that the individual gains privately from an investment in education...[whereas] the equity argument for public support of education rests on the belief that access to education and the resultant opportunities should not be limited solely to those who have the ability to pay for it. (p. 28-29)

For Breneman and Nelson (1981), "the essential question is not whether higher education is good for society but whether private decisions [without public subsidy] produce enough of it from the public perspective" (p. 46). Apparently this particular issue has long since been decided, for the question is no longer whether there are any public benefits from higher education to be subsidized, but rather, how much of higher education should be subsidized ?

The economic answer to this latter question depends on how one allocates educational outcomes between public and private benefits.

From an economic perspective, higher education can be represented by a production function, the output of which is human capital. Thomas and Griffith (1969) make the following observations with respect to human capital as the economic proxy for educational output:

> Like other forms of investment, expenditures for the production of human capital may produce both private and social benefits. Private benefits include the ability to secure employment and to increase one's income, as well as to enjoy the nonmaterial benefits associated with education. Social benefits include those advantages which accrue to the wider society as a result of education. Among the many benefits which adult education, broadly defined, is expected to produce is a well integrated social system. In the past, programs designed to meet these goals, especially the Americanization programs for recent immigrants, have apparently been most successful. (p. 174)

Using Thomas' and Griffith's (1969) definition of the social benefits to be derived from an investment in human capital, the community colleges' commitments to remedial education and to those continuing education programs relating to "citizen" education as referred to by Atwell, Vaughan and Sullins (1982), are both worthy of public subsidy. Breneman and Nelson (1981) would agree in part--"Remedial courses, including adult basic education, should be tuition free, with full state and local subsidy" (p.203)--but they would not go so far as to include all noncredit community service programs--"Community service programs that are noncredit and primarily for personal enrichment [a private good] should be self-supporting from user fees or subsidized from local funds [only] if public benefits are judged to be present" (p. 203).

In the final analysis, however, it is the subjective character of deciding what is a public versus private benefit that preclude Breneman and Nelson (1981) from making any quantitative economic analysis of the educational outcomes of community colleges. After discussing rather extensively the efficient pricing of community college offerings, Breneman and Nelson conclude, somewhat meekly, that "no single best system of financing community colleges can be derived from efficiency considerations, for determination of efficiency depend upon value judgments about public benefits and upon voter preferences, both of which are as diverse as the [community] colleges themselves" (p. 203).

Other researchers beyond Breneman and Nelson (1981) may venture into making their own value judgments as to what are the public versus private benefits of educational outcomes. Having done so, these researchers will undoubtedly proceed to conduct quantitative economic analyses of these educational outcomes. However, no attempt has been made here to pursue human capital as an economically measurable educational outcome. Such a study will be left to those more venturesome. Instead, the present study limited the proxies for educational output to those previously identified from a purely educational perspective--enrollment, market penetration and curricular diversity.

Educational Cost

For all but accountants and economists, the term "cost" is synonymous with the term "expenditure". Hence, cost is an expenditure and vice versa. For an accountant, however, cost and expenditure are not interchangeable. An expenditure represents either a current or past cash outlay, whereas an accounting "cost" represents an obligation incurred either currently or in the past, the payment of which may have already been made, may be currently due, or may be due at some future date quite beyond the current accounting or reporting period. For an accountant, then, the definition of cost is as follows:

$$\text{Cost} = \text{Current (and Past) Expenditures} + \begin{array}{c}\text{Current Obligations}\\ \text{To Make Future}\\ \text{Expenditures}\end{array}$$

The economist also includes both current and past expenditures as part of "cost." However, the economist, unlike the accountant, is <u>not</u> concerned with current obligations to make future expenditures. Rather, economic cost must instead include the cost of opportunities foregone. The "real" cost of any endeavor, therefore, includes an element of cost associated with the benefits that dould have been realized had the resources invested in the present endeavor been put to alternative uses. For an economist, then, the definition of cost is as follows:

Cost = Current (and Past) Expenditures + Opportunity Costs

Bowen (1980) applies this economic definition of cost to the concept of educational costs as follows:

> The real costs, however, lie beneath the money payments. The products or outcomes of higher education are obtained through the use of scarce resources....These same resources, however, could be allocated to alternative purposes. The real cost of higher education, then, consists of the benefits that might have been realized from these resources, but were sacrificed, because these resources were committed to higher education. These alternative benefits might have been in the form of consumer goods--such as food, gasoline, or tennis rackets--and social goods--such as highways, police protection, or environmental improvement. These are the kinds of benefits that are sacrificed when resources are devoted to higher education. These sacrificed opportunities represent the real costs, or, as they are sometimes called, the opportunity costs. (p. 2)

From a purely economic point of view, educational costs must include not only current expenditures (both public and private) but also the costs associated with opportunities foregone (again, both public and private). However, for purposes of the present study, educational costs have been limited to current instructional expenditures (educational and general expenditures less expenditures for research and public service) as reported by NCES (HEGIS XVI 1980-81): Financial Statistics of Institutions of Higher Education for Fiscal Year Ending 1981. Since most, if not all, educational institutions report revenues and costs on a cash basis, NCES's financial data base is limited to current revenues received and current expenditures made. This data base, therefore, represents what might be best described as "financial" cost and does not reflect costs as defined by either accountants or economists.

Definition of cost terms.

The following are the definitions of all cost terms used throughout the present study:[12]

1. Total Educational and general expenditures (TOTEG): Part B, line 12 of the HEGIS XVI financial survey form. TOTEG includes expenditures for instruction, departmental research, academic support, student services, institutional support, operation and maintenance of plant, scholarships and fellowships, and educational/mandatory transfers.

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[12] A related cost term (ADJAVSAL), representing a variable used in the present study to control for any differences in average faculty salary costs that might exist between institutions, is defined in Chapter II.

2. Research expenditures (RESEARCH): Part B, line 2 of the HEGIS XVI financial survey form: Commissioned or sponsored research by an agency external to the institution or separately budgeted by an organizational unit within the institution (but not departmental research).
3. Public service expenditures (PUBSERV): Part B, line 3 of the HEGIS XVI financial survey form: Public service expenditures and amounts expended for activities established primarily to provide noninstructional services beneficial to groups external to the institution.
4. Instructional Educational and general expenditures (IEG):

$$IEG = TOTEG - (RESEARCH + PUBSERV)$$

5. Total Cost (TC)--also referred to as IEGHAT:[13] The predicted or estimated IEG for any class of educational institutions under analysis.

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[13] The derivation of the term, IEGHAT, as used throughout the present study, is as follows. "Hat" is a statistical term commonly used to identify the estimation of a variable--in this case the estimation of IEG--hence, the derivation of the variable, IEGHAT. More specifically, in statistical parlance, the "hat" portion of IEGHAT is symbolized by the placement of a caret (Λ) over the variable to be estimated, IEG. IEGHAT is equivalent to IEG with such a caret or "hat."

6. Average predicted TC: derived from the regression of FTE on the mean value of IEGHAT for only those FTE levels reported within the data base under analysis. Average predicted TC is subsequently referenced as part of the curve smoothing techniques described in Chapter II and reported in Chapter III.
7. Continuous IEGHAT: derived from the regression of FTE on the mean value of IEGHAT for only those FTE levels reported within the data base under analysis, but including imputed IEGHAT values for any missing FTE levels within the domain of the particular TC function being smoothed. Continuous IEGHAT is subsequently referenced as part of the curve smoothing techniques described in Chapter II and reported in Chapter III.
8. Cost (C): represents either IEG (actual cost) or IEGHAT (predicted cost) depending on the context used. Specifically, in the graphing of cost functions, Cost (C) is always designated as the (y) or vertical axis, in which case the plots of IEG (with respect to FTE as the (x) or horizontal axis) are always represented by the letter "A" (actual IEG), whereas the plots of IEGHAT are always represented by the letter "P" (predicted IEG).

9. Fixed Cost (FC): represents that portion of TC (IEGHAT) that does <u>not</u> vary with changes in output, i.e., with changes in FTE enrollment.

10. Variable Cost (VC): represents that portion of TC (IEGHAT) that varies with changes in output, i.e., with changes in FTE enrollment.

11. Average Cost (AC): derived from TC (IEGHAT) by dividing TC (IEGHAT) by output, i.e., by FTE enrollment.

12. Marginal Cost (MC): derived from TC (IEGHAT) in that MC represents the increment to TC (IEGHAT) of educating the last (or the next), i.e., the marginal, student. Mathematically, MC is represented by the slope of the TC function over the domain of the function, that is, over any given range of FTE enrollment, for example. Specifically, between any two FTE enrollment levels, MC is the change in TC (IEGHAT) divided by the corresponding change in FTE enrollment-- MC is the instantaneous average rate of change of TC (IEGHAT) with respect to FTE enrollment over any given interval of such enrollment. However, if TC is a multi-variate function, MC <u>cannot</u> be the first derivative of the TC function. For a more precise discussion as to how MC was derived from TC, see Chapter II.

Description of the Institutions

The present study has been limited to two-year public colleges, often referred to as community, junior or technical colleges. Only those institutions identified as two-year public colleges by both HEGIS and by AACJC were included.

The distinction between "small" and "nonsmall" or "large" two-year public colleges was arbitrarily determined by headcount enrollment.[14] For purposes of the present study, small has been arbitrarily defined as HEAD < 2,500. Based on this criterion, the HEGIS XV enrollment survey confirms that there were 337 small two-year public community or junior colleges in the fall, 1980 census report. The distinction between "rural" and "nonrural" or "urban/suburban" is not determinable from HEGIS data, but is determinable from membership data gathered by the AACJC. According to AACJC(1983), there were 571 rural community, junior or technical colleges (both public and private) included on their membership rolls during 1983. By cross-referencing 321 small, comprehensive,[15] two-year public

[14] HEAD is preferable to FTE enrollment as the distinguishing criterion between small versus large two-year public colleges, simply because a large portion of these institutions' enrollment is part-time rather than full-time. However, for cost analysis purposes, total educational and general expenditures per FTE (and not per HEAD) has been used, since most enrollment-driven state funding formulas are based on FTE, not on HEAD.

[15] For an institution to have been considered as being

community or junior colleges per HEGIS with the 571 rural community/junior/technical colleges per AACJC, it was determined that there were 248 comprehensive, small rural two-year public colleges eligible for inclusion in the present study. In addition, for comparison purposes, 89 small two-year public, technical-only institutions[16] and 100 randomly sampled large two-year public community or junior colleges were also identified and included in the present study. The complete universe of known two-year public colleges as of 1980-81 (the eligible universe) and those included in the present study (the usable universe) are analyzed in Table 1.

The classification scheme summarized in Table 1 is unique to the present study and, therefore, does not compare readily with other, more notable classification schemes such as that developed by the National Center for Higher

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"comprehensive" in the present study, that institution must have reported: (1) transferable associate degrees earned under HEGIS XVI classification code 5600 (arts and science or general programs, not organized as occupational programs) and, (2) either associate degrees or certificates, diplomas, etc., awarded in one or more occupational curriculum areas.

[16] For purposes of the present study, a technical institution is one which did not report any transferable associate degrees earned under HEGIS XVI classification code 5600 (arts and science or general programs, not organized as occupational programs), but did report associate degrees or certificates, diplomas, etc., in more than one of 69 different possible occupational curriculum areas (excluding any "other" classifications reported).

Table 1

Analysis of Usable Universe of Two-Year Public Institutions

	Number of institutions			
	1980-81 HEGIS	Total surveyed	Total responses	% of responses to total surveyed
Total usable universe[1]	886	510	388	76.1%
Comprised of:				
Small and rural	248	248	200	80.6
Small, not rural	73	73	51	69.9
Total small	321	321	251	78.2
Small technical	89	89	69	77.5
Large technical	29			
Total technical	118	89	69	77.5
Medium large	174	39	26	66.7
Very large	273	61	42	68.9
Total large c.c.	447	100	68	68.0

[1] See Table A-1 of Appendix A for a reconciliation between the total observations of the 1980-81 HEGIS data bases, hereinafter referred to as the eligible universe, and those of the usable universe as defined by the present study.

Education Management Services (NCHEMS). The NCHEMS classification scheme for institutions of less than four years does not distinguish between either small and large, or rural and nonrural. Instead, NCHEMS distinguishes between two-year institutions on the basis of the number of degrees (but not certificates and diplomas) awarded in occupational and vocational areas versus those awarded in the academic or transfer area (the 5600 field in the HEGIS taxonomy). Brinkman (1981) describes the NCHEMS classification scheme for less than four-year institutions as follows:

> 1. Comprehensive Two-Year Institutions: Institutions in which the number of degrees [excluding certificates, diplomas and awards] in occupational and vocational areas is greater than 20% but less than 80% of all degrees [excluding certificates, diplomas, etc.] awarded.
>
> 2. Academic [Transfer] Two-Year Institutions: Institutions in which the number of degrees [excluding certificates, etc.] awarded in the academic [transfer] area...is at least 80% of all degrees [excluding certificates, etc.] awarded.
>
> 3. Multiprogram Occupational [Technical] Two-Year Institutions: Institutions which confer degrees or awards in two or more occupational programs and which grant less than 20% of their degrees [or awards] in the academic [transfer] area. (p. 214-215)

Although the NCHEMS classification scheme may be useful in other contexts, it was not used in the present study, principally because (1) NCHEMS does not distinguish between institutions on the basis of criteria critical to the present study, e.g., small versus large, or rural versus nonrural, and (2) with the exception of "multiprogram occupational institutions," NCHEMS does not consider less than associate degree work, i.e., certificates, diplomas, and awards, in distinguishing between institutions.

In contrast, the present study has considered certificates, diplomas, and awards as being of equal importance to the overall mission of all two-year public colleges, whether small or large and/or rural or nonrural.

Delimitations

By design, the present study was limited to public two-year colleges. Accordingly, any conclusions reached herein cannot be generalized to either private institutions or four-year colleges. Technical schools offering only occupational or career education in a single curriculum area have also been excluded; so too have multi-purpose technical schools in excess of 2,500 head count enrollment. Finally, while the present study has acknowledged that educational output should ultimately be defined in qualitative (not quantitative) terms, nevertheless, the proxies selected as measures of educational output in the present study were largely quantitative. However, to the extent that quality is, in part, a function of the relative degree to which the various states and/or localities provide financial support for their respective community college systems, the present study has controlled for funding differences that inevitably exist between these states and/or localities. Thus, while differences in the quality of educational output may exist for reasons other than economies of scale, an attempt has been made to control for these differences. For a more precise description of this control, see the section pertaining to the control variable, ADJAVSAL, in Chapter II.

Limitations

The present study has applied microeconomic theory in the estimation of cost functions of two-year public colleges. Because the underlying assumptions of microeconomic theory are not necessarily valid assumptions in the analysis of educational institutions, care must be exercised in the interpretation of the predicted TC, AC, and MC curves produced from the data. Despite the inapplicability of the underlying assumptions of microeconomic theory to an educational setting, the objectives of the present study were to present concrete financial information, analysis, and interpretation for practical, not theoretical, use by the providers and allocators of funds, principally the states and their legislators. Any violations of these or other economic assumptions, therefore, in no way detracts from this objective.

Except for MARKET data gathered from the Atwell and Sullins (1984) survey, the data base used for educational cost, enrollment, and curricular diversity was that provided by public two-year colleges in response to HEGIS surveys conducted by NCES.[17] While differences in interpretation of HEGIS instructions on the part of responding institutions are considered to be minimal in the case of enrollment and curricular diversity data, varying interpretations as to the appropriate classifications of TOTEG expenditures could be extensive. As a result, well intending institutions could have inadvertently reported financial cost data that were inconsistent with NCES instructions and hence equally inconsistent with data received from other responding institutions. Reliability or consistency of the responses within the HEGIS XVI financial data must at least be somewhat suspect. However, the present study considered any such inconsistencies of cost data between responding institutions to have been random errors of measurement and not systematic errors of measurement. Finally, the reliability or representativeness of all cost data used was statistically evaluated by calculating the standard error of the estimate (SEE) for each independent variable of every TC function derived--see Chapter II.

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[17] See Appendix C for a more precise description of this source.

CHAPTER II

METHODOLOGY

Mathematical Representation

As indicated at the outset, the purpose of this study was to investigate the relationship between educational costs and educational output in two-year public colleges. This relationship can be expressed mathematically by a simple equation--equation (1):

$$y = f(x)$$

read as: "y is a function of x."

If (y) represents educational costs (the dependent variable) and (x) represents educational output (the independent variable), then, as hypothesized in the present study, educational costs (y) becomes a function of educational output (x).

As previously established, the proxy for educational costs (y) in the present study was TC, or IEGHAT, and the proxy for educational output (x) was comprised of three variables: FTE, MARKET, and DIVERSITY. Consequently, equation (1) became--equation (2):

TC = f(FTE,MARKET,DIVERSITY)
read as: "TC is a function of FTE,MARKET, and DIVERSITY."

However, because TC may also be a function of some unidentified or unaccounted for variable(s) and/or because those variables that have been identified (FTE, MARKET and DIVERSITY) may not be independent of one another in their contribution toward explaining variations in the dependent variable (y), equation (2) had to be expanded once again as follows--equation (3):

TC = f(FTE,MARKET,DIVERSITY,ERROR)
read as: "TC is a function of FTE,MARKET,DIVERSITY,and ERROR."

Finally, in an attempt to minimize the ERROR term of equation (3), a control variable, average 9-month salary, was introduced into the TC function. Furthermore, this control variable was itself adjusted for any regional differences in the consumer price index--see the Chapter II section entitled, "The Control Variable--ADJAVSAL." Consequently, equation (3) was further expanded as follows--equation (4):

TC = f(FTE,MARKET,DIVERSITY,ADJAVSAL,ERROR)
read as: "TC is a function of FTE,MARKET DIVERSITY,ADJUSTED AVERAGE SALARY, and ERROR."

Graphical Representation

All mathematical functions have a very useful property in that they can be plotted graphically. The graphing of a function provides a concise, visual representation of what otherwise is often a complex set of relationships among variables. The plotting of a mathematical function that describes these relationships serves to transform this intrinsic complexity into a welcomed simplicity. Because of their ability to communicate so effectively, graphic representations of numerous TC, AC, and MC functions have been used extensively throughout Chapter III of the present study. The following discussion serves as a review of the basic plotting techniques used throughout these graphic representations.

The y, or dependent, variable (TC) is always represented as the vertical axis, and the x, or independent/control, variables (FTE, MARKET, DIVERSITY, and ADJAVSAL) are always represented as the horizontal axes. The independent/control variables are positioned at right angles to one another and at right angles to the dependent variable. Using the simplest or univariate case, where $y = f(x) = a_0 + b_1X_1$, the resulting graph of such a hypothetical function would appear as in Figure 3, for example.

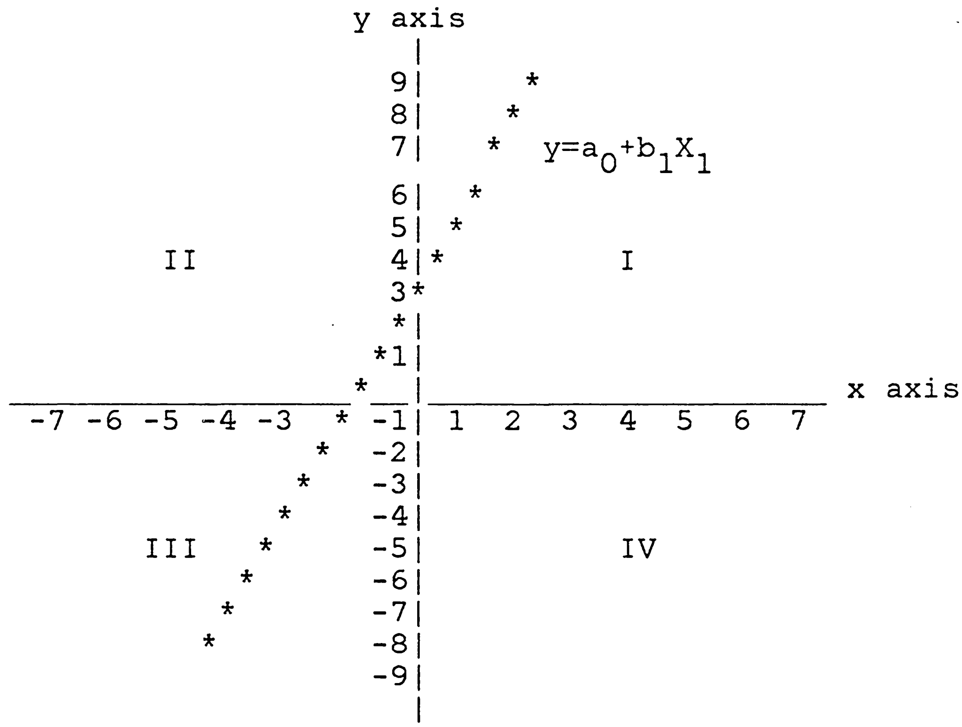

Figure 3. Illustration of a hypothetical linear function.

Mathematically, "a function is a rule that assigns each element of a set D, called the domain, to one and only one element of a set R, called the range." (Williams, 1978, p. 20). The domain of the hypothetical function portrayed in Figure 3 is a set of all real numbers represented by the positive/negative values of the independent variable, x. The range of this same function is a set of all real numbers represented by the positive/negative values of the dependent variable, y.

The graph of the hypothetical function of Figure 3 is divided into four quadrants, I-IV. Depending upon a function's range and domain, the function is said to exist in one or more quadrants, i.e., depending on the positive or negative values of (x,y) that define the function's range and domain, the function is said to exist in one or more quadrants.

For purposes of the present study, the slope and direction of the TC, AC and MC functions as they exist in Quadrant I are the principal areas of interest. Because the range of the dependent variable (TC) is always represented by positive real numbers, and because the domain of each independent/control variable (FTE, MARKET, DIVERSITY and ADJAVSAL) is also always represented by positive real numbers, all plots of the TC, AC and MC functions presented in Chapter III are quadrant I graphs.

The plotting of a cost function having more than two independent variables results in a graph of more than three dimensions. Accordingly, plots of functions with more than two independent variables can exist only in a world of abstraction. Because the present study involved three independent variables, FTE, MARKET, and DIVERSITY, and one control variable, ADJAVSAL, the plotting of such a multi-dimensional cost function became quite impossible. Although the multi-dimensional hyperplane representing such a multivariate TC function could not itself be plotted, both its direction and its slope with respect to at least one independent variable (FTE, for example) could be projected rather easily on a two-dimensional graph. Accordingly, the present study used this two-dimensional graphing technique to plot all multivariate TC functions reported in Chapter III.

Computational Models

Linear Model

To allow for the possibility that the TC function, after controlling for ADJAVSAL, might be a linear combination of the independent variables, FTE, MARKET, and DIVERSITY, equation (4) of the present study took the following computational form--equation (5.1):

$$IEGHAT=a_0+b_1(FTE)+b_2(MARKET)+b_3(DIVERSITY)+b_4(ADJAVSAL)$$

where: a_0 = the y-intercept or the value of IEGHAT when the values of FTE, MARKET, DIVERSITY, and ADJAVSAL are all zero.

b_1,b_2,b_3,b_4 = real numbers, called parameter estimates representing the slope of a four dimensional hyperplane that minimizes the standard error of these estimates (SEE) over the domain of the function.

NOTE: The ERROR term of equation (4) drops out of equation (5.1), as it is statistically represented by the independently calculable SEE.

When graphed, Equation (5.1) can only produce a linear or flat hyperplane since it represents an extension of the mathematical definition of a straight line, or $y = f(x) = a_0 + b_1X_1$, where a_0 is the value of y when X_1 is zero (the y-intercept), and b_1 is the slope of the straight line produced by the graphing of such a linear function, e.g., Figure 3. Since the graph of $y = f(x) = a_0 + b_1X_1$ can only be a straight line, the slope (b_1) of such a function has certain universal mathematical properties, including the following:

1. If the value of b_1 is positive, (i.e., $b_1 > 0$), "the line ascends to the right [in quadrant I where $x > 0$ and $y > 0$]." (Arya and Lardner, 1979, p. 23).

2. The larger the value of b_1, "the more steeply the line is inclined to the horizontal [that is, inclined to be parallel to the x axis and perpendicular to the y axis]." (Arya and Lardner, 1979, p. 23).

3. If the value of b_1 is negative, (i.e., $b_1 < 0$), "the line descends to the right [in quadrant I where $x > 0$ and $y > 0$]." (Arya and Lardner, 1979, p. 23).

4. If the value of b_1 is equal to zero, (i.e., $b_1 = 0$), "the line is a horizontal one [that is, parallel to the x axis and perpendicular to the y axis]." (Arya and Lardner, 1979, p. 23).

5. If the value of b_1 is undefined, the line is vertical or parallel to the y axis and perpendicular to the x axis, for "the slope of a vertical line is not defined." (Arya and Lardner, 1979, p. 23).

6. Since the value of the slope (b_1) represents the ratio of the change in y per unit change in x, "the sign of the slope indicates simply whether the value of y increases or decreases as the value of x increases. For example, if the slope is positive, the value of y increases as the value of x increases; conversely, if the slope is negative, the value of y decreases as the value of x increases." (Williams, 1978, p. 40).

7. The slope (b_1) of a linear function is constant over the domain of the function, that is, over all values of x. Consequently, using equation (5.1), the ratio of the change in IEGHAT per unit change in FTE, or marginal cost per FTE, will be constant over all values of FTE. Thus, if the TC function is linear, the derived MC function will also be linear.

The y-intercept value (a_0) of the TC function also has certain universal mathematical properties, including the following:

1. As a constant in the linear function, $y = f(x) = a_0 + b_1X_1$, the value of a_0 "does not create any change in y for different values of x." (Williams, 1978, p. 34).

2. If a_0 is positive, i.e., $a_0 > 0$, "the point of intersection is above the x axis [in quadrants I or II]", and if a_0 is negative, i.e., $a_0 < 0$, "the line produced by a graph of such a linear [function] intercepts the y axis below the x axis [in quadrants III or IV]." (Williams, 1978, p. 34).

Equation (5.1) can also be referred to as an equation of the first order (or a degree one equation) in that, being a linear function, equation (5.1) has only one root --when y (IEGHAT) is set to zero, there can be only one value of x (FTE,MARKET, DIVERSITY,ADJAVSAL) that satisfies the condition, y = f(x) = 0. In other words, when y (IEGHAT) is zero, the hyperplane produced by a graph of Equation (5.1) will cross each x axis (FTE,MARKET,DIVERSITY,ADJAVSAL) only once, since equation (5.1) is a linear function. "More precisely, a root of the function f(x) is any value of x such that [y=] f(x) = 0. Linear equations have only one root." (Williams, 1978, p. 41). In contrast, quadratic equations may have up to two roots and cubic equations may have up to three roots. TC functions with multiple roots, therefore, will be nonlinear. They will be curvilinear, in which case their slopes (marginal cost) will not be constant over the domain of the function, that is, over all values of FTE, or alternatively, over all values of either MARKET or DIVERSITY.

Quadratic Model

To allow for the possibility that TC, after controlling for ADJAVSAL, might not be a nonlinear function of FTE, MARKET, and DIVERSITY, equation (4) of the present study was also expressed computationally in a quadratic form as follows--equation (6.1):

$$\begin{aligned} \text{IEGHAT} = a_0 &+ b_1(\text{FTE}) + b_2(\text{MARKET}) + b_3(\text{DIVERSITY}) \\ &+ b_4(\text{FTE})^2 + b_5(\text{MARKET})^2 + b_6(\text{DIVERSITY})^2 \\ &+ b_7(\text{FTE*MKT}) + b_8(\text{FTE*DIV}) + b_9(\text{MKT*DIV}) \\ &+ b_{10}(\text{ADJAVSAL}) \end{aligned}$$

where: MKT = MARKET
DIV = DIVERSITY

* = the multiplicative operand.

a_0 = the y-intercept or the value of IEGHAT when the values of FTE, MARKET, DIVERSITY, and ADJAVSAL are all zero.

$b_1 - b_{10}$ = real numbers, called parameter estimates representing the slope of a ten dimensional hyperplane that minimizes the standard error of these estimates (SEE) over the domain of the function.

NOTE: The ERROR term of equation (4) drops out of equation (6.1), as it is statistically represented by the independently calculable SEE.

Equation (6.1) contains four levels of terms. The first level represents the same linear terms found in equation (5.1). To the extent that these linear terms, relative to the other terms of equation (6.1), dominate the prediction of TC, the slope of the resulting hyperplane, as defined by the corresponding least-squares regression procedure, will also appear to be linear or flat, despite the introduction of the squared terms of equation (6.1). In this event, equation (6.1), despite being quadratic in structure, may have only one root, just as equation (5.1) has, by definition, only one root. The squared terms, identified as the second level of equation (6.1), allow the slope of the resulting hyperplane to be curvilinear, provided nonlinearity in fact best describes the prediction of TC by the independent variables, FTE, MARKET and DIVERSITY. To the extent that the squared terms of equation (6.1) dominate the prediction of TC, then the MC function derivable from equation (6.1) will not be constant over the domain of the function with respect to FTE as in equation (5.1). Instead, the related MC function of equation (6.1) will necessarily also be nonlinear.

The third level of equation (6.1) contains the cross-product terms, which, by their presence, allow any interactions that may exist between the independent variables to contribute to the shape of the resulting hyperplane.[18] The fourth and final level of equation (6.1) introduces the control variable, ADJAVSAL, which, by its

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[18] The interactive terms of equation (6.1) can be removed without disturbing the basic quadratic structure of equation (6.1). The resulting equation (without these interactive terms) is referred to hereinafter as equation (6.1A).

presence, serves to minimize the prediction errors inherent in equation (6.1).

Being quadratic in structure, equation (6.1) is an extension of the mathematical definition of a parabola, which is nonlinear, and takes the following general or standard form (Williams, 1978, p. 53):

$$y = f(x) = a_0 + b_1X_1 + b_2X^2$$

Being parabolic, the quadratic function may have two roots--when y (IEGHAT) is set to zero, there may be two values of each x (FTE, MARKET, DIVERSITY, and ADJAVSAL) that satisfy the condition, $y = f(x) = 0$. In other words, when y (IEGHAT) is zero, the hyperplane created by a graph of equation (6.1) may cross each x axis (FTE, MARKET, DIVERSITY, and ADJAVSAL) twice, since equation (6.1) structurally is a nonlinear or curvilinear function. If equation (6.1) does prove to have two roots, then its related MC function will also be nonlinear, unlike that derivable from equation (5.1).

<u>Cubic Model</u>

Another general form of a nonlinear function is the cubic, or degree three equation. To allow for the possibility that TC, after controlling for ADJAVSAL, might be a cubic function of FTE, MARKET, and DIVERSITY, equation (4) of the present study was also expressed computationally in a cubic form as follows--equation (7.1):

$$\begin{aligned}\text{IEGHAT}=a_0 &+ b_1(\text{FTE}) + b_2(\text{MARKET}) + b_3(\text{DIVERSITY}) \\ &+ b_4(\text{FTE})^2 + b_5(\text{MARKET})^2 + b_6(\text{DIVERSITY})^2 \\ &+ b_7(\text{FTE})^3 + b_8(\text{MARKET})^3 + b_9(\text{DIVERSITY})^3 \\ &+b_{10}(\text{ADJAVSAL})\end{aligned}$$

where: a_0 = the y-intercept or the value of IEGHAT when the values of FTE, MARKET, DIVERSITY, and ADJAVSAL are all zero.

b_1 - b_{10} = real numbers, called parameter estimates representing the slope of a ten dimensional hyperplane that minimizes the standard error of these estimates (SEE) over the domain of the function.

NOTE: The ERROR term of equation (4) drops out of equation (7.1), as it is statistically represented by the independently calculable SEE.

Equation (7.1) also contains four levels of terms. The first level represents the same linear terms found in equations (5.1) and (6.1). To the extent that these linear terms, relative to the other terms of equation (7.1), dominate the prediction of TC, the slope of the resulting hyperplane, as defined by the corresponding least-squares regression procedure, will appear to be linear or flat, despite the introduction of the squared and cubic terms of equation (7.1). In this event, equation (7.1), despite its cubic structure, may have only one root, just as equation (5.1) has, by definition, only one root. The squared and cubic terms, identified as the second and third levels of equation (7.1), allow the slope of the resulting hyperplane to be curvilinear, provided nonlinearity in fact best describes the prediction of TC by the independent variables (FTE, MARKET and DIVERSITY). To the extent the cubic terms of equation (7.1) dominate the prediction of TC, the MC function derivable from equation (7.1) will not be constant over the domain of the function as in equation (5.1). Instead, the related MC function of equation (7.1) will necessarily also be nonlinear. Unlike equation (6.1), equation (7.1) contains no cross-product terms.[19] The fourth and final level of equation (7.1) introduces the control variable, ADJAVSAL, which, by its presence, serves to minimize the prediction errors inherent in equation (7.1).

Being cubic in structure, equation (7.1) is an extension of the basic cubic function, which, like the quadratic function, is nonlinear. The basic cubic function takes the following general or standard form:

$$y = f(x) = a_0 + b_1X_1 + b_2X_1^2 + b_3X_1^3$$

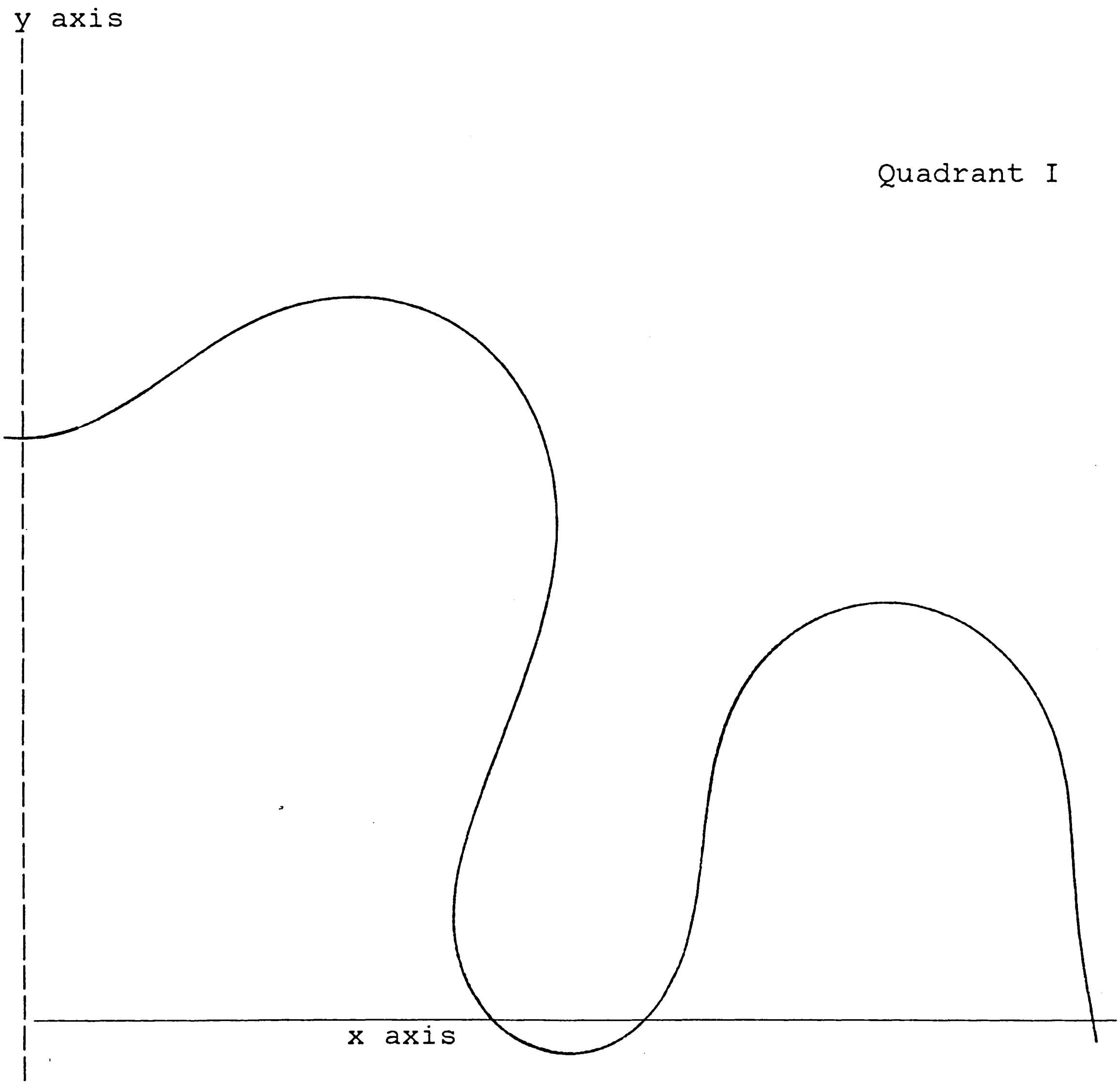
The cubic function may have up to three roots-- when y (IEGHAT) is set to zero, there may be three values of each x (FTE, MARKET, DIVERSITY, and ADJAVSAL) that satisfy the

[19] Interactive terms could have been introduced into equation (7.1) without disturbing its basic cubic structure. However, to include all of the possible interactions into such an expanded cubic form would result in additional and unnecessary multicollinearity among the principal variables represented by levels 1, 2, and 3 of equation (7.1). For this reason, no interactive terms were introduced in equation (7.1).

condition, $y = f(x) = 0$. In other words, when y (IEGHAT) is zero, the hyperplane produced by a graph of equation (7.1) may cross each x axis (FTE, MARKET, DIVERSITY, and ADJAVSAL) three times, since equation (7.1) is a nonlinear or curvilinear function. If equation (7.1) does prove to have three roots, then its related MC function will also be nonlinear, unlike that derivable from equation (5.1).

Cubic functions such as equation (7.1) have some interesting universal characteristics worth noting. Unlike first and second degree equations, the resulting hyperplane of a third degree equation enters a quadrant while sloping in one direction and leaves that same quadrant while sloping in the opposite direction. Also, the slope of the resulting hyperplane of a cubic function may change directions three times within the same quadrant, whereas the slope of a quadratic function can change direction only twice within a given quadrant. These two universal properties of cubic functions are explained more precisely and are graphically represented by Figure 4, as follows:

> Polynomial functions of degrees greater than 2 can have graphs that have several peaks and valleys (or maxima and minima). The number of peaks and valleys is limited by the degree of the function. The graph of a polynomial function with even degree will have the extreme ends of the graph arriving and leaving the graph [quadrant] from the same direction. For a function of odd degree, the extremes arrive from one direction and depart to the opposite direction, as shown in [Figure 4]. (Williams, 1978, p. 53).



Note. Adapted from Modern Mathematics for Business Decision Making (2nd ed., p. 53) by D. R. Williams, 1978, Belmont, CA: Wadsworth Publishing Company, Inc. Copyright 1978 by Wadsworth Publishing Company, Inc.

Figure 4. Illustration of a hypothetical cubic function.

The plot of equation (7.1) as used in the present study, however, will not have the appearance of Figure 4. Rather, if the cubic terms of equation (7.1) dominate the prediction of IEGHAT, then its plot will be similar to the hypothetical TC function portrayed in Figure 1 of Chapter 1, in that the TC function represented by equation (7.1) is not expected to cross any of the x axes (FTE, MARKET, DIVERSITY, or ADJAVSAL) within quadrant I. Yet, a closer inspection of Figure 1 indicates that the same cubic properties described above and portrayed in Figure 4 are equally applicable to the hypothetical TC function portrayed in Figure 1, wherein the latter function, as defined by its range and domain, also enters quadrant I in one direction, changes direction three times, and then leaves quadrant I in the opposite direction.

Multiplicative Model

To allow for the possibility that TC, after controlling for ADJAVSAL, might be an exponential growth function[20] of FTE, MARKET, and DIVERSITY, equation (4) of the present study was also expressed in a multiplicative form as follows--equation (8.1):

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[20] A function is referred to as exponential if the independent/control variables are themselves exponents or powers within the equation (Williams, 1978, p. 62-63).

$$IEGHAT=a_0*FTE^{b1}*MARKET^{b2}*DIVERSITY^{b3}*e^{b4(ADJAVSAL)}$$

where: $*$ = the multiplicative operand.

e = the natural constant = 2.718281828+.

To accommodate the Statistical Analysis System (SAS) software package (SAS Institute Inc. [Statistics], 1982) used throughout the present study, equation (8.1) was transformed into the following computational form--equation (8.1A):

$$\ln IEGHAT = \ln a_0 + b_1(\ln FTE) + b_2(\ln MARKET) + b_3(\ln DIVERSITY) + b_4(ADJAVSAL)$$

where: ln = the natural log.

a_0 = the y-intercept or the ln value of IEGHAT when the ln values of FTE, MARKET, DIVERSITY, and ADJAVSAL are all zero.

$b_1 - b_4$ = real numbers, called parameter estimates representing the slope of a four dimensional hyperplane that minimizes the standard error of these estimates (SEE) over the domain of the function.

NOTE: The ERROR term of equation (4) drops out of equation (8.1A), as it is statistically represented by the independently calculable SEE.

Because the natural log of IEGHAT was not of any particular interest, the antilog of equation (8.1A) was then taken to produce that which was of interest, namely IEGHAT. Mathematically, the antilog of equation (8.1A) was computed as follows--equation (8.1B):

$$e^{y} = e^{\ln \text{IEGHAT}} = \text{IEGHAT}$$

where: e = the natural constant = 2.718281828+.

y = ln IEGHAT.

ln = the natural log.

Translog Model

To allow for the possibility that TC, after controlling for ADJAVSAL, might be yet a different exponential growth function of FTE, MARKET, and DIVERSITY, equation (4) of the present study was also expressed in a translog form as follows--equation (9.1):

$$\text{IEGHAT}=a_0 * \text{FTE}^{b1} * \text{MARKET}^{b2} * \text{DIVERSITY}^{b3} * e^{z}$$

where: $z = b_4(\text{FTE})+b_5(\text{MARKET})+b_6(\text{DIVERSITY})+b_7(\text{ADJAVSAL})$.

* = the multiplicative operand.

e = the natural constant = 2.718281828+.

In order to accommodate the Statistical Analysis System (SAS) software package used throughout the present study, equation (9.1) was transformed into the following computational form--equation (9.1A):

$$\begin{aligned}\ln \text{IEGHAT} = {} & \ln a_0 \\ & +b_1(\ln \text{FTE})+b_2(\ln \text{MARKET})+b_3(\ln \text{DIVERSITY}) \\ & +b_4(\text{FTE})+b_5(\text{MARKET})+b_6(\text{DIVERSITY}) \\ & +b_7(\text{ADJAVSAL})\end{aligned}$$

where: ln = the natural log.

a_0 = the y-intercept or the ln value of IEGHAT when the ln values of FTE, MARKET, DIVERSITY, and ADJAVSAL are all zero.

$b_1 - b_7$ = real numbers, called parameter estimates representing the slope of a seven dimensional hyperplane that minimizes the standard error of these estimates (SEE) over the domain of the function.

NOTE: The ERROR term of equation (4) drops out of equation (9.1A), as it is statistically represented by the independently calculable SEE.

Because the natural log of IEGHAT was not of any particular interest, the antilog of equation (9.1A) was then taken to produce that which was of interest, namely IEGHAT. Mathematically, the antilog of equation (9.1B) was computed as follows--equation (9.1B):

$$e^{y} = e^{\ln \text{IEGHAT}} = \text{IEGHAT}$$

where: e = the natural constant = 2.718281828+.

y = ln IEGHAT.

ln = the natural log.

Statistical Representation

Statistically, FTE, MARKET, and DIVERSITY represent a set of predictor or independent variables, whereas IEG represents the predicted or criterion (the dependent) variable. Given a data base of values for FTE, MARKET, DIVERSITY, ADJAVSAL (the control variable), and IEG, an "average" value of IEG can be predicted using ordinary least-squares regression (OLSR) techniques. The resulting prediction (IEGHAT) is an "average" prediction of IEG in that it is a summary statistic, which, over the domain of the function, minimizes the sum of the squared differences between the actual and predicted values of IEG. The sum of the squared differences between actual and predicted IEG is hereinafter referred to as the Residual Sum of Squares, or more simply, as RSS. Of equations (5.1) through (9.1), that TC function with the least RSS would be the best function attempted in terms of its ability to predict IEG.

While equations (5.1) through (9.1) from an economic perspective are TC functions, statistically they also represent regression equations. In using these equations, the objective of the OLSR procedure is to predict IEG with a minimum amount of predictive error. In the process of making this prediction, the OLSR procedure furnishes equations (5.1) through (9.1) with values for the regression coefficients (called b-values)[21] associated with each predictor/control variable. The OLSR procedure also

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[21] Regression coefficients are sometimes referred to as beta weights, beta values, or simply as betas. When this alternative term is used, the betas are typically identified by a single Greek letter, (e.g., Brinkman, 1981, p. 80). However, there is a distinction to be made between betas and b-values. Betas are the true regression coefficients when there is zero error in the prediction of the dependent variable by the independent variable(s), whereas b-values are unbiased estimators of these betas. All regression coefficients throughout the present study are referred to as b-values, since the related betas are unknown. Moreover, the presence of b-values in equations (5.1) through (9.1) indicate that each of these same TC functions contain an implicit ERROR term.

supplies equations (5.1) through (9.1) with the a_0 or y-intercept value-- the value of IEGHAT when each of the predictor variables is zero.

How well a given TC function, relative to other TC functions, performs in predicting IEG is a question of how well that function minimizes the amount of error in making its prediction. The standard error of the estimate is a statistical measure of the ERROR term implicit in each of the equations (5.1) through (9.1).

The standard error of the estimate is sometimes referred to as the standard deviation of the error scores. In this context, the standard error of the estimate is a statistical measure of the dispersion of predicted IEG from actual IEG. The smaller the dispersion between IEG and IEGHAT, the smaller the standard error of the estimate will be. Of equations (5.1) through (9.1), that TC function with the smallest standard error of the estimate would be the best regression equation attempted in predicting IEG.

By minimizing the ERROR term implicit in equations (5.1) through (9.1), the OLSR procedure also maximizes the amount of variance in IEG that is explained by the predictor variables (FTE, MARKET, and DIVERSITY) after controlling for ADJAVSAL. This principle of maximization is summarized by the statistic, R-squared, which is sometimes referred to as the square of multiple R, which itself is frequently referred to as the Pearson product-moment correlation coefficient, (R), (Hinkle, et al, 1979, p. 400). Of equations (5.1) through (9.1), that TC function with the largest R-squared statistic would be the best regression equation attempted in predicting IEG, in that it maximizes the amount of variance in IEG explained by the independent variables.

The Control Variable: ADJAVSAL

As previously noted, each of the TC functions represented by equations (5.1) through (9.1) contain a control variable referred to as ADJAVSAL. This control variable was introduced in an attempt to minimize the ERROR term implicit in equations (5.1) through (9.1). In other words, FTE, MARKET and DIVERSITY were not expected to be the sole predictors of IEG. For example, one reason why IEG may vary between institutions of different states (other than because of differences in FTE, MARKET and DIVERSITY) is that states vary in the degree to which they financially support their community college system. If FTE, MARKET and DIVERSITY are to become significant predictors of IEG, then any difference in state funding levels becomes an important variable to control. Because 65% to 80% of all higher educational expenditures are for faculty salaries (Toombs, 1973), the present study considered average faculty salaries, as adjusted by CPI, (ADJAVSAL) to be a reasonable proxy for the differences in funding levels that exist between states. Brinkman (1981), Mullen (1981), and Bowen (1980), in their respective studies, also recognized the existence of funding differences between states.

To insure that differences in average faculty salaries were reflective of differences in state support rather than differences in cost of living between localities, each institution's average faculty salary data were first adjusted by their regional consumer price index (CPI) and then compared to the mean average faculty salary as adjusted for CPI. The specific calculation of ADJAVSAL was as follows--equation (10):

ADJAVSAL = (AVE_SAL)(100/CPI) - MEANADJSAL

where: AVE_SAL = The combined weighted average salary of 9-month contracts and 9-month equivalent of 12 month contracts--see Appendix D for source.

CPI = The 1980-81 average consumer price index applicable to each institution according to its (a) region and (b) population--see Appendix D for source.

MEANADJSAL = The mean average AVE_SAL (as adjusted for CPI) of all institutions included in each respective data base.

Because several institutions included in the stratified and composite data bases of Table 1 of Chapter I did not report either numbers of faculty and/or salaries paid in the

HEGIS XV Salaries and Fringe Benefit Survey of 1980-81, the number of institutions included in the present study had to be further reduced[22] from those reported in Table 1 of Chapter I. The revised numbers of institutions included in the present study are presented in Table 2.

Description of the COMPOSITE Data Bases

In addition to the stratified data bases summarized in Table 2, equations (5.1) through (9.1) were applied to three composite data bases using OLSR techniques. The first composite data base (COMPOSITE I) included the total usable universe reported in Table 2 (N=377). The second composite data base (COMPOSITE II) consisted of 309 institutions, including 245 small rural/nonrural and 64 large community colleges, but excluding the 68 small technical schools, as the latter group was not as comprehensive as the former two groups--see Table 2. In addition, a third composite data base (COMPOSITE III) was formed by weighting the large institutions included in COMPOSITE II by a factor of five (N=565). The rationale for COMPOSITE III is as follows:

Excluding all 118 (large and small) technical schools from the original 1980-81 HEGIS data base reported in Table 1 of Chapter I, there were 768 institutions forming the initial eligible universe, of which the small (rural and

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[22] For a detailed list of those institutions not providing salary data, see Appendix B.

Table 2

Revised Analysis of Usable Universe of Two-Year Public Institutions

	Number of institutions			
	Total responses (Table 1)	No HEGIS XV salary data	Usable responses	% usable responses to total surveyed
Total usable universe	388	11	377	73.9%
Comprised of:				
Small and rural	200	6	194	78.2
Small, not rural	51		51	69.9
Total small	251	6	245	76.3
Small technical	69	1	68	76.4
Large technical				
Total technical	69	1	68	76.4
Medium large	26	1	25	64.1
Very large	42	3	39	63.9
Total large c.c.	68	4	64	64.0

Note: See Table 1 of Chapter I for the "total surveyed" data not repeated here.

See also Tables G-1 through G-5 of Appendix G for the complete data base relating to each of the 377 institutions included in the present study.

nonrural) group made up 41.8% (321/768) and the large group made up 58.2% (447/768)--see Table 1 of Chapter I. The composition of COMPOSITE II as derived from Table 2 had changed rather dramatically to where the small (rural and nonrural) group had increased to 79.3% (245/309) at the expense of the larger institutions which had fallen off to only 20.7% (64/309)--see Table 2. Because of this disparity between the eligible and usable universes, a COMPOSITE III data base was formed to give the larger institutions of the usable universe a weight more in line with their initial representation in the eligible universe. COMPOSITE III, therefore, consists of 245 small (rural and nonrural) --as before--and 320 (5 X 64) large community colleges, for a total of 565 institutions. Thus, in applying the regression equations (5.1) through (9.1) to COMPOSITE III, each of the 64 large institutions of the usable universe were included five times, whereas each of the 245 small institutions were included only once. The resulting composition of COMPOSITE III is presented in Table 3.

The inclusion of three COMPOSITES rather than one, like the "total small" and the "total large" sub-composite groupings included in the present study, served to provide a broader basis of comparison relative to the findings of that grouping of primary interest--the 194 small rural community colleges. COMPOSITE I is the only grouping containing all

Table 3

Composition of the COMPOSITE III Data Base

	Number of Institutions	%
Small and rural	194*	34.3
Small, not rural	51*	9.0
Total small	245*	43.3
Medium large (25* x 5)	125	22.1
Very large (39* x 5)	195	34.5
Total large c.c.	320	56.6
Total COMPOSITE III	565	100.0

* From Table 2.

institutions included in the present study, from 190 to 14,507 FTE. However, COMPOSITE I contains 68 small technical institutions with a systematically different mix of comprehensiveness than all other institutions included therein. Moreover, COMPOSITE I does not represent the medium and very large community colleges in the same proportion as they exist in the known population of all two-year public colleges--hence the need for COMPOSITE II and III to provide representative results. The reader should note, however, that the replication of observations to gain proportionality does inflate the error degrees of freedom and thus overstates the significance of the results.

INDEXCOMP: An Alternative to DIVERSITY

As previously reported, one of the independent variables used in the present study was DIVERSITY. This independent variable was first defined in Chapter I as follows:

> Diversity is...the ratio of the number of different HEGIS curricula in which degrees, certificates, or diplomas were awarded to the total maximum possible HEGIS curricula [70] for every reporting institution.

Although every curricular offering has the same weight as every other curricula in the calculation of DIVERSITY, clearly the associated cost of delivering different curricula cannot be equal over the entire range of all curricula. To test whether DIVERSITY would be a better predictor of IEG were it weighted by type of curricular offering, DIVERSITY was correlated with a weighted index of comprehensiveness (INDEXCOMP) first developed by Kaplan (1983) and later reported by Atwell and Sullins (1984).[23] This correlation was performed for each of the stratified and composite data bases previously referred to. In those cases where DIVERSITY was found to be significantly correlated with INDEXCOMP, DIVERSITY would be retained as one of the independent variables. However, in those cases where DIVERSITY and INDEXCOMP were clearly not correlated with one another, the regressions of equations (5.1) through (9.1) would be run both ways--first using DIVERSITY, together with FTE and MARKET, as an independent variable, and then using the alternate variable, INDEXCOMP (in lieu of DIVERSITY) together with FTE and MARKET--equations (5.2 through 9.2). Whichever alternate variable (DIVERSITY vs. INDEXCOMP) proved to be the best copredictor of IEG for 194 small rural 2-year public colleges was retained (along with FTE and MARKET) throughout the analysis of the remaining data bases.

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[23] A brief description of the weighting procedures developed by Kaplan (1983) is provided in Appendix E.

Sampling Procedures

While the values for FTE, DIVERSITY, AVE_SAL (which was the basis of ADJAVSAL), and IEG were all taken from the 1980-81 HEGIS data bases maintained by NCES, the value for MARKET was taken from responses received from a survey on curriculum comprehensiveness conducted by Atwell and Sullins (1984).

As reported in Chapter I, MARKET is the ratio of headcount enrollment to an institution's target population, or HEAD/TARGET. The value for TARGET was provided by each institution's answer to the following question included in the Atwell and Sullins (1984) survey and in a follow-up, second request post card mailing conducted by the present researcher:

> SERVICE REGION POPULATION: What is the approximate population of the Institutional Service Region? If the institution has no clearly defined service region, please indicate the approximate population within a 50 mile radius of the institution.________________persons.

The values for TARGET were solicited from 100% of the small (rural and nonrural) eligible universe and from 100% of the small technical eligible universe--see Table 1. As reported in Table 2, usable response rates for TARGET ranged from 69.9% to 78.2%.

A random sample, using the SAS procedure PROC PLAN, was taken of 100 large community colleges and the values for TARGET were solicited from this sample. By design, this sample included 39 medium large (FTE between 2,500 and 4,999) and 61 very large (FTE of 5,000+) community colleges. The resulting sample represented the respective proportions of 39% (174/447) and 61% (273/447) that these two sub-groups were found in the combined eligible population (N=447) of all large community colleges (FTE in excess of 2,500).

Curve-smoothing Techniques

Prior to the derivation of the average cost (AC) and marginal cost (MC) functions, IEGHAT, as determined by OLSR procedures using equations (5.1) through (9.1) applied to the stratified data bases of Table 2 (including COMPOSITES I, II and III), had to be subjected to certain curve-smoothing techniques. These techniques became necessary because IEGHAT was predicted by more than one independent variable. Had IEGHAT been dependent upon only one variable (FTE, for example), such curve-smoothing techniques would not have been necessary because, in the graphing of such a univariate TC function, each of the predicted values of IEG would have fallen on a single line--see Figure 3, for example. Even more important, the predicted values of IEG for all observations having the same FTE would have been superimposed on that line.

Curve-smoothing techniques became necessary in the multivariate case when attempts were made to project the slope of a multivariate cost function on a two dimensional graph featuring Cost (C) as the dependent (y) axis and FTE as the independent (x) axis. The two dimensional projection of such a multi-dimensional plane produced more than one predicted value of IEG whenever observations had the same FTE but different MARKET, DIVERSITY and ADJAVSAL values. For example, if three institutions having the same FTE also have three different MARKET and/or DIVERSITY values, the resulting two dimensional projection of IEGHAT with respect to FTE will necessarily reflect three different predicted values of IEG. Multiple IEGHAT values at the same level of FTE reflect the slope of the hyperplane with respect to the other independent variables which cannot otherwise be portrayed on a two dimensional projection of a multi-dimensional plane.

Accordingly, multiple IEGHAT values at each level of FTE, whenever they occurred, had to be reduced or smoothed to only one value of IEGHAT per FTE level, so that the related AC and MC functions would also be "smooth" cost functions. To achieve this objective, three curve-smoothing steps were necessary. The first was to calculate the mean IEGHAT at each level of FTE within the domain of the TC function being smoothed. FTE was then regressed on the mean IEGHAT, using the same model (linear, quadratic, etc.) as that being smoothed, to produce an average predicted TC. The resulting function of average predicted TC, although generally smooth, was not yet continuous because of missing IEG and FTE values in the original data base. The missing average predicted TC values were imputed by using the very same regression equation that had just produced the discontinuous average predicted TC. This three step process in arriving at a smooth and continuous IEGHAT over the entire domain of the function assured that the related AC and MC functions would also have but one cost value for each level of FTE.

Marginal and Average Cost Functions

Once smooth TC functions (equations (5.1) through (9.1)) had been determined for each of the stratified data bases of Table 2 (including COMPOSITE I, II, and III), average cost (AC) functions with respect to FTE were derived as follows--equation (11):

$$AC = IEGHAT/FTE$$

The derivation of marginal cost (MC) became somewhat more complex. Certain universal mathematical properties had to be satisfied in the derivation of each MC function. These properties have been described by Hirshleifer (1980) as follows:

> 1. When a total function or magnitude [TC] is rising, the corresponding marginal function [MC] is positive (p. 49).

2. When a total magnitude [TC] is falling, the corresponding marginal magnitude [MC] is negative (p. 49).

3. When a total magnitude [TC] reaches a maximum or a minimum [that is, when the TC function stalls or changes direction], the corresponding marginal magnitude [MC] is zero (p. 49).

4. When the average magnitude [AC] is falling, the marginal magnitude [MC] must be below it (p. 50).

5. When the average magnitude [AC] is rising the marginal magnitude [MC] must lie above it (p. 51).

6. When an average magnitude [AC] is neither rising nor falling (at a minimum or maximum, or other stationary point) [that is, when the AC function stalls or changes direction], the marginal magnitude [MC] must be equal to it [i.e., AC = MC] (p. 51).

In terms of the objectives of the present study, proposition (6) above is the most critical of all, for economies of scale exist over the domain of the TC function whenever AC > MC. Thus, the determination of that level of FTE enrollment where AC = MC was of critical importance to the present study.

The MC function was first defined in Chapter I as the increment to TC of educating the last, or marginal student. Mathematically, the MC function is the slope of its related TC function. If the TC function is defined in terms of a single independent variable, MC is the first derivative of such a univariate function. However, if the TC function is defined in terms of two or more independent variables, the derivative of such a function can only be a partial derivative with respect to one of those independent variables. For example, after controlling for ADJAVSAL, if TC = f(FTE, MARKET and DIVERSITY), then the first derivative of TC with respect to FTE will only partially account for the observed change in IEGHAT, since in the process of taking such a partial derivative, MARKET and DIVERSITY would be treated as constants. Since changes in IEGHAT are also attributable to changes in MARKET and DIVERSITY, the resulting MC function would narrowly represent MC with respect to FTE alone.

Whereas Brinkman (1981) was satisfied that such partial derivatives were equivalent to "the marginal cost of [educating] an additional student of that type"[24] (p. 50), the present study was concerned with the marginal cost of educating an additional student of all types, or more specifically, without regard to type. While Brinkman, by design, limited his dissertation (1981) to defining MC functions with respect to each independent variable within a multivariate TC function, his failure in a follow-up publication (1983) to define MC functions in terms of all

[24] Brinkman's (1981) multivariate TC functions were defined in terms of up to seven independent variables, including lower division, upper division, and graduate division enrollments, total FTE enrollment, total full-time and total part-time headcount enrollments. Reliance upon partial derivatives of multivariate TC functions as being equivalent to marginal cost led Allen and Brinkman (1983) to the illogical, yet fortunately non-significant, conclusion that the marginal cost of lower division instruction at public research universities was a negative $90 per FTE over the entire domain of his TC function (p. 30).

(not each) independent variables was, at best, disappointing and may well have been a serious oversight on Allen's and Brinkman's part.

Brinkman's (1981 and 1983) approach to marginal costing techniques was, therefore, inappropriate for purposes of the present study. As an alternative, the present study used a method by which the change in IEGHAT was put "in terms of FTE" rather than "with respect to FTE." In this way, the entire change in IEGHAT (whether due to changes in FTE, MARKET, DIVERSITY, or ADJAVSAL) was put in terms of the corresponding change that took place in FTE. Specifically, the MC function relating to each of equations (5.1) through (9.1) was derived from its related TC function as follows--equation (12):

$$MC = (MC_1 + MC_2) / 2$$

where: MC_1 = downward unit Δ in TC / downward unit Δ in FTE

MC_2 = upward unit Δ in TC / upward unit Δ in FTE

Equation (12) is referred to by Hirshleifer (1980) as the "better approximation method" (p. 48). It is so labeled because the average of the upward and downward changes in TC is a better approximation of the instantaneous rate of change in IEGHAT per unit change in FTE that is actually taking place along the surface of the hyperplane representing the TC function. For illustrative purposes only, a hypothetical example of the derivation of the MC function used in the present study is presented in Table 4.

Table 4

Hypothetical Derivation of the MC Function

TC	FTE	MC Approximation: Delta TC/Delta FTE	Better MC Approximation: Equation (11)
$ 400,000	0		
		$500000/400=$1,250	
$ 900,000	400		$ 875[1]
		$100000/200=$ 500	
$1,000,000	600		$1,250
		$200000/100=$2,000	
$1,200,000	700		$2,500
		$150000/ 50=$3,000	
$1,350,000	750		

[1] Computed as follows:

MC_1=Downward change: $ 900,000 - $400,000 / 400- 0 = $1,250
MC_2= Upward change: $1,000,000 - $900,000 / 600-400= $ 500

MC = Average change: $ 1,250 + $ 500 = $ 1,750 / 2 = $ 875

Summary of Research Design

To summarize the research design of the present study, OLSR procedures, using equations (5.1) through (9.1) as regression equations, were applied to each of the stratified data bases identified in Table 2 (including COMPOSITE I, II and III). The OLSR procedures used were those supplied by SAS computerized software. Prior to using the applicable SAS regression procedure, the observations included in each of the data bases identified in Table 2 (including COMPOSITE I, II and III) were sorted in ascending order by the following variables:

IEG, FTE, MARKET, DIVERSITY/INDEXCOMP, ADJAVSAL

Using equations (5.1) through (9.1) as the regression equations, IEGHAT was determined for each data base by the applicable SAS regression procedure identified in Table 5.

Once IEGHAT was determined for these respective data bases, that equation which best predicted IEG was plotted as a two-dimensional graph with TC as the vertical axis and FTE as the horizontal axis. Since these graphs indicated both the direction and the slope of each "winning" TC function in terms of FTE, they became the basis for the derivation of the respective AC and MC functions. Prior to their derivation, however, certain curve-smoothing techniques were first applied to each of the "winning" TC functions.

Table 5

Summary of SAS Regression Procedures Used

Equation	General Form	Expected IEGHAT Result	SAS Procedure Used
5	Linear	Linear	PROC REG[1]
6	Quadratic	Nonlinear	PROC NLIN[2]
6A	Quadratic	Nonlinear	PROC NLIN[2]
7	Cubic	Nonlinear	PROC NLIN[2]
8A	Multiplicative	Nonlinear	PROC REG[3]
9A	Translog	Nonlinear	PROC REG[3]

[1] PROC REG is a general-purpose regression procedure which, among other things, "estimates parameters [b-values] subject to linear restrictions, tests linear hypotheses, [and] tests multivariate hypotheses" (SAS Institute Inc. [Statistics], 1982, p. 5).

[2] PROC NLIN "implements iterative methods that attempt to find least-squares estimates [of regresssion coefficients] for nonlinear models. The default method is GAUSS-NEWTON, although several other methods [MARQUARDT, steepest descent (GRADIENT), and secant (DUD)] are available.... Nonlinear models are more difficult to specify and estimate than linear models. Instead of simply listing regressor variables, you must write the regression expression [equation], declare parameter names [b1, b2, etc.], guess starting values for them, and specify [partial] derivatives of the model with respect to [each] of the parameters [rather than with respect to each of the regressor variables] (SAS Institute Inc. [Statistics], 1982, p. 6 and 15).

[3] Although the multiplicative and translog TC functions were expected to be nonlinear, equations (8A) and (9A) represent linear transformations of nonlinear equations (8.1) and (9.1). Thus, PROC REG became quite appropriate. The antilog of the result was then taken, thereby allowing for the possibility of curvilinearity to surface.

In order to determine which TC function best represented its respective data base, three statistical measures of "goodness of fit" were calculated and compared, as follows:

1. Residual sum of squares (RSS),
2. Standard error of the estimate (SEE), and
3. R-squared.

To insure that each equation, both within and between every data base tested, would be evaluated on the same basis as every other equation, the "winning" TC function representing each data base had to have the highest R-squared statistic and either the least RSS or the least SEE of all those equations attempted. To the extent that the minimization of SEE usually involves the presence of significant estimates, the latter--representing a qualitative, yet equally appropriate, criterion--was also used in the selection of the best model.

Finally, as a statistical measure of how significant each TC function was in its ability to predict IEG, the following hypothesis was tested (using the F-distribution) with respect to every regression attempted:

> After controlling for ADJAVSAL, is there a significant relationship between the dependent variable (IEG) and the three independent variables (FTE, MARKET, and DIVERSITY/INDEXCOMP) ? The associated null hypothesis is that $R = 0$, that is, no such relationship exists other than by chance.

CHAPTER III

FINDINGS

Method of Presentation

Based on the methodology prescribed by Chapter II, the findings to be reviewed in Chapter III will be presented in the following sequence:

1. Results of the correlation between DIVERSITY and INDEXCOMP, and between each of these two independent variables and IEG, will be presented first. Based on these correlations, tentative conclusions as to which variable (DIVERSITY or INDEXCOMP) might be the better co-predictor of IEG will be presented.
2. Regression results for each of the stratified data bases of Table 1 of Chapter I (including COMPOSITE I, II and III) will be presented and analyzed by equation representing each of the five models tested--LINEAR, QUADRATIC, CUBIC, MULTIPLICATIVE and TRANS-LOG.
3. The regression results reported in (2) above will include both DIVERSITY and INDEXCOMP as alternate co-predictors of IEG, but only for the first of ten data bases to be analyzed--the 194 small rural community colleges. If the regression results

pertaining to this first data base confirm the tentative conclusions drawn from the correlation results in (1) above, then the regression results for the remaining nine data bases will be reported using only that co-predictor (DIVERSITY or INDEXCOMP) which best predicts IEG.

4. Because graphic representations convey dynamic information about mathematical functions that cannot be ascertained from statistic or tabular representations, the present study emphasizes the use of figures to present all derived cost functions. Moreover, the curve-smoothing techniques described in Chapter II require several plottings of each function before a completely smooth and continuous TC function emerges. To facilitate the overall presentation, only those figures essential to the ten data bases under analysis will be retained within the text of Chapter III. For the more serious reader, additional supporting figures will be included as Appendix F.

5. Statistically supportable conclusions will be inferred relative to each data base analyzed. An overall review and summary of findings also will be presented at the end of Chapter III.

DIVERSITY versus INDEXCOMP

As a preview of which of two independent variables--DIVERSITY or INDEXCOMP--might be the better predictor of IEG, these two variables were correlated with one another using the Pearson product-moment statistical technique. The results of this correlation are presented in Table 6.

Based on the admittedly arbitrary criterion that the Pearson product-moment correlation statistic, Rho or R, must be a significant ($p < .05$) value of $|.75|$ or better to establish that a relationship exists, the results confirmed that, with the singular exception of that exhibited by 68 small technical two-year colleges, no such relationship existed between DIVERSITY and INDEXCOMP. Moreover, except for the distinction between medium and very large two-year public colleges, the lack of any relationship between DIVERSITY and INDEXCOMP was statistically significant ($p < .05$). Based on these results, DIVERSITY and INDEXCOMP are clearly not interchangeable independent variables, i.e. whatever they individually measure, DIVERSITY and INDEXCOMP will not behave in the same way in predicting the value of some third variable.

In terms of the present study, this third variable of interest was IEG. If DIVERSITY and INDEXCOMP generally are not perfect substitutes for each other, which one exhibits

Table 6: Summarized Results of Correlations: DIVERSITY, INDEXCOMP, and IEG

# of Observations	Institutional Type	DIVERSITY and INDEXCOMP		IEG and DIVERSITY		IEG and INDEXCOMP	
		R	PROB > |R|	R	PROB > |R|	R	PROB > |R|
194	Small Rural	.31910*	.0001	.60804*	.0001	.32071*	.0001
51	Small, Nonrural	.35979*	.0095	.42860*	.0017	.05707	.6908
245	Total Small CC	.32650*	.0001	.56555*	.0001	.26397*	.0001
68	Small Technical	.75340*	.0001	.52384*	.0001*	.47498*	.0000
25	Medium Large	.36429	.0734	.54774*	.0046*	.02731	.8969
39	Very Large	.16734	.3086	.76023*	.0001*	.05467	.7410
64	Total Large	.31317*	.0117	.81191*	.0001*	.16128	.2030
377	Composite I	.30649*	.0001	.75228*	.0001*	.25730*	.0001
309	Composite II	.34261*	.0001	.77582*	.0001*	.21126*	.0002
565	Composite III	.35101*	.0001	.83448*	.0001*	.22182*	.0001

*Significant at the .05 level, or better

the stronger relationship with IEG? To answer this follow-up question, both DIVERSITY and INDEXCOMP were independently correlated with IEG using the Pearson product-moment statistical technique. The results of this correlation are also presented in Table 6.

Using the same criterion as before (significant $R > |.74|$), DIVERSITY exhibited a positive relationship with IEG in the very large and total large two-year public colleges as well as in each of COMPOSITES I, II, and III. In contrast, no relationship was found between INDEXCOMP and IEG at any level of any institutional type tested. Moreover, the <u>lack</u> of relationship between INDEXCOMP and IEG proved to be statistically significant ($p < .05$) in six out of the ten institutional types tested. In contrast, the relationship (or lack of relationship) between DIVERSITY and IEG was statistically significant in all ten institutional types tested.

Because these tests of relationship were conducted in isolation of the other two independent variables (FTE and MARKET) and of the control variable (ADJAVSAL), only tentative conclusions with respect to the relationship between DIVERSITY and IEG and that between INDEXCOMP and IEG could be made at this point in the present study. These tentative conclusions were as follows:

(1) The parameter estimate or regression coefficient for DIVERSITY, acting in concert with those for FTE and MARKET, probably would <u>not</u> be a statistically significant contributor to the prediction of IEG, except for the very large, the total large, and each of the three COMPOSITE data bases.

(2) Despite this hypothesized inability to contribute significantly to the prediction of IEG in the case of smaller institutions, the parameter estimate for DIVERSITY, acting in concert with those for FTE and MARKET, probably would be a statistically significant contributor to the prediction of IEG in more models tested than would INDEXCOMP.

(3) Similarly, models with DIVERSITY as a co-predictor of IEG would consequently reflect higher R-squared statistics than would models with INDEXCOMP.

194 Small Rural Colleges

<u>Selecting the Best Model</u>

Based on the three criteria established in Chapter II (the maximization of R-squared and the minimization of either RSS or SEE), the linear model with DIVERSITY--equation (5.1)--produced the highest R-squared statistic (.7030).[25] The linear model with DIVERSITY also

[25] The R-squared statistic reported throughout Chapter III is an "adjusted" R-squared statistic, wherein the calculated R-squared statistic has been adjusted for N-1

satisfied the minimization of SEE by reflecting significant parameter estimates ($p < .05$, or better) for all three independent variables (FTE, MARKET, and DIVERSITY), which was something no other equation tested, except for the multiplicative model with DIVERSITY--equation (8.1)--was able to do.

While the adjusted R-squared statistic of the linear model with DIVERSITY--equation (5.1)--was only slightly better than that for the quadratic models with DIVERSITY (.6940 for equation 6.1 and .6985 for equation 6.2A) and the cubic model with DIVERSITY (.6971), the parameter estimates for the quadratic and cubic terms in these alternative equations were not significant. In contrast, the parameter

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observations and κ number of predictors. Since the calculated R-squared statistic can always be increased by adding more independent variables (including even suppressor variables) to any regression equation (Hinkle et al., 1979, p. 403), the improvement in the R-squared statistic attributable to these additional independent variables has been eliminated by reporting this statistic on an adjusted basis throughout the present study. Hence, any differences in the "adjusted" R-squared statistic among the 12 regression equations tested can be interpreted as real (i.e., unbiased) differences. If, alternatively, R-squared had been reported on an unadjusted basis, that equation with the most independent variables would have always been the "best" at predicting IEG. In this event, a stepwise F-test (Hinkle et al., 1979, p. 407) of the differences between the (unadjusted) R-squared statistic of each equation would have been appropriate to evaluate whether the difference in the (unadjusted) R-squared statistic attributable to the additional variable(s) was statistically significant. Such an F-test is inappropriate, however, in comparing R-squared statistics on an adjusted basis, since the effect of κ number of variables on the R-squared statistic has estimates for the linear terms representing all three independent variables (FTE, MARKET, and DIVERSItY) were significant in the linear model with DIVERSITY. Accordingly, the difference in the respective R-squared terms between the linear model--equation (5.1)--and its close competitors--equations (6.1, 6.2A, and 7.1)--was greater than a simple comparison would otherwise indicate. Since the parameter estimates of the independent variables represent the resulting slope of the TC function, the significance of all three parameter estimates associated with the linear model, as compared to the nonsignificance of quadratic and cubic terms of alternative models, further substantiated the selection of the linear model--equation (5.1)--as the model most representative of TC for 194 small rural community colleges.

The relationship between statistically significant parameter estimates (i.e., equation 5.1) and the minimization of the standard error of the estimate (SEE) as a criterion for evaluating models in the prediction of TC, is as follows. Although each parameter estimate in a regression model has a calculable SEE associated with it, such error is minimized whenever the parameter estimates are statistically significant relative to the hypothesis being tested. For example, with respect to equation (5.1), the

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already been eliminated.

regression coefficient for FTE was estimated by the linear model as 2250.855 with a standard error of 163.143. The null hypothesis tested was: beta = 0 or beta - 0 = 0, i.e., it was hypothesized that there was no difference between the true parameter, beta, and zero. The alternative hypothesis was that beta did not equal zero, which implied a two-tailed test of significance probability. The τ statistic to test this hypothesis was calculated as follows: (b - beta)/SEE, or (2250.855 - 0)/163.143 = 13.797.

In this case, "the probability that a τ statistic would obtain a greater absolute value than that observed, given that the true parameter is zero," (SAS STATISTICS, p. 69) was .0001. Accordingly, the null hypothesis was rejected since the difference between the calculated parameter estimate (2250.855) and the hypothesized value for beta (zero) was too great to have been due solely to chance. In this case the calculated τ statistic (13.797) was greater than the related critical value of the τ distribution for N-1, or 193, degrees of freedom. Had the standard error of the estimate been any value larger than 163.143, then the calculated τ statistic would have been not only less than 13.797, but more importantly, also less than the .0001 critical value of the related τ distribution. Had this been the case, the null hypothesis could not have been rejected at the .0001 level of significance.

Hence, significant parameter estimates are indicative of minimal standard errors of the estimate (SEE). The minimization of SEE was one of three criteria established to evaluate which of five different models tested was the best at predicting TC. Since the linear model with DIVERSITY (equation 5.1) was the only model (except for equation (8.1), which was rejected from further consideration on the basis of too low an R-squared statistic--R-squared = .6584) to produce significant parameter estimates for each of the three independent variables (FTE, MARKET and DIVERSITY), it was the only model to minimize SEE on a consistent basis, i.e., across all three independent variables.

To summarize, the linear model with DIVERSITY (equation 5.1) was selected as the best model in predicting TC for 194 small rural two-year public colleges. Equation (5.1) had the largest R-squared statistic (.7030), which was interpreted as follows: After controlling for ADJAVSAL, 70.30 percent of the variation in the dependent variable (TC) could be explained by 100 percent of the variation in the three independent variables (FTE, MARKET, and DIVERSITY). Although equation (5.1) produced only the fourth least RSS, it was one of only two equations in which the parameter estimates for each of the three independent variables (FTE, MARKET and DIVERSITY) were statistically significant ($p < .05$, or better). Statistical significance affirmed that the third criterion--minimization of SEE--had been achieved by equation (5.1) and by no other equation (once equation 8.1 had been eliminated from consideration on other grounds). Finally, in predicting TC, equation (5.1) was itself statistically significant ($p < .0001$), which was interpreted as follows: After controlling for ADJAVSAL, the relationship between the three independent variables (FTE, MARKET, and DIVERSITY) and the dependent variable (IEG) was too great (R = square root of .7030) to have been due solely to chance.

To confirm the selection of the linear model with DIVERSITY (equation 5.1) as an appropriate model in predicting TC for 194 small rural two-year public colleges, equation 5.1 was subjected to an analysis of the amount of residual or error of prediction (actual versus predicted values of IEG) inherent in the underlying regression procedure. This error analysis tested the assumption of regression--that the errors have a constant variation over the range of FTE and follow a normal distribution (Draper and Smith, p. 141). In testing these assumptions as they related to this equation (5.1) and to those other "winning" TC functions representing each of the other stratified data bases yet to be reported, these assumptions did not appear to have been violated.

Table 7: Summarized Regression Results of Predicting TC For Small Rural Two-Year Public Colleges (N = 194)

Model	Equation	Alternate Variable	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameters Having Significant (@.05) PROB > |T|
LINEAR	(5.1)	DIVERSITY	.0001	.7030	9.01953E+13	FTE, MARKET, DIVERSITY
	(5.2)	INDEXCOMP	.0001	.6865	9.51946E+13	FTE, MARKET
QUADRATIC	(6.1)	DIVERSITY (with interactive terms)	.0001	.6940	8.99621E+13	FTE
	(6.2)	INDEXCOMP (with interactive terms)	.0001	.6865	9.21759E+13	FTE, $INDEXCOMP^2$
	(6.1A)	DIVERSITY (without interactive terms)	.0001	.6985	9.00823E+13	FTE
	(6.2A)	INDEXCOMP (without interactive terms)	.0001	.6912	9.22710E+13	FTE, $INDEXCOMP^2$
CUBIC	(7.1)	DIVERSITY	.0001	.6971	8.90495E+13	FTE
	(7.2)	INDEXCOMP	.0001	.6929	9.02872E+13	FTE
MULTICATIVE[2]	(8.1)	DIVERSITY	.0001	.6584	10.37110E+13	FTE, MARKET, DIVERSITY
	(8.2)	INDEXCOMP	.0001	.6374	11.00890E+13	FTE, MARKET
TRANS-LOG[2]	(9.1)	DIVERSITY	.0001	.6988	9.00188E+13	FTE
	(9.2)	INDEXCOMP	.0001	.6873	9.34477E+13	FTE, INDEXCOMP

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) included in each equation (5.1-9.2) according to the following formula:

$$\text{adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

[2] Results shown for exponential models are those of predicting the natural log of IEG.

Table 7 presents the summarized regression results of all equations tested by model, and Table 8 presents the estimated parameter values, the regression coefficients, for every term of each equation within the five models defined by the present study. Aside from providing a basis for comparing the best model (equation 5.1) with each of the other models tested in predicting IEG, the results presented in Tables 7 and 8 are noteworthy in at least two other respects--(1) the significance (or lack thereof) of the y-intercept values (Table 8), and (2) the verification (or lack thereof) of the DIVERSITY versus INDEXCOMP issue (Tables 7 and 8).

<u>The Y-intercept Values</u>

The reader will recall from Chapter I that the y-intercept represents that value of TC when the values of the independent variables (FTE, MARKET and DIVERSITY) are each zero. In short-run economic analysis of TC functions, the y-intercept represents the average fixed cost included in TC over the domain of the TC function, or the overall levels of output (including zero levels of output). In long-run economic analysis, the y-intercept must also be zero as all costs, including those otherwise considered to be fixed, are, by definition, variable costs. By design, each equation of every model tested by the present study has a y-

Table 8: Estimated Parameter Values By Equation For Small Rural Two-Year Public Colleges (N = 194)

Model Equation	Linear (5.1)	Linear (5.2)	Quadratic (6.1): With DIVERSITY & Interactive Terms	Quadratic (6.2): With INDEXCOMP & Interactive Terms	Quadratic (6.1A): With DIVERSITY & No Interactive Terms	Quadratic (6.2A): with INDEXCOMP & No Interactive Terms
Y-intercept	$89494.608	$ 129093	$ 131453	$ 607839	$ 164584	$ 637063
FTE	2250.855*	2519.201*	2351.655*	2813.126*	2266.844*	2730.669*
MARKET	11662218*	12961787	8605579	2007251	6635458	4432506
DIVERSITY	3274368*	---	2590927	---	2807652	---
INDEXCOMP	---	13368.097	---	-80709.032	---	-79750.584
ADJAVSAL	8.621403	5.263227	8.144533	0.603308	8.964799	1.378180
FTE¬2			-0.017924	-0.085718	-0.00585235	-0.149932
MARKET¬2			99007051	140632918	79553961	137847123
DIVERSITY¬2			-208965	---	1434081	---
INDEXCOMP¬2			---	3911.255*		3529.316*
FTE BY MARKET			-7428.154	506.386		
FTE BY DIVERSITY			375.851	---		
FTE BY INDEXCOMP			---	-13.288921		
MARKET BY DIVERSITY			25202063	---		
MARKET BY INDEXCOMP			---	117337		

*Significant at the .05 level, or better

Table 8 (Continued)

Model Equation	Cubic (7.1) with DIVERSITY	Cubic (7.2) With INDEXCOMP	Multicative (8.1) With DIVERSITY	Multicative (8.2) With INDEXCOMP	Translog (9.1) With DIVERSITY	Translog (9.2) With INDEXCOMP
Y-intercept	$ 193889	$ -218082	$ -7257485*	$ -9905902*	$ - 1493958	$ -972043
FTE	3709.649*	3510.582*			2033.094*	2070.911
MARKET	11577147	24159184			11611923	12105221
DIVERSITY	-7898439	---			4566738	---
INDEXCOMP	---	102389				66482.97*
FTE¬2	-1.488564	-1.022193				
MARKET¬2	-56616338	-591263871				
DIVERSITY¬2	70911871	---				
INDEXCOMP¬2	---	-11872.110				
FTE¬3	0.0004326097	0.0002535258				
MARKET¬3	1162215398	6897481119				
DIVERSITY¬3	-132155512	---				
INDEXCOMP¬3	---	379.380				
ADJAVSAL	7.224568	3.965204	15.144878	9.165031	7.192900	1.38850088
LN FTE			1757968*	1993362*	182726	349439
LN MARKET			183155*	205830*	509.999	26179.77
LN DIVERSITY			459766*	---	-181011	---
LN INDEXCOMP				99836.582		-585188.44

*Significant at the .05 level, or better

intercept represented by a real number other than zero--see Table 8. The resulting TC function, therefore, in all cases tested must be interpreted as being a short-run TC function wherein some costs (the y-intercept value) are fixed and other costs are variable.

In contrast, Brinkman's (1981) estimated cost functions were interpreted as "long-run functions" (p. 59). Although Brinkman never reported any y-intercept values, those relying on Brinkman's research have no choice but to conclude that the y-intercepts for every function reported by Brinkman must have been zero. To have been any value other than zero would have been inconsistent with the interpretation Brinkman himself placed on his estimated TC functions. Since long-run and short-run TC functions are structurally so vastly different, the results of the present study, being short-run TC functions with y-intercepts other than zero, are not comparable with Brinkman's results, which were long-run TC functions, presumably with y-intercept values of zero.

Of the five models defined within the present study, the y-intercept value of only one such model--the multiplicative model (equations 8.1 and 8.2)--was statistically significant ($p < .05$). Despite the insignificant y-intercept value of $89,495 reflected by equation (5.1), the linear model with DIVERSITY remained as the best model in predicting TC for 194 small rural two-year public colleges. While its y-intercept value of $89,495 simply cannot be relied upon as the predicted TC when FTE, MARKET and DIVERSITY are each zero, nevertheless, such an insignificant y-intercept value in no way detracts from the significance of the slope of the TC function represented by equation (5.1). The significance, or lack thereof, of the y-intercept value is quite immaterial to the evaluation of this or any other TC function relating to 194 small rural two-year public colleges, since the y-intercept (FTE = 0) lies outside the domain of any TC function relating to this institutional type (FTE = 190 to 2,257).

DIVERSITY Versus INDEXCOMP

Although it had been hypothesized earlier in Chapter III that, in the case of 194 small rural two-year colleges, the parameter estimate for DIVERSITY would not be significant, such a tentative conclusion was not universally supported by the findings of the present study. The parameter estimates for DIVERSITY proved to be significant ($p < .05$, or better) in two of the five models tested (equations 5.1 and 8.1) -- see Tables 7 and 8. The significance attributable to DIVERSITY was not expected, especially when considering the degree of collinearity between the dominant independent variable, FTE, and

DIVERSITY.[26]

In contrast, as hypothesized, the frequency in which the parameter estimate for DIVERSITY proved to be significant in the prediction of IEG for 194 small rural two-year colleges did exceed that of INDEXCOMP. As reported in Tables 7 and 8, of the five models defined by the present study, the parameter estimate for DIVERSITY was significant in both the linear and multiplicative models (equations 5.1 and 8.1). In contrast, the parameter estimate for INDEXCOMP was significant only once[27] --The trans-log model: equation (9.2). Similarly, as hypothesized, the R-squared statistic in all five models tested was higher for those with DIVERSITY as a co-predictor than those with INDEXCOMP--see Table 7.

Assuming that diverse educational programs have different costs associated with them, and that INDEXCOMP, being a weighted index, should be a better measure of

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[26] Stepwise (forward) regression was performed using equation (5.1). Of the total R-squared achieved of 70.9 percent, 67.2 percent of the variation in IEG was explained by a single variable, FTE. Moreover, within equation (5.1) among all possible combinations of the independent (and control) variables, the parameter estimates between FTE and DIVERSITY reflected the largest covariance and the largest collinearity (-.5935).

[27] The parameter estimate associated with the squared term of INDEXCOMP was also significant in the quadratic model (equations 6.2 and 6.2A). However, as an independent variable of the first power, INDEXCOMP's regression coefficient was significant in only one of 12 equations tested for 194 small rural two-year public colleges--see Tables 7 and 8.

comprehensiveness than its more simplistic rival, DIVERSITY, the inability of INDEXCOMP to outperform DIVERSITY as a co-predictor of IEG for 194 small rural two-year public colleges suggests that either educational programs offered by such colleges may be so similar that their associated costs also tend to be similar, not different, or that DIVERSITY gives more weight to programs with different costs (e.g., occupational/technical programs) than does INDEXCOMP. Hence, DIVERSITY outperformed INDEXCOMP as a co-predictor of IEG, thereby supporting the proposition that educational programs offered by 194 small rural two-year public colleges may be more similar than diverse and hence less comprehensive than their educational objective requires them to be. Such a conclusion is presented here simply as a possible, tentative explanation and has not been tested empirically in the present study. Future researchers may wish to pursue such a tentative explanation more adequately. As indicated earlier in Chapter III, INDEXCOMP as an alternate co-predictor of IEG will not be pursued with respect to the remaining nine data bases of the present study.

Curve Smoothing Techniques

Figure 5 is a two dimensional representation of the linear model, equation (5.1), and depicts the actual (IEG)

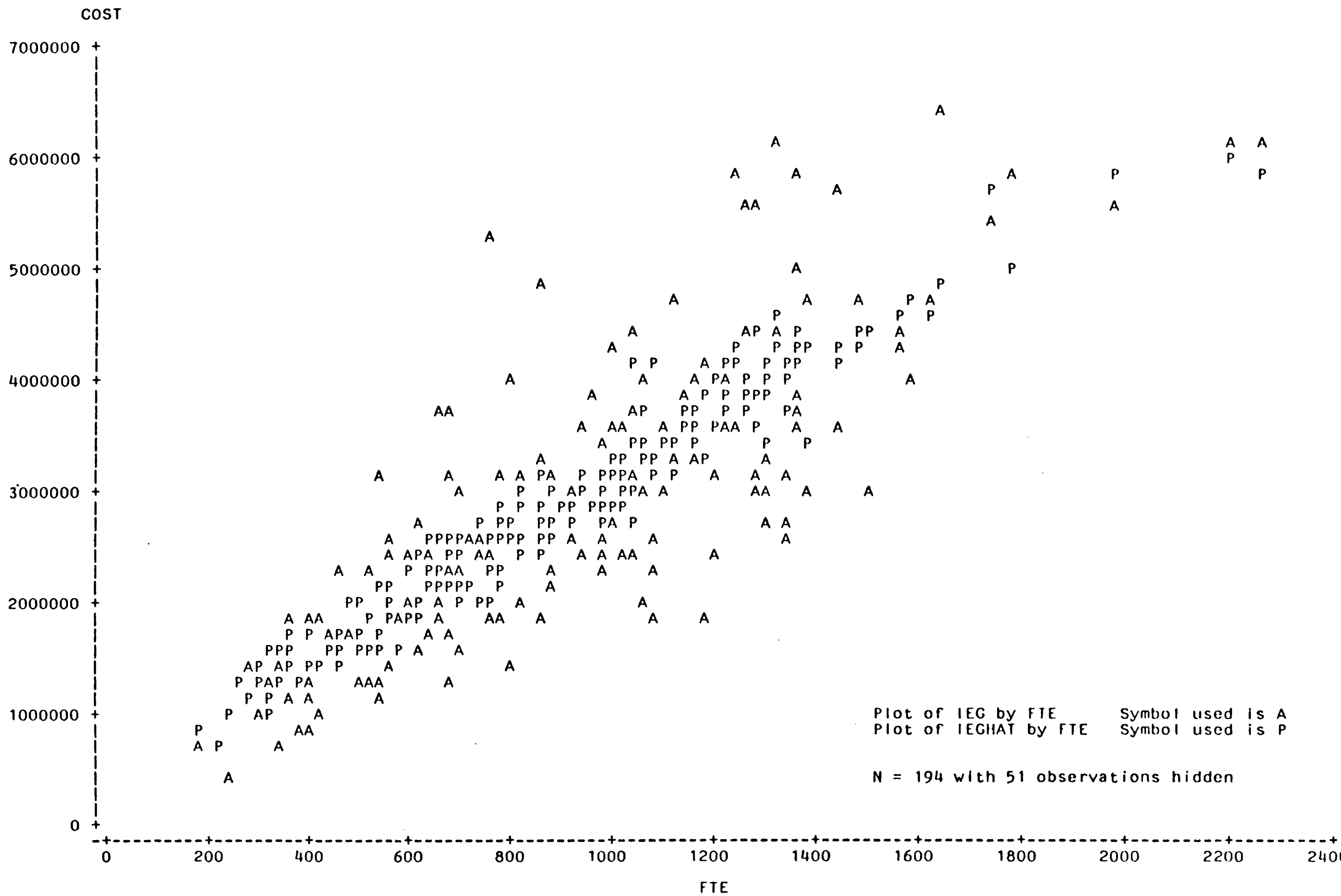

Figure 5. Actual (IEG) vs. predicted (IEGHAT) total cost: Equation (5.1) linear model for small rural 2-year public colleges.

versus predicted (IEGHAT) total cost in terms of FTE for 194 small rural two-year public colleges. An inspection of Figure 5 indicates that there are a few small rural community colleges (nine to be exact) at the high end of the FTE scale (1,700 to 2,500 FTE) whose FTE enrollment in 1980-81 was made up almost entirely of full-time students. For example, the school with the highest FTE enrollment (2,257) included in Figure 5 reported a total headcount enrollment of 2,447, consisting of 2,162 full-time and 285 part-time students. However, taken as a group, enrollments in 194 small rural colleges in 1980-81 were about equally distributed between full-time (130,595) and part-time (135,037) students.

The linearity of equation (5.1), although detectable in Figure 5, becomes even more predominant in Figure F-1 of Appendix F, which portrays predicted TC (IEGHAT) without the corresponding actual cost (IEG). For reasons previously cited in Chapter II, the TC function represented by the P-values in Figure 5 is not yet a continuous, smooth function.

Based on the curve smoothing techniques described in Chapter II, a continuous, smooth TC function was developed--see Figure 6 and supporting Figures F-1 through F-3 of Appendix F. The resulting continuous, smooth TC

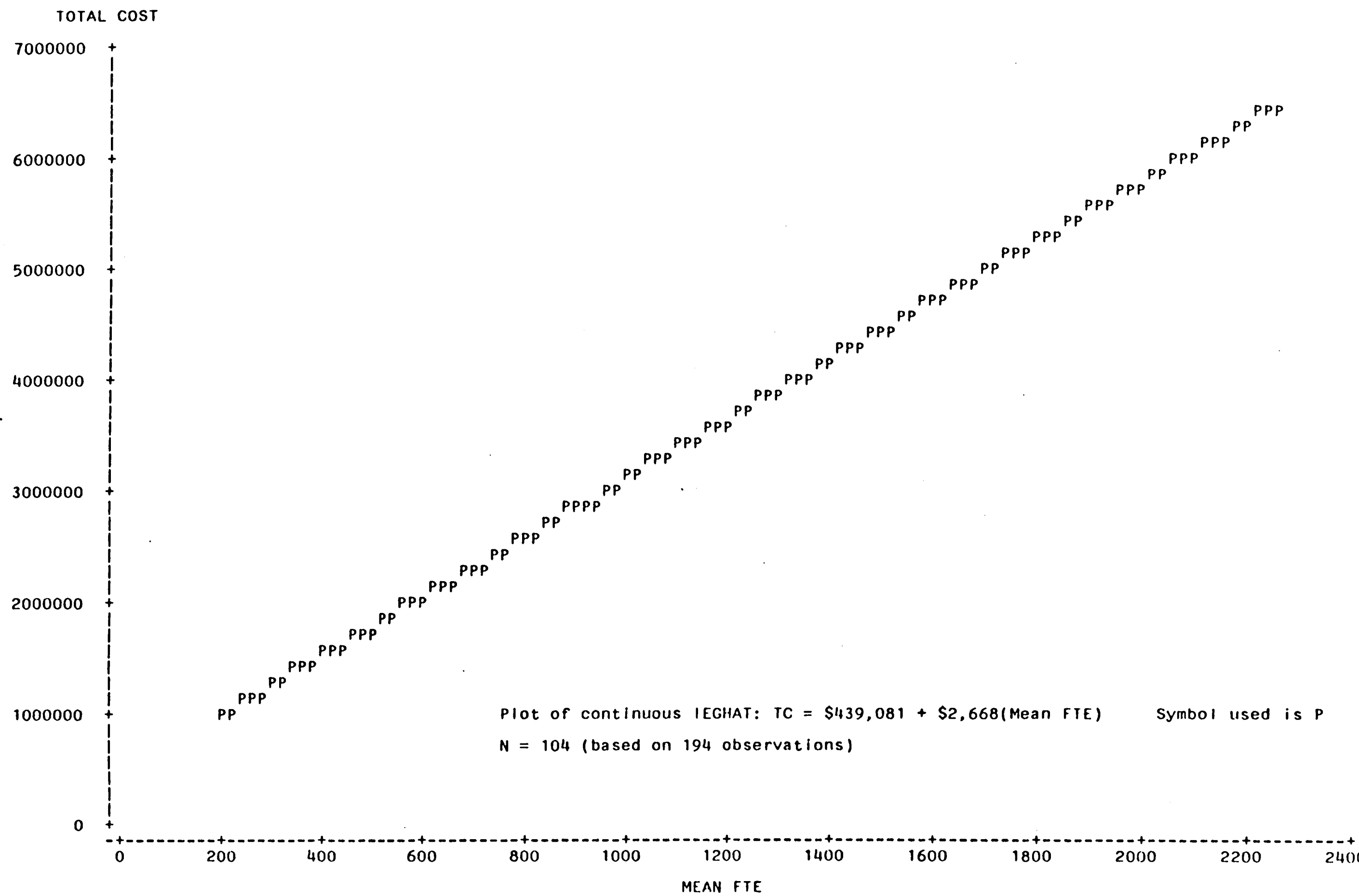

Figure 6. Continuous average predicted total cost: Equation (5.1.1) linear model for small rural 2-year public colleges.

function defined in terms of a single variable, FTE, and represented by equation (5.1.1),[28] is equivalent to the linear model equation (5.1), defined in terms of FTE, MARKET and DIVERSITY (after controlling for ADJAVSAL). In mathematical terms, both TC functions represent an identity, i.e., equation (5.1.1) is equivalent to equation (5.1), or:

$89494+$2250(FTE)+11662218(MARKET)+3274368(DIVERSITY)+8.62 (ADJAVSAL)

is equivalent to

$439081 + $2668(FTE).

Derivation of MC and AC Functions

Based on the continuous, smooth TC function represented by equation (5.1.1), the AC and MC functions for 194 small rural two-year colleges were derived as follows:

AC = TC/Mean FTE

MC = first derivative of TC = $2,668.

The reader should note that whereas MC could not be derived by taking the first partial derivative (with respect to FTE) of the multivariate TC function represented by equation (5.1), or $2,250, MC could be derived by taking the first derivative of the equivalent univariate TC function represented by equation (5.1.1). However, to substantiate that the first derivative of equation (5.1.1) or $2,668, was

[28] Average predicted TC = $439081 + 2667.538 (mean FTE). For a summary of the regression results, see Table 9.

Table 9: Summarized Regression Results of Curve Smoothing Techniques for Small Rural Two-Year Public Colleges (N = 194)

Model	Equation	Prob > |F|	Adjusted R-Squared[1]	Residual SS	Parameter Estimate	T for H0: Parameter = 0	Prob > |T|
LINEAR	5.1.1	.0001	.9803	2.40710E+12	Y-intercept: 439081	9.136	.0001
					Mean FTE: 2667.538	59.477	.0001

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) according to the following formula:

$$\text{Adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

in fact the true MC associated with that particular TC function, Hirshleifer's (1980) better approximation method, as previously described in Chapter II, was calculated for every unit change in mean FTE value over the domain of the TC function represented by equation 5.1.1. MC derived by this better approximation method was also $2,668. The resulting MC and AC functions derived from equation 5.1.1 were then plotted together so that they could be readily compared with one another -- see Figure 7.

Since the TC function represented by equation (5.1.1) is linear--see Figure 6--the MC function derived from it (Figure 7) must be (and is, in fact) consistent with the universal properties of all linear TC functions as previously outlined in Chapter II. Of special interest is the property that the MC of a linear TC function must be constant over the domain of the function. In the case of 194 small rural two-year public colleges, the estimated MC is an absolute constant value of $2,668 per FTE. A constant MC function means that AC will always be greater than MC, thereby assuring that economies of scale are achievable by small rural colleges over all enrollment levels. In contrast, the estimated AC function varies from a maximum of $4,978 per FTE at an enrollment level of 190 FTE to a minimum of $2,862 per FTE at an enrollment level of 2,257 FTE.

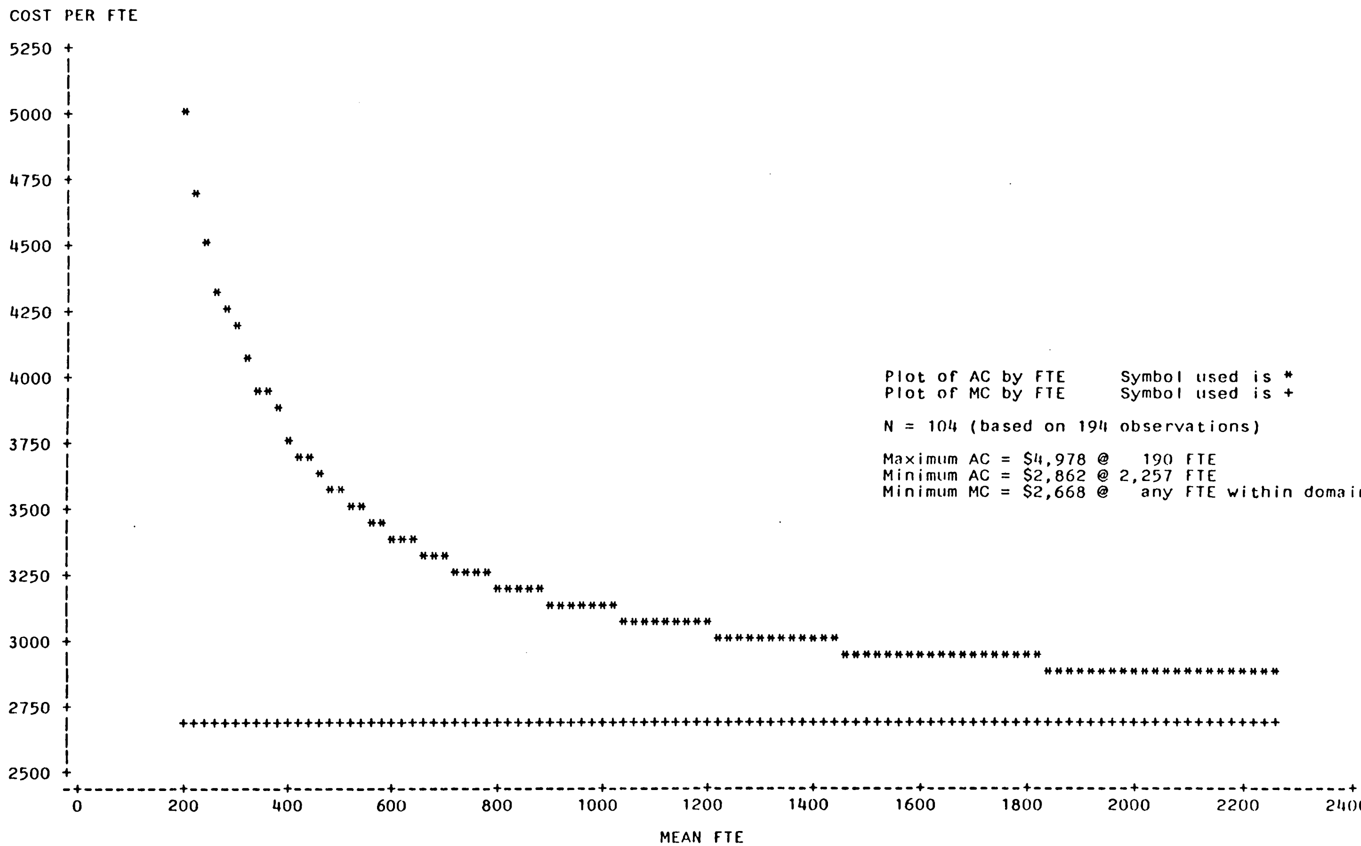

Figure 7. Average (AC) and marginal (MC) cost functions: Derived from equation (5.1.1) for small rural 2-year public colleges.

The derived functions presented in Figure 7 also satisfy those universal properties, as previously outlined in Chapter II, that must exist between AC and MC functions. For example, the AC function portrayed in Figure 7 is continually and relentlessly decreasing over the domain of the function. Such a behavioral pattern of AC requires, as previously outlined in Chapter II, that MC must always lie below AC. An inspection of Figure 7 confirms that this requirement has been satisfied in the case of 194 small rural two-year public colleges.

The estimated economies of scale achievable is represented by the difference between AC and MC. The reader should recall from Chapter I that economies of scale exist whenever AC > MC. Based on the excess of AC over MC demonstrated in Figure 7 at every enrollment level from 190 FTE to 2,257 FTE, the economies of scale achievable by 194 small rural two-year public colleges ranged from a high of $2,310 at 190 FTE to a low of $194 at 2,257 FTE. However, this range may be somewhat distorted by the fact that equation (5.1) failed to achieve the least RSS of six equations tested. Nevertheless, the resulting estimated achievable economies of scale are presented graphically in Figure 8.

To complete the cost analysis of 194 small rural two-year public colleges, the computed TC functions for each of

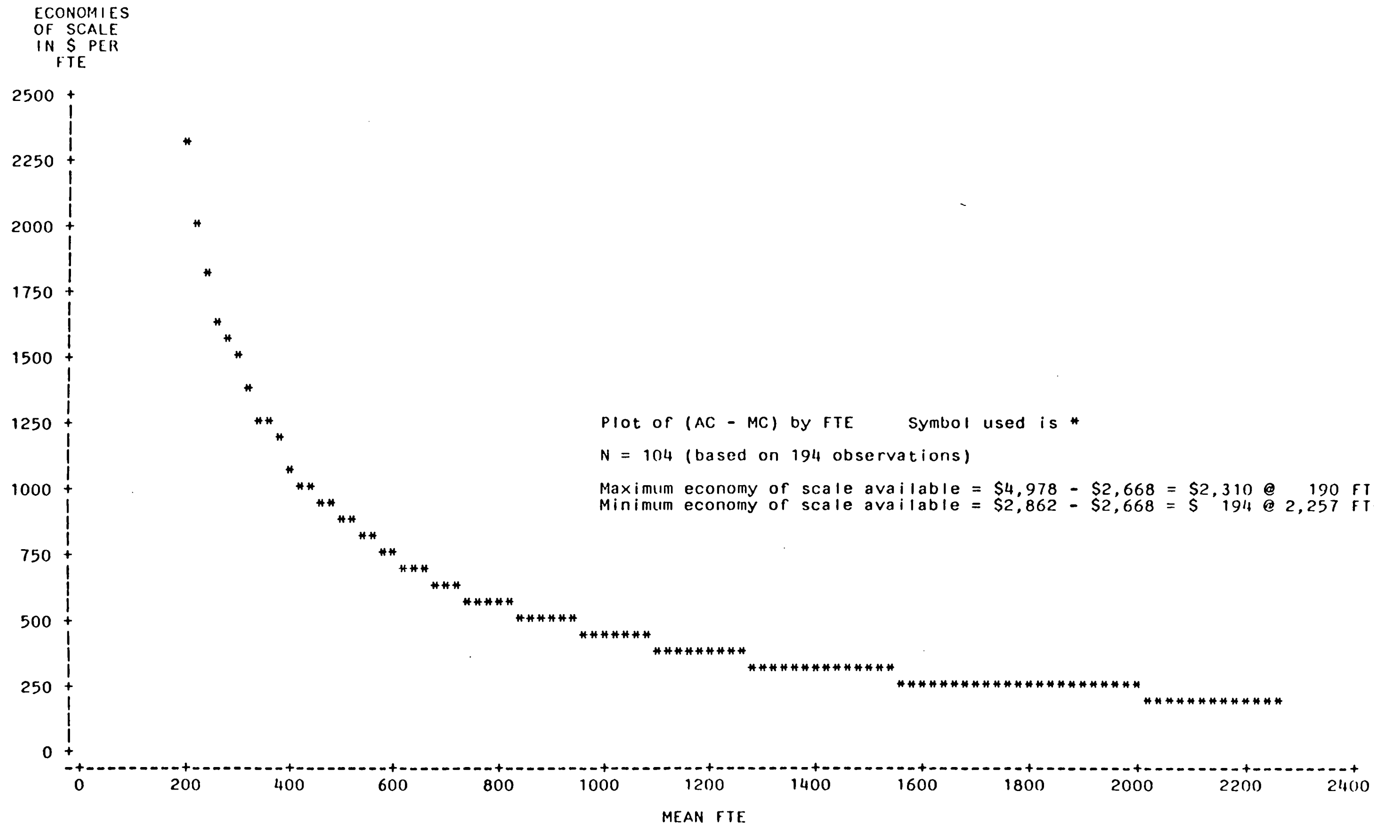

Figure 8. Economies of scale: Derived from equation (5.1.1) linear model for small rural 2-year public colleges.

the other models tested (equations 5.2 through 9.2) are presented graphically in Figures F-4 through F-18 of Appendix F. The linearity between these TC functions is strikingly consistent, even among the nonlinear models tested (equations 6.1 through 9.2). This consistency in the behavioral pattern of TC, with the possible exception of the exponential TC functions (equations 8.1 through 9.2), is evidence of the dominance of the linear terms, i.e., the first power terms of FTE, MARKET, and either DIVERSITY or INDEXCOMP, in each of the nonlinear models tested. Such linear consistency further substantiates why the linear model, as represented by equation (5.1), was in fact the best of all models tested in predicting TC for 194 small rural two-year public colleges.

51 Small Nonrural Colleges

Selecting the Best Model

In terms of the first criterion--the highest R-squared statistic--the quadratic model with interactive terms (equation 6.1) was the best model in predicting TC for 51 small nonrural two-year public colleges (R-squared = .6140). The next closest model was the cubic model (R-squared = .5980). Interestingly enough, the linear model (equation 5.1), which was the best model in predicting TC for 194 small rural colleges, finished last (R-squared = .4265) in terms of R-squared for 51 small nonrural two-year public colleges. While a nonlinear TC function for a comprehensive two-year public college is indicative of different costs associated with different curricular offerings, a linear TC function indicates constant costs associated with increasing or decreasing curricular offerings. Accordingly, small nonrural colleges (represented by a nonlinear TC function), as enrollment changes, appear to add or delete curricula that have different costs, whereas small rural colleges (represented by a linear TC function), as enrollment changes, appear to add or delete curricula having the same costs.

In terms of the second criterion, the least residual sum of squares (RSS), the quadratic model with interactive terms--equation (6.1)--also had the least RSS value of the six equations tested (RSS = 2.41532E+13). The cubic model--equation (7.1)--was the next best model tested in terms of this criterion (RSS = 2.51526E+13). The worst showing in terms of the RSS statistic was the linear model--equation (5.1): RSS = 4.12692E+13.

Finally, in terms of the third and last criterion--the least standard error of the estimate (SEE)--the model with the lowest SEE was also the quadratic model with interactive terms--equation (6.1)--as this was the only model tested which demonstrated significant parameter estimates (regression coefficients) involving all three of the independent variables--FTE, DIVERSITY, and the interactive term, MARKET By DIVERSITY ($p < .05$, or better).

The parameter estimate for FTE, which was significant ($p < .05$, or better) for each of the six equations tested with respect to 194 small rural colleges (Table 7), did not fare nearly so well with respect to the 51 small nonrural colleges. Four of the six equations tested did not reflect significant parameter estimates for FTE, including the cubic model--equation (7.1)--which, overall, was the second best model in predicting TC for 51 small nonrural colleges.

To summarize, the quadratic model with interactive terms, (equation 6.1), based on the three criteria selected for evaluation--R-squared, RSS, and SEE--was the best model in predicting TC for 51 small nonrural two-year public colleges. Equation (6.1) had the largest R-squared statistic (.6140), which was interpreted as follows: After controlling for ADJAVSAL, 61.40 percent of the variation in the dependent variable (TC) could be explained by 100 percent of the variation in the three independent variables (FTE, MARKET, and DIVERSITY) and in the three interactive terms (FTE by MARKET, FTE by DIVERSITY, and MARKET by DIVERSITY). Moreover, the parameter estimates for three of these six terms (FTE, MARKET, and MARKET by DIVERSITY) were statistically significant ($p < .05$, or better) which was interpreted as follows--the difference between the calculated parameter estimate (3735.368 for FTE, 21854628 for DIVERSITY and -669099324 for MARKET by DIVERSITY) and zero was too large to have been due solely to chance. As previously substantiated in Chapter III, significant parameter estimates are indicative of minimal standard errors of the estimate (SEE). In addition, equation (6.1) reflected the least RSS. Finally, in predicting TC, equation (6.1) was itself statistically significant ($p < .0001$), which was interpreted as follows: After controlling for ADJAVSAL, the relationship between the three independent variables (FTE, MARKET, and DIVERSITY) including their interactions, and the dependent variable (IEG) was too large (R = square root of .6140) to have been due solely to chance.

Table 10 presents the summarized regression results of all equations by model for 51 small nonrural colleges and Table 11 presents the estimated parameter values (regression coefficients) for every term of each equation within the five models defined by the present study.

Table 10: Summarized Regression Results of Predicting TC For Small Nonrural Two-Year Public Colleges (N = 51)

Model	Equation	Alternate Variable	Prob > |F|	Adjusted R-Squared[1]	Residual SS	Parameters Having Significant (@.05) Prob > |T|
LINEAR	(5.1)	DIVERSITY	.0001	.4265	4.12692E+13	FTE
QUADRATIC	(6.1)	DIVERSITY (with interactive terms)	.0001	.6140	2.41532E+13	FTE, DIVERSITY, MARKET BY DIVERSITY
	(6.1A)	DIVERSITY (without interactive terms)	.0001	.5429	3.07484E+13	FTE, DIVERSITY, $DIVERSITY^2$, ADJAVSAL
CUBIC	(7.1)	DIVERSITY	.0001	.5980	2.51526E+13	MARKET, $DIVERSITY^3$, ADJAVSAL
MULTIPLICATIVE[2]	(8.1)	DIVERSITY	.0001	.4803	3.73963E+13	FTE, DIVERSITY, ADJAVSAL
TRANS-LOG[2]	(9.1)	DIVERSITY	.0001	.5107	3.29101E+13	MARKET

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) included in each equation (5.1-9.1) according to the following formula:

$$\text{adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

[2] Results shown for exponential models are those of predicting the natural log of IEG.

Table 11: Estimated Parameter Values By Equation For Small Nonrural Two-Year Public Colleges (N = 51)

Model Equation	Linear (5.1)	Quadratic (6.1)	Quadratic (6.1A)	Cubic (7.1)	Multiplicative (8.1)	Translog (9.1)
Y-intercept	$ 930653*	$ -1763997	$ -27048.075	$ 2038756	$ -5473684*	$ -5219476
FTE	1839.686*	3735.368*	2787.917*	2136.186		1013.471
MARKET	-10530900	6651214	-107464582	-300921597*		77828447*
DIVERSITY	3140059	21854628*	19041234*	-13102214		-2493823
ADJAVSAL	68.221882	59.664970	88.218533*	81.911587*	96.54020*	64.843265
FTE^2		-0.612999	-0.599946	0.540553		
MARKET^2		2859717165	3010676953	17609055035		
DIVERSITY^2		-4674105	-40083645*	143451097		
FTE^3				-0.000373772		
MARKET^3				-2.98243E+11		
DIVERSITY^3				-307905889*		
FTE BY MARKET		861.467				
FTE BY DIVERSITY		-4384.272				
MARKET BY DIVERSITY		-669099324*				
LN FTE					1294435*	534389
LN MARKET					-224287	-1033552*
LN DIVERSITY					591877*	832927

*Significant at the .05 level, or better

Curve Smoothing Techniques

Figure 9 is a two dimensional representation of the quadratic model, equation (6.1), and depicts the actual (IEG) versus predicted (IEGHAT), total cost in terms of FTE for 51 small nonrural two-year public colleges. For reasons previously cited in Chapter II, the TC function represented by the P-values in Figure 9 is not yet a continuous, smooth function.

Based on the curve smoothing techniques described in Chapter II, a continuous smooth TC function was developed--see Figure 10 and supporting figures F-19 through F-21 of Appendix F. The resulting continuous, smooth TC function, defined in terms of a single variable, FTE, and represented by equation (6.1.1),[29] is equivalent to the quadratic model equation (6.1), defined in terms of FTE, MARKET, DIVERSITY--including interactive terms--after controlling for ADJAVSAL. In mathematical terms, both TC functions represent an identity. Equation (6.1.1) is identically equivalent to equation (6.1) or:

$$\$-1763997+3735(FTE)-6651214(MARKET)+21854628(DIVERSITY)$$
$$-0.612999(FTE)^2+2859717165(MARKET)^2-4674105(DIVERSITY)^2$$
$$+861.467(FTE)(MARKET)-4384.272(FTE)(DIVERSITY)-669099324$$
$$(MARKET)(DIVERSITY)+59.664970(ADJAVSAL)$$

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[29] Average predicted TC = \$336630+3398.0131(mean FTE)-1.0257(mean FTE).^{2} For a summary of the regression results, see Table 12.

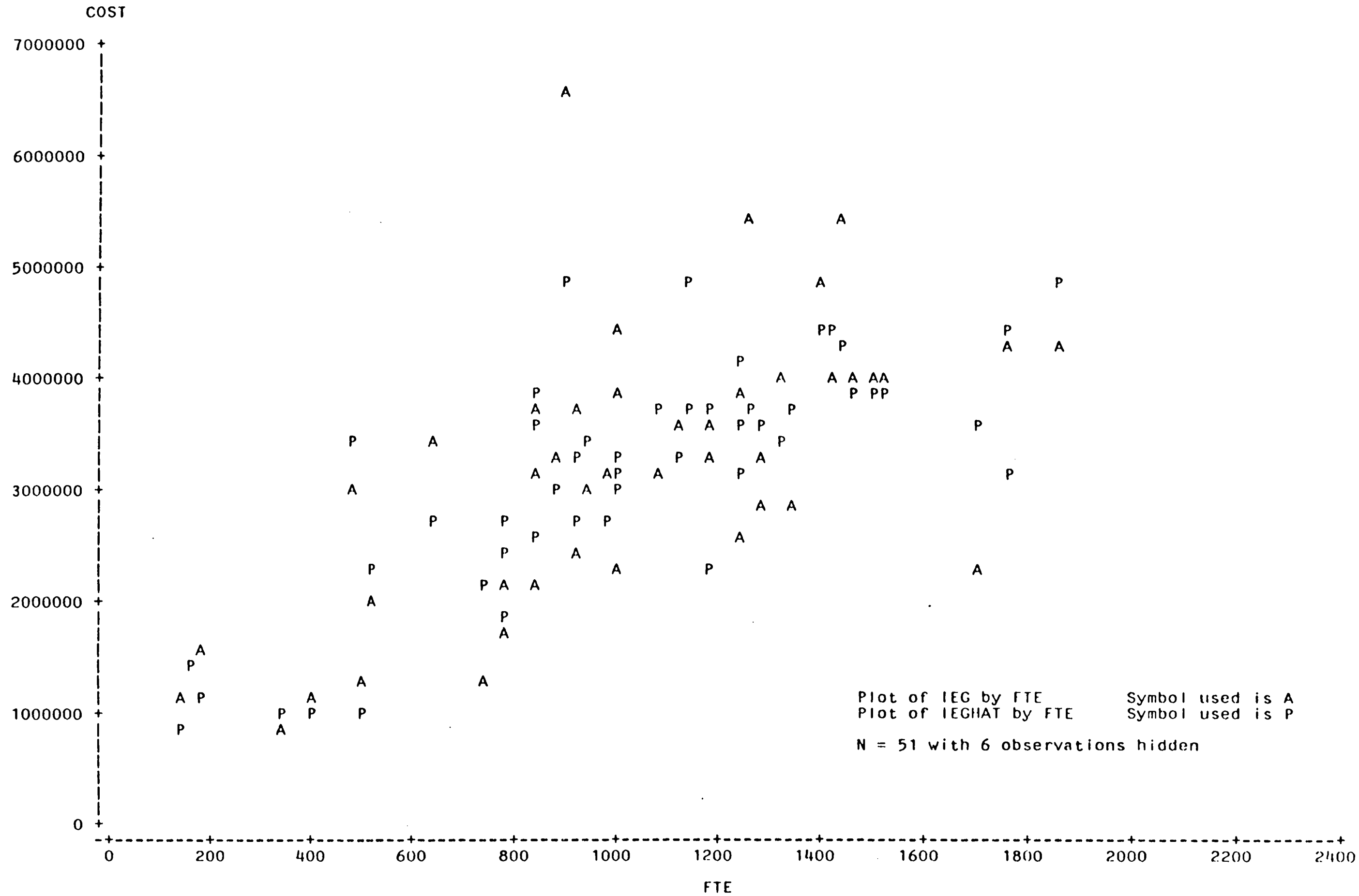

Figure 9. Actual (IEG) vs. predicted (IEGHAT) TC: Equation (6.1) quadratic model for small nonrural 2-year public colleges.

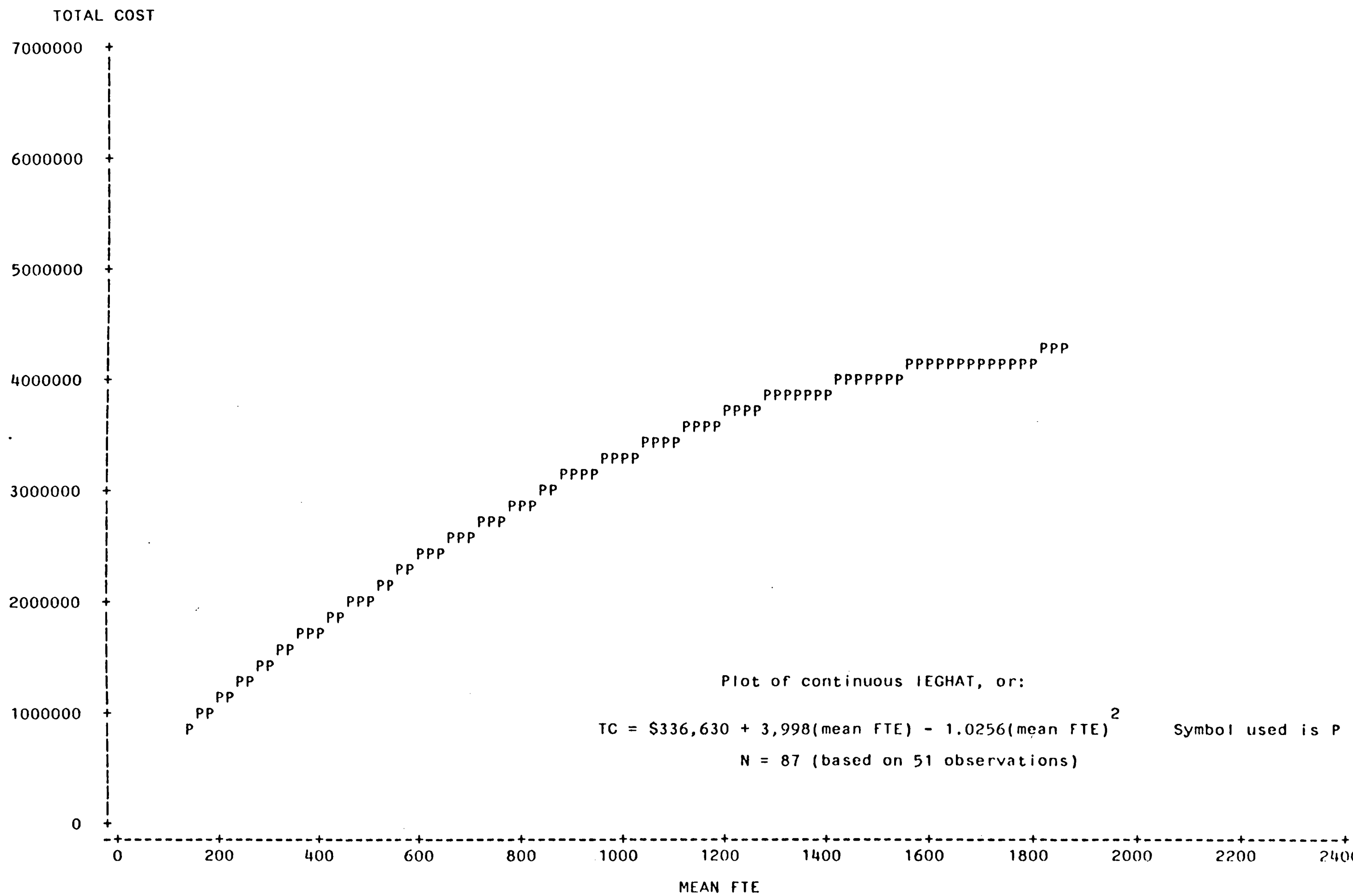

Figure 10. Continuous average predicted total cost: Equation (6.1.1) quadratic model for small nonrural 2-year public colleges.

Table 12: Summarized Regression Results of Curve Smoothing Techniques for Small Nonrural Two-Year Public Colleges (N = 51)

Model	Equation	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameter Estimate		T for H0: Parameter = 0	Prob > |T|
QUADRATIC	6.1.1	.0001	.7219	1.17984E+13	Y-intercept:	336630	.86	.3978
					Mean FTE:	3998.0131	4.58	.0001
					$(\text{Mean FTE})^2$:	-1.0256	-2.32	.0267

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) according to the following formula:

$$\text{Adjusted } R^2 = R^2 -(1-R^2)k/N-k-1)$$

is equivalent to $\$336630+3998(FTE)-1.0256(FTE)^2$.

Derivation of MC and AC Functions

Based on the continuous, smooth TC function represented by equation (6.1.1), the AC function for 52 small nonrural two-year colleges was derived as follows:

$$AC = TC/\text{Mean FTE}$$

Because equation (6.1.1) is a multivariate TC function, the first derivative of such an equation with respect to FTE would only be a partial derivative and, therefore, would not yield a valid MC function for the reasons previously cited in Chapter II. Accordingly, the applicable MC function was derived by using Hirshleifer's (1980) better approximation method, also previously described in Chapter II. The resulting MC and AC functions derived from equation (6.1.1) were then plotted together so that they could be readily compared with one another--see Figure 11.

Since the TC function represented by equation (6.1.1) is quadratic--see Figure 10--the MC function derived from it (Figure 11) must be (and is, in fact) consistent with the universal properties of all quadratic TC functions as previously outlined in Chapter II. Of special interest is the property that the MC of a quadratic TC function, unlike that of a linear TC function, cannot be constant over the domain of the function. MC derived from a quadratic TC

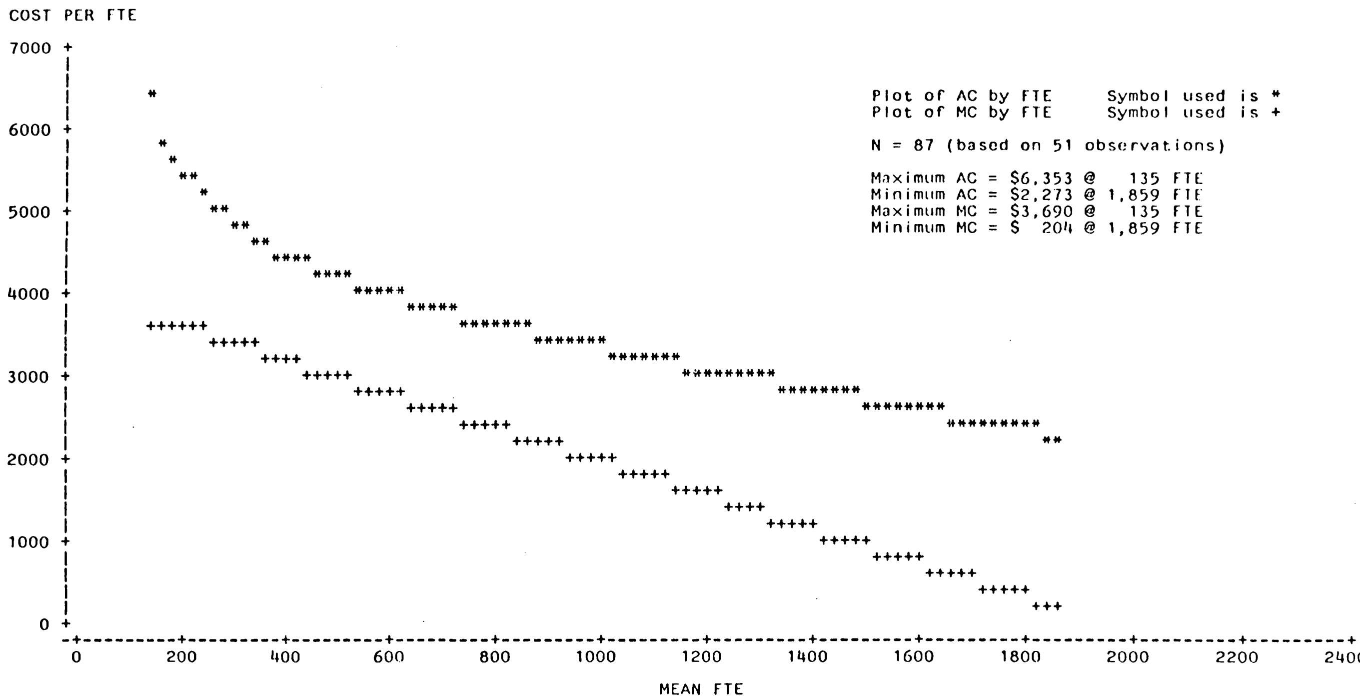

Figure 11. Average (AC) and marginal (MC) cost functions: Derived from equation (6.1.1) for small nonrural 2-yr public colleges.

function must be curvilinear, rather than linear. Similarly, unlike that of a linear TC function, the quadratic function may have two roots. There may be two values of FTE which satisfy the condition, IEG = f (FTE, FTE^2) = zero. Hence, unlike a linear TC function, a quadratic TC function may change direction twice within the same quadrant.

An inspection of Figures 10 and 11 indicates that equation (6.1.1) is consistent with these universal properties of quadratic TC functions. Although the domain of equation (6.1.1)--(from 135 to 1,859 FTE)--serves as a restriction on its own quadratic characteristics, one-half of its inherent parabolic structure is quite evident. Moreover, the MC function derived from equation (6.1.1) is nonconstant, ranging from $3,690 per FTE at an enrollment level of 135 FTE to only $204 per FTE at 1,859 FTE--see Figure 11.

The derived functions presented in Figure 11 also satisfy those universal properties, as previously outlined in Chapter II, that must exist between AC and MC functions. For example, the AC function portrayed in Figure 11 relentlessly declining over the domain of the function. Such a behavioral pattern of AC requires, as previously outlined in Chapter II, that MC must always lie below AC. An inspection of Figure 11 confirms that this requirement has been satisfied in the case of 51 small nonrural two-year public colleges.

Based on the excess of AC over MC at every enrollment level from 135 FTE to 1,859 FTE, the estimated economies of scale achievable by 51 small nonrural two-year public colleges ranged from a high of $2,663 at 135 FTE to a low of $1,166 at 649 FTE, and then increasing again to $2,069 at 1,859 FTE--see Figure 12.

245 Total Small Colleges

Selecting the Best Model

The linearity of equation (5.1) for 194 small rural two-year public colleges combined with the curvilinearity of equation (6.1) for 51 small, but not rural, two-year public colleges to make equation (7.1)--the cubic model--as the best model in predicting total cost for 245 total small two-year public colleges. Not only did equation (7.1) demonstrate the highest R-squared statistic (.6694) of the six equations tested, but it also reflected the least RSS and lowest SEE, as five of its nine parameters were statistically significant ($p < .05$), including one quadratic term (DIVERSITY) and one cubic term (DIVERSITY). Not surprisingly, the quadratic equation (6.1A) and the linear equation (5.1) were the next best models in predicting TC for 245 total small two-year public colleges. Also

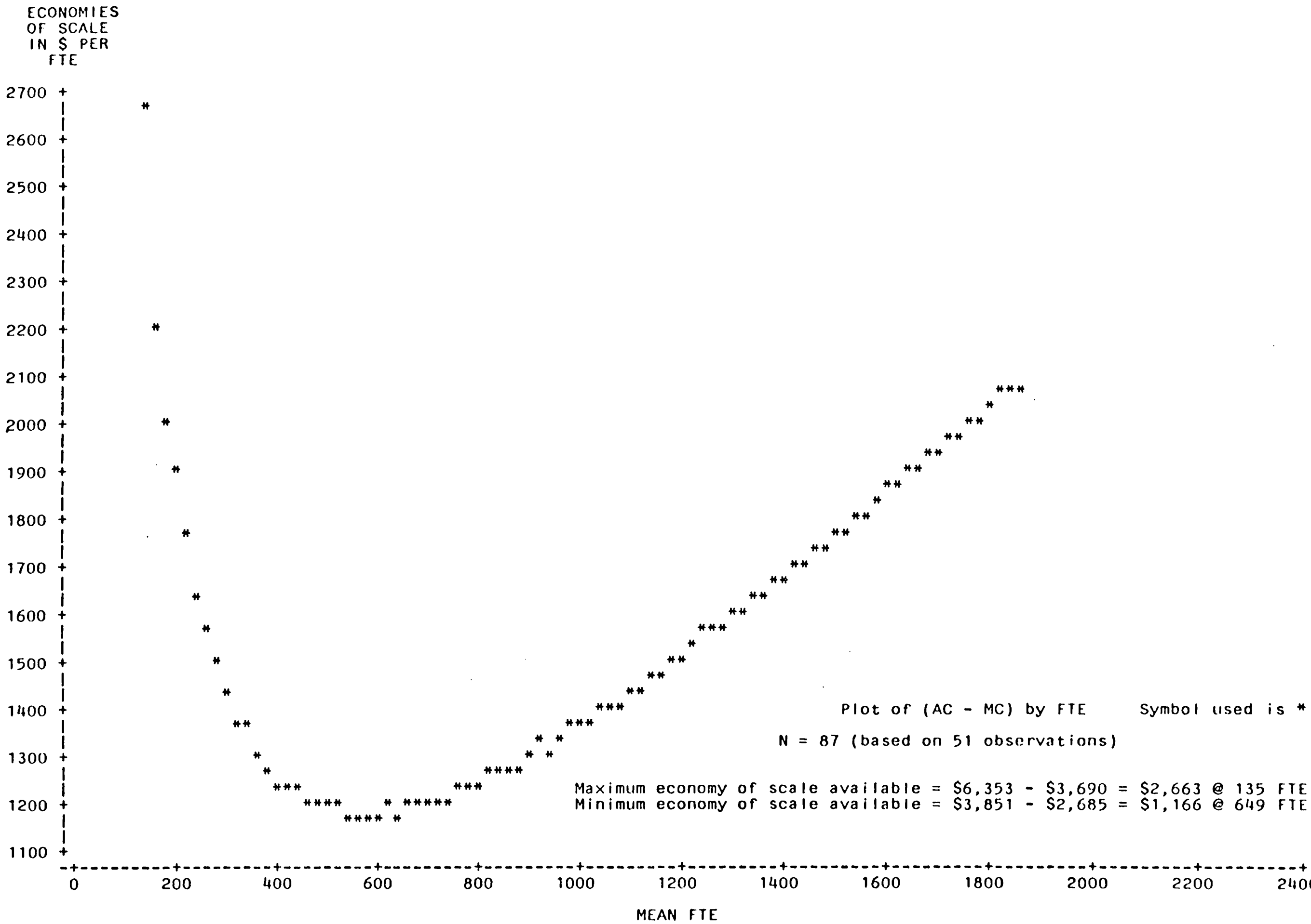

Figure 12. Economies of scale: Derived from equation (6.1.1) quadratic model for small nonrural 2-year public colleges.

consistent with earlier findings, the worst model in predicting TC for this institutional type was the multiplicative model--equation (8.2).

The superiority of the cubic model in predicting TC for 245 total small two-year public colleges was interpreted as follows:

(1) R-squared = .6694: After controlling for ADJAVSAL, 66.94 percent of the variation in the dependent variable (TC) could be explained by 100 percent of the variation in the three independent variables (FTE, MARKET, and DIVERSITY) acting together as a linear combination of their linear (first power), quadratic (second power) and cubic (third power) terms, i.e., equation (7.1).

(2) RSS - by posting the least RSS, equation (7.1) achieved what no other equation tested had achieved--the sum of the squared differences between the actual and predicted values for TC over the domain of equation i.e., 135 FTE to 2,257 FTE, was the least of any of the six equations tested--see Table 13.

(3) SEE: In posting the highest R-squared statistic and the least RSS statistic, the parameter estimates (i.e., regression coefficients) for FTE, DIVERSITY, $DIVERSITY^2$, $DIVERSITY^3$ and ADJAVSAL

Table 13: Summarized Regression Results of Predicting TC For Total Small Two-Year Public Colleges (N = 245)

Model	Equation	Alternate Variable	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameters Having Significant (@.05) PROB > |T|
LINEAR	(5.1)	DIVERSITY	.0001	.6465	1.36190E+14	FTE, MARKET, DIVERSITY, ADJAVSAL
QUADRATIC	(6.1)	DIVERSITY (with inter-active terms)	.0001	.6498	1.31531E+14	FTE, DIVERSITY, ADJAVSAL
	(6.1A)	DIVERSITY (without interactive terms)	.0001	.6523	1.32270E+14	FTE, DIVERSITY, DIVERSITY^2, ADJAVSAL
CUBIC	(7.1)	DIVERSITY	.0001	.6694	1.24153E+14	FTE, DIVERSITY, DIVERSITY^2, DIVERSITY^3, ADJAVSAL
MULTIPLICATIVE[2]	(8.1)	DIVERSITY	.0001	.6167	1.50110E+14	FTE, DIVERSITY, ADJAVSAL
TRANS-LOG[2]	(9.1)	DIVERSITY	.0001	.6501	1.33089E+14	FTE, MARKET, ADJAVSAL

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) included in each equation (5.1-9.1) according to the following formula:

$$\text{adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

[2] Results shown for exponential models are those of predicting the natural log of IEG.

were statistically significant ($p < .05$, or better), i.e., the difference between the calculated parameter estimates for each of these variables and zero was too large to have been due solely to chance. As substantiated earlier in Chapter III, significant parameter estimates are indicative of minimal standard errors of the estimate (SEE).

(4) In predicting TC, equation (7.1) was itself statistically significant ($p < .0001$), i.e., after controlling for ADJAVSAL, the relationship between the three independent variables (FTE, MARKET and DIVERSITY), expressed in their linear (first power), quadratic (second power) and cubic (third power) terms, and the dependent variable (IEG) was too large (R = square root of .6694) to have been due solely to chance.

Table 13 presents the summarized regression results of all equations by model for 245 total small two-year public colleges, and Table 14 presents the estimated parameter values (regression coefficients) for every term of each equation within the five models defined by the present study.

Table 14: Estimated Parameter Values By Equation For Total Small Two-Year Public Colleges (N = 245)

Model EQUATION	Linear (5.1)	Quadratic (6.1)	Quadratic (6.1A)	Cubic (7.1)	Multiplicative (8.1)	Translog (9.1)
Y-intercept	$ 267323	$ -289535	$ -148827	$ 802276	$ -6873995	$ -2107747
FTE	2157.096*	2484.901*	2417.382*	3650.920*		1824.703*
MARKET	9443775*	5918518	-1771482	-15777385		23230311*
DIVERSITY	3015962*	9343502*	9031019*	-17914471*		1419379
ADJAVSAL	31.424325*	37.082922	38.082922	31.763601*	49.708113	35.333323*
FTE^2		-0.089784	-0.127929	-1.396562		
MARKET^2		2070233969	181824525	-804755907		
DIVERSITY^2		-13273829	-17739860*	146033423*		
FTE^3				0.0003827		
MARKET^3				-6397013804		
DIVERSITY^3				-2090555338*		
FTE BY MARKET		-2086.128				
FTE BY DIVERSITY		-597.230				
MARKET BY DIVERSITY		-64196475				
LN FTE					1645605	285484
LN MARKET					87215.828	-292871
LN DIVERSITY					461529	240282

*Significant at the .05 level, or better

Curve Smoothing Techniques

Figure 13 is a two dimensional representation of the cubic model, equation (7.1), and depicts the actual (IEG) versus predicted (IEGHAT), total cost in terms of FTE for 245 total small two-year public colleges. For reasons previously cited in Chapter II, the TC function represented by the P-values in Figure 13 is not yet a continuous, smooth function.

Based on the curve smoothing techniques described in Chapter II, a continuous smooth TC function was developed--see Figure 14 and supporting Figures F-22 through F-24 of Appendix F. The resulting continuous, smooth TC function, defined in terms of a single variable, FTE, and represented by equation (7.1.1)[30] is equivalent to the cubic model equation (7.1), defined in terms of FTE, MARKET, DIVERSITY--including first, second and third power terms--after controlling for ADJAVSAL. In mathematical terms, both TC functions represent an identity, (i.e., equation (7.1.1) is identically equivalent to equation (7.1) or:

$$\$802276+3650(FTE)-15777385(MARKET)-17914474(DIVERSITY)$$
$$-1.396562(FTE)^2+804755907(MARKET)^2+146033423(DIVERSITY)^2$$
$$+0.0003827(FTE)^3-63970138049(MARKET)^3-290555338(DIVERSITY)^3$$

---

[30] Average predicted TC = 802276+3141.2625(mean FTE)-1.02070271(mean FTE)^2+0.00028438(mean FTE)^3. For a summary of the regression results, see Table 15.

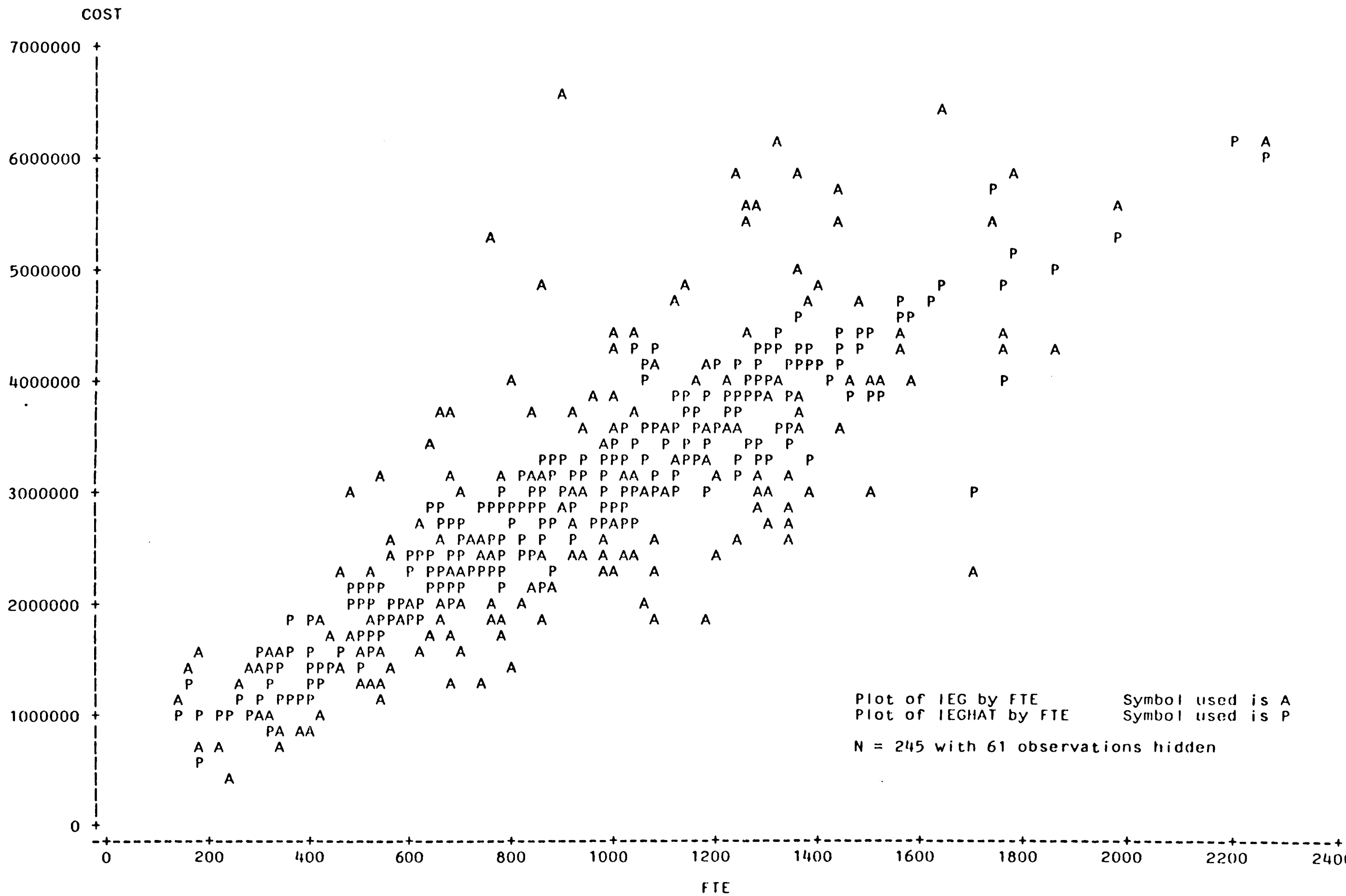

Figure 13. Actual (IEG) vs. predicted (IEGHAT) total cost: Equation (7.1) cubic model for total small 2-year public colleges.

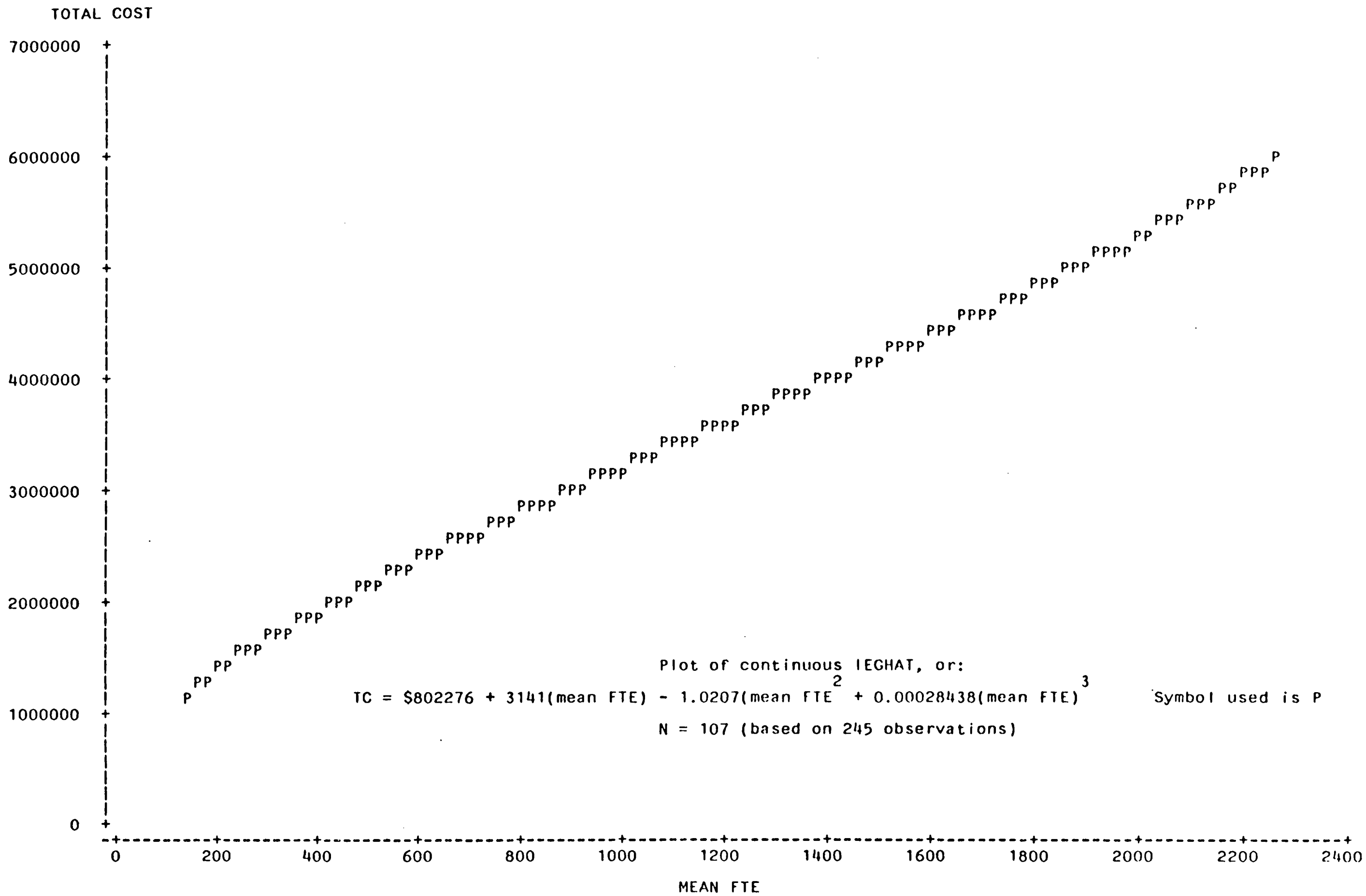

Figure 14. Continuous average predicted total cost: Equation (7.1.1) cubic model for total small 2-year public colleges.

Table 15: Summarized Regression Results of Curve Smoothing Techniques for Total Small Two-Year Public Colleges (N = 245)

Model	Equation	Prob > |F|	Adjusted R-Squared[1]	Residual SS	Parameter Estimate	
CUBIC	7.1.1	.0001	.9870	1.09593E+13	Y-intercept:	802276
					Mean FTE:	3141.2625
					$(\text{Mean FTE})^2$:	-1.02070271
					$(\text{Mean FTE})^3$:	0.00028438

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) according to the following formula:

$$\text{Adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

$+31.763601(\text{ADJAVSAL})$

is equivalent to $\$802276+3141.2625(\text{FTE})-1.02070271(\text{FTE})^2$
$+0.00028438(\text{FTE})^3$

Derivation of MC and AC Functions

Based on the continuous, smooth TC function represented by equation (7.1.1), the AC function for 245 total small two-year colleges was derived as follows:

$$AC = TC/\text{Mean FTE}$$

Because equation (7.1.1) is a multivariate TC function, the first derivative of such an equation, with respect to FTE, would only be a partial derivative and, therefore, would not yield a valid MC function for the reasons previously reviewed in Chapter II. Accordingly, the applicable MC function was derived by using Hirshleifer's (1980) better approximation method, also previously described in Chapter II. The resulting MC and AC functions, derived from equation (7.1.1), were then plotted together so that they could be readily compared with one another--see Figure 15.

Since the TC function represented by equation (7.1.1) is cubic--see Figure 14--the MC function derived from it (Figure 15) must be (and is, in fact) consistent with the universal properties of all cubic TC functions as previously outlined in Chapter II. Of special interest is the property

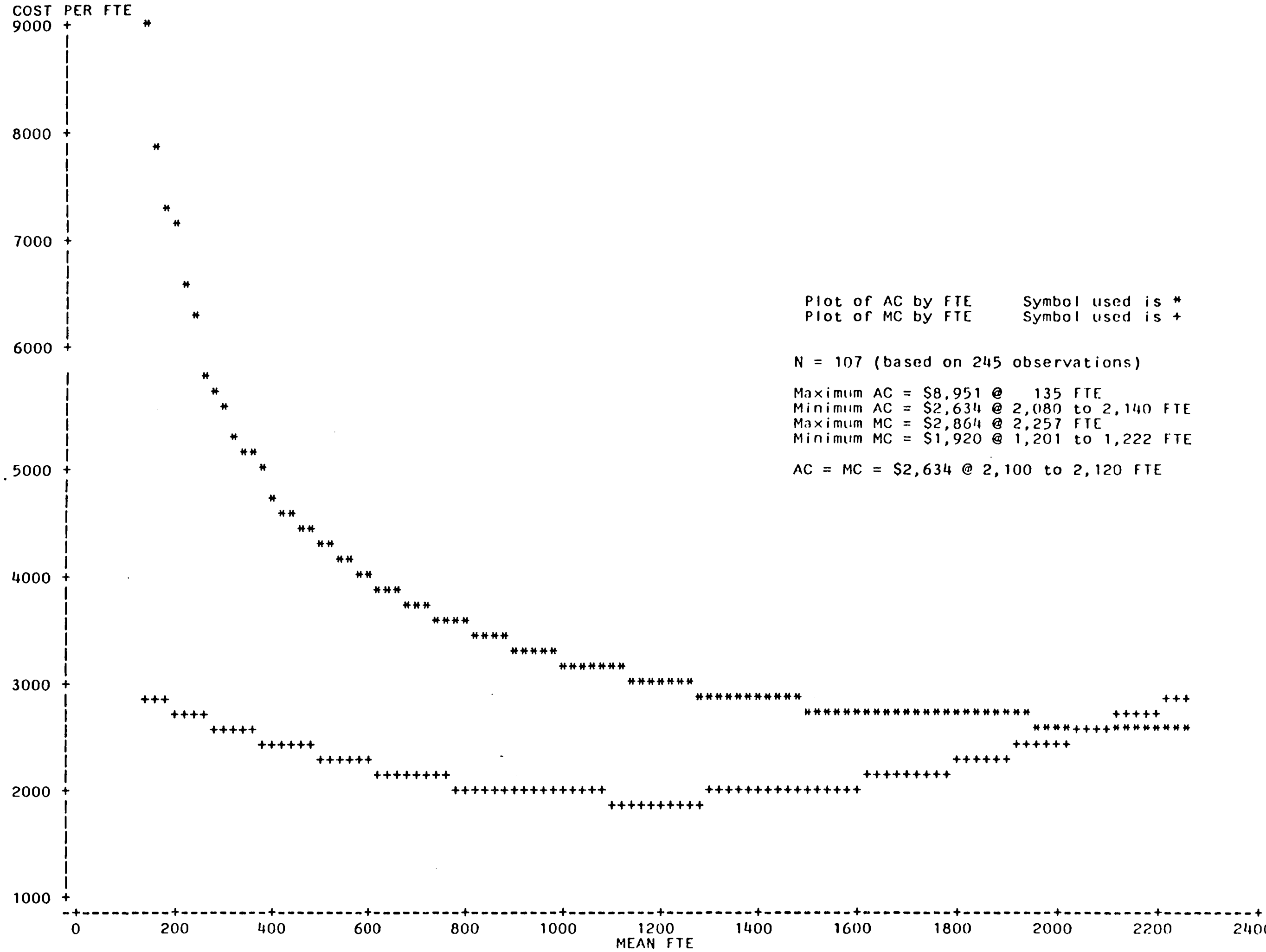

Figure 15. Average (AC) and marginal (MC) cost functions: Derived from equation (7.1.1) for total small 2-year public colleges.

that the MC of a cubic TC function, unlike that of a linear TC function, cannot be constant over the domain of the function. MC derived from a cubic TC function must be curvilinear, rather than linear. Similarly, unlike that of a linear TC function, the cubic function may have three roots. In other words, there may be three values of FTE which satisfy the condition, IEG = f (FTE, FTE^2, FTE^3) = zero. Hence, unlike a linear TC function, a cubic TC function may change direction three times within the same quadrant.

An inspection of Figures 14 and 15 indicates that equation (7.1.1) is consistent with these universal properties of cubic TC functions. For example, while the overall appearance of the plot of equation (7.1.1) is linear, a closer inspection of Figure 14 confirms the fact that this equation is curvilinear. The curvilinearity of the slope of equation (7.1.1) becomes even more apparent in its associated MC function (Figure 15), which is nonconstant, ranging from $2,854 at 135 FTE to a minimum of $1,920 between 1,201 and 1,222 FTE and to a maximum of $2,860 at 2,257 FTE. Consistent with all cubic functions, the MC function lies below AC over a large portion of the domain of its related TC function, indicating that economies of scale are achievable over this range. As with all cubic functions, equation (7.1.1) reflects these economies up to a certain point (AC = MC = $2,634 at 2,100 to 2,120 FTE). It is precisely at this point (between 2,100 and 2,120 FTE) when MC becomes greater than AC, in which case diseconomies of scale begin to set in. In other words, based on an analysis of 245 total small two-year public colleges, economies of scale are achievable up to enrollment levels of between 2,100 and 2,120 FTE--see Figure 16. Thereafter, the data indicates that any future growth in operations that a small two-year public college might contemplate can be achieved only at the expense of increasing the average cost of educating all students through that prospective higher enrollment level.

68 Small Technical Colleges

Selecting the Best Model

Of the six equations tested across the five models defined by the present study, the cubic model--equation (7.1)--demonstrated the highest R-squared statistic (.5900) and the least RSS (6.38020E+13) in predicting TC for 68 small technical colleges. However, none of the three parameter estimates (regression coefficients) were statistically significant ($p < .05$)--see Table 16. The worst model in predicting TC for this institutional type was the multiplicative model--equation (8.1)--R-squared = .5421.

The superiority of the cubic model in predicting TC for 68 small technical two-year public colleges was interpreted as follows:

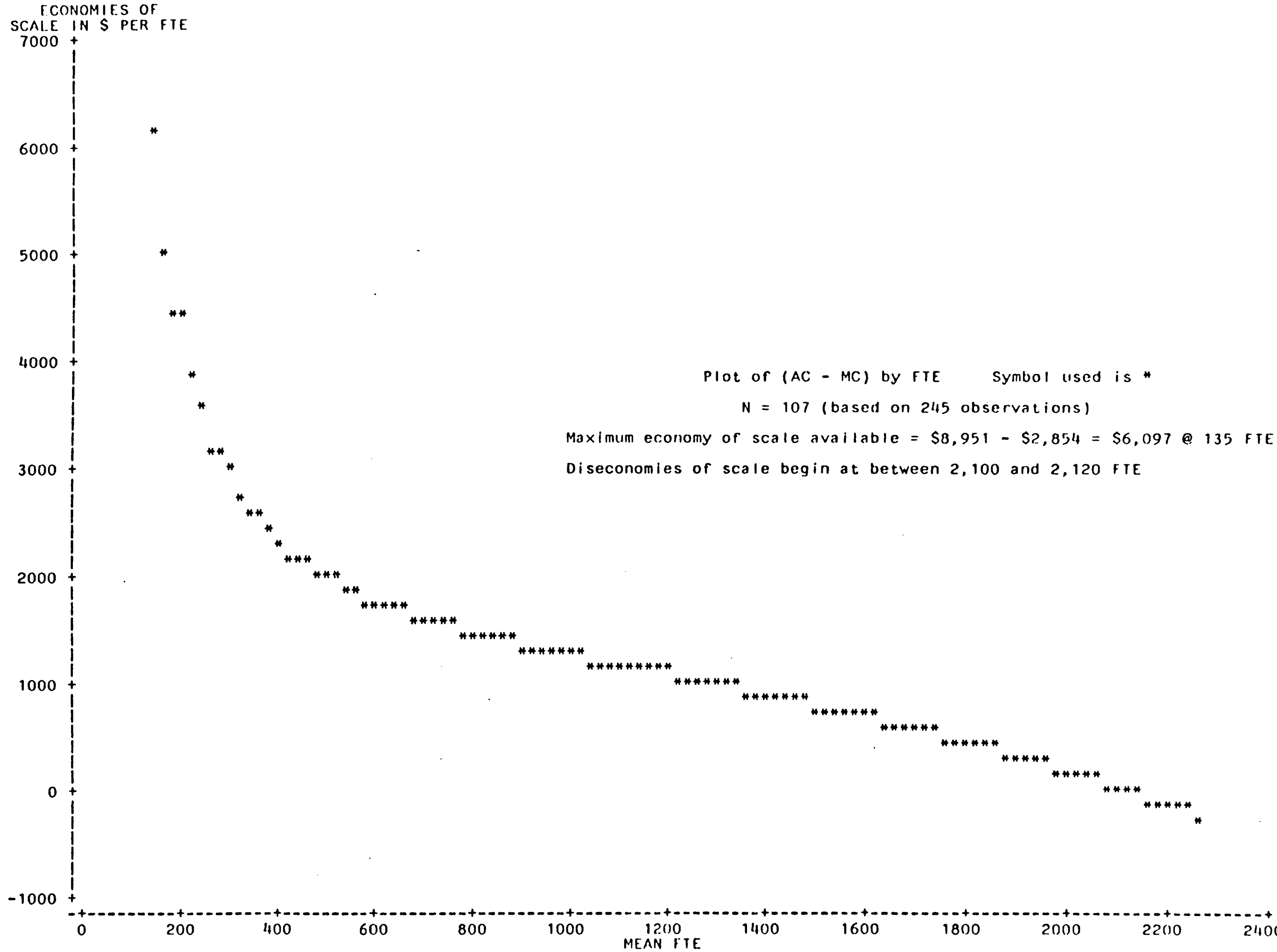

Figure 16. Economies of scale: derived from equation (7.1.1) cubic model for total small 2-year public colleges.

Table 16: Summarized Regression Results of Predicting TC For Small Technical Two-Year Public Colleges (N = 68)

Model	Equation	Alternate Variable	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameters Having Significant (@.05) PROB > |T|
LINEAR	(5.1)	DIVERSITY	.0001	.5836	7.16207E+13	FTE, DIVERSITY, ADJAVSAL
QUADRATIC	(6.1)	DIVERSITY (with interactive terms)	.0001	.5709	6.67817E+13	
	(6.1A)	DIVERSITY (without interactive terms)	.0001	.5889	6.73474E+13	
CUBIC	(7.1)	DIVERSITY	.0001	.5900	6.38020E+13	
MULTIPLICATIVE[2]	(8.1)	DIVERSITY	.0001	.5421	7.87526E+13	FTE, DIVERSITY, ADJAVSAL
TRANS-LOG[2]	(9.1)	DIVERSITY	.0001	.5747	6.96617E+13	

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) included in each equation (5.1-9.1) according to the following formula:

$$\text{adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

[2] Results shown for exponential models are those of predicting the natural log of IEG.

(1) R-squared = .5900: After controlling for ADJAVSAL, 59 percent of the variation in the dependent variable (TC) could be explained by 100 percent of the variation in the three independent variables (FTE, MARKET, and DIVERSITY) acting together as a linear combination of their linear, quadratic, and cubic terms (equation (7.1).

(2) RSS - by posting the least RSS, equation (7.1) achieved what no other equation tested had achieved: the sum of the squared differences between the actual and predicted values for TC over the domain of the equation--from 113 FTE to 1,795 FTE--was the least of any of the six equations tested.

(3) SEE: In posting the highest R-squared statistic and the least RSS statistic, the parameter estimates (regression coefficients) for all variables were statistically insignificant ($p <$ .05, or better). The difference between the calculated parameter estimates for each of the independent variable were not significantly different from zero. Hence, the parameter estimates associated with equation (7.1) may have been due solely to chance. As substantiated earlier in Chapter III, only significant parameter

estimates are indicative of minimal standard errors of the estimate (SEE). Accordingly, each of the parameter estimates associated with equation (7.1) for 68 small technical colleges contain estimation errors too large to be statistically reliable. Since parameter estimates (regression coefficients) represent the slope of the TC and since the slope of TC is, by definition, equivalent to MC, insignificant parameter estimates seriously impair the validity of equation (7.1) as being representative of the TC function for 68 small technical colleges. However, no other equation reported significant parameter estimates either.

(4) In predicting TC, equation (7.1) was itself statistically significant ($p < .0001$). After controlling for ADJAVSAL, the relationship between the three independent variables (FTE, MARKET and INDEXCOMP), expressed in their linear, quadratic, and cubic terms, and the dependent variable (IEG) was too large (R = square root of .5900) to have been due solely to chance.

Table 16 presents the summarized regression results of all equations by model for 68 small technical two-year public colleges, and Table 17 presents the estimated

Table 17: Estimated Parameter Values By Equation For Small Technical Two-Year Public Colleges (N = 68)

Model Equation	Linear (5.1)	Quadratic (6.1)	Quadratic (6.1A)	Cubic (7.1)	Multiplicative (8.1)	Translog (9.1)
Y-Intercept	$ 171053	$ 208685	$ 321077	$ 2102183	$ -3208930	$ -6346634
FTE	1766.152*	1636.477	1864.654	957.821		1545.730
MARKET	17529945*	-71106825	-99317900	102049241		66910949
DIVERSITY	7668269*	9041777	7359149	-32134648		13474818
ADJAVSAL	106.323*	203	84.398506	89.198314	112.788*	77.672203
FTE^2		-0.659278	-0.125903	0.623772		
$MARKET^2$		3394570617	3702870424	-11464799809		
$DIVERSITY^2$		-7519067	5228014	222392066		
FTE^3				-0.000234106		
$MARKET^3$				298774045798		
$DIVERSITY^3$				-356021936		
FTE BY MARKET		26860.218				
FTE BY DIVERSITY		5310.481				
MARKET BY DIVERSITY		-233430418				
LN FTE					1305847*	105054
LN MARKET					9715.321	-544641
LN DIVERSITY					1388187*	-831912

*Significant at the .05 level, or better

parameter values (regression coefficients) for every term of each equation within the five models defined by the present study.

Curve Smoothing Techniques

Figure 17 is a two dimensional representation of the cubic model, equation (7.1), and depicts the actual (IEG) versus predicted (IEGHAT), total cost in terms of FTE and 68 small technical two-year public colleges. For reasons previously cited in Chapter II, the TC function represented by the P-values in Figure 17 is not yet a continuous, smooth function.

Based on the curve smoothing techniques described in Chapter II, a continuous smooth TC function was developed--see Figure 18 and supporting Figures F-25 through F-27 of Appendix F. The resulting continuous, smooth TC function, defined in terms of a single variable, FTE, and represented by equation (7.1.1)[31] is equivalent to the cubic model equation (7.1.) defined in terms of FTE, MARKET, DIVERSITY--including first, second and third power terms--after controlling for ADJAVSAL. In mathematical terms, both TC functions represent an identity. Equation (7.1.1) is identically equivalent to equation (7.1) or:

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[31] Average predicted TC = 142850+2905.6830(mean FTE)+0.33190782(mean FTE)^2-0.00019533(mean FTE)^3. For a summary of the regression results, see Table 18.

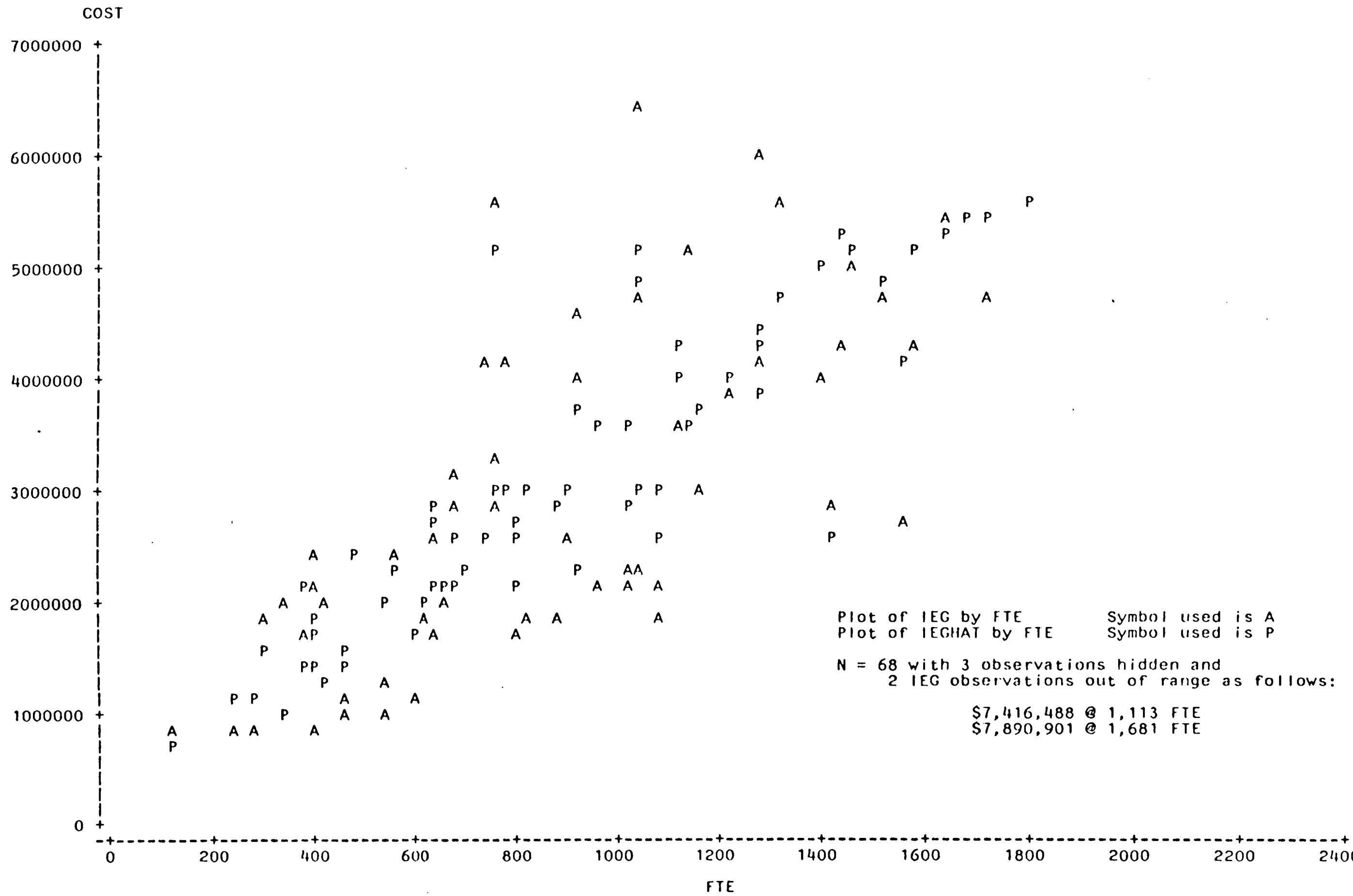

Figure 17. Actual (IEG) vs. predicted (IEGHAT) total cost: Equation (7.1) cubic model for small technical 2-year public colleges.

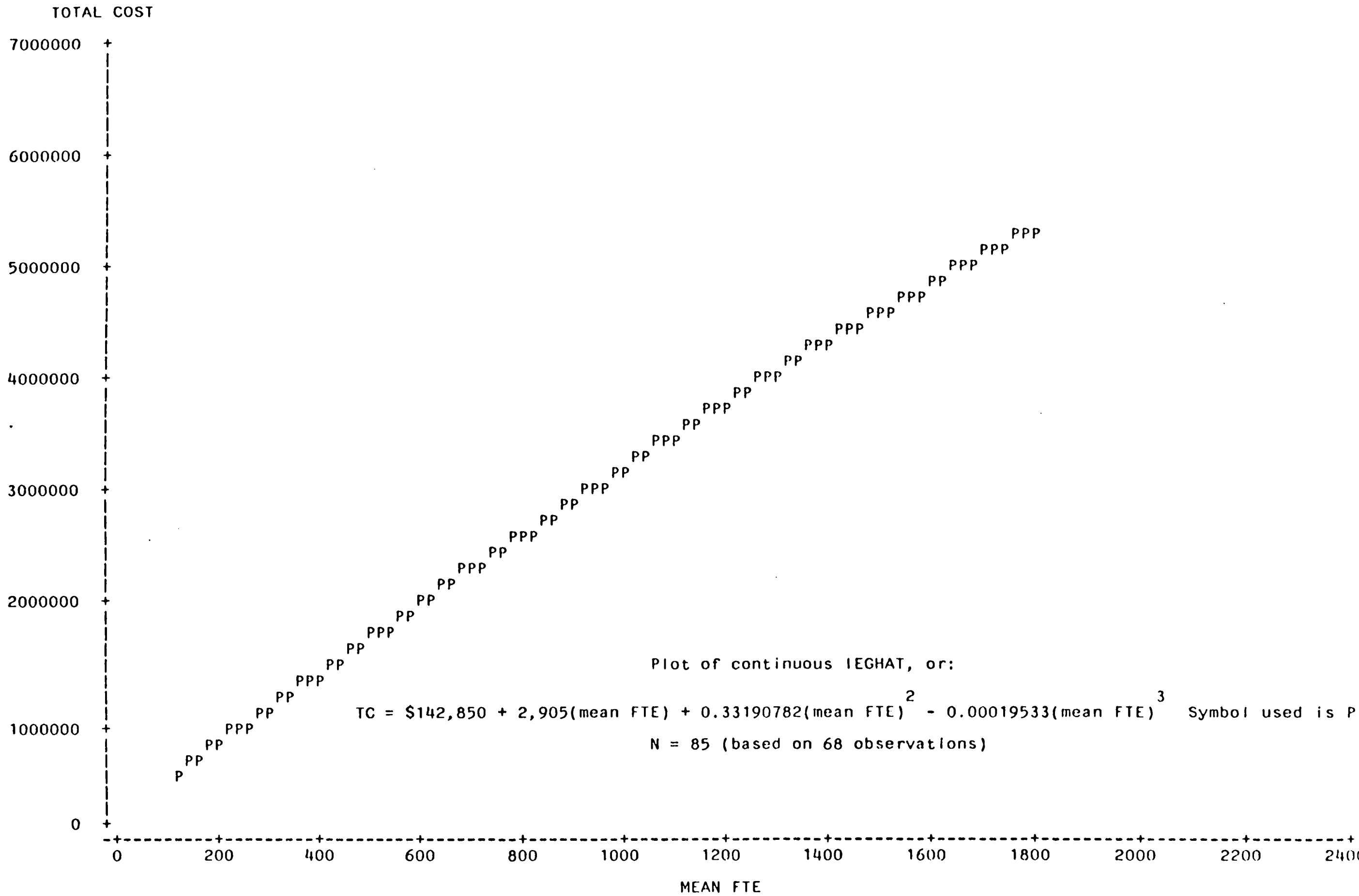

Figure 18. Continuous average predicted total cost: Equation (7.1.1) cubic model for small technical 2-year public colleges.

Table 18: Summarized Regression Results of Curve Smoothing Techniques for Small Technical 2-Year Public Colleges (N = 68)

Model	Equation	Prob > |F|	Adjusted R-Squared[1]	Residual SS	Parameter Estimate	
CUBIC	7.1.1	.0001	.9832	8.59996E+12	Y-intercept:	142850
					Mean FTE:	2905.6830
					$(\text{Mean FTE})^2$:	0.33190782
					$(\text{Mean FTE})^3$:	-0.00019533

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) according to the following formula:

$$\text{Adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

$$\$2102183+957(FTE)+102049241(MARKET)-32134648(DIVERSITY)$$
$$+0.623772(FTE)^2-11464799809(MARKET)^2+222392066(DIVERSITY)^2$$
$$-0.000234106(FTE)^3+298774045798(MARKET)^3-356021936(DIVERSITY)^3$$
$$+89.198314(ADJAVSAL)$$

is equivalent to

$$\$142850+2905.6830(FTE)+0.33190782(FTE)^2-0.00019533(FTE)^3.$$

Derivation of MC and AC Functions

Based on the continuous, smooth TC function represented by equation (7.1.1), the AC function for 68 small technical two-year colleges was derived as follows:

$$AC = TC/Mean\ FTE$$

Because equation (7.1.1) is a multivariate TC function, the first derivative of such an equation with respect to FTE would only be a partial derivative and, therefore, would not yield a valid MC function for the reasons previously reviewed in Chapter II. Accordingly, the applicable MC function was derived by using Hirshleifer's (1980) better approximation method, also previously described in Chapter II. The resulting MC and AC functions derived from equation (7.1.1), were then plotted together so that they could be readily compared with one another--see Figure 19.

Since the TC function represented by equation (7.1.1) is cubic--see Figure 18--the MC function derived from it (Figure 19) must be consistent with the universal properties

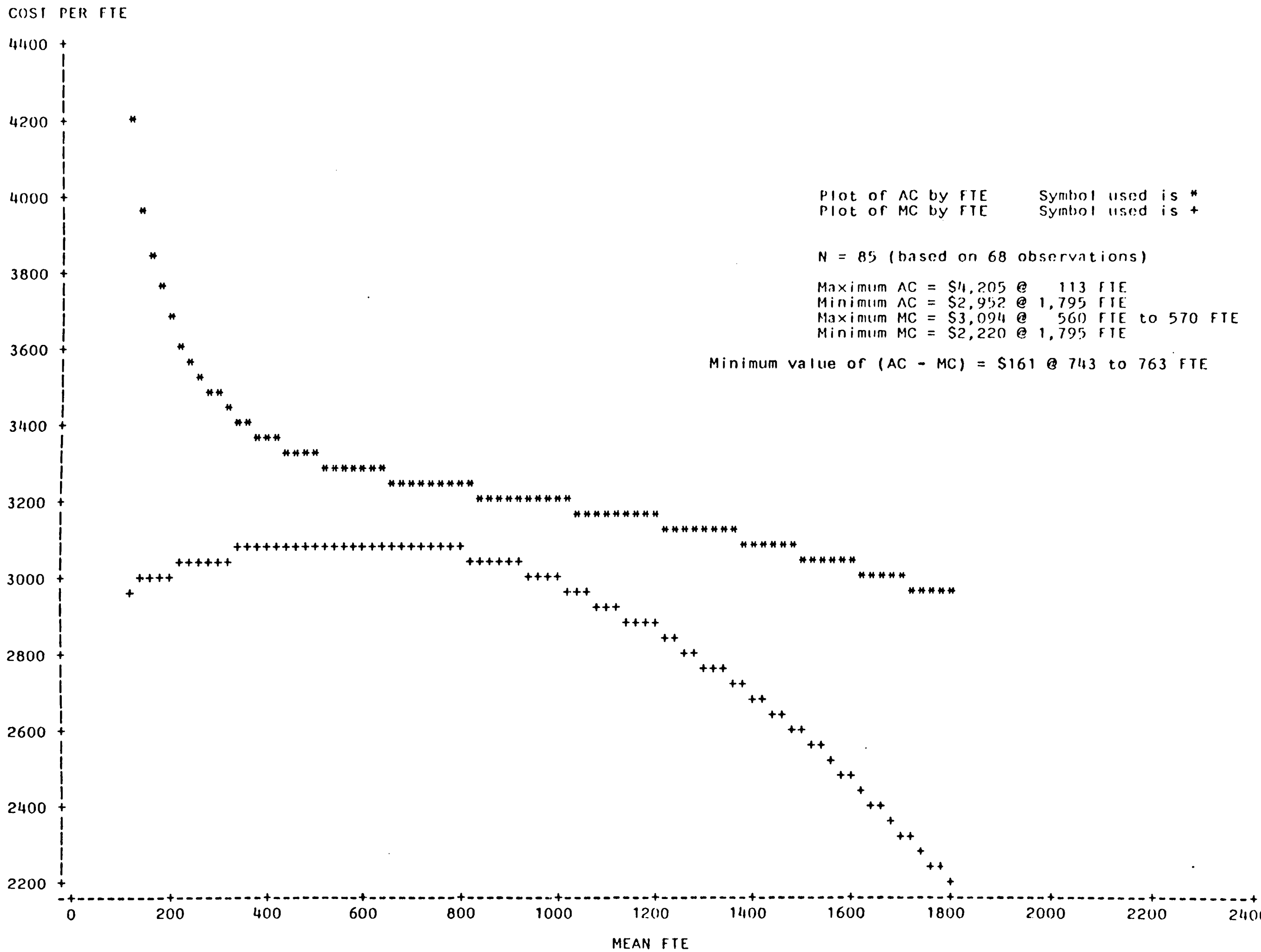

Figure 19. Average (AC) and marginal (MC) cost functions: Derived from equation (7.1.1) for small technical 2-yr public colleges.

of all cubic TC functions as previously outlined in Chapter II. Of special interest is the property that the MC of a cubic TC function, unlike that of a linear TC function, cannot be constant over the domain of the function. MC derived from a cubic TC function must be curvilinear, rather than linear. Similarly, unlike that of a linear TC function, the cubic function may have three roots--that is, there may be three values of FTE which satisfy the condition, IEG = f (FTE, FTE^2, FTE^3) = zero. Hence, unlike a linear TC function, a cubic TC function may change direction three times within the same quadrant.

An inspection of Figures 18 and 19 indicates that equation (7.1.1) is consistent with these universal properties of cubic TC functions. For example, while the overall appearance of the plot of equation (7.1.1) is linear, a closer inspection of Figure 18 confirms the fact that this equation is curvilinear. The curvilinearity of the slope of equation (7.1.1) becomes even more apparent in its associated MC function (Figure 19), which is nonconstant, ranging from a maximum of $4,205 at 113 FTE to a minimum of $2,952 at 1,795 FTE. Consistent with all cubic functions, the MC function lies below AC over a large portion of the domain of its related TC function, indicating that economies of scale are achievable over this range. Equation (7.1.1) reflects these economies over the function's entire domain--see Figure 20.

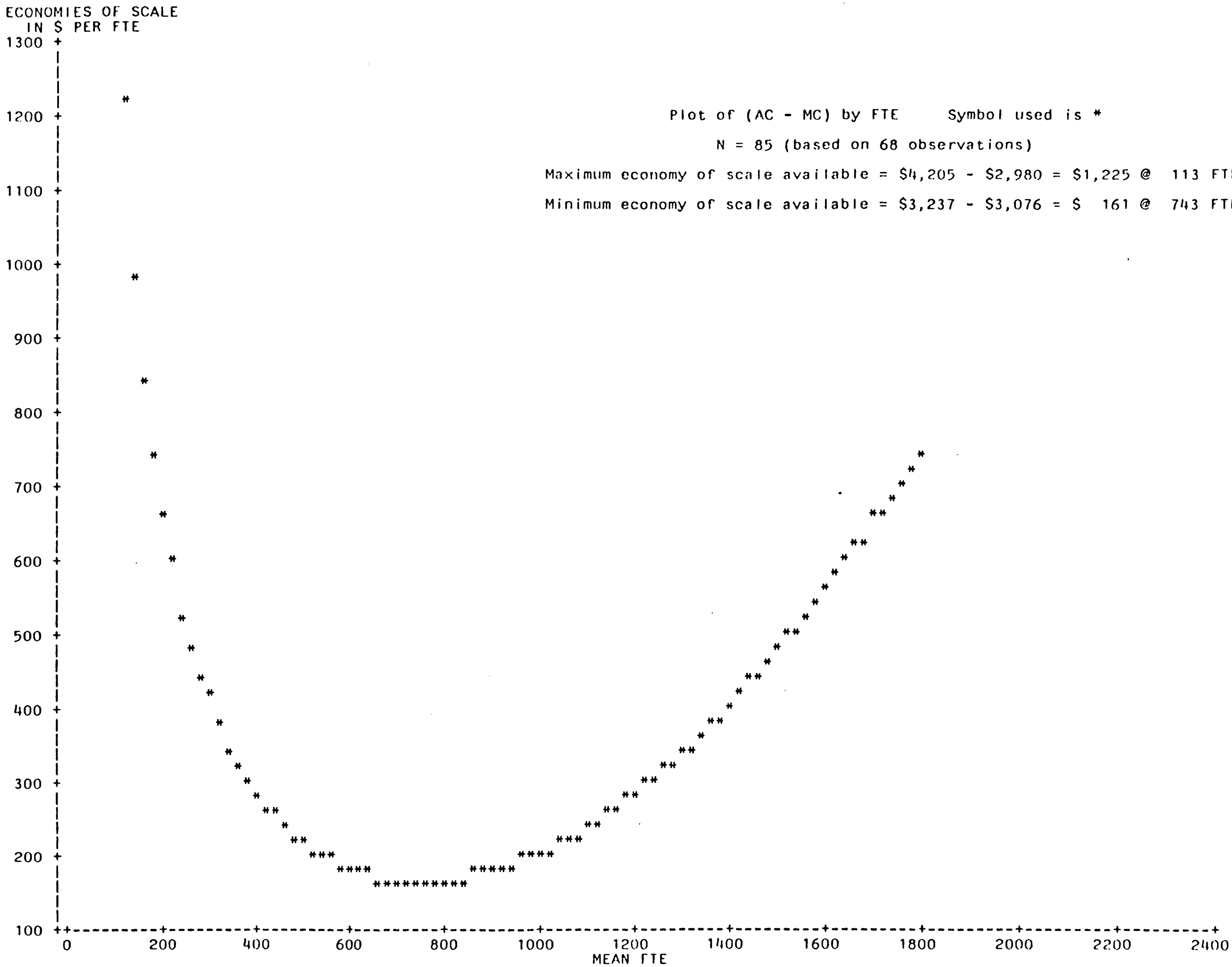

Figure 20. Economies of scale: Derived from equation (7.1.1) cubic model for small technical 2-year public colleges.

What is unusual about the cubic function expressed by equation (7.1.1) is that the parameter estimate for the cubic term $(FTE)^3$ is negative. It is this negative attribute which keeps the function looking like a quadratic, not a cubic function when it is plotted. Thus, the TC function portrayed in Figure 18 has a slight convex curvature over the entire domain of the function without ever changing direction. Consequently, subject to the limitation associated with insignificant parameter estimates noted above, the function never turns upward creating the concave appearance at higher enrollment levels as, for example, equation (7.1.1) did for 245 total small colleges--see Figure 14. As a result, the derived MC function--Figure 19 takes on the characteristics typically attributable to those of a quadratic function. Hence, the curvature of the MC function for 68 small technical colleges (Figure 19) is similar to that for 51 small, but not rural colleges (Figure 11). Consequently, subject to the limitation associated with insignificant parameter estimates noted above, positive economies of scale are achievable by small technical schools at all enrollment levels within the domain of the function analyzed, (between 113 FTE and 1,795 FTE)--see Figure 20.

25 Medium Large Colleges

Selecting the Best Model

Of the six equations tested across the five models defined by the present study, the linear model--equation (5.1)--demonstrated the highest R-squared statistic (.5110) and only the fifth least RSS (3.76168E+13) in predicting TC for 25 medium large colleges. However, equation (5.1) was the only equation tested to have two of the three parameter estimates (regression coefficients)--FTE and MARKET--as statistically significant ($p < .05$)--see Table 19. As was the case for 68 small technical schools, the worst model in predicting TC for 25 medium large colleges was the multiplicative model--equation (8.1)--R-squared = .4044.

The superiority of the linear model in predicting TC for 25 medium large two-year public colleges was interpreted as follows:

(1) R-squared = .5110: After controlling for ADJAVSAL, 51.10 percent of the variation in the dependent variable (TC) could be explained by 100 percent of the variation in the three independent variables (FTE, MARKET, and DIVERSITY). Although in absolute terms, an R-squared of only .5110 is not indicative of a particularly strong relationship, the R-squared values for all six equations tested were generally low because the

Table 19: Summarized Regression Results of Predicting TC For Medium Large Two-Year Public Colleges (N = 25)

Model	Equation	Alternate Variable	Prob > |F|	Adjusted R-Squared[1]	Residual SS	Parameters Having Significant (@.05) PROB > |T|
LINEAR	(5.1)	DIVERSITY	.0009	.5110	3.76168E+13	FTE, MARKET
QUADRATIC	(6.1)	DIVERSITY (with interactive terms)	.0596	.3799	3.33915E+13	
	(6.1A)	DIVERSITY (without interactive terms)	.0135	.4372	3.68002E+13	
CUBIC	(7.1)	DIVERSITY	.0446	.4130	3.16088E+13	
MULTIPLICATIVE[2]	(8.1)	DIVERSITY	.0055	.4044	4.58207E+13	FTE
TRANS-LOG[2]	(9.1)	DIVERSITY	.0097	.4631	3.51102E+13	MARKET

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) included in each equation (5.1-9.1) according to the following formula:

$$\text{adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

[2] Results shown for exponential models are those of predicting the natural log of IEG.

number of observations (N = 25) was too few to achieve an R-squared statistic comparable to the other institutional types tested.

(2) RSS - by posting only the fifth least RSS out of the six equations tested, equation (5.1) failed to achieve one of the three criteria established to determine which equation best predicted TC. The sum of the squared differences between actual and predicted values for TC over the domain of the function (from 1,144 FTE to 3,064 FTE) was lower in four other equations tested. Hence, the range,but not the slope, of the TC function represented by equation (5.1) may be suspect.

(3) SEE: In posting the highest R-squared statistic and the fifth least RSS statistic, the parameter estimates (regression coefficients) for FTE and MARKET were statistically significant ($p < .05$, or better). The difference between the calculated parameter estimates for each of these variables and zero was too large to have been due solely to chance. As substantiated earlier in Chapter III, significant parameter estimates are indicative of minimal standard errors of the estimate (SEE). However, due to the small sample size (25), these parameter estimates, although significant, are, nevertheless, unstable.

(4) In predicting TC, equation (5.1) was itself statistically significant ($p < .0009$). After controlling for ADJAVSAL, the relationship between the three independent variables (FTE, MARKET and INDEXCOMP) and the dependent variable (IEG) was too large (R = square root of .5110) to have been due solely to chance.

Table 19 presents the summarized regression results of all equations tested by model, for 25 medium large two-year public colleges, and Table 20 presents the estimated parameter values (regression coefficients) for every term of each equation within the five models defined by the present study.

Curve Smoothing Techniques

Figure 21 is a two dimensional representation of the linear model, equation (5.1), and depicts the actual (IEG) versus predicted (IEGHAT) total cost in terms of FTE for 25 medium large two-year public colleges. For reasons previously cited in Chapter II, the TC function represented by the P-values Figure 21 is not yet a continuous, smooth function.

Based on the curve smoothing techniques described in Chapter II, a continuous smooth TC function was developed--see Figure 22 and supporting Figures F-28 through

Table 20: Estimated Parameter Values By Equation For Medium Large Two-Year Public Colleges (N = 25)

Model Equation	Linear (5.1)	Quadratic (6.1)	Quadratic (6.1A)	Cubic (7.1)	Multiplicative (8.1)	Translog (9.1)
Y-intercept	$-89420.710	$ 2805489	$ 1801315	$ 14186693	$-28905830	$-20726489
FTE	2388.485*	44.875503	2414.222	-287.206		1699.193
MARKET	28652376*	30354379	22003679	-110301183		45136308*
DIVERSITY	1193774	-6984856	-16920747	-180696630		19236966
ADJAVSAL	-95.423190	-116.927	-93.228672	-14.052709	-13.742858	-89.044016
FTE^2		0.060581	-0.020848	1.547927		
$MARKET^2$		60680066	65983614	3388521440		
$DIVERSITY^2$		31342837	42187725	886472913		
FTE^3				-0.000280805		
$MARKET^3$				-18810012846		
$DIVERSITY^3$				-1369494811		
FTE BY MARKET		65243.049				
FTE BY DIVERSITY		3347.912				
MARKET BY DIVERSITY		-579185892				
LN FTE					4807533*	1308469
LN MARKET					425371	-482268
LN DIVERSITY					-14791.404	-3679801

*Significant at the .05 level, or better

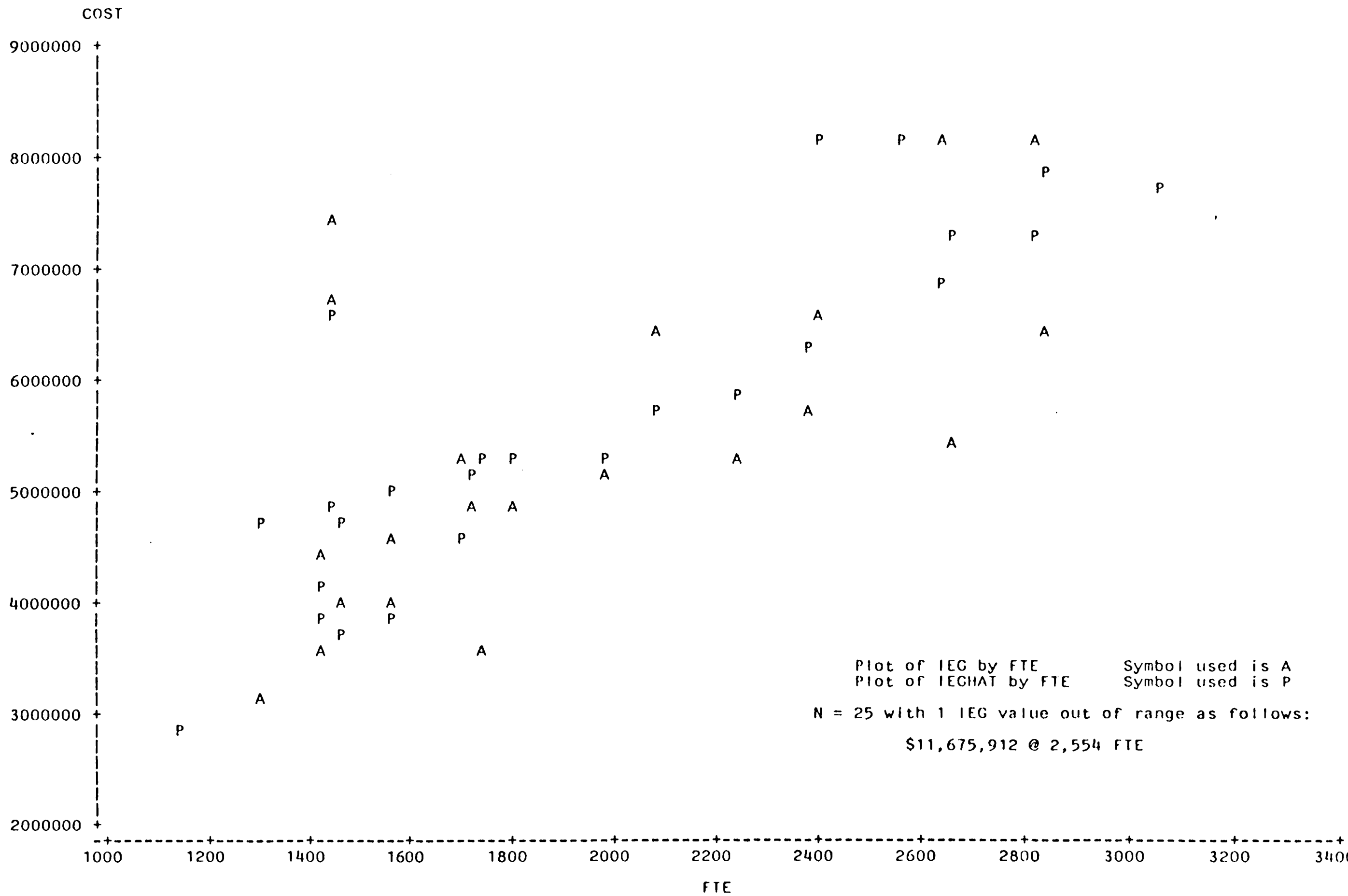

Figure 21. Actual (IEG) vs. predicted (IEGHAT) total cost: Equation (5.1) linear model for medium large 2-year public colleges.

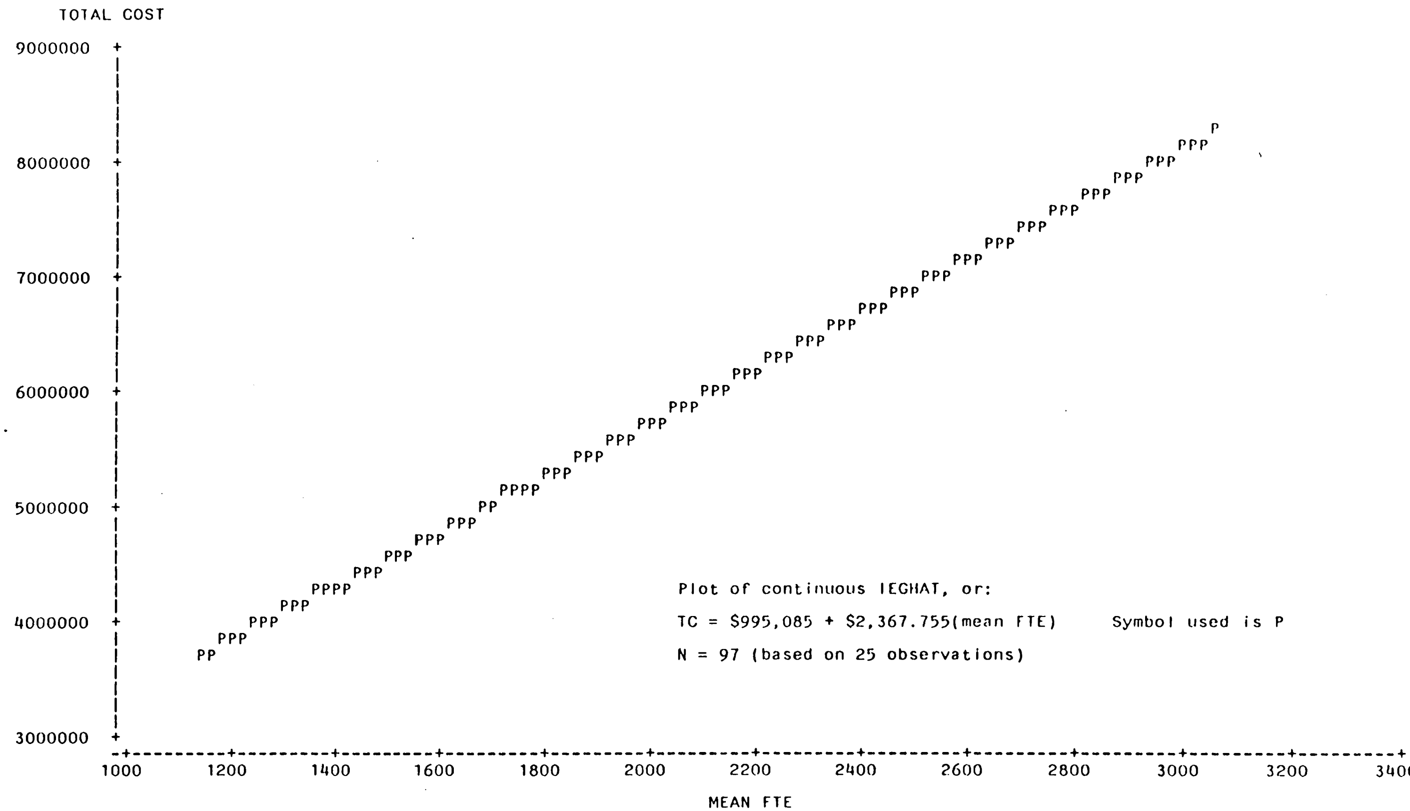

Figure 22. Continuous average predicted total cost: Equation (5.1.1) linear model for medium large 2-year public colleges.

Table 21: Summarized Regression Results of Curve Smoothing Techniques for Medium Large Two-Year Public Colleges (N = 25)

Model	Equation	Prob > |F|	Adjusted R-Squared[1]	Residual SS	Parameter Estimate		T for H0: Parameter = 0	Prob > |T|
LINEAR	5.1.1	.0001	.8151	7.86762E+12	Y-intercept:	995085	1.873	.0766
					Mean FTE:	2367.755	9.443	.0001

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) according to the following formula:

$$\text{Adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

F-30 of Appendix F. The resulting continuous, smooth TC function, defined in terms of a single variable, FTE, and represented by equation (5.1.1),[32] is equivalent to the linear model, equation (5.1), defined in terms of FTE, MARKET, and DIVERSITY after controlling for ADJAVSAL. In mathematical terms, both TC functions represent an identity. Equation (5.1.1) is identically equivalent to equation (5.1) or:

-89420+2388(FTE)+28652376(MARKET)+1193774(DIVERSITY)
-95.423190(ADJAVSAL)

is equivalent to

995085+2368(FTE).

<u>Derivation of MC and AC Functions</u>

Based on the continuous, smooth TC function represented by equation (5.1.1), the AC function for 25 medium large two-year colleges was derived as follows:

AC - TC/Mean FTE

Because equation (5.1.1) is a univariate TC function, the first derivative of such an equation with respect to FTE (in this case $2,368) yields a valid MC function for the reasons previously reviewed in Chapter II. Nevertheless, the applicable MC function was derived by using Hirshleifer's (1980) better approximation method, also

[32] Average predicted TC = 995085+2367.755(mean FTE). For a summary of the regression results, see Table 21.

previously described in Chapter II. The result of this better approximation method also produced a MC of $2,368 for medium large colleges. The resulting MC and AC functions derived from equation (5.1.1), were then plotted together so that they could be readily compared with one another--see Figure 23.

Since the TC function represented by equation (5.1.1) is linear--see Figure 22--the MC function derived from it (Figure 23) is consistent with the universal properties of all linear TC functions as previously outlined in Chapter II. Of special interest is the property that the MC of a linear function must also be linear, since the slope of the TC function is constant over the domain of a linear function. Similarly, the linear function can only have one root. There can be only one value of FTE which satisfies the condition, IEG = f (FTE) = zero.

An inspection of Figures 22 and 23 indicates that equation (5.1.1) is consistent with these universal properties of linear TC functions. For example, while the AC for medium large colleges is decreasing over the entire domain of the function (from a maximum of $3,238 at 1,144 FTE to a minimum of $2,693 at 3,064 FTE) the associated MC function remains a constant $2,368 over all enrollment levels. Since MC always lies below AC, economies of scale are achievable over the entire domain of the function,

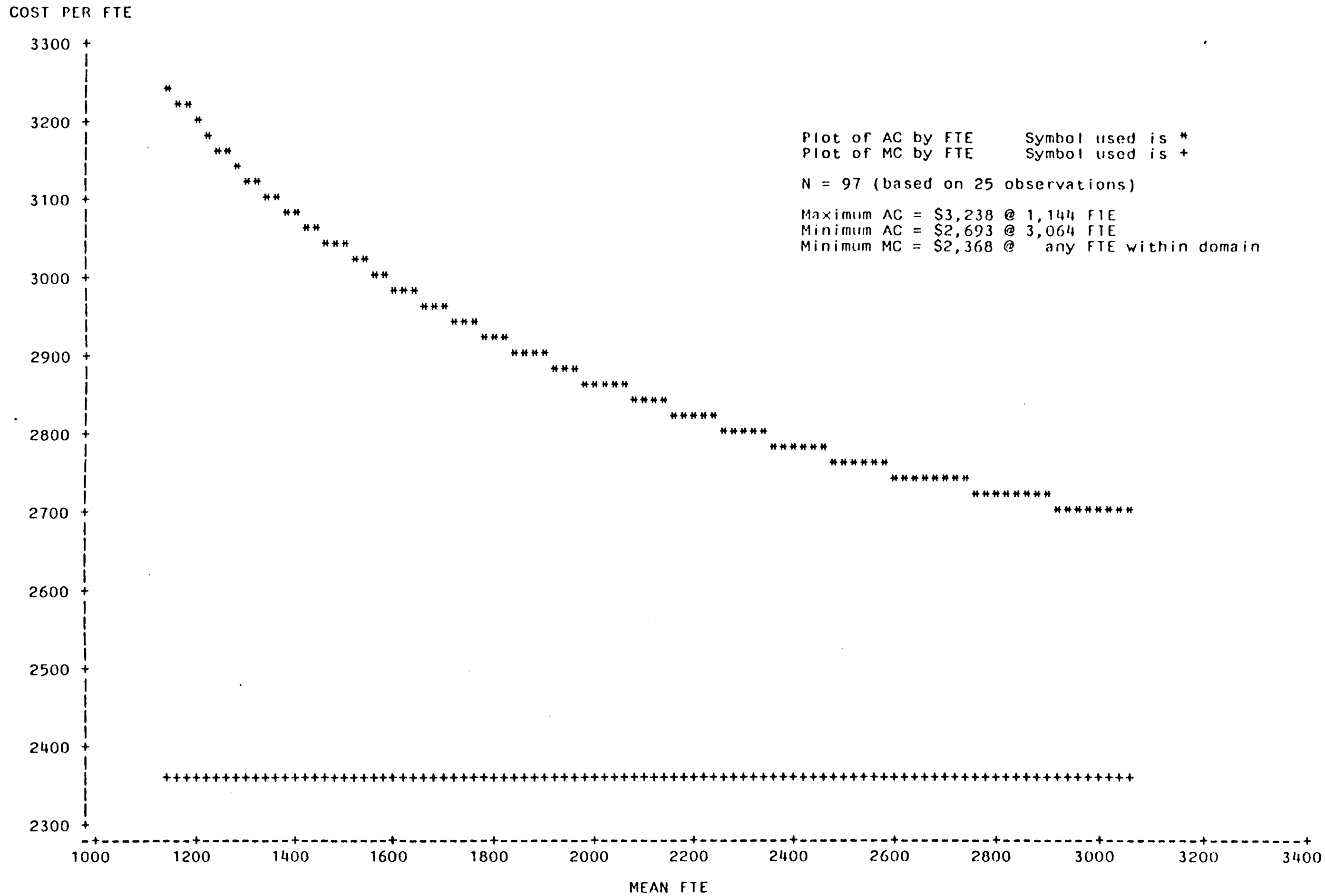

Figure 23. Average (AC) and marginal (MC) cost functions: Derived from equation (5.1.1) for medium large 2-year public colleges.

although their range may be somewhat distorted by the fact that equation (5.1) failed to achieve the least RSS of six equations tested. Equation (5.1.1) reflects these economies and Figure 24 is a graphical representation of these estimated achievable economies of scale.

What was at least somewhat surprising was the fact that for medium large schools, AC is always greater than MC over all enrollment ranges. In other words, as two-year public colleges grow larger, one would expect diseconomies of scale (MC > AC) to set in at some enrollment level within the domain of the TC function for these larger colleges. In terms of the present study, this was simply not the case. However, because the number of observations (N = 25) was so small relative to the known universe of 174 medium large two-year public colleges--see Table 1 in Chapter I--these findings cannot be generalized to the larger population of medium large two-year public colleges.[33]

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[33] Although 39 medium large colleges were randomly selected from the known universe of 174 medium large two-year public colleges, only 25 observations could be used in the present study since 14 schools had to be eliminated for lack of MARKET and/or ADJAVSAL data. Moreover, alternative methods to estimate such missing data were not attempted. As a result, the generalizability of equation (5.2.1) to the population of all medium large two-year public colleges cannot be made.

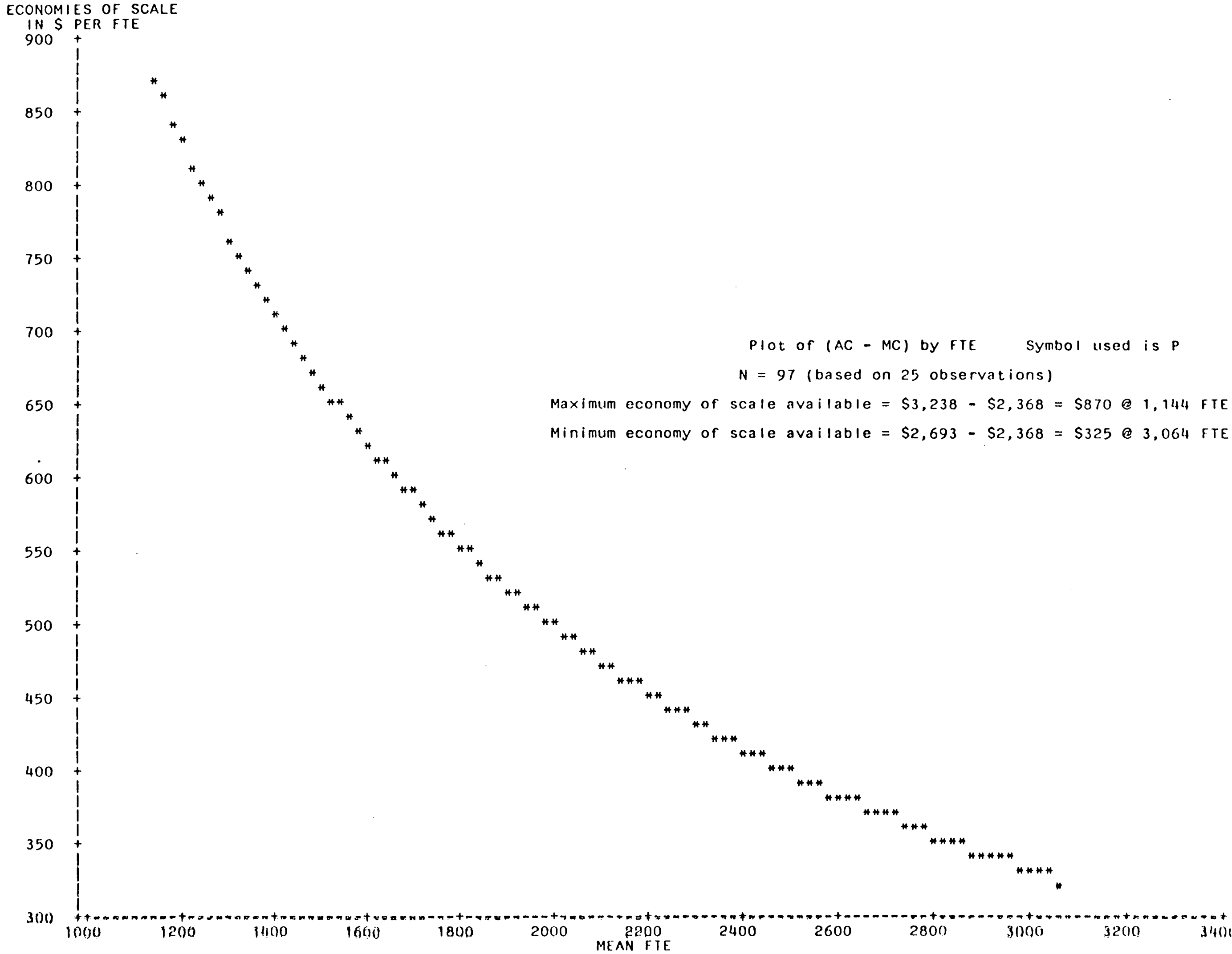

Figure 24. Economies of scale: Derived from equation (5.1.1) linear model for medium large 2-year public colleges.

39 Very Large Colleges

Selecting the Best Model

Of the five models defined by the present study, the quadratic model (without interactive terms)--equation (6.1A)--demonstrated the highest R-squared statistic (.8673) and the second least RSS (2.49612E+14) in predicting TC for 39 very large two-year public colleges. The cubic model--equation (7.1)--reflected the least RSS (2.34636E+14) but had no significant parameter estimates, i.e., regression coefficients. The parameter estimate for FTE was, however, significant ($p < .05$) in no less than four of the six equations tested. The only equation with a second significant ($p < .05$) parameter estimate, FTE squared, was the same equation which recorded the highest R-squared statistic - equation 6.1A. The worst model in predicting TC for 39 very large colleges was the linear model - equation (5.2)--R-squared = .8530.

The superiority of the quadratic model (without interactive terms) in predicting TC for 39 very large two-year public colleges was interpreted as follows:

(1) R-squared = .8673: After controlling for ADJAVSAL, 86.73 percent of the variation in the dependent variable (TC) could be explained by 100 percent of the variation in the first and second

power terms of the three independent variables (FTE, MARKET, and DIVERSITY).

(2) RSS - by posting the second least RSS, equation 6.1A achieved what four of five equations tested had not achieved--the sum of the squared differences between the actual and predicted values for TC over the domain of equation, i.e., 2,019 FTE to 14,507 FTE, was the second best of any of the five equations tested. Hence, the range, but not the slope, of the TC function represented by equation (6.1A) may be somewhat suspect.

(3) SEE: In posting the highest R-squared statistic and the second least RSS statistic, the parameter estimates, (regression coefficients) for FTE and FTE-squared were statistically significant ($p < .05$, or better). The difference between the calculated parameter estimates for each of these variables and zero was too great to have been due solely to chance. As substantiated earlier in Chapter III, significant parameter estimates are indicative of minimal standard errors of the estimate (SEE).

(4) In predicting TC, equation (6.1A) was itself statistically significant ($p < .0001$). After

controlling for ADJAVSAL, the relationship between the first and second power terms of the three independent variables (FTE, MARKET, and DIVERSITY), and the dependent variable (IEG) was too large (R = square root of .8673) to have been due solely to chance.

Table 22 presents the summarized regression results of all equations tested by model for 39 very large two-year public colleges, and Table 23 presents the estimated parameter values, (regression coefficients) for every term of every equation within all five models defined by the present study.

Curve Smoothing Techniques

Figure 25 is a two dimensional representation of the quadratic model, equation (6.1A), and depicts the actual (IEG) versus predicted (IEGHAT) total cost in terms of FTE for 39 very large two-year public colleges. For reasons previously cited in Chapter II, the TC function represented by the P-values in Figure 25 is not yet a continuous, smooth function.

Based on the curve smoothing techniques described in Chapter II, a continuous, smooth TC function was developed--see Figure 26 and the supporting Figures F-31 through F-33 of Appendix F. The resulting continuous,

Table 22: Summarized Regression Results of Predicting TC For Very Large Two-Year Public Colleges (N = 39)

Model	Equation	Alternate Variable	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameters Having Significant (@.05) PROB > |T|
LINEAR	(5.1)	DIVERSITY	.0001	.8530	3.03202E+14	FTE
QUADRATIC	(6.1)	DIVERSITY (with interactive terms)	.0001	.8548	2.46699E+14	FTE
	(6.1A)	DIVERSITY (without interactive terms)	.0001	.8673	2.49612E+14	FTE, FTE^2
CUBIC	(7.1)	DIVERSITY	.0001	.8619	2.34636E+14	
MULTIPLICATIVE[2]	(8.1)	DIVERSITY	.0001	.8543	3.00637E+14	FTE
TRANS-LOG[2]	(9.1)	DIVERSITY	.0001	.8653	2.53381E+14	FTE

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) included in each equation (5.1-9.1) according to the following formula:

$$\text{adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

[2] Results shown for exponential models are those of predicting the natural log of IEG.

Table 23: Estimated Parameter Values By Equation For Very Large Two-Year Public Colleges (N = 39)

Model Equation	Linear (5.1)	Quadratic (6.1)	Quadratic (6.1A)	Cubic (7.1)	Multiplicative (8.1)	Translog (9.1)
Y-Intercept	$ -288233	$ 797069	$ 901533	$ -491771	$-89185271*	$-111803854*
FTE	1818.710*	3715.418*	3526.027*	4108.825		195.787
MARKET	-22721398	-36372131	-66967672	-319417989		71624296
DIVERSITY	13807012	-26378961	-21345233	47813799		49028871
ADJAVSAL	-27.204848	63.328497	105.571	109.203	1.721189	53.917379
FTE^2		-0.081743	-0.118545*	-0.196736		
MARKET^2		541434491	851157241	8328991217		
DIVERSITY^2		61648582	5099680	-164636164		
FTE^3				.0000027992		
MARKET^3				-58554551220		
DIVERSITY^3				208076186		
FTE BY MARKET		-8125.072				
FTE BY DIVERSITY		-1067.669				
MARKET BY DIVERSITY		96708934				
LN FTE					12585039*	10010254*
LN MARKET					246495	-2093830
LN DIVERSITY					2437266	-11586159

*Significant at the .05 level, or better

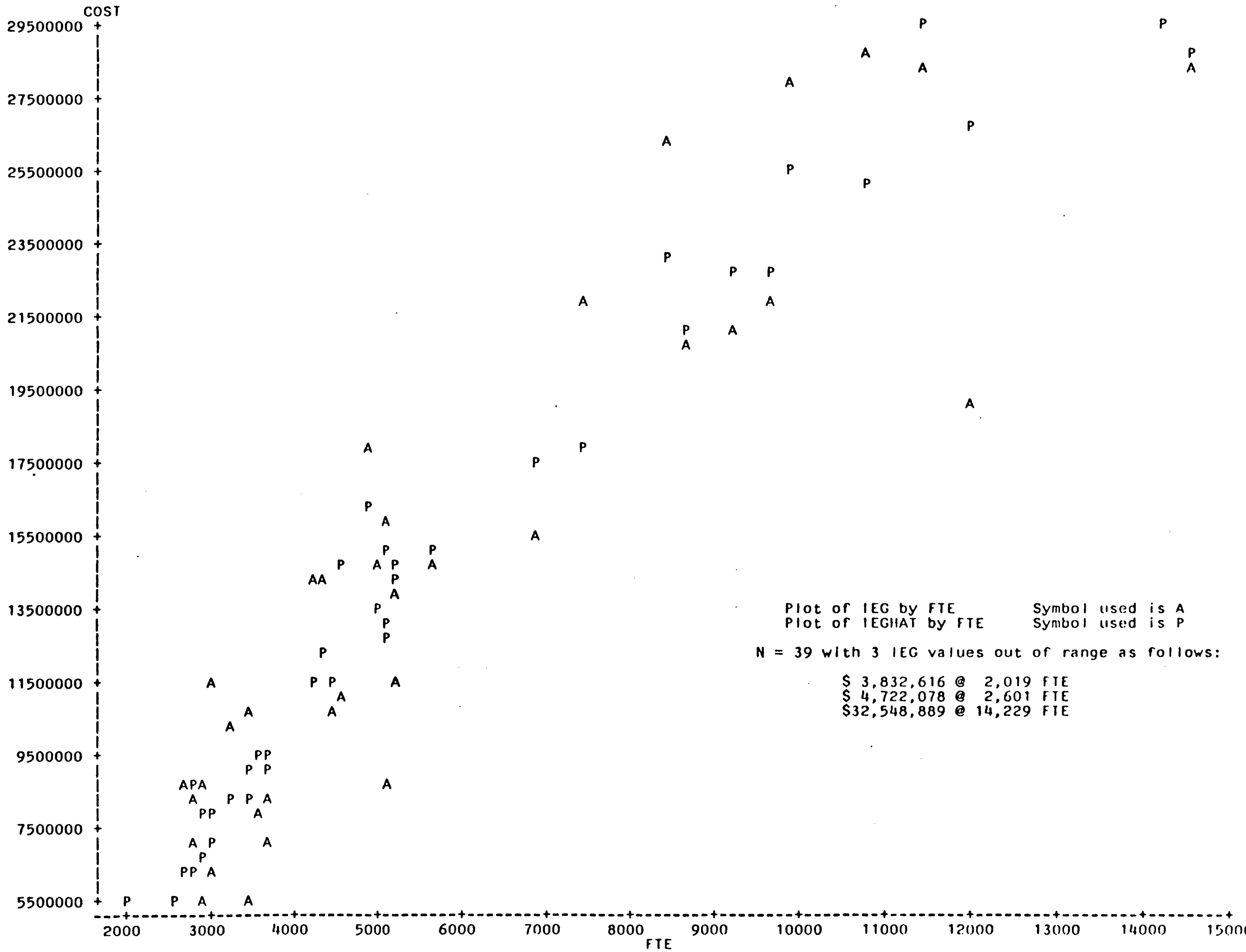

Figure 25. Actual (IEG) vs. predicted (IEGHAT) total cost: Equation (6.1A) quadratic model for very large two-year public colleges.

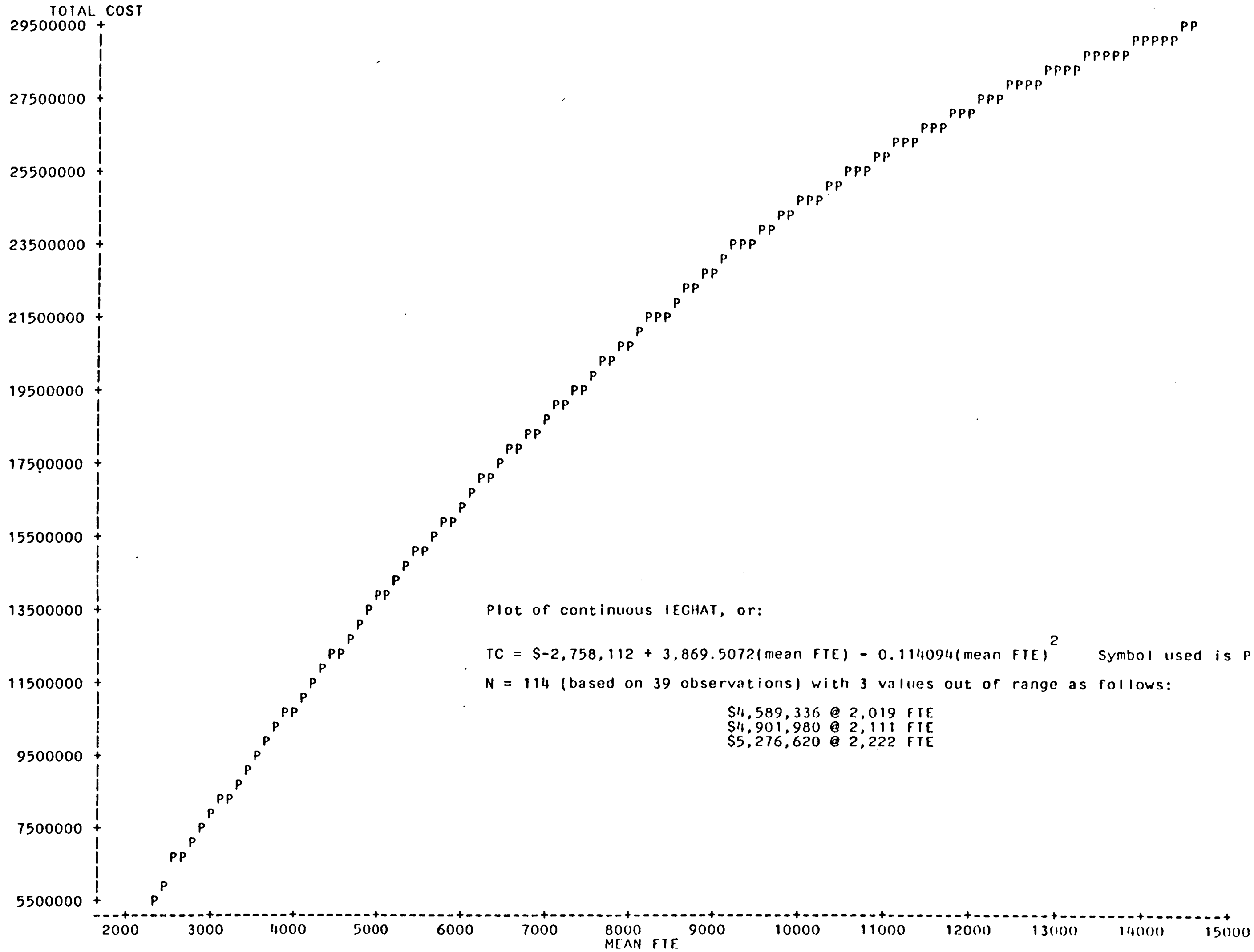

Figure 26. Continuous average predicted total cost: Equation (6.1A.1) quadratic model for very large two-year public colleges.

smooth TC function, defined in terms of the first and second powers of a single variable, FTE, and represented by equation (6.1A.1),[34] is equivalent to the quadratic model, equation (6.1A), defined in the first and second power terms of FTE, MARKET, and DIVERSITY after controlling for ADJAVSAL. In mathematical terms, both TC functions represent an identity. Equation (6.1A.1) is identically equivalent to equation (6.1A) or:

$$901533+3526(FTE)-66967672(MARKET)-21345233(DIVERSITY)$$
$$-0.118545(FTE)^2+851157240(MARKET)^2+50996979(DIVERSITY)^2$$
$$+105.57104(ADJAVSAL)$$

is equivalent to:

$$-2758112+3869.5072(FTE)-0.11409367(FTE)^2.$$

Derivation of MC and AC Functions

Based on the continuous, smooth TC function represented by equation (6.1A.1), the AC function for 39 very large two-year colleges was derived as follows:

AC = TC/Mean FTE

Because equation (6.1A.1) is a multivariate TC function, the first derivation of such an equation with respect to FTE (in this case $3,869) cannot yield a valid MC function for the reasons previously reviewed in Chapter II.

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[34] Average predicted TC = $-2758112+3869.5072$(mean FTE)-0.11409367(mean FTE)^2. For a summary of the regression results, see Table 24.

Table 24: Summarized Regression Results of Curve Smoothing Techniques for Very Large Two-Year Public Colleges (N=39)

Model	Equation	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameter Estimate		T for HO: Parameter = 0	Prob > |T|
QUADRATIC	6.1A.1	.0001	.9790	3.50002E+13	Y-intercept:	-2758112	-3.09	.0045
					Mean FTE:	3869.5072	14.13	.0001
					$(\text{Mean FTE})^2$:	-0.11409367	-6.64	.0001

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) according to the following formula:

$$\text{Adjusted } R^2 = R^2 - (1-R^2)k/N-k-1)$$

Accordingly, the applicable MC function was derived using Hirshleifer's (1980) better approximation method, also previously described in Chapter II. The result of this better approximation method produced an MC ranging from a minimum of $566 @ 2,019 FTE to a maximum of $3,398 @ 14,507 FTE for very large colleges. The resulting MC and AC functions derived from equation (6.1A.1), were then plotted together so that they could be readily compared with one another--see Figure 27.

Since the TC function represented by equation (6.1A.1) is quadratic--see Figure 26--the MC function derived from it (Figure 27) must be (and is, in fact) consistent with the universal properties of all quadratic TC functions as previously outlined in Chapter II. Of special interest is the property that the MC of a nonlinear function must also be nonlinear, since the slope of the TC function is nonconstant over the domain of a nonlinear function.

An inspection of Figures 26 and 27 indicates that equation (6.1A.1) is consistent with these universal properties of quadratic TC functions. For example, the TC represented by equation (6.1A.1) and plotted as Figure 26 has the familiar convex slope associated with all quadratic functions. This particular function is, however, restricted by its domain (from 2,019 FTE to 14,507 FTE) and, accordingly, the function never does maximize, that is, it

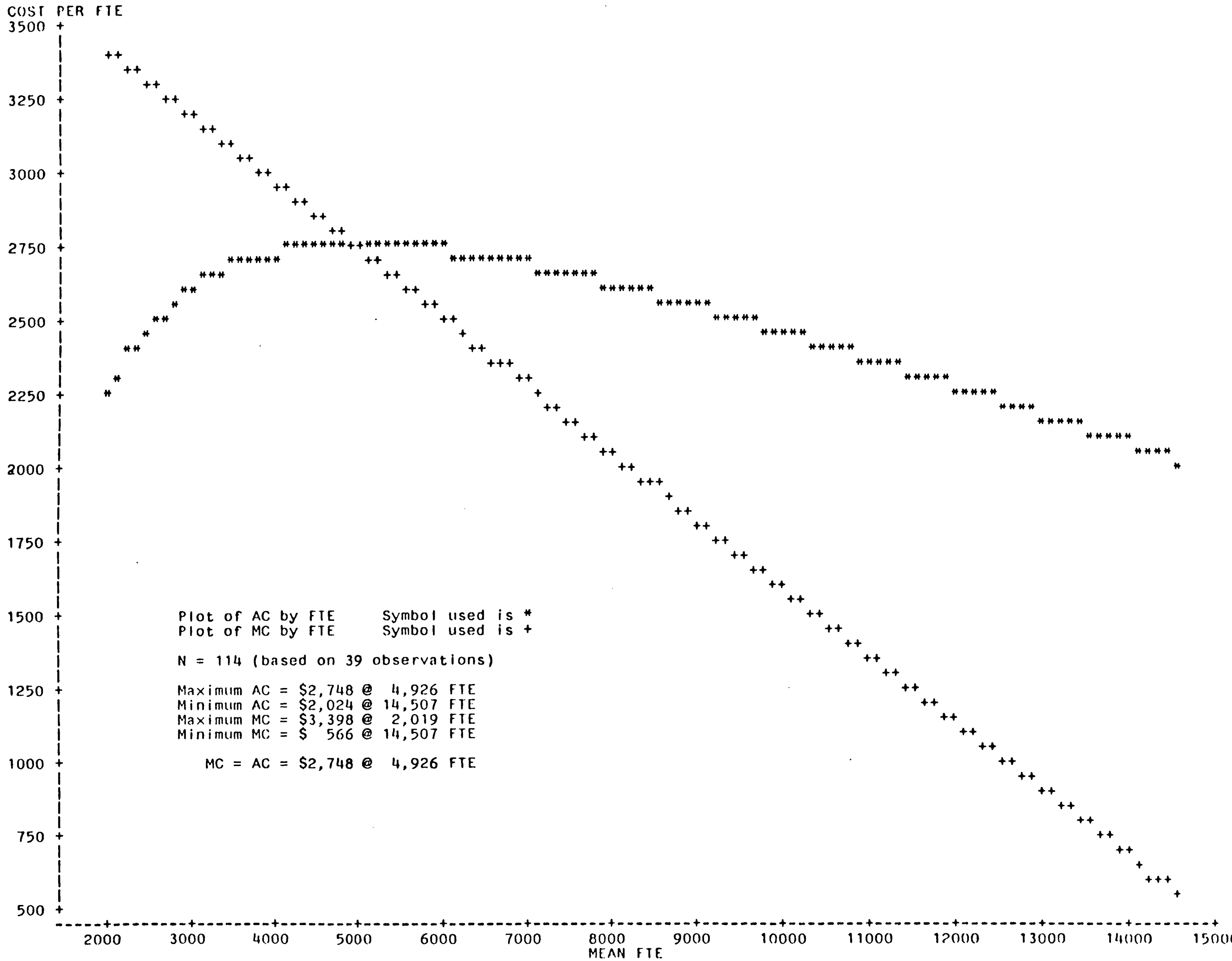

Figure 27. Average (AC) and marginal (MC) cost functions: Derived from equation (6.1A.1) for very large two-year public colleges.

never does begin a downward slope expected of quadratic functions generally. Accordingly, the TC function represented by equation (6.1A.1) does not have two roots. There are no two values of FTE which satisfy the condition, IEG = f(FTE, FTE^2) = zero. The reader may recall from the discussion in Chapter II that a quadratic function may have up to two roots. Such a condition is, of course, sufficient, but not necessary.

What is most interesting about the AC derived from equation 6.1A.1 is the narrowness of its range relative to the expanse of its domain--see Figure 27. The AC associated with very large two-year public colleges changes by only $724 per FTE across enrollment levels that vary from a low of 2,019 FTE to a high of over 14,000 FTE. Moreover, as reflected in Figure 27, the AC of very large colleges is $2,273 at 2,019 FTE, rises to a maximum value of $2,748 at 4,926 FTE, then begins a persistent slide to a minimum value of $2,024 at 14,507 FTE.

In contrast, the MC associated with very large two-year public colleges has a range as extensive as its domain--see also Figure 27. The average cost of education in a very large college ranges from a high of $3,398 at only 2,019 FTE to a low of only $566 at 14,507 FTE. Moreover, in relation to AC, the marginal cost (MC) is greater than the average cost (AC) between 2,019 to 4,926 FTE and less than AC between 4,926 and 14,507 FTE. The relationship between AC and MC is, of course, central to the economy/diseconomy of scale issue. In the case of very large two-year public colleges, any growth in enrollment between 2,019 and 4,926 FTE will be done so at the expense of increasing the overall AC of educating all students through that prospective enrollment level, for this is a period where diseconomies of scale may fail for very large two-year public colleges. On the other hand, any growth in enrollment levels beyond 4,926 FTE will serve to reduce the overall AC through that prospective enrollment level, so that economies of scale are achievable--see also Figure 28.

Because equation (6.1A) failed to achieve the least RSS of six equations tested, the range of values (but not their slope) represented in Figure 28 may not be as precise as it could be, but it is a reasonably close approximation. Moreover, as was the case with the medium large two-year public colleges, because the number of observations (N = 39) was so small relative to the known universe of 273 very large two-year public colleges--see Table 1 of Chapter

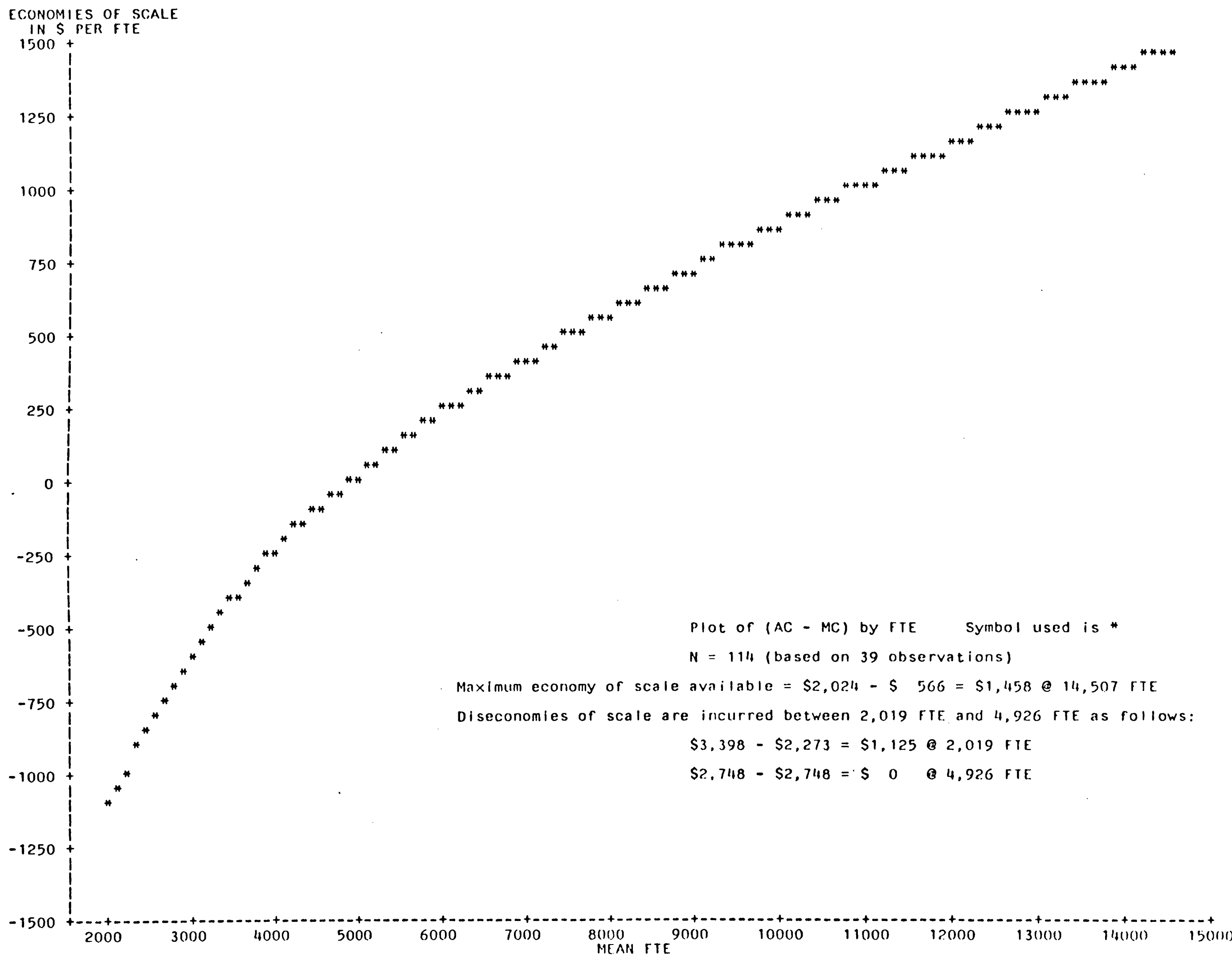

Figure 28. Economies of scale: Derived from equation (6.1A.1) quadratic model for very large two-year public colleges.

I--these findings cannot be generalized to the larger population of very large two-year public colleges.[35]

64 Total Large Colleges

Selecting the Best Model

The dominance of the quadratic model associated with 39 very large colleges prevailed over the linearity associated with 25 medium large colleges. As a result, the quadratic model (without interactive terms)--equation (6.1A)--was the best of the five models defined by the present study in predicting TC for 64 total large two-year public colleges. Equation (6.1A) reflected the highest R-squared statistic (.9046). While equation (6.1A) demonstrated only the third least RSS statistic (3.07181E+14)--behind equation (6.1) (2.94485E+14) and equation (7.1) (3.00252E+14)--equation (6.1A) also reflected three of its seven parameter terms as significant ($p < .05$)--FTE, FTE^2 and $DIVERSITY^2$. No other equation tested had more than two significant parameter estimates. The worst model in predicting TC for 64 total large colleges was the multiplicative model--equation (8.1)--which had the least R-squared statistic (.8361) and

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[35] Although 61 very large colleges were randomly selected from the known universe of 273 very large two-year public colleges, only 39 observations could be used in the present study since 22 schools had to be eliminated for lack of MARKET and/or ADJAVSAL data. Moreover, alternative methods to estimate such missing data were not attempted. As a result, the generalizations of equation (6.1A.1) to the population of all very large two-year public colleges could not be made.

the highest RSS statistic (5.56277E+14).

The superiority of the quadratic model in predicting TC for 64 total large two-year public colleges was interpreted as follows:

(1) R-squared = .9046: After controlling for ADJAVSAL, 90.46 percent of the variation in the dependent variable (TC) could be explained by 100 percent of the variation in the first and second power terms of the three independent variables (FTE, MARKET, and DIVERSITY).

(2) RSS - by posting only the third least RSS out of the six equations tested, equation (6.1A) failed to achieve one of the three criteria established to determine which equation best predicted TC. The sum of the squared differences between actual and predicted values for TC over the domain of the function, from 1,144 FTE to 14,507 FTE, lower in two other equations tested. Hence, the range (but not the slope) of the TC function represented by equation (6.1A) may be suspect.

(3) SEE: In posting the highest R-squared statistic and the third least RSS statistic, the parameter estimates (regression coefficients) for FTE, FTE^2 and $DIVERSITY^2$ were statistically significant ($p <$ .05. or better. The differences between the

calculated parameter estimates for each of these variables and zero was too large to have been due solely to chance. As substantiated earlier in Chapter III, significant parameter estimates are indicative of minimal standard errors of the estimate (SEE).

(4) In predicting TC, equation (6.1A) was itself statistically significant ($p < .0001$), i.e., after controlling for ADJAVSAL, the relationship between the first and second power terms of the three independent variables (FTE, MARKET and DIVERSITY) and the dependent variable (IEG) was too large (R = square root of .9046) to have been due solely to chance.

Table 25 presents the summarized regression results of all equations tested by model for 64 total large two-year public colleges, and Table 26 presents the estimated parameter values, (regression coefficients) for every term of each equation within the five models defined by the present study.

Curve Smoothing Techniques

Figure 29 is a two dimensional representation of the quadratic model, equation (6.1A), and depicts the actual (IEG) versus predicted (IEGHAT) total cost in terms of FTE for 64 total large two-year public colleges. For reasons

Table 25: Summarized Regression Results of Predicting TC For Total Large Two-Year Public Colleges (N = 64)

Model	Equation	Alternate Variable	Prob > $\lvert F \rvert$	Adjusted R-squared[1]	Residual SS	Parameters Having Significant (@.05) PROB > $\lvert T \rvert$
LINEAR	(5.1)	DIVERSITY	.0001	.8917	3.67425E+14	FTE, DIVERSITY
QUADRATIC	(6.1)	DIVERSITY (with interactive terms)	.0001	.9034	2.94485E+14	FTE
	(6.1A)	DIVERSITY (without interactive terms)	.0001	.9046	3.07181E+14	FTE, FTE^2, $DIVERSITY^2$
CUBIC	(7.1)	DIVERSITY	.0001	.9015	3.00252E+14	FTE
MULTIPLICATIVE[2]	(8.1)	DIVERSITY	.0001	.8361	5.56277E+14	FTE
TRANS-LOG[2]	(9.1)	DIVERSITY	.0001	.8978	3.29322E+14	FTE, DIVERSITY

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) included in each equation (5.1-9.1) according to the following formula:

$$\text{adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

[2] Results shown for exponential models are those of predicting the natural log of IEG.

Table 26: Estimated Parameter Values By Equation for Total Large Two-Year Public Colleges (N = 64)

Model Equation	Linear (6.1)	Quadratic (6.1)	Quadratic (6.1A)	Cubic (7.1)	Multiplicative (8.1)	Translog (9.1)
Y-Intercept	$ 752917	$ 1725161	$ 2359011	$ 1654447	-72202254*	$-53802229*
FTE	188.074*	3131.285*	3125.384*	2521.452*		1098.715*
MARKET	7613064	14586911	-21096325	-88377174		44286139
DIVERSITY	11353928*	-23567421	-24044817	-3087070		38297216*
ADJAVSAL	-31.230077	-15.690877	31.812373	56.856643	115.020	26.004256
FTE^2		-0.049641	-0.091795*	-0.009554736		
$MARKET^2$		127692403	331590220	2028892248		
$DIVERSITY^2$		52188867	51329919*	-11466046		
FTE^3				-0.00000477		
$MARKET^3$				-9979129641		
$DIVERSITY^3$				60105433		
FTE BY MARKET		-12364.956				
FTE BY DIVERSITY		-467.084				
MARKET BY DIVERSITY		73374610				
LN FTE					10311200*	4024693*
LN MARKET					158763	-1040627
LN DIVERSITY					15674.212	-8275050

*Significant at the .05 level, or better

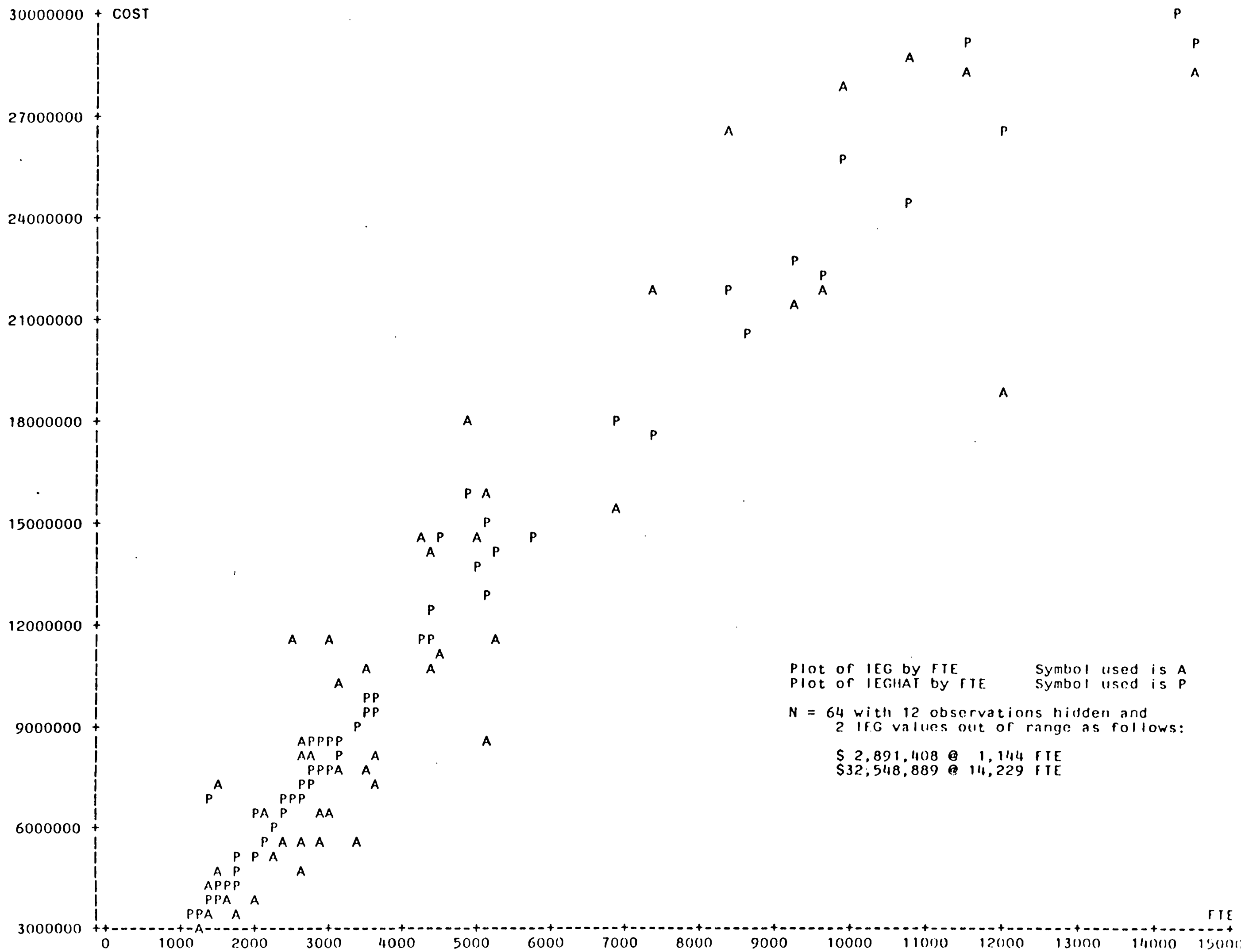

Figure 29. Actual (IEG) vs. predicted (IEGHAT) total cost: Equation (6.1A) quadratic model for total large two-year public colleges.

previously cited in Chapter II, the TC function represented by the P-values in Figure 29 is not yet a continuous, smooth function.

Based on the curve smoothing techniques described in Chapter II, a continuous, smooth TC function was developed--see Figure 30 and the supporting Figures F-34 through F-36 of Appendix F. The resulting continuous, smooth TC function, defined in terms of a single variable, FTE, and represented by equation (6.1A.1),[36] is equivalent to the quadratic model, equation (6.1A), defined in the first and second power terms of FTE, MARKET, and DIVERSITY after controlling for ADJAVSAL. In mathematical terms, both TC functions represent an identity. Equation (6.1A.1) is identically equivalent to equation (6.1A) or:

$$2359011+3125(FTE)-21096325(MARKET)-24044817(DIVERSITY)$$
$$-0.091795(FTE)^2+331590220(MARKET)^2+51329919(DIVERSITY)^2$$
$$+31.812373(ADJAVSAL)$$

is equivalent to

$$-748712+3303.2724(FTE)-0.08157718(FTE)^2.$$

[36] Average predicted TC = $-748712+3303.2724(\text{mean FTE})-0.08157718(\text{mean FTE})^2$. For a summary of the regression results, see Table 27.

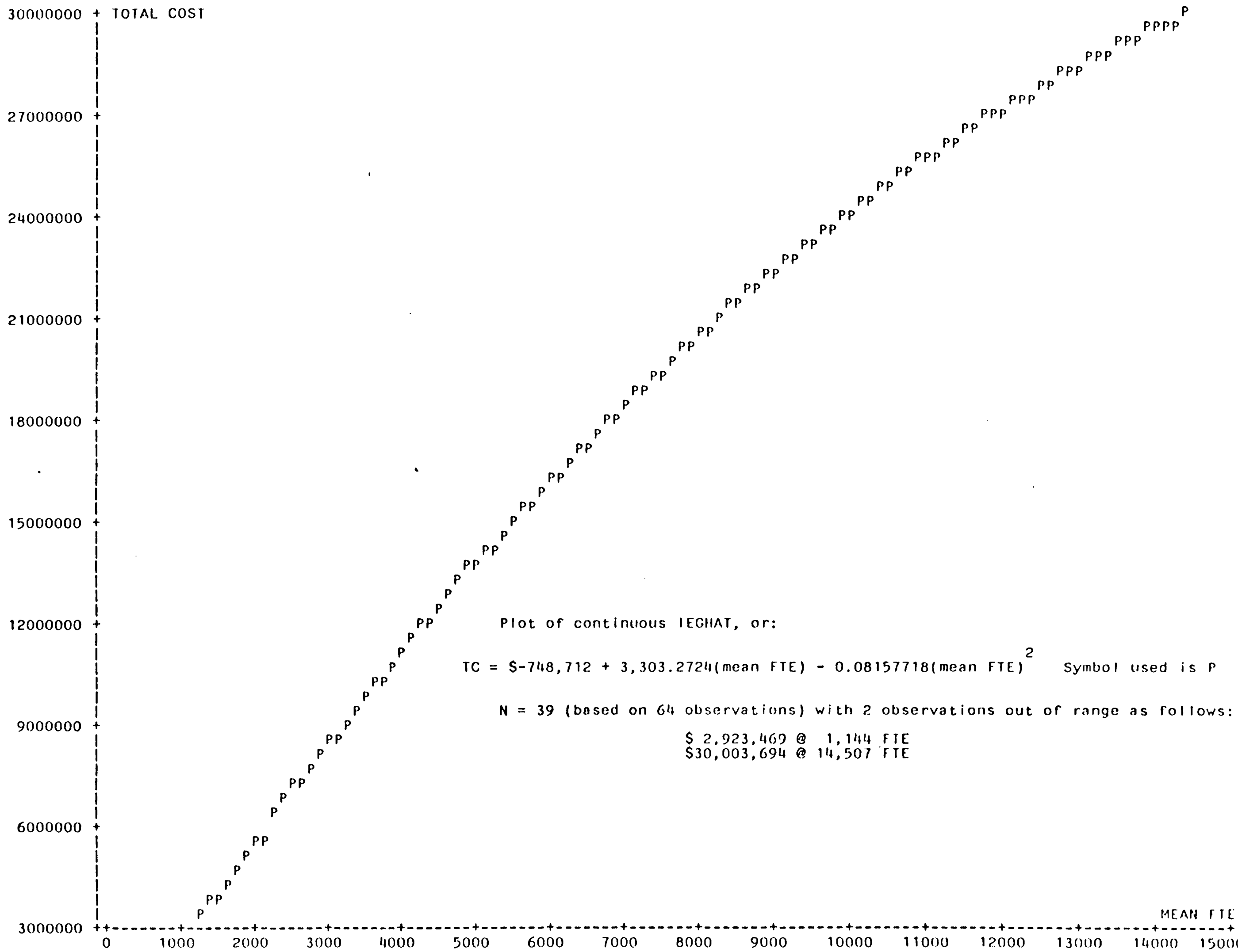

Figure 30. Continuous average predicted total cost: Equation (6.1A.1) quadratic model for total large two-year public colleges.

Table 27: Summarized Regression Results of Curve Smoothing Techniques for Total Large Two-Year Public Colleges (N = 64)

Model	Equation	Prob > |F|	Adjusted R-Squared[1]	Residual SS	Parameter Estimate	T for H0: Parameter = 0	Prob > |T|
QUADRATIC	6.1A.1	.0001	.9862	3.40778E+13	Y-intercept: -748712	-1.57	0.1243
					Mean FTE: 3303.2724	19.24	0.0001
					Mean FTE^2: -0.08157718	-6.95	0.0001

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) according to the following formula:

$$\text{Adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

Derivation of MC and AC Functions

Based on the continuous, smooth TC function represented by equation (6.1A.1), the AC function for 64 total large two-year colleges was derived as follows:

AC - TC/Mean FTE

Because equation (6.1A.1) is a multiplicative TC function, the first derivative of such an equation with respect to FTE (in this case $3,303) cannot yield a valid MC function for the reasons previously reviewed in Chapter II. Accordingly, the applicable MC function was derived by using Hirshleifer's (1980) better approximation method, also previously described in Chapter II. The result of this better approximation method produced a MC ranging from a minimum of $947 @ 1,144 FTE to a maximum of $3,103 @ 14,507 FTE for total large colleges. The resulting MC and AC functions derived from equation (6.1A.1), were then plotted together so that they could be readily compared with one another--see Figure 31.

Since the TC function represented by equation (6.1A.1) is quadratic--see Figure 30--the MC function derived from it (Figure 31) is in fact) consistent with the universal properties of all quadratic TC functions as previously outlined in Chapter II. Of special interest is the property that the MC of a nonlinear function must also be nonlinear, since the slope of the TC function is nonconstant over the domain of a nonlinear function.

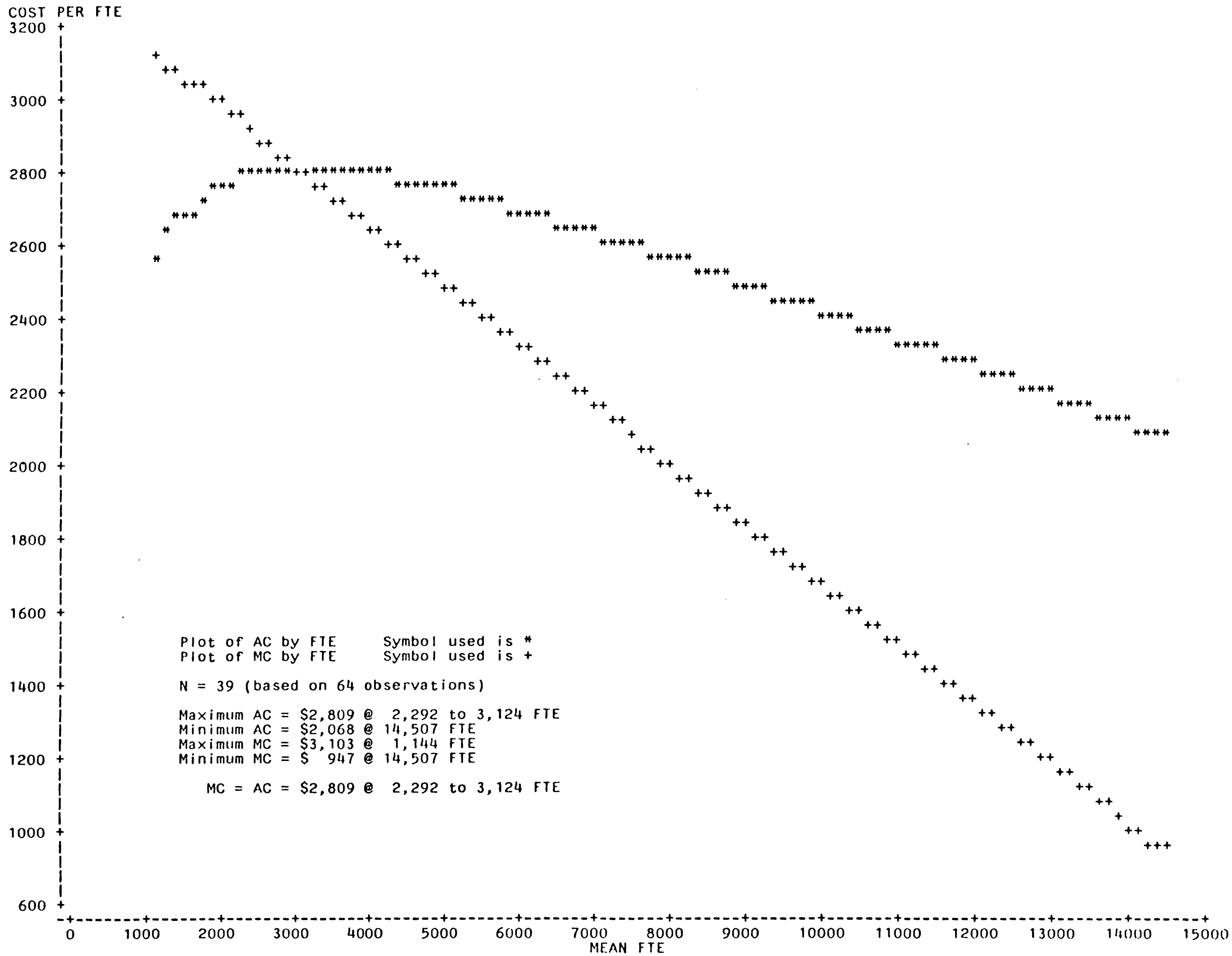

Figure 31. Average (AC) and marginal (MC) cost functions: Derived from equation (6.1A.1) for total large two-year public colleges.

An inspection of Figures 30 and 31 indicates that equation (6.1A.1) is consistent with these universal properties of quadratic TC functions. For example, the TC represented by equation (6.1A.1) and plotted as Figure 30 has the familiar convex slope associated with all quadratic functions. This particular function is, however, restricted by its domain (from 1,144 FTE to 14,507 FTE) and, accordingly, the function never does maximize. There are no two values of FTE which satisfy the condition, IEG = f(FTE, FTE^2) = zero. However, such a condition is, of course, sufficient, but not necessary.

Like that expressed by equation 6.1A.1 in defining the AC of 39 very large colleges, the AC of 64 total large colleges had a very narrow range--see Figure 31. The AC associated with total large two-year public colleges changes by only $741 per FTE across enrollment levels that vary from a low of 1,144 FTE to a high of over 14,000 FTE. Moreover, as reflected in Figure 31, the AC of total large colleges is $2,555 at 1,144 FTE, rises to a maximum value of $2,809 at 2,992 FTE, then begins a persistent path to a minimum value of $2,068 at 14,507 FTE. While MC = AC = $2,748 at 4,926 FTE for very large two-year public colleges, MC = AC = $2,809 at only 2,992 FTE for total large two-year public colleges. The rather sharp drop in enrollment level where MC = AC (from 4,926 FTE to only 2,992 FTE) is, of course, due to the inclusion of 25 medium large institutions with enrollment levels ranging from 1,144 to 3,064 FTE.

In contrast, the MC associated with total large two-year colleges has a range as extensive as its domain--see also Figure 31. The cost of educating the marginal student in a large two-year public college (with headcount > 2,500) ranges from a high of $3,103 at 1,144 FTE to a low of only $947 at 14,507 FTE. Moreover, in relation to AC, the marginal cost (MC) is greater than the average cost (AC) between 1,114 to 2,992 FTE, and less than AC between 2,992 and 14,507 FTE. The relationship between AC and MC is crucial to the economy/diseconomy of scale issue. In the case of large two-year public colleges (with headcount > 2,500), any growth in enrollment between 1,144 and 2,992 will be done so at the expense of increasing AC, in which case such a college will be operating uneconomically. In contrast, any growth in enrollment levels beyond 2,992 FTE will serve to reduce the overall AC through that prospective enrollment level, so that economies of scale are achievable--see also Figure 32. Because equation 6.1A failed to achieve the least RSS of six equations tested, the range of values, but not their slope, represented in Figure 32 is suspect. Moreover, for the reasons cited earlier in Chapter III with respect to 25 medium large and 39 very large two-year public colleges, the findings with respect to

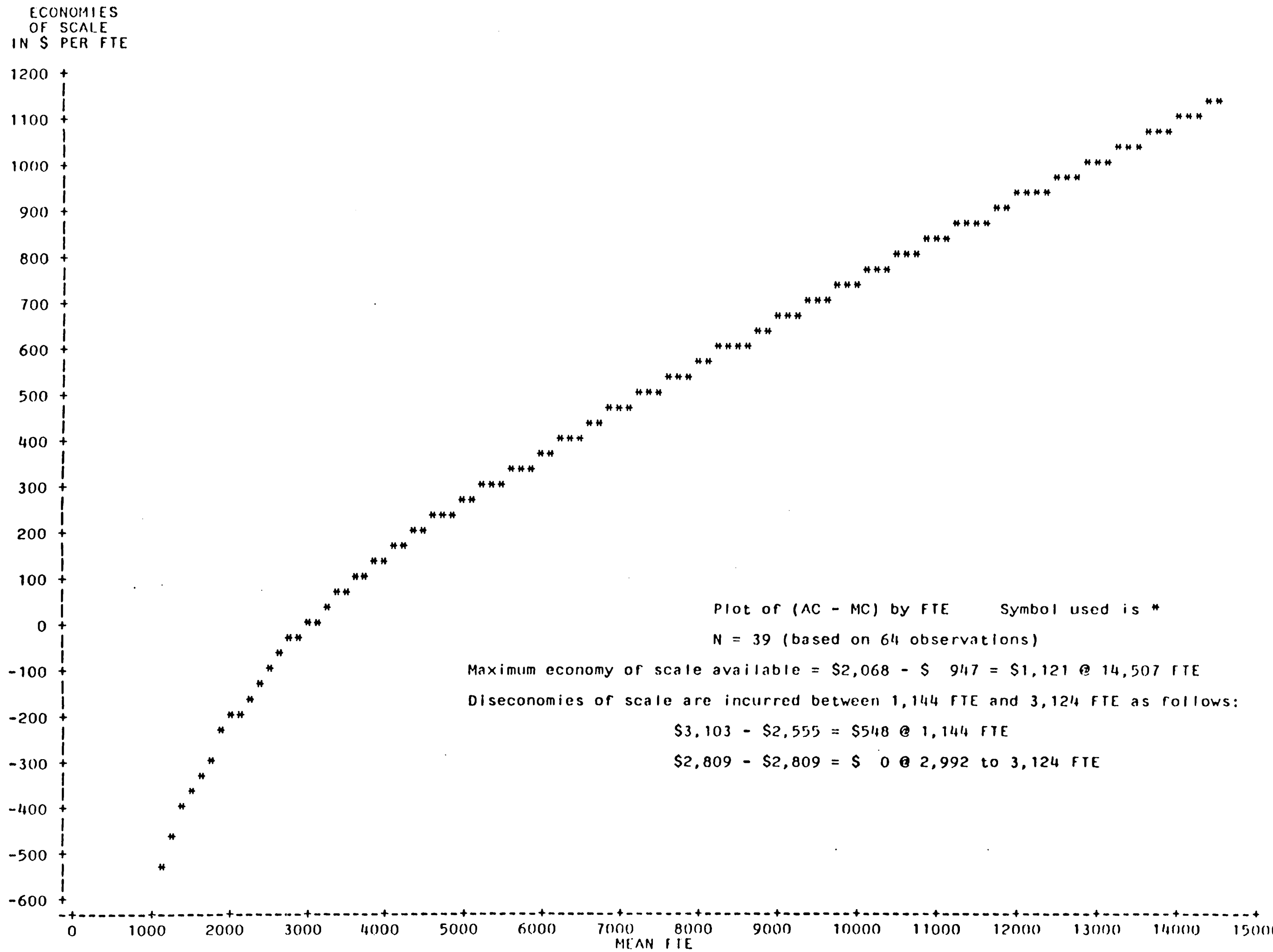

Figure 32. Economies of scale: Derived from equation (6.1A.1) quadratic model for total large two-year public colleges.

64 total large colleges cannot be generalized to the larger population of all large two-year public colleges (N = 447 per Table 1 of Chapter I).

377 COMPOSITE I Colleges

Selecting the Best Model

Both the quadratic model with interactive terms--equation (6.1)--and the cubic model--equation (7.1)--reflected the highest R-squared statistics (.9300) for 377 COMPOSITE I two-year public colleges, (i.e., for 194 small rural + 51 small nonrural + 68 small technical + 25 medium large + 39 very large colleges). Although the cubic model--equation (7.1)--minimized SEE by having five of its ten parameter estimates as significant ($p < .05$), the quadratic model with interactive terms--equation (6.1)--reflected the least RSS (5.26559E+14) of all equations tested. Moreover, the mix of significant parameter estimates for equation (6.1) involved all three independent variables--FTE, MARKET and DIVERSITY--whereas the mix of significant parameter estimates for equation (7.1) involved only FTE and DIVERSITY. Accordingly, the quadratic model with interactive terms--equation (6.1)--was the best model in predicting TC for 377 COMPOSITE I two-year public colleges. Consistent with earlier findings, the worst model in predicting TC for COMPOSITE I colleges was the multiplicative model--equation (8.1)--with an R-squared statistic of only .6920 and an RSS of 23.55080E+14.

The superiority of the quadratic model with interactive terms in predicting TC for 377 COMPOSITE I two-year public colleges was interpreted as follows:

(1) R-squared = .9300: After controlling for ADJAVSAL, 93.00 percent of the variation in the dependent variable (TC) could be explained by 100 percent of the variation in the three independent variables (FTE, MARKET, and (DIVERSITY) acting together as a linear combination of their linear (first power), quadratic (second power) and interactive terms, i.e., equation (6.1).

(2) RSS - by posting the least RSS, equation (6.1) achieved what no other equation tested had achieved: the sum of the squared differences between the actual and predicted values for TC over the domain of the equation--150 FTE to 14,507 FTE, was the least of any of the six equations tested--see Table 28.

(3) SEE: In posting the highest R-squared statistic and the third least RSS statistic, the parameter estimates (regression coefficients) for FTE, FTE^2, FTE by MARKET, and FTE BY DIVERSITY were statistically significant ($p < .05$. or better). The differences between the calculated parameter estimates for each of these variables and zero was

Table 28: Summarized Regression Results of Predicting TC For COMPOSITE I Two-Year Public Colleges (N = 377)

Model	Equation	Alternate Variable	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameters Having Significant (@.05) PROB > |T|
LINEAR	(5.1)	DIVERSITY	.0001	.9213	6.02124E+14	FTE, DIVERSITY
QUADRATIC	(6.1)	DIVERSITY (with interactive terms)	.0001	.9300	5.26559E+14	FTE, FTE^2, FTE BY MARKET, FTE BY DIVERSITY
	(6.1A)	DIVERSITY (without interactive terms)	.0001	.9270	5.53967E+14	FTE, FTE^2, $DIVERSITY^2$
CUBIC	(7.1)	DIVERSITY	.0001	.9300	5.26924E+14	FTE, FTE^2, FTE^3, $DIVERSITY^3$, ADJAVSAL
MULTIPLICATIVE[2]	(8.1)	DIVERSITY	.0001	.6920	23.55080E+14	FTE, ADJAVSAL
TRANS-LOG[2]	(9.1)	DIVERSITY	.0001	.9226	5.87408E+14	FTE, MARKET, DIVERSITY

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) included in each equation (5.1-9.1) according to the following formula:

$$\text{adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

[2] Results shown for exponential models are those of predicting the natural log of IEG.

too large to have been due solely to chance. As substantiated earlier in Chapter III, significant parameter estimates are indicative of minimal standard errors of the estimate (SEE).

(4) In predicting TC, equation (6.1) was itself statistically significant ($p < .0001$). After controlling for ADJAVSAL, the relationship between the three independent variables (FTE, MARKET and DIVERSITY) expressed in their linear (first power), quadratic (second power) and interactive terms, and the dependent variable (IEG) was too large (R = square root of .9300) to have been due solely to chance.

Table 28 presents the summarized regression results of all equations by model for 377 COMPOSITE I two-year public colleges, and Table 29 presents the estimated parameter values, (regression coefficients) for every term of each equation within the five models defined by the present study.

Curve Smoothing Techniques

Figure 33 is a two dimensional representation of the quadratic model, equation (6.1), and depicts the actual (IEG) versus predicted (IEGHAT), total cost in terms of FTE for 377 COMPOSITE I two-year public colleges. For reasons previously cited in Chaper II, the TC function represented

Table 29: Estimated Parameter Values By Equation For COMPOSITE I Two-Year Public Colleges (N = 377)

Model Equation	Linear (5.1)	Quadratic (6.1)	Quadratic (6.1A)	Cubic (7.1)	Multiplicative (8.1)	Translog (9.1)
Y-intercept	$15277.256	$ 330248	$ 770464*	$ 225492	$-25790073*	$ -6222979*
FTE	2040.177*	2052.787*	2469.049*	1889.501*		1896.854*
MARKET	8048753	10453963	-6923025	-21844068		21179590*
DIVERSITY	5895372*	2265331	-4429137	11520965		11506170*
ADJAVSAL	38.222926	27.584590	29.569858	44.652532*	184.402*	31.062712
FTE^2		-0.082184*	-0.046509*	0.094199*		
MARKET^2		208465215	195675788	64949170		
DIVERSITY^2		-3336464	22069837*	-43471796		
FTE^3				-0.000007849*		
MARKET^3				-3080715425		
DIVERSITY^3				76676193*		
FTE BY MARKET		-7716.337*				
FTE BY DIVERSITY		2839.531*				
MARKET BY DIVERSITY		-25035498				
LN FTE					4400940*	301200
LN MARKET					-99694.471	-299074
LN DIVERSITY					502598	-988076*

*Significant at the .05 level, or better

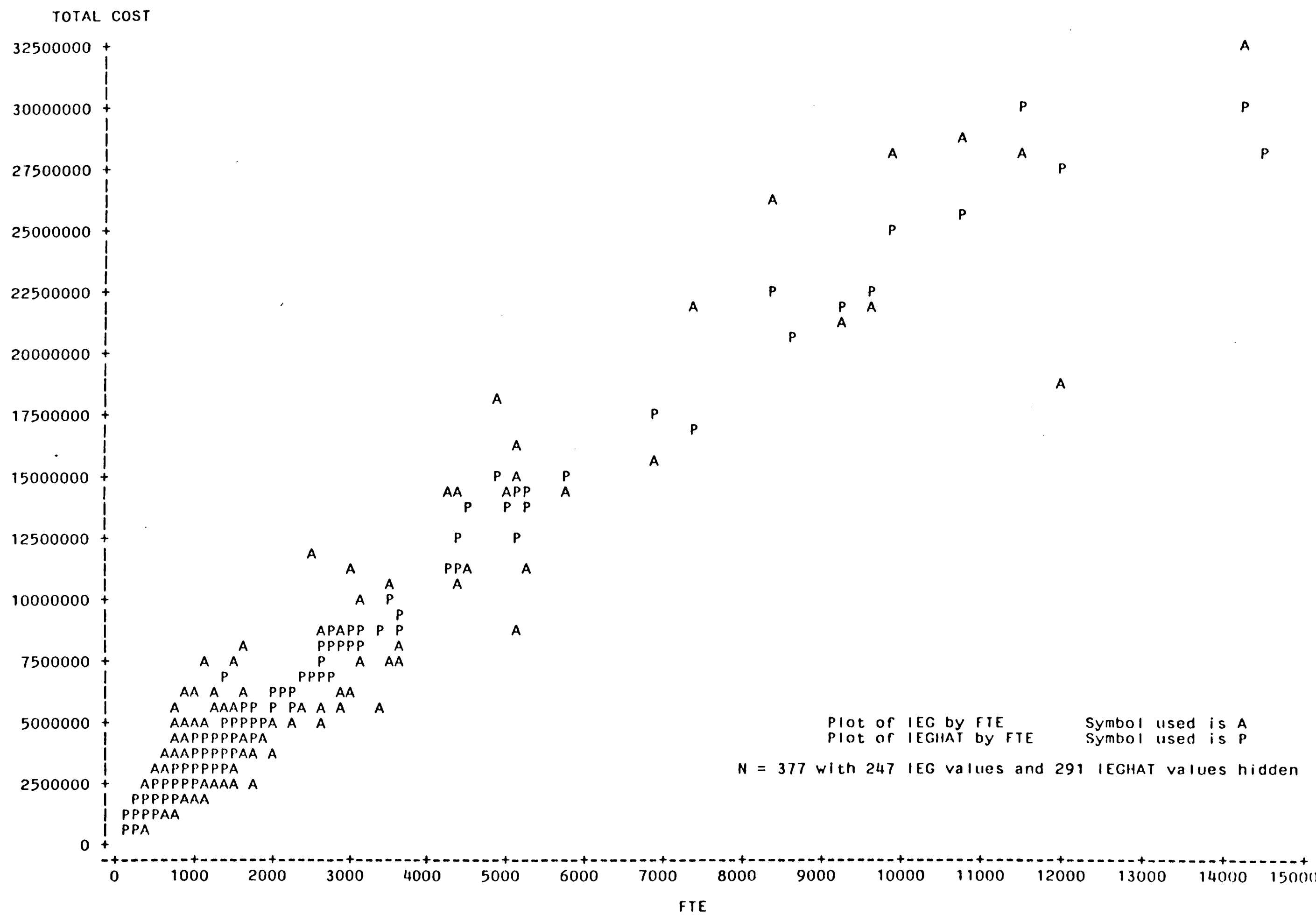

Figure 33. Actual (IEG) vs. predicted (IEGHAT) TC: Equation (6.1) quadratic model for COMPOSITE I 2-year public colleges.

by the P-values in Figure 33 is not yet a continuous, smooth function.

Based on the curve smoothing techniques described in Chapter II, a continuous smooth TC function was developed--see Figure 34 and supporting Figures F-37 through F-39 of Appendix F. The resulting continuous, smooth TC function, defined in terms of a single variable, FTE, and represented by equation (6.1.1)[37] is equivalent to the quadratic model equation (6.1), defined in terms of FTE, MARKET, DIVERSITY--including first power, second power, and interactive terms--after controlling for ADJAVSAL. In mathematical terms, both TC functions represent an identity. Equation (6.1.1) is identically equivalent to equation (6.1) or:

$$330248+2053(FTE)-10453963(MARKET)+2265331(DIVERSITY)$$
$$-0.08218419(FTE)^2+208465214(MARKET)^2-3336463(DIVERSITY)^2$$
$$-7716(FTE\ BY\ MARKET)+2839(FTE\ BY\ DIVERSITY)-25035498(MARKET\ BY$$
$$DIVERSITY)+27.58458962(ADJAVSAL)$$

is equivalent to $132398+2989.7716(FTE)-0.06160759(FTE)^2$.

<u>Derivation of MC and AC Functions</u>

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[37] Average predicted TC = 132,398 + 2,989(mean FTE)-0.06160759(mean FTE)^2. For a summary of the regression results, see Table 30.

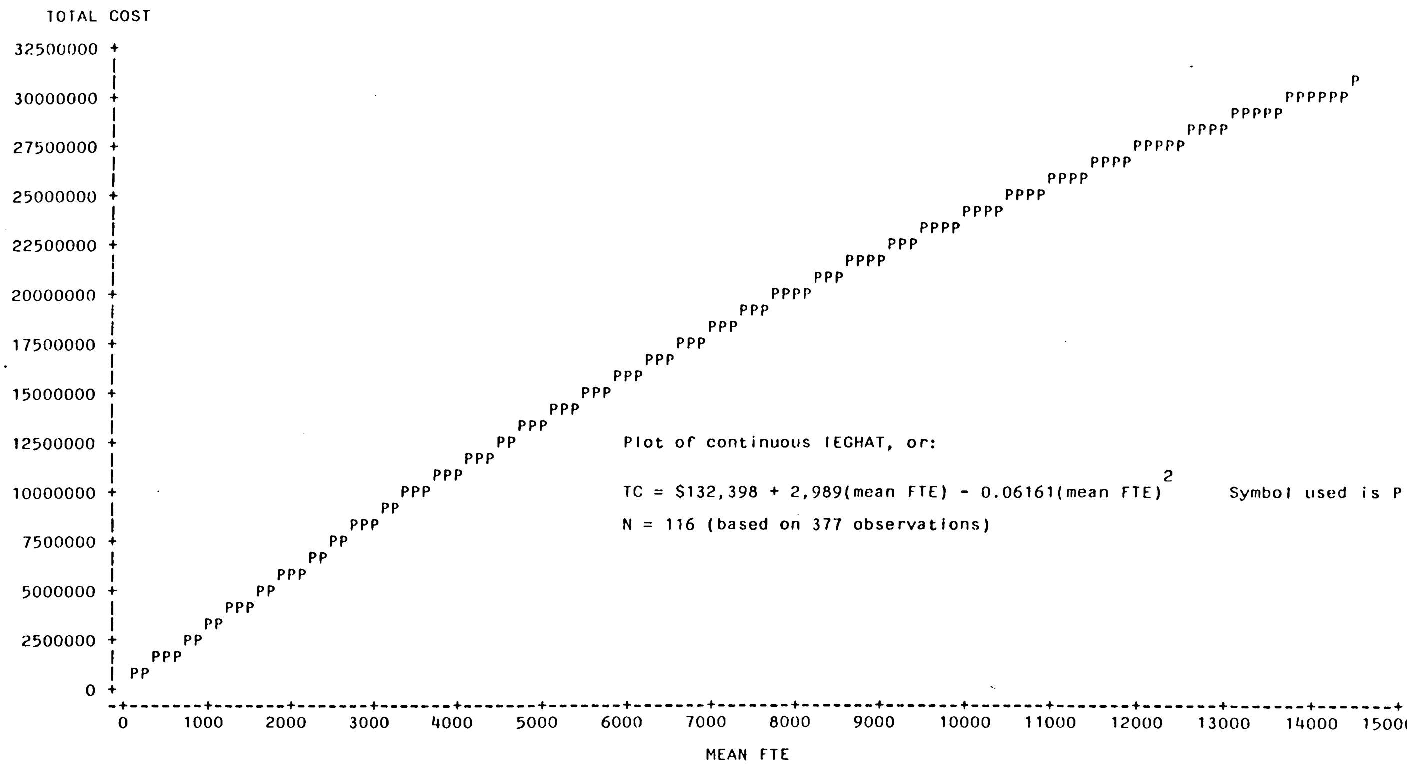

Figure 34. Continuous average predicted total cost: Equation (6.1.1) quadratic model for COMPOSITE I 2-year public colleges.

Table 30: Summarized Regression Results of Curve Smoothing Techniques for COMPOSITE I Two-Year Public Colleges (N = 377)

Model	Equation	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameter Estimate		T for HO: Parameter = 0	Prob > |T|
QUADRATIC	6.1.1	.0001	.9879	3.93486E+13	Y-intercept:	132398	.44	.6601
					Mean FTE:	2989.7716	24.04	.0001
					$(\text{Mean FTE})^2$:	-0.06161	-6.71	.0001

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) according to the following formula:

$$\text{Adjusted } R^2 = R^2 - (1-R^2)k/N-k-1)$$

Based on the continuous, smooth TC function represented by equation (6.1.1), the AC function for 377 COMPOSITE I two-year colleges was derived as follows:

AC = TC/Mean FTE

Because equation (6.1.1) is a multivariate TC function, the first derivative of such an equation, with respect to FTE would only be a partial derivative and, therefore, would not yield a valid MC function for the reasons previously reviewed in Chapter II. Accordingly, the applicable MC function was derived by using Hirshleifer's (1980) better approximation method, also previously described in Chapter II. The resulting MC and AC functions, derived from equation (6.1.1), were then plotted together so that they could be readily compared with one another--see Figure 35.

Since the TC function represented by equation (6.1.1) is quadratic--see Figure 34--the MC function derived from it (Figure 35) must be consistent with the universal properties of all quadratic TC functions as previously outlined in Chapter II. Of special interest is the property that the MC of a quadratic TC function, unlike that of a linear TC function, cannot be constant over the domain of the function. MC derived from a quadratic TC function must be curvilinear, rather than linear. Similarly, unlike that of a liner TC function, the quadratic function may have two roots. There may be two values of FTE which satisfy the

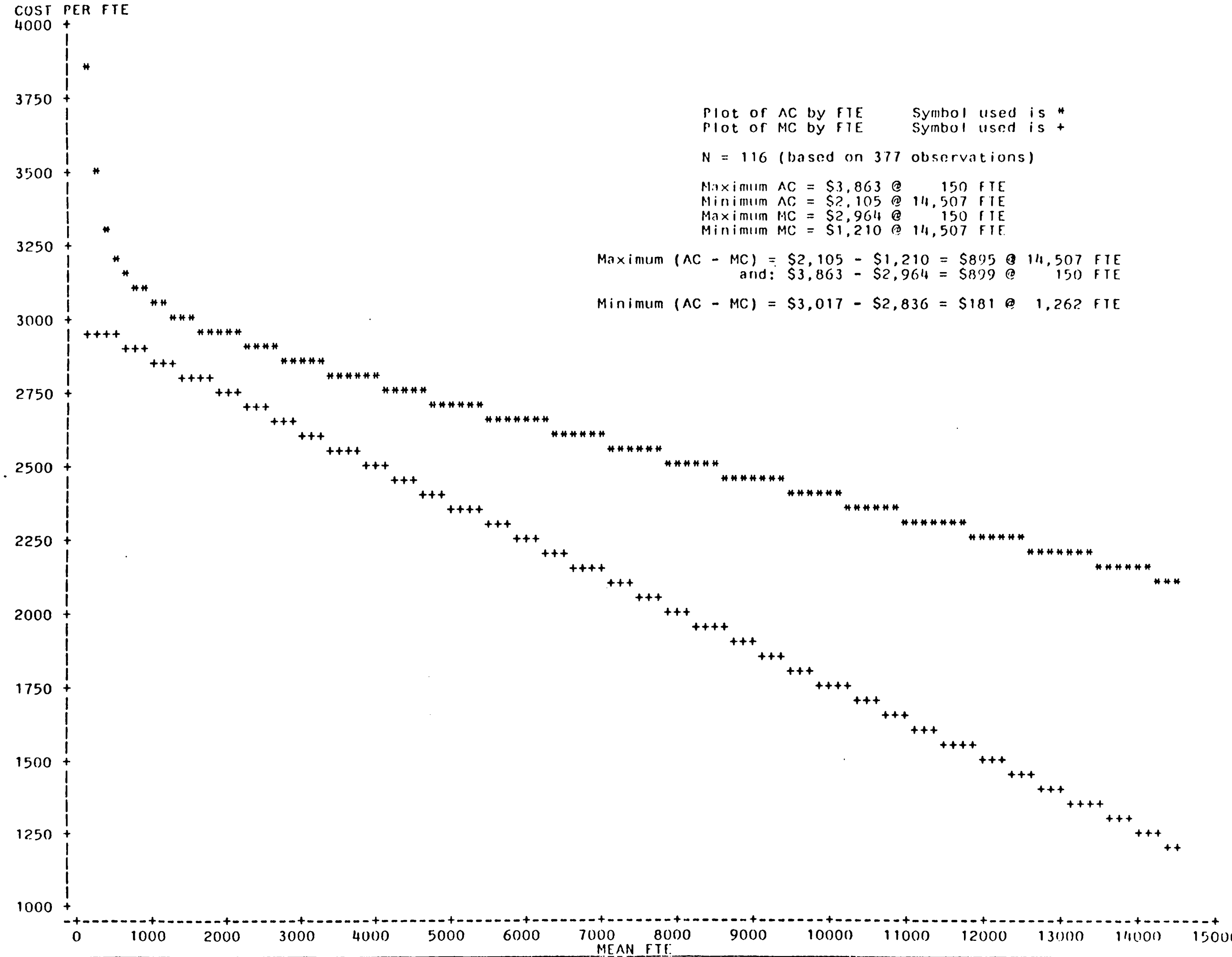

Figure 35. Average (AC) and marginal (MC) cost functions: Derived from equation (6.1.1) for COMPOSITE I 2-yr public colleges.

condition, IEG = f (FTE, FTE^2) = zero. Hence, unlike a linear TC function, a quadratic TC function may change direction two times within the same quadrant.

An inspection of Figures 34 and 35 indicates that equation (6.1.1) is consistent with these universal properties of quadratic TC functions. For example, while the overall appearance of the plot of equation (6.1.1) is linear, a closer inspection of Figure 34 confirms the fact that this equation is curvilinear. The curvilinearity of the slope of equation (6.1.1) becomes even more apparent in its associated MC function (Figure 35), which is nonconstant, ranging from $2,964 at 150 FTE to a minimum of $1,210 at 14,507 FTE. Consistent with all quadratic functions, the MC function lies below AC over a large portion of the domain of its related TC function, indicating that economies of scale are achievable over this range. Consequently, based on an analysis of 377 COMPOSITE I two-year public colleges, economies of scale are achievable over all enrollment levels between 150 and 14,507 FTE--see Figure 36.

However, for the reasons cited earlier in Chapter III with respect to 25 medium large and 39 very large two-year public colleges, the findings with respect to 377 COMPOSITE I two-year public colleges cannot be generalized to the larger population of all two-year public colleges (N = 886 per Table 1 of Chapter I).

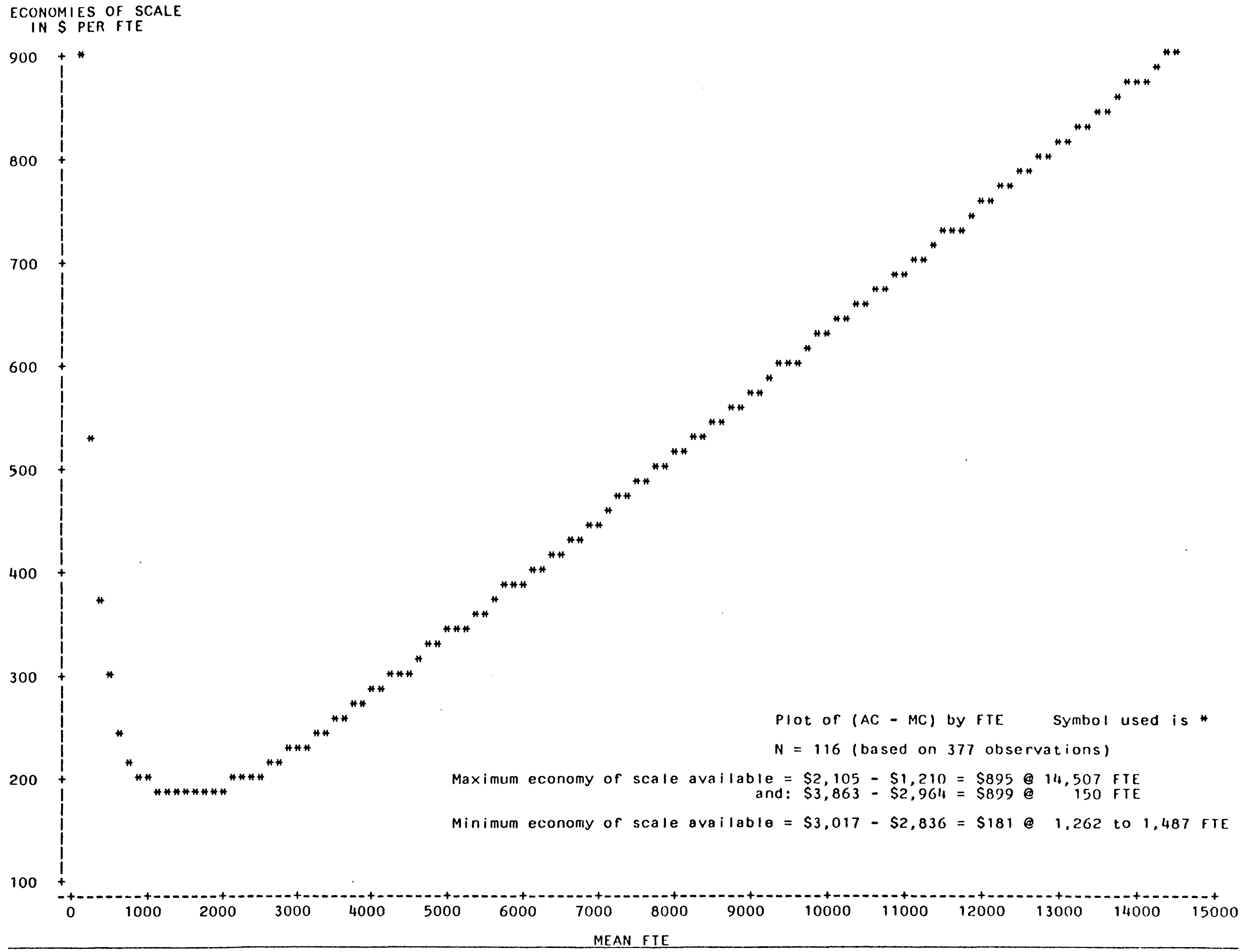

Figure 36. Economies of scale: Derived from equation (6.1.1) quadratic model for COMPOSITE I 2-year public colleges.

309 COMPOSITE II Colleges

Selecting the Best Model

The quadratic model with interactive terms--equation (6.1)--was the best model in predicting IEG for 309 COMPOSITE II two-year public colleges, that is, for 194 small rural + 51 small nonrural + 25 medium large + 39 very large colleges. The quadratic model reflected the highest R-squared statistic (.9379) and the least RSS (4.45318E+14) of all equations tested. In addition, equation (6.1) had more significant parameter estimates ($p < .05$) than any other equation tested. Consistent with earlier findings, the multiplicative model--equation (8.1)--was the worst model in predicting IEG for 309 COMPOSITE II colleges--(R-squared = .7146 and RSS = 20.87040E+14).

The superiority of the quadratic model with interactive terms in predicting TC for 309 COMPOSITE II two-year public colleges was interpreted as follows:

(1) R=squared = .9379: After controlling for ADJAVSAL, 93.79 percent of the variation in the dependent variable (TC) could be explained by 100 percent of the variation in the three independent variables (FTE, MARKET, and DIVERSITY) acting together as a linear combination of their linear, quadratic, and interactive terms, equation (6.1).

(2) RSS - by posting the least RSS, equation (6.1) achieved what no other equation tested had achieved--the sum of the squared differences between the actual and predicted values for TC over the domain of equation, 162 FTE to 14,507 FTE, was the least of any of the six equations tested--see Table 31.

(3) SEE: In posting the highest R-squared statistic and the least RSS statistic, the parameter estimates (regression coefficients) for FTE, FTE^2, FTE BY MARKET and FTE BY DIVERSITY were statistically significant ($p < .05$, or better). The differences between the calculated parameter estimates for each of these variables and zero was too large to have been due solely to chance. As substantiated earlier in Chapter III, significant parameter estimates are indicative of minimal standard errors of the estimate (SEE).

(4) In predicting TC, equation (6.1) was itself statistically significant ($p < .0001$). After controlling for ADJAVSAL, the relationship between the three independent variables (FTE, MARKET and DIVERSITY), expressed in their linear, quadratic, and interactive terms, and the dependent variable (IEG) was too large (R = square root of .9379) to have been due solely to chance.

Table 31: Summarized Regression Results of Predicting TC for COMPOSITE II Two-Year Public Colleges (N = 309)

Model	Equation	Alternate Variable	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameters Having Significant (@.05) PROB > |T|
LINEAR	(5.1)	DIVERSITY	.0001	.9280	5.26471E+14	FTE, DIVERSITY
QUADRATIC	(6.1)	DIVERSITY (with inter-active terms)	.0001	.9379	4.45318E+14	FTE, FTE^2, FTE BY MARKET, FTE BY DIVERSITY
	(6.1A)	DIVERSITY (without interactive terms)	.0001	.9348	4.72520E+14	FTE, DIVERSITY, FTE^2, DIVERSITY^2
CUBIC	(7.1)	DIVERSITY	.0001	.9377	4.46713E+14	FTE, FTE^3, DIVERSITY^3
MULTIPLICATIVE[2]	(8.1)	DIVERSITY	.0001	.7146	20.87040E+14	FTE, ADJAVSAL
TRANS-LOG[2]	(9.1)	DIVERSITY	.0001	.9296	5.09598E+14	FTE, MARKET, DIVERSITY

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) included in each equation (5.1-9.1) according to the following formula:

$$\text{adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

[2] Results shown for exponential models are those of predicting the natural log of IEG.

Table 31 presents the summarized regression results of all equations by model for 309 COMPOSITE II two-year public colleges, and Table 32 presents the estimated parameter values (regression coefficients) for every term of each equation within the five models defined by the present study.

Curve Smoothing Techniques

Figure 37 is a two dimensional representation of the quadratic model, equation (6.1), and depicts the actual (IEG) versus predicted (IEGHAT), total cost in terms of FTE for 309 COMPOSITE II small two-year public colleges. For reasons previously cited in Chapter II, the TC function represented by the P-values in Figure 37 is not yet a continuous, smooth function.

Based on the curve smoothing techniques described in Chapter II, a continuous smooth TC function was developed--see Figure 38 and supporting Figures F-40 through F-42 of Appendix F. The resulting continuous, smooth TC function, defined in terms of a single variable, FTE, and represented by equation (6.1.1)[38] is equivalent to the quadratic model equation (6.1), defined in terms of FTE, MARKET, DIVERSITY--including first power, second power and

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[38] Average predicted TC = 26299+3031(mean FTE)-0.06431378(mean FTE)^2. For a summary of the regression results, see Table 33.

Table 32: Estimated Parameter Values By Equation For Composite II Two-Year Public Colleges (N = 309)

Model Equation	Linear (5.1)	Quadratic (6.1)	Quadratic (6.1A)	Cubic (7.1)	Multiplicative (8.1)	Translog (9.1)
Y-intercept	$38498.170	$ 403517	$ 822665*	$ 209922	$-29605847*	$ -7487783*
FTE	2062.294*	2123.992*	2565.739*	1983.317*		1887.891*
MARKET	8325126	6207486	-7523448	-24888378*		23120160*
DIVERSITY	5534865*	1470451	-5767867*	12369353		11677479*
ADJAVSAL	27.791529	17.096469	18.926460	35.082753	189.817*	20.746107
FTE^2		-0.091380*	-0.051998*	0.088332		
$MARKET^2$		199241144	207884251	726868131		
$DIVERSITY^2$		-7236021	23362638*	-52113961		
FTE^3				-0.000007761*		
				-3363980708		
$MARKET^3$				88060357*		
$DIVERSITY^3$						
FTE BY MARKET		-9015.585*				
FTE BY DIVERSITY		3194.591*				
MARKET BY DIVERSITY		16586604				
LN FTE					4864211*	405001
LN MARKET					-113001	-364787
LN DIVERSITY					216225	-1098743*

*Significant at the .05 level, or better

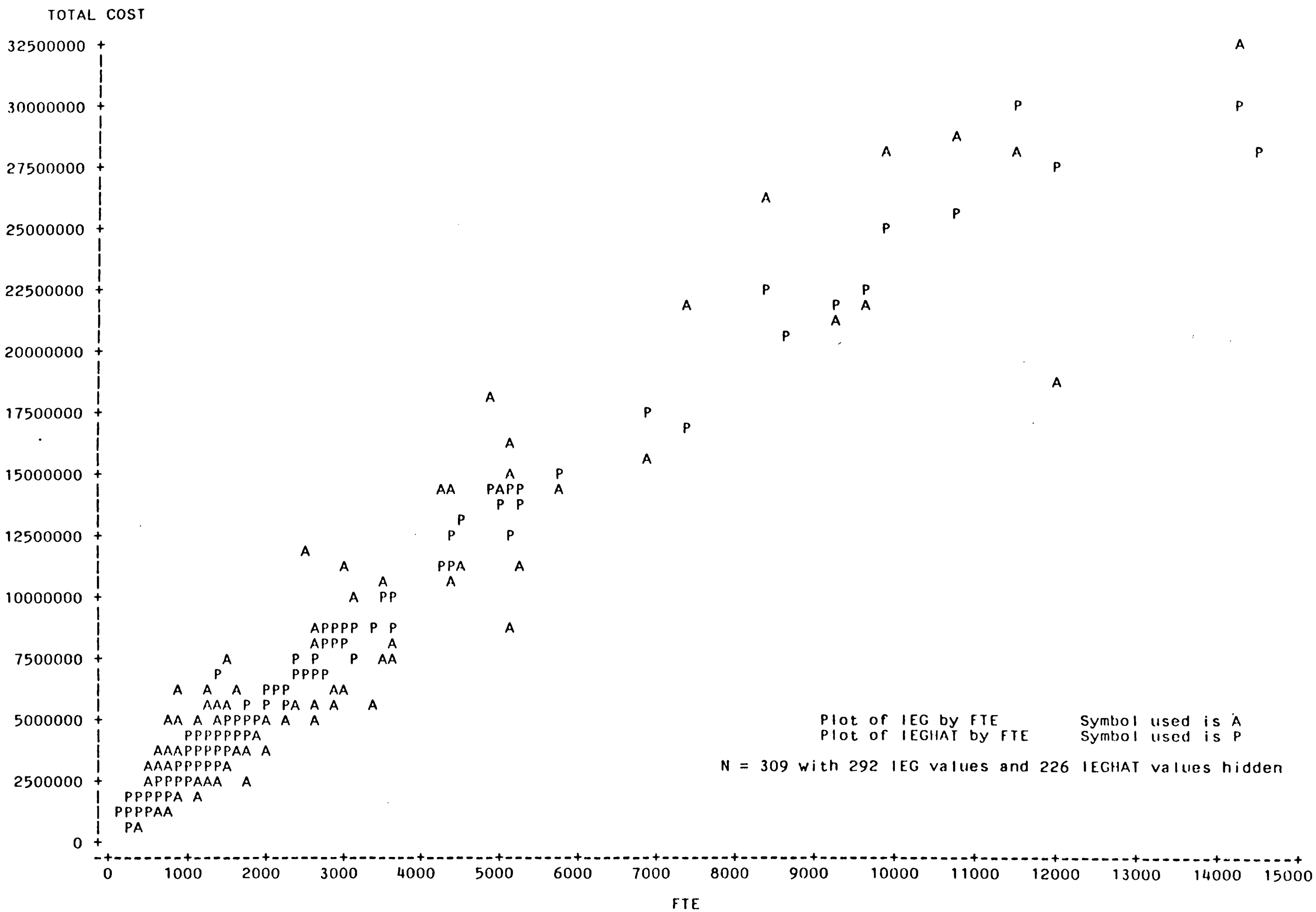

Figure 37. Actual (IEG) vs. predicted (IEGHAT) TC: Equation (6.1) quadratic model for COMPOSITE II 2-year public colleges.

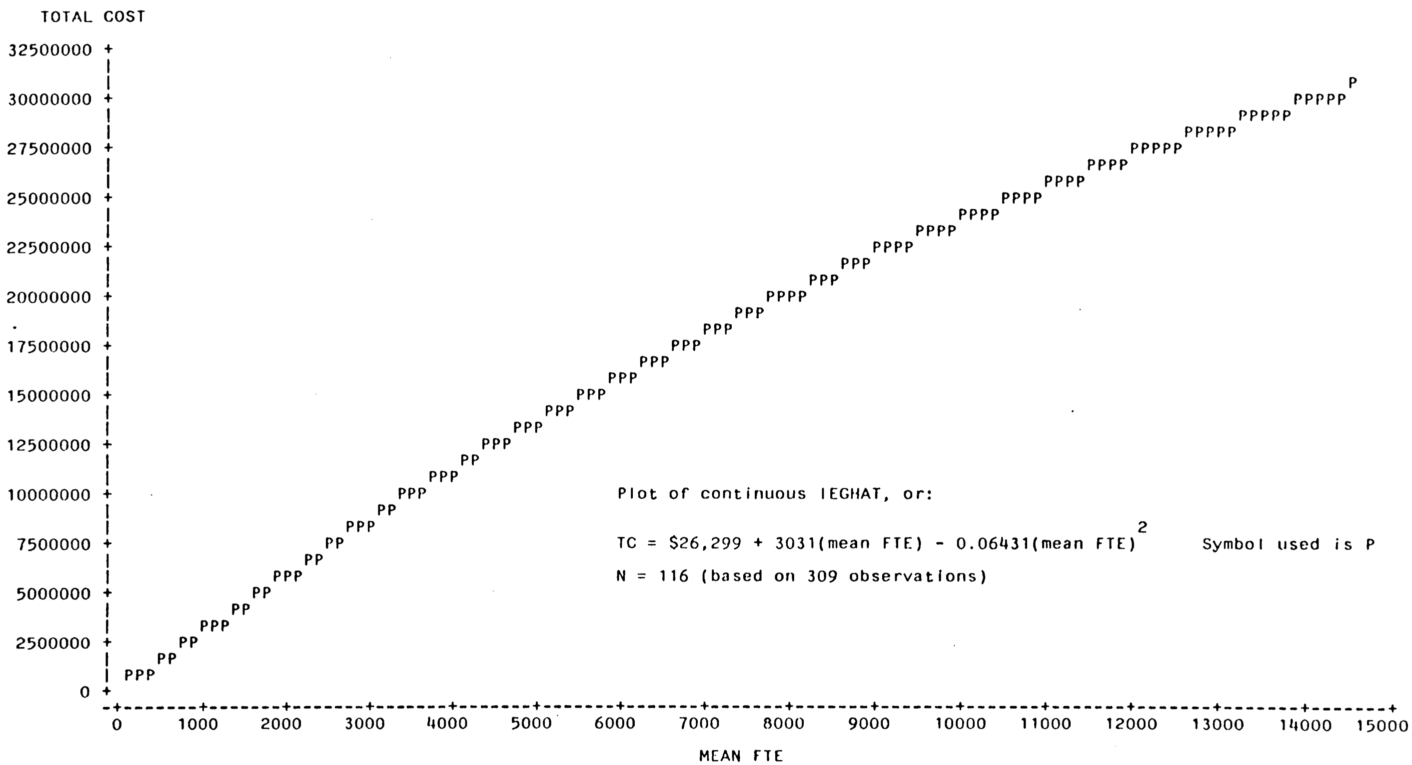

Figure 38. Continuous average predicted total cost: Equation (6.1.1) quadratic model for COMPOSITE II 2-year public colleges.

Table 33: Summarized Regression Results of Curve Smoothing Techniques for COMPOSITE II Two-Year Public Colleges (N = 309)

Model	Equation	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameter Estimate	T for HO: Parameter = 0	Prob > |T|
QUADRATIC	6.1.1	.0001	.9881	3.90109E+13	Y-intercept: 26299.7	.09	.93
					Mean FTE: 3031.1418	24.49	.0001
					$(\text{Mean FTE})^2$: -0.06431378	-7.04	.0001

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) according to the following formula:

$$\text{Adjusted } R^2 = R^2 - (1-R^2)k/N-k-1)$$

interactive terms--after controlling for ADJAVSAL. In mathematical terms, both TC functions represent an identity, that is, equation (6.1.1) is identically equivalent to equation (6.1) or:

$$403517+2123(FTE)+6207486(MARKET)+1470451(DIVERSITY)$$
$$-0.09137969(FTE)^2+199241144(MARKET)^2-7236020(DIVERSITY)^2$$
$$-9015(FTE\ BY\ MARKET)+3149(FTE\ BY\ DIVERSITY)+16586603(MARKET\ BY$$
$$DIVERSITY)+17.09646907(ADJAVSAL)$$

is equivalent to $\$26299+3031.1418(FTE)-0.06431378(FTE)^2$.

Derivation of MC and AC Functions

Based on the continuous, smooth TC function represented by equation (6.1.1), the AC function of 309 COMPOSITE II two-year colleges was derived as follows:

$$AC = TC/Mean\ FTE$$

Because equation (6.1.1) is a multivariate TC function, the first derivative of such an equation, with respect to FTE, would only be a partial derivative and, therefore, would not yield a valid MC function for the reasons previously reviewed in Chapter II. Accordingly, the applicable MC function was derived by using Hirshleifer's (1980) better approximation method, also previously described in Chapter II. The resulting MC and AC functions, derived from equation (6.1.1), were then plotted together so that they could be readily compared with one another--see Figure 39.

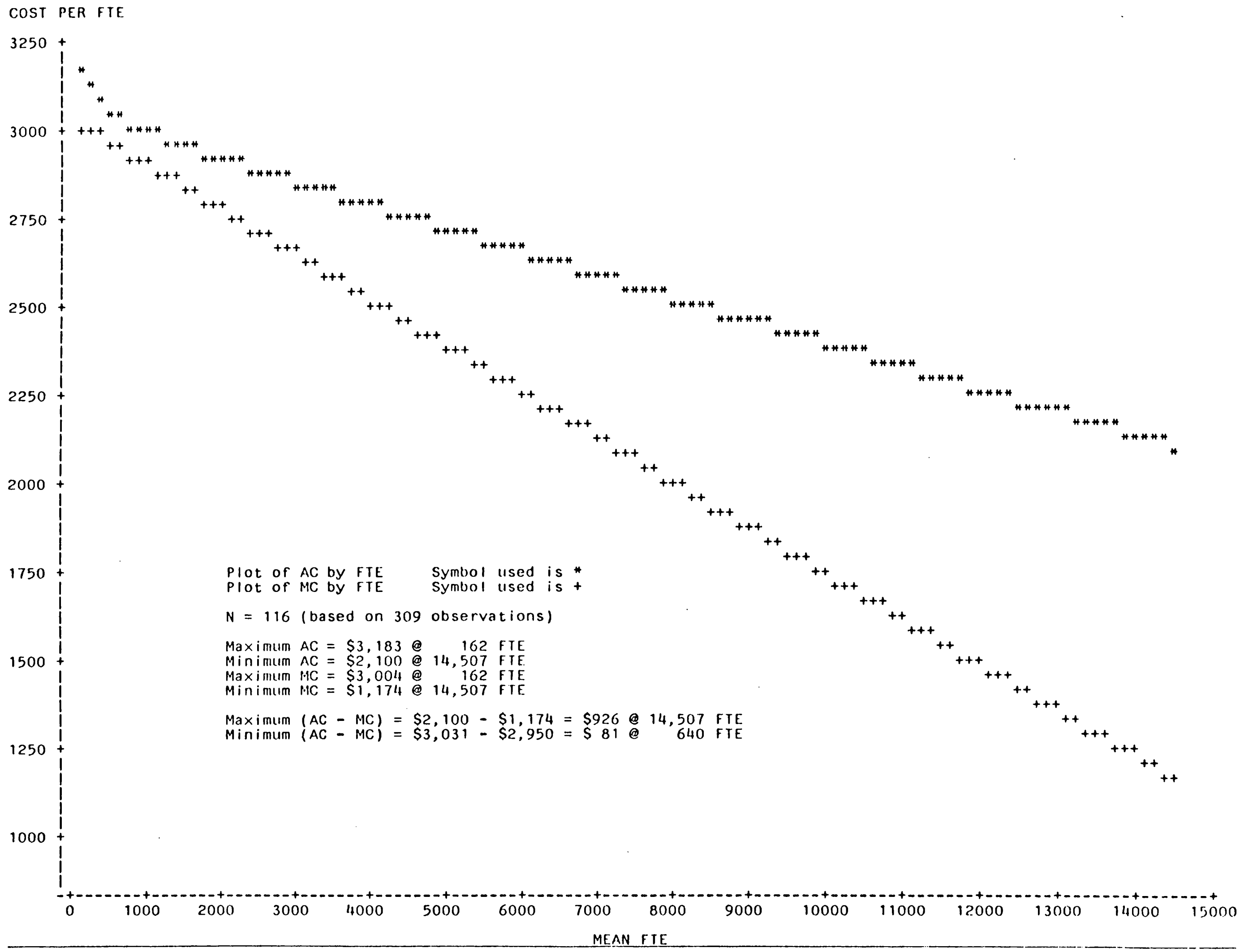

Figure 39. Average (AC) and marginal (MC) cost functions: Derived from equation (6.1.1) for COMPOSITE II 2-yr public colleges.

Since the TC function represented by equation (6.1.1) is quadratic--see Figure 38--the MC function derived from it (Figure 39) must be (and is, in fact) consistent with the universal properties of all quadratic TC functions as previously outlined in Chapter II. Of special interest is the property that the MC of a quadratic TC function, unlike that of a linear TC function, cannot be constant over the domain of the function. There may be two values of FTE which satisfy the condition, IEG = f (FTE, FTE^2) = zero. Hence, unlike a linear TC function, a quadratic TC function may change direction two times within the same quadrant.

An inspection of Figures 38 and 39 indicates that equation (6.1.1) is consistent with these universal properties of quadratic TC functions. For example, while the overall appearance of the plot of equation (6.1.1) is linear, a closer inspection of Figure 38 confirms the fact that this equation is curvilinear. The curvilinearity of the slope of equation (6.1.1) becomes even more apparent in its associated MC function (Figure 39), which is nonconstant, ranging from $3,004 at 162 FTE to a minimum of $1,174 at 14,507 FTE. Consistent with all quadratic functions, the MC function lies below AC over a large portion of the domain of its related TC function, indicating that economies of scale are achievable over this range. Consequently, based on an analysis of 309 COMPOSITE II two-year public colleges, economies of scale are achievable over all enrollment levels between 162 and 14,507 FTE--see Figure 40.

However, for the reasons cited earlier in Chapter III with respect to 25 medium large and 39 very large two-year public colleges, the findings with respect to 309 COMPOSITE II two-year public colleges cannot be generalized to the larger population of all two-year public colleges (N = 886 per Table 1 of Chapter I).

565 COMPOSITE III Colleges

Selecting the Best Model

The quadratic model with interactive terms--equation (6.1)--was the best model in predicting TC for 565 COMPOSITE III two-year public colleges, (for 194 small rural + 51 small nonrural + (5 x 25 = 125) medium large + (5 x 39 = 195) very large colleges. The quadratic model reflected the highest R-squared statistic (.9395) and the least RSS (1.65172E+15) of all equations tested. In addition, three of equation (6.1)'s ten parameter estimates were significant ($p < .05$). Consistent with earlier findings, the multiplicative model--equation (8.1)--was the worst model in predicting IEG for 565 COMPOSITE III colleges--(R-squared = .7640 and RSS = 6.51426E+15).

The superiority of the quadratic model with interactive terms in predicting TC for 565 COMPOSITE III two-year public colleges was interpreted as follows:

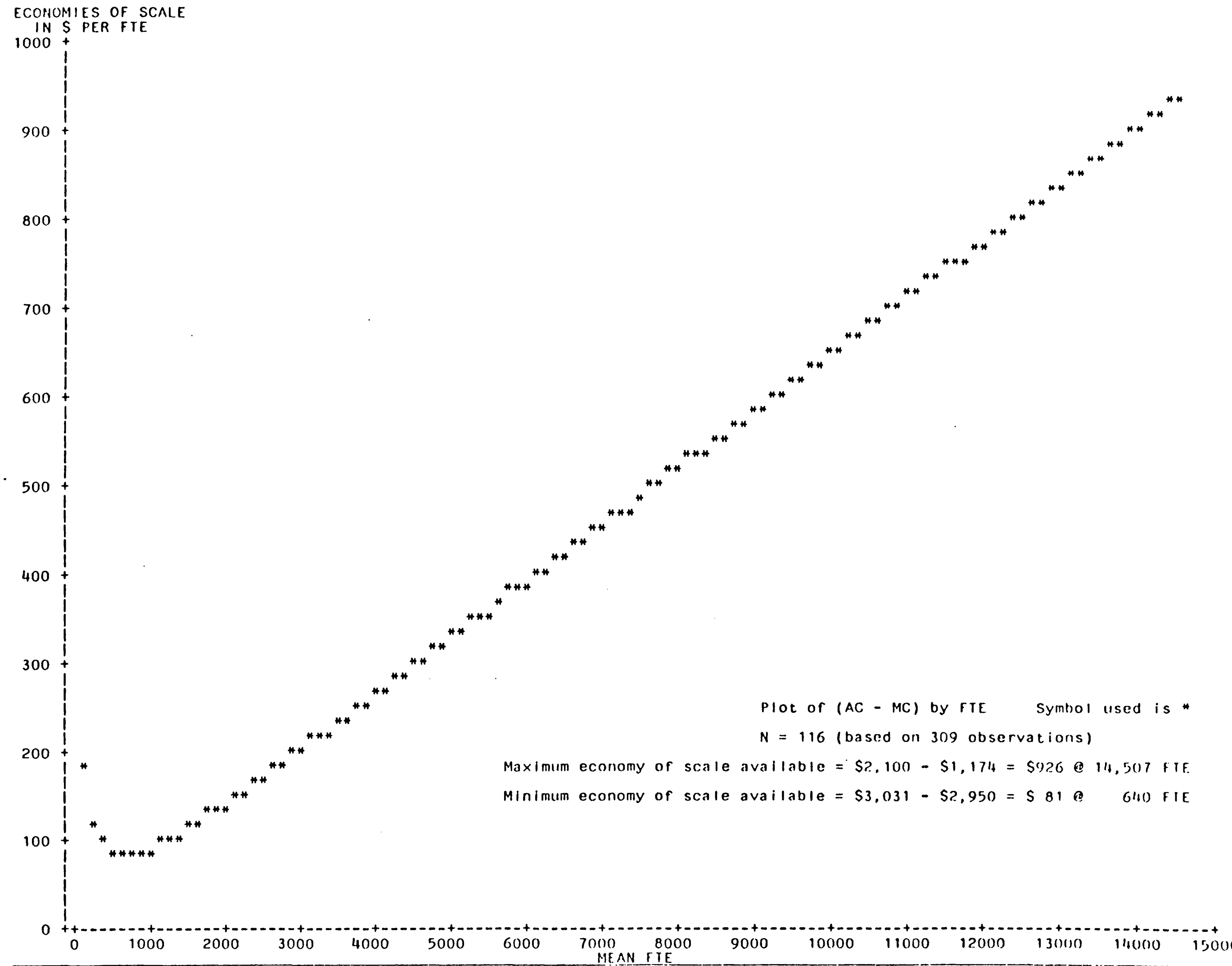

Figure 40. Economies of scale: Derived from equation (6.1.1) quadratic model for COMPOSITE II 2-year public colleges.

(1) R-squared = .9395: After controlling for ADJAVSAL, 93.95 percent of the variation in the dependent variable (TC) could be explained by 100 percent of the variation in the three independent variables (FTE, MARKET, and DIVERSITY) acting together as a linear combination of their linear, quadratic, and interactive terms, equation (6.1).

(2) RSS - by posting the least RSS, equation (6.1) achieved what no other equation tested had achieved--the sum of the squared differences between the actual and predicted values for TC over the domain of equation, 162 FTE to 14,507 FTE, was the least of any of the six equations tested--see Table 34.

(3) SEE: In posting the highest R-squared statistic and the least RSS statistic, the parameter estimates (regression coefficients) for FTE, FTE^2, FTE BY MARKET) were statistically significant ($p < .05$, or better. The difference between the calculated parameter estimates for each of these variables and zero was too large to have been due solely to chance. As substantiated earlier in Chapter III, significant parameter estimates are indicative of minimal standard errors of the estimate (SEE).

Table 34: Summarized Regression Results of Predicting TC For COMPOSITE III Two-Year Public Colleges (N = 565)

Model	Equation	Alternate Variable	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameters Having Significant (@.05) PROB > |T|
LINEAR	(5.1)	DIVERSITY	.0001	.9265	2.02793E+15	FTE, DIVERSITY
QUADRATIC	(6.1)	DIVERSITY (with interactive terms)	.0001	.9395	1.65172E+15	FTE, FTE^2, FTE BY MARKET
	(6.1A)	DIVERSITY (without interactive terms)	.0001	.9367	1.73753E+15	FTE, DIVERSITY, FTE^2, $MARKET^2$, $DIVERSITY^2$
CUBIC	(7.1)	DIVERSITY	.0001	.9391	1.66170E+15	FTE, MARKET, FTE^2, $MARKET^2$, FTE^3, $MARKET^3$, $DIVERSITY^3$
MULTIPLICATIVE[2]	(8.1	DIVERSITY	.0001	.7640	6.51426E+15	FTE, ADJAVSAL
TRANS-LOG[2]	(9.1)	DIVERSITY	.0001	.9299	1.92556E+15	FTE, MARKET, DIVERSITY

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) included in each equation (5.1-9.1) according to the following formula:

$$\text{adjusted } R^2 = R^2 - (1-R^2)k/(N-k-1)$$

[2] Results shown for exponential models are those of predicting the natural log of IEG.

(4) In predicting TC, equation (6.1) was itself statistically significant p < .0001). After controlling for ADJAVSAL, the relationship between the three independent variables (FTE, MARKET and DIVERSITY), expressed in their linear (first power), quadratic (second power) and interactive terms, and the dependent variable (IEG) was too large (R = square root of .9379) to have been due solely to chance.

Table 34 presents the summarized regression results of all equations by model for 565 COMPOSITE III two-year public colleges, and Table 35 presents the estimated parameter values (regression coefficients) for every term of each equation within the five models defined by the present study.

Curve Smoothing Techniques

Figure 41 is a two dimensional representation of the quadratic model, equation (6.1), and depicts the actual (IEG) versus predicted (IEGHAT), total cost in terms of FTE for 565 COMPOSITE III two-year public colleges. For reasons previously cited in Chapter II, the TC function represented by the P-values in Figure 41 is not yet a continuous, smooth function.

Based on the curve smoothing techniques described in Chapter II, a continuous smooth TC function was

Table 35: Estimated Parameter Values By Equation For COMPOSITE III Two-Year Public Colleges (N = 565)

Model Equation	Linear (5.1)	Quadratic (6.1)	Quadratic (6.1A)	Cubic (7.1)	Multiplicative (8.1)	Translog (9.1)
Y-intercept	$ -313493	$ 1351181*	$ 1351181*	$ 699739	$-42098201*	$-14657749*
FTE	1595.971*	2538.925*	2753.600*	2034.013*		1711.495*
MARKET	7551170	9163461	-16266485	-52554771*		27380734*
DIVERSITY	8688169*	-7839658	-12015627*	9347403		18700291*
ADJAVSAL	8.508505	-8.373118	6.217216	35.896302	138.442*	-1.317805*
FTE^2		-0.065168*	-0.066685*	0.077694*		
MARKET^2		16508927	284984953*	1284869242*		
DIVERSITY^2		17570647	34400753*	-43190177		
FTE^3				-0.000007364*		
MARKET^3				-6171351122*		
DIVERSITY^3				83311196*		
FTE BY MARKET		-11388.929*				
FTE BY DIVERSITY		1404.957				
MARKET BY DIVERSITY		58889540				
LN FTE					6496885*	846189*
LN MARKET					-139530	-550115*
LN DIVERSITY					-121316	-2287930*

*Significant at the .05 level, or better

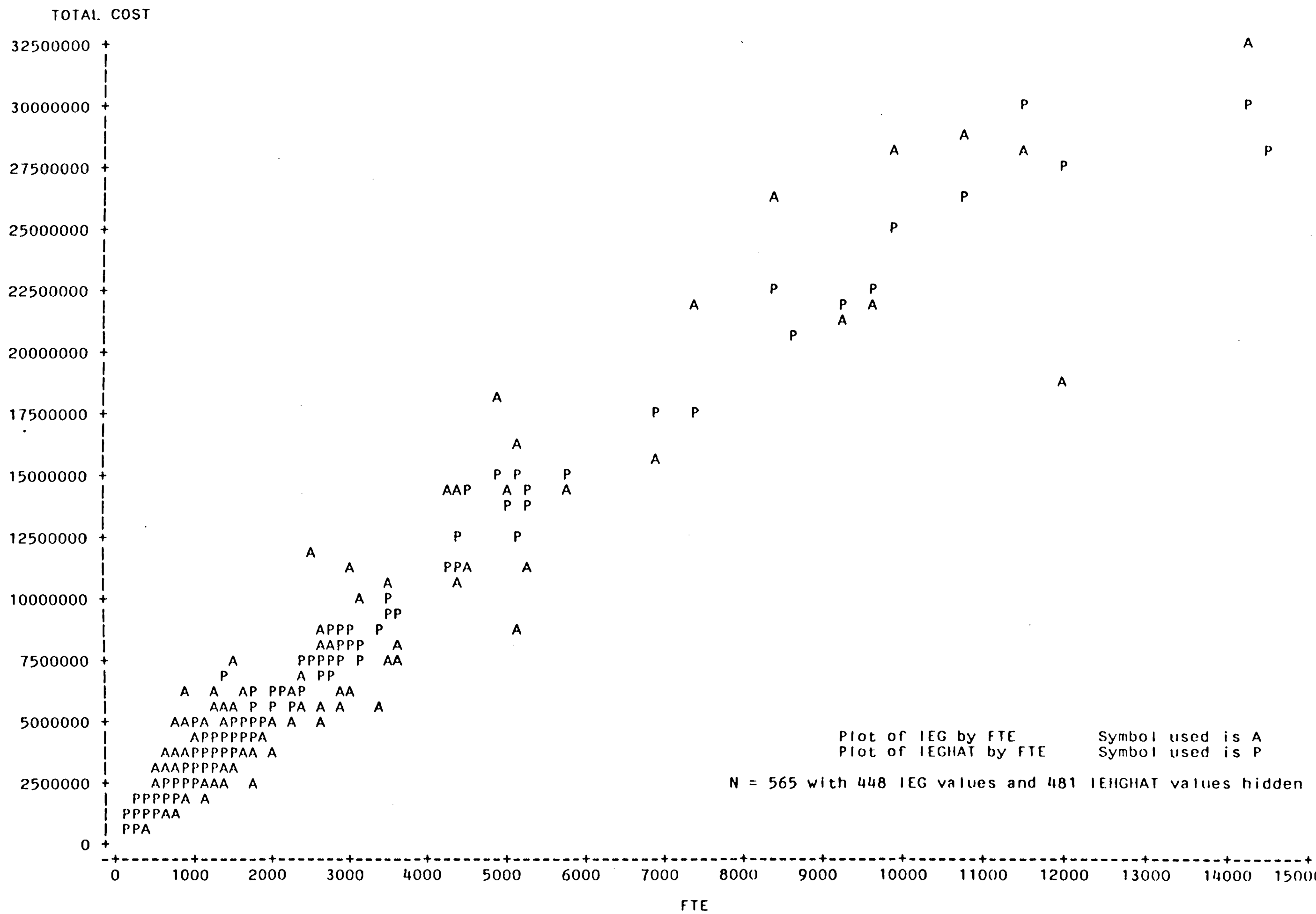

Figure 41. Actual (IEG) vs. predicted (IEGHAT) TC: Equation (6.1) quadratic model for COMPOSITE III 2-year public colleges.

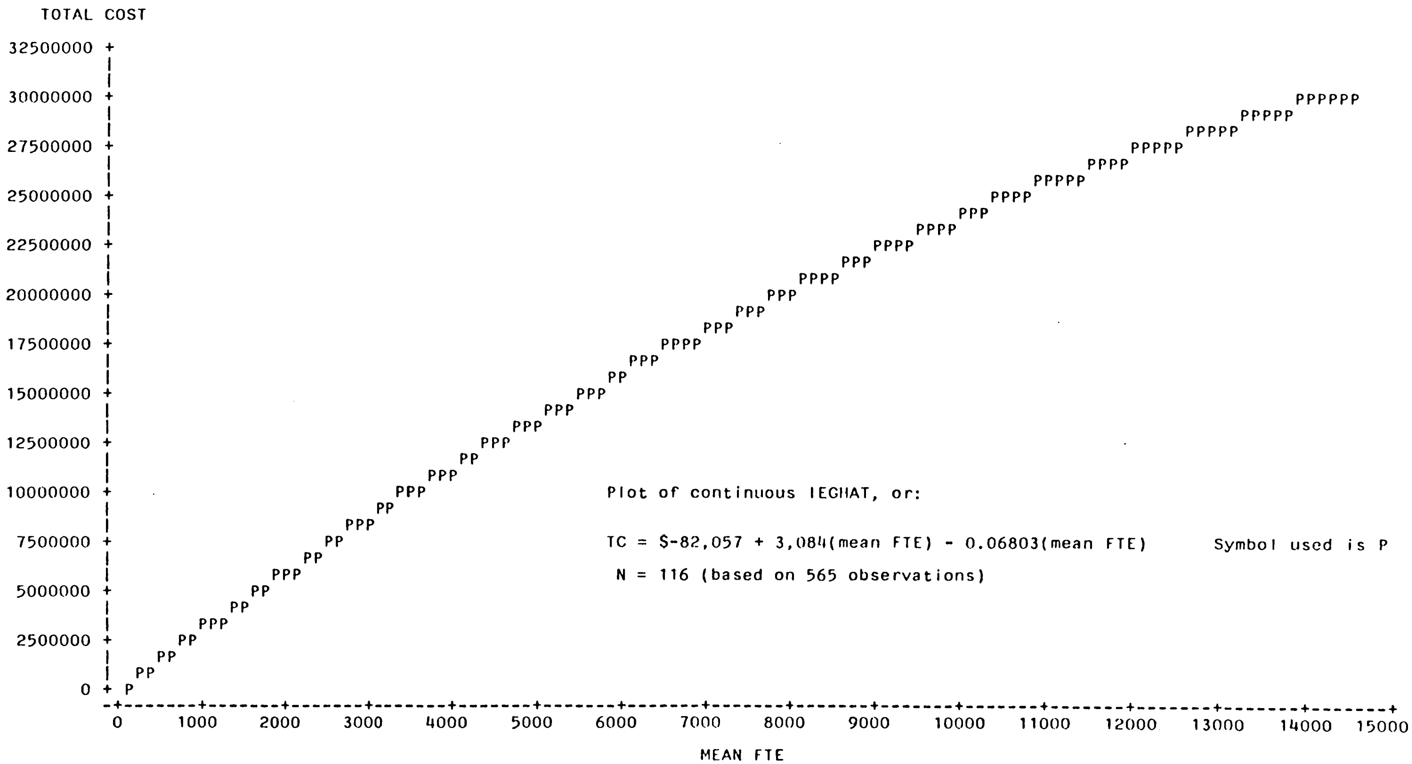

Figure 42. Continuous average predicted total cost: Equation (6.1.1) quadratic model for COMPOSITE III 2-year public colleges.

developed--see Figure 42 and supporting Figures F-43 through F-45 of Appendix F. The resulting continuous, smooth TC function, defined in terms of a single variable, FTE, and represented by equation (6.1.1)[39] is equivalent to the quadratic model equation (6.1), defined in terms of FTE, MARKET, DIVERSITY--including first power, second power, and interactive terms--after controlling for ADJAVSAL. In mathematical terms, both TC functions represent an identity. Equation (6.1.1) is identically equivalent to equation (6.1) or:

$$\$801024+2538(FTE)+9163461(MARKET)-7839658(DIVERSITY) -0.065168(FTE)^2+165089727(MARKET)^2+17570647(DIVERSITY)^2 -11398(FTE\ BY\ MARKET)+1404(FTE\ BY\ DIVERSITY)+58889540(MARKET\ BY\ DIVERSITY)-8.373118(ADJAVSAL)$$

is equivalent to $-82057+3084.7170(FTE)-0.06803489(FTE)^2$.

Derivation of MC and AC Functions

Based on the continuous, smooth TC function represented by equation (6.1.1), the AC function for 565 COMPOSITE III two-year colleges was derived as follows:

$$AC = TC/Mean\ FTE$$

[39] Average predicted TC = $-82057+3084.7170(\text{mean FTE})-0.06803489(\text{mean FTE}^2)$. For a summary of the regression results, see Table 36.

Table 36: Summarized Regression Results of Curve Smoothing Techniques for COMPOSITE III Two-Year Public Colleges (N = 565)

Model	Equation	Prob > |F|	Adjusted R-squared[1]	Residual SS	Parameter Estimate		T for H0: Parameter = 0	Prob > |T|
QUADRATIC	6.1.1	.0001	.9877	4.08166E+13	Y-intercept:	-82057	-0.27	.7888
					Mean FTE:	3084.7170	24.36	.0001
					$(\text{Mean FTE})^2$:	-0.06803	-7.27	.0001

[1] Because the addition of predictor variables to a regression equation always increases the associated R-squared statistic, R-squared has been adjusted for N-1 degrees of freedom and for the number of independent variables (k) according to the following formula:

$$\text{Adjusted } R^2 = R^2 - (1-R^2)k/N-k-1)$$

Because equation (6.1.1) is a multivariate TC function, the first derivative of such an equation, with respect to FTE, would only be a partial derivative and, therefore, would not yield a valid MC function for the reasons previously reviewed in Chapter II. Accordingly, the applicable MC function was derived by using Hirshleifer's (1980) better approximation method, also previously described in Chapter II. The resulting MC and AC functions, derived from equation (6.1.1), were then plotted together so that they could be readily compared with one another--see Figure 43.

Since the TC function represented by equation (6.1.1) is quadratic--see Figure 42--the MC function derived from it (Figure 43) must be consistent with the universal properties of all quadratic TC functions as previously outlined in Chapter II. Of special interest is the property that the MC of a quadratic TC function, unlike that of a linear TC function, cannot be constant over the domain of the function. MC derived from a quadratic TC function must be curvilinear, rather than linear. Similarly, unlike that of a linear TC function, the quadratic function may have two roots. There may be two values of FTE which satisfy the condition, IEG = f (FTE, FTE^2) = zero. Hence, unlike a linear TC function, a quadratic TC function may change direction two times within the same quadrant.

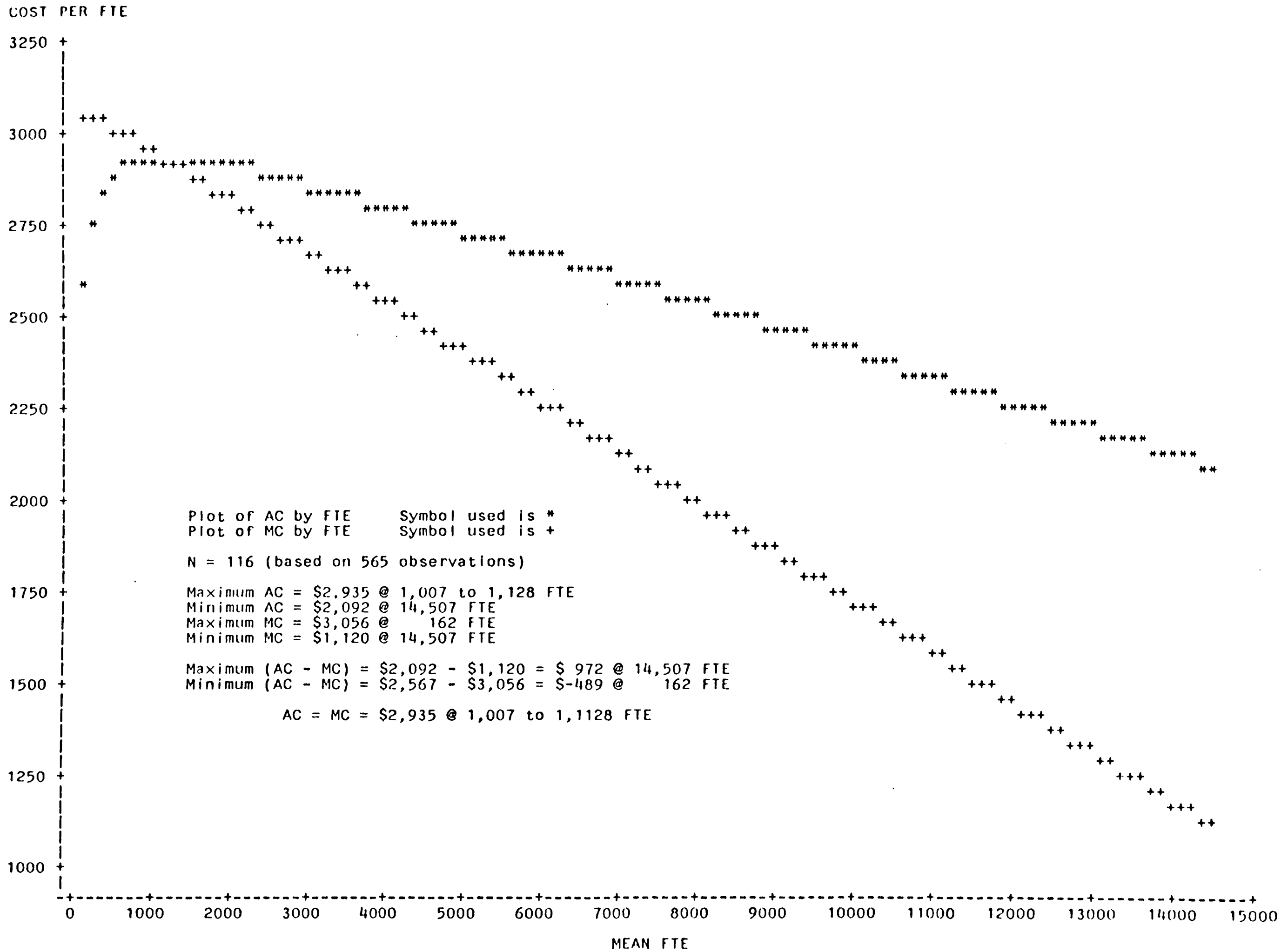

Figure 43. Average (AC) and marginal (MC) cost functions: Derived from equation (6.1.1) for COMPOSITE III 2-yr public colleges.

An inspection of Figures 42 and 43 indicates that equation (6.1.1) is consistent with these universal properties of quadratic TC functions. For example, while the overall appearance of the plot of equation (6.1.1) is linear, a closer inspection of Figure 42 confirms the fact that this equation is curvilinear. The curvilinearity of the slope of equation (6.1.1) becomes even more apparent in its associated MC function (Figure 43), which is nonconstant, ranging from $3,056 at 162 FTE to a minimum of $1,120 at 14,507 FTE. Consistent with all quadratic functions, the MC function lies below AC over a large portion of the domain of its related TC function, indicating that economies of scale are achievable over this range. Consequently, based on an analysis of 565 COMPOSITE III two-year public colleges, economies of scale are achievable over all enrollment levels between 162 and 14,507 FTE--see Figure 44.

However, for the reasons cited earlier in Chapter III with respect to 25 medium large and 39 very large two-year public colleges, the findings with respect to 565 COMPOSITE III two-year public colleges cannot be generalized to the larger population of all two-year public colleges (N = 886 per Table 1 of Chapter I).

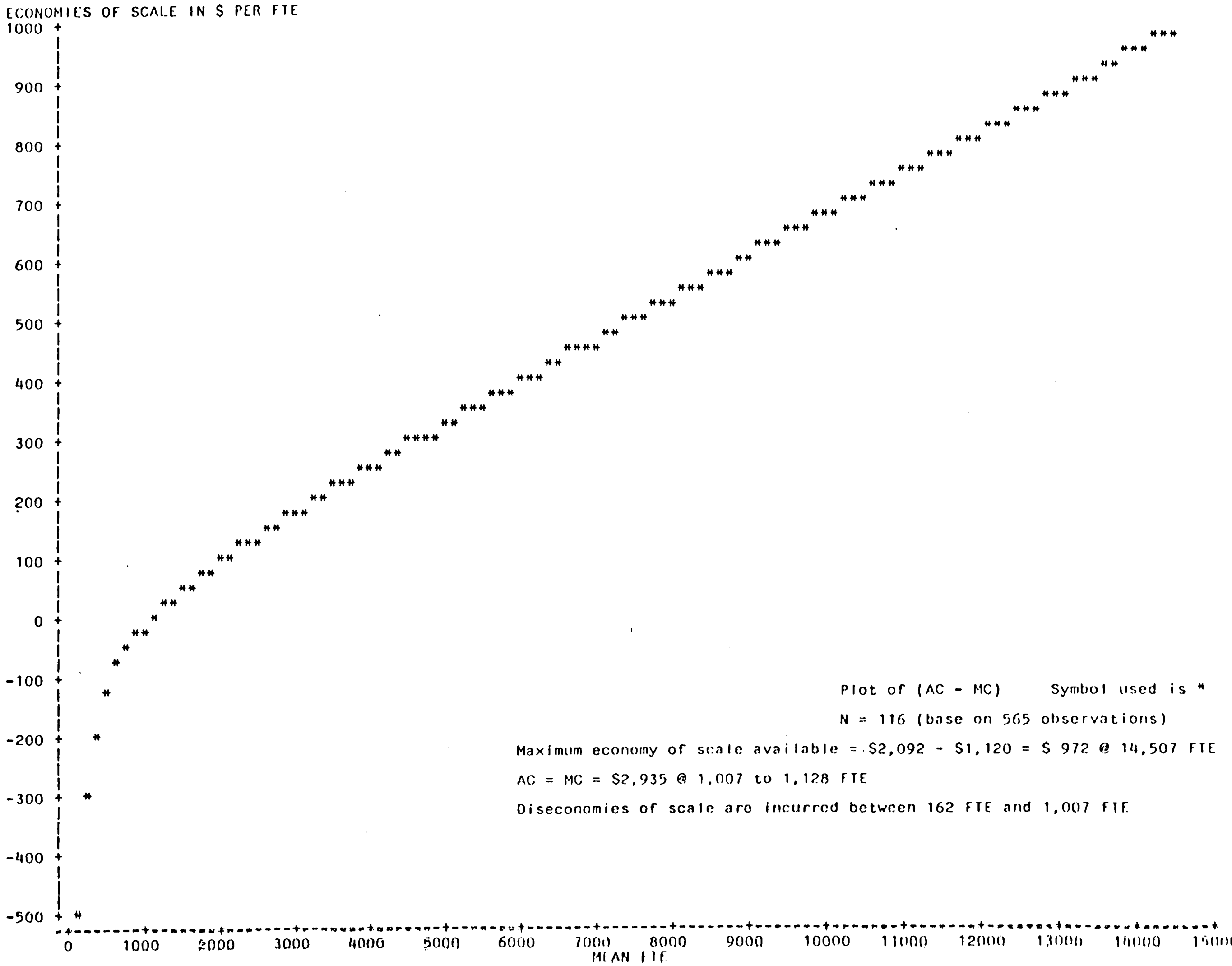

Figure 44. Economies of scale: Derived from equation (6.1.1) quadratic model for COMPOSITE III 2-year public colleges.

Summary of Findings

The following is a summary of the findings of the present study:

1. The total cost of providing educational programs in two-year public colleges, irrespective of institutional size, does not grow exponentially with changes in FTE, MARKET and DIVERSITY, after controlling for ADJAVSAL. The two exponential growth models--the multiplicative and the translog models--were consistently the worst models (based on comparative R-squared, RSS and SEE statistics) in predicting TC for all data bases tested.
2. With two notable exceptions--small rural and medium large colleges--the total cost of providing educational programs for two-year public colleges follows a curvilinear path in response to changes in FTE, MARKET and DIVERSITY, after controlling for ADJAVSAL.
3. The predominant curvilinear total cost path followed by two-year public colleges is either quadratic or cubic in structure. Institutional size appears to affect which of these two curvilinear functions prevails. Whereas the cubic function tends to describe the total cost of providing educational programs at smaller colleges

(*e.g.*, total small and small technical colleges), the quadratic function tends to describe the total cost of providing educational programs at larger colleges (*e.g.* very large, total large, and COMPOSITE I, II, and III colleges). However, the quadratic model tends to describe the total cost of providing educational programs at small, but nonrural, colleges as well.

4. The total cost of providing educational programs at small rural two-year public colleges and at medium large comprehensive two-year public colleges follows a linear path relative to changes in FTE, MARKET and DIVERSITY, after controlling for ADJAVSAL. Linear total cost functions at these two types of institutions translates into constant marginal cost functions over all enrollment levels, *e.g.*, $2,668 per FTE for small rural colleges and $2,368 per FTE for medium large colleges.
5. FTE is the dominant predictor of IEG, irrespective of either institutional type or number of other independent variables introduced into the regression equation -- see Table 37.
6. The mean average cost per FTE is considerably higher at smaller institutions than at larger institutions -- see Table 38.

7. Economies of scale are achievable within specified enrollment ranges for all two-year public colleges, irrespective of size--see Table 39.

Table 37: Summary of Stepwise Regression Results by Institutional Type

Institutional Type	N	Equation (No.)	Adjusted R-Squared	Unadjusted R-Squared	Stepwise Contribution to Unadjusted R-Squared
Small Rural	194	Linear (5.1)	70.30%	70.91%	FTE (67.26%), DIVERSITY (2.03%), MARKET (1.58%), ADJAVSAL (.04%)
Small Nonrural	51	Quadratic (6.1)	61.40%	69.12%	FTE (42.27%), FTE^2 (3.24%), ADJAVSAL (4.75%), DIVERSITY (2.50%), DIVERSITY^2 (5.03%), all others under 2% each (11.33%)
Total Small	245	Cubic (7.1)	66.94%	68.30%	FTE (61.66%), DIVERSITY (1.71%), MARKET^2 (1.38%), DIVERSITY^3 (1.02%), DIVERSITY^2 (1.67%), all others less than 1% (.24%)
Small Technical	68	Cubic (7.1)	59.00%	65.12%	FTE (52.29%), DIVERSITY (4.40%), MARKET^3 (3.99%), MARKET^2 (1.71%), ADJAVSAL (1.54%), all others less than 1% each (1.19%)
Medium Large	25	Linear (5.1)	51.10%	59.25%	FTE (45.41%), MARKET (12.60%), ADJAVSAL (1.16%), DIVERSITY (.08%)
Very Large	39	Quadratic (6.1A)	86.73%	89.18%	FTE (84.69%), FTE^2 (2.62%), DIVERSITY^2 (1.84%), all others less than 1% each (.03%)
Total Large	64	Quadratic (6.1A)	90.46%	91.52%	FTE (88.71%), FTE^2 (1.45%), all others less than 1% each (1.36%)
COMPOSITE I	377	Quadratic (6.1)	93.00%	93.19%	FTE (91.34%), all others less than 1% each (1.85%)
COMPOSITE II	309	Quadratic (6.1)	93.79%	93.99%	FTE (92.21%), all others less than 1% each (1.78%)
COMPOSITE III	565	Quadratic (6.1)	93.95%	94.06%	FTE (91.89%), FTE^2 (1.06%), all others less than 1% each (1.11%)

Table 38: Summary Mean and Range Statistics by Institutional Type

Institutional Type	N	Actual Values From 1980-81 HEGIS Data Base: Mean FTE	Actual Values From 1980-81 HEGIS Data Base: Mean Average Cost/FTE	Predicted Values After Curve-Smoothing: Mean FTE	Mean Average Cost/FTE	Range of AC Per FTE: From	Range of AC Per FTE: To	Mean Marginal Cost/FTE	Range of MC Per FTE: From	Range of MC Per FTE: To	Mean Economy of Scale
Small Rural	194	905	$3,265	1,230	$3,192	$2,862	$4,978	$2,668	$2,668	$2,668	$ 524
Small Nonrural	51	1,027	3,439	1,000	3,487	2,273	6,353	1,946	204	3,690	1,541
Total Small	245	931	3,301	1,200	3,507	2,634	8,951	2,245	1,920	2,864	1,262
Small Technical	68	883	3,645	960	3,233	2,952	4,205	2,862	2,220	3,094	371
Medium Large	25	1,952	2,928	2,100	2,880	2,693	3,238	2,368	2,368	2,368	512
Very Large	39	5,830	2,572	8,275	2,486	2,024	2,748	1,981	566	3,398	505
Total Large	64	4,315	2,711	7,814	2,521	2,068	2,809	2,028	947	3,103	492
COMPOSITE I	377	1,497	3,263	7,313	2,586	2,105	3,863	2,089	1,210	2,964	497
COMPOSITE II	309	1,632	3,179	7,313	2,570	2,100	3,183	2,091	1,174	3,004	480
COMPOSITE III	565	2,847	2,967	7,313	2,558	2,092	2,935	2,090	1,120	3,056	469

Table 39: Summary of Achievable Economies of Scale Per FTE by Institutional Type

Institutional Type	Model	Equation	Economies of Scale Per FTE			Achivable Over FTE Enrollment Levels		
			From	To	Least	From	To	Least
Small Rural	LINEAR	5.1	$2,310	$ 194	$ 194	$ 190	$2,257	$2,257
Small, Nonrural	QUADRATIC	6.1	$2,663	2,069	1,166	135	1,859	649
Total Small	CUBIC	7.1	6,097	(222)	0	135	2,257	2,100
Small Technical	CUBIC	7.1	1,225	732	161	113	1,795	743
Medium Large	LINEAR	5.1	870	325	325	1,144	3,064	3,064
Very Large	QUADRATIC	6.1A	(1,125)	1,458	0	2,019	14,507	4,926
Total Large	QUADRATIC	6.1A	(548)	1,121	0	1,144	14,507	2,992
COMPOSITE I	QUADRATIC	6.1	899	895	181	150	14,507	1,262
COMPOSITE II	QUADRATIC	6.1	179	926	81	162	14,507	640
COMPOSITE III	QUADRATIC	6.1	(489)	972	0	162	14,507	1,007

CHAPTER IV

REVIEW, CONCLUSIONS AND RECOMMENDATIONS

Review

As presented earlier in Chapter I, the small rural community college is dedicated to providing its clientele with equality of educational opportunity. To fulfill this commitment, these colleges, despite their limited enrollment, must be in a financial position to offer comprehensive educational programs to meet student needs that transcend community boundaries. Whereas the student needs in a more provincial society were different because of social and economic differences that may have existed between communities (e.g., rural versus urban), such differences have recently been diffused into similarities by a more uniform society on the threshold of high technology.

Such a commitment to high technology is found in rural as well as in urban settings. For example, whereas the country doctor once served the small rural community with little, if any, medical technological support, that same country doctor now requires a staff of trained medical technicians and nurses, just as does his/her urban counterpart. Similarly, whereas the computer found its initial application in industrial, commercial and research endeavors characteristic of urban settings, the use of computerized farming techniques in agricultural settings has created similar educational needs in small rural communities. Hence, in an age of high technology, the small rural community has educational needs that are assumed to be more similar to, than different from, larger population centers.

Within this context, the present study is based on the hypothesis that the small rural community college, simply because it <u>is</u> small, cannot provide the same diversity of educational opportunity measured by the degree of comprehensiveness in its curriculum at either the same average cost or the same marginal cost per student as the larger community college. The findings presented in Chapter III supported this research hypothesis in the following respects:

1. The disparity in both the predicted mean average cost per FTE and the predicted mean marginal cost per FTE between small and large two-year public colleges is considerable (Table 38). The interpretation of this disparity will be developed throughout the remainder of this chapter.
2. Considered as a group, 194 small rural two-year public colleges are represented by a linear total cost function. Hence, they have a constant

marginal cost of $2,668 over all enrollment levels, from 190 FTE to 2,257 FTE. One of a number of alternative interpretations of a constant MC (and the one preferred by the present researcher) is that the small rural community college, in response to changes in enrollment, adds or deletes educational programs having the same, not different, costs. If comprehensiveness implies educational programs of different, not similar, cost, the linear TC function and constant MC function for 194 small rural two-year public colleges indicates that these colleges continue to offer essentially the same, not a different, mix of relative curricular comprehensiveness over all enrollment levels. More importantly, however, although economies of scale (from $2,310 to $194 per FTE) are achievable over these same enrollment levels, the constant MC ($2,668) indicates that the small rural college, simply because it is small, may not be able to convert these achievable economies of scale into increased comprehensiveness, since it continues to offer additional educational programs at the same, not different, cost. Support for this interpretation of a constant marginal cost, as well as a discussion of alternative inferences, will be developed at a later point in Chapter IV.

3. Assuming INDEXCOMP may intuitively be a far more valid and more reliable measure of comprehensiveness than DIVERSITY, as reported in Chapter III, the failure of the former to outperform the latter as a co-predictor of IEG (along with FTE and MARKET, after controlling for ADJAVSAL) with respect to 194 small rural two-year public colleges is yet another indication that small rural colleges may not be as comprehensive as their educational objective requires them to be.

The reader may recall that INDEXCOMP gives extra weight to the first educational program offered within a cluster of similar curricula, with lesser weight to the addition of separate programs within that same general area. In contract, DIVERSITY gives the same weight to all curricula.[40] The data indicate that IEG increases, not as the curriculum

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[40] Moreover, based on the correlation results also reported in Chapter III, INDEXCOMP, as a co-predictor of IEG, was not expected to outperform its more simplistic alternative, DIVERSITY, even when the data base was expanded to include the larger colleges. Such a finding was probably due to the fact that the more costly occupational/technical programs in the aggregate were weighted far more heavily in the determination of DIVERSITY (69/70) than in the determination of INDEXCOMP (63/100).

is expanded into educational programs not previously offered, but simply as curriculum is expanded into either new or similar academic areas. In the case of small rural community colleges, the inference offered here is that the curriculum is expanded into similar (not different) academic areas, since such expansion is into educational programs which have the same marginal cost ($2,668/FTE) at all enrollment levels.

4. In contrast to the 194 small rural two-year public colleges, each of the following institutional types (as reported in Chapter III) were represented by a nonlinear TC function:

   a) 51 small nonrural colleges

   b) 245 total small colleges

   c) 68 small technical colleges

   d) 39 very large colleges

   e) 64 total large colleges

   e) 377 COMPOSITE I colleges

   f) 309 COMPOSITE II colleges

   g) 565 COMPOSITE III colleges

   Hence, each of the above groups has a nonconstant MC over their respective enrollment levels. To pursue the present researcher's own interpretation of this finding, as enrollment changes, 39 very large colleges appear to add or delete educational programs having different, not the same, costs, indicating that these larger colleges may be offering a different, not the same, mix of curricular comprehensiveness across different enrollment levels. Although these 39 very large colleges, by virtue of size alone, operate less economically at any enrollment level below 4,926 FTE (where MC = AC = $2,748/FTE) their achievable economies of scale from that point on (upwards to $1,458 per FTE at 14,507 FTE) are considerable, especially after multiplying by their respective FTE levels. The magnitude of such economies of scale, attributable to sheer size along, is simply unavailable to the small rural two-year public college. This point will be developed at a later point in Chapter IV.

Additional Research Questions

Is comprehensiveness a function of size? While the present study was not designed primarily to investigate this question, the answer is nevertheless critical to the inference made herein--that small rural two-year public colleges, by exhibiting a constant marginal cost of $2,668/FTE over all enrollment levels, may be offering curricula having the same (not different) cost at every enrollment level.

Atwell and Sullins (1984), using essentially the same data base as the present researcher, provided an answer to this question by concluding that comprehensiveness and size are indeed related:

> We have demonstrated the strong, positive relationship between size (headcount enrollment) and curricular diversity (comprehensiveness index). Tables 12, 13, and 14 [not reproduced here] reveal statistically significant differences in mean comprehensiveness index scores between small colleges, rural and nonrural, and large colleges, and between size categories within the small rural and the large college groupings." (p. 35)

In arriving at this conclusion, Atwell and Sullins used HEAD to represent size and INDEXCOMP to represent comprehensiveness. In terms of the variables used in the present study, the critical question becomes, is DIVERSITY a function of FTE? If DIVERSITY is a function of FTE, then size (FTE) would necessarily become a strong predictor of comprehensiveness (DIVERSITY). One test of the predictive quality of FTE on DIVERSITY can be provided by correlating FTE with DIVERSITY, and comparing the relative strength of the Pearson product moment coefficient, R, for each institutional type. Such a correlation analysis was performed, and the results are presented in Table 40.

Table 40: Correlation Results - FTE With DIVERSITY

Institution Type	N	Pearson Correlation Coefficient, R
Small Rural	194	.60263*
Small Nonrural	51	.54278*
Total Small	245	.58508*
Small Technical	68	.56622*
Medium Large	25	.59822*
Very Large	39	.53767*
Total Large	64	.79449*
COMPOSITE I	377	.72693*
COMPOSITE II	309	.75688*
COMPOSITE III	565	.81797*

*Significant at the .0001 level

While the results presented in Table 40 confirm that FTE and DIVERSITY are at least moderately correlated in each of the first six institutional types tested (from R = .60 to R = .53), these same two variables exhibit a much stronger positive relationship when the enrollment range is broadened to include both very small and very large colleges within the same data base as in COMPOSITE I, II, and III (from R = .72 to R = .81).

While 194 small rural colleges reflect a somewhat stronger relationship between FTE and DIVERSITY (R = .60) than do 39 very large colleges (R = .53), it would be erroneous to conclude that small rural colleges were therefore more comprehensive within their enrollment range than were very large two-year public colleges. What the correlation results confirm is that as enrollment increases, all two-year public colleges, irrespective of type, are more likely to add degrees, certificates, diplomas, and awards in academic areas not previously offered than not. While some would simply perceive comprehensiveness in terms of increments of one (even INDEXCOMP did not do that), the sheer number of new curricula may not be indicative of any qualitative expansion in the comprehensiveness of existing curricula. Expanding real versus perceived curricular comprehensiveness perhaps implies the addition of new curricula at a marginal cost that differs from existing curricula. For example, does the contemplated addition of a program in sociology, which may cost the same as an existing program in law enforcement, increase comprehensiveness as much as, say, adding computer science, which incrementally may cost an amount that is quite different from an existing curricula that includes both sociology and law enforcement?

What the correlation results do not address is whether new educational programs are added to existing curricula at either the same or different marginal cost relative to existing educational programs. To determine the incremental cost at which new curricula are added, one must perform a marginal cost analysis. Since IEG is not reported by institution on a per curriculum basis, researchers have little choice--short of performing cost studies at selected institutions--except to perform their marginal cost analysis by predicting the slope of total IEG, which data is readily available.

In summary, what the combined marginal cost analysis (presented in Chapter III) and the correlation results (presented here) indicate is that:

1) With increases in FTE enrollment, all two-year public colleges tend to add new curricula.
2) Small rural community colleges expand curricula at a constant marginal cost while all other two-year public colleges (other than medium large colleges)

expand their curricula at a nonconstant marginal cost.

The interpretation offered here is that small rural colleges add (or delete) educational programs having the same (not different) cost and, as a result, may be less comprehensive than other institutional types that add (or delete) educational programs having different (not the same) cost. To illustrate this interpretation, consider the opposite of curricular growth, i.e., curricular decline.

Assume, for example, that a hypothetical small rural community college experiences an FTE enrollment drop of 20 students which is equivalent to a reduction of five classes of 20 students per class in each of three quarters of an academic year (one FTE = 15 credit hours = 5 classes x 3 credit hours per class). Although the administration at such a hypothetical small rural college may have a number of alternative strategies available, short of reducing DIVERSITY by a factor of one to five (depending on how many different programs of study were affected by the dropping of five courses), the link between enrollment changes and these alternative strategies (such as maintaining the existing level of DIVERSITY, but reducing organizational complexity or reducing the quality of all existing curricula) has not been substantiated by this or by any other research known to the present researcher. What has been established here is that DIVERSITY is a function of FTE and that the marginal cost of offering educational programs at small rural colleges is $2,668 at all enrollment levels. Thus, as FTE declines, so too must DIVERSITY also decline. We can, therefore, expect that some reduction in DIVERSITY will be experienced by the loss of say 20 FTE students. To pursue the hypothetical illustration presented here, this reduction in DIVERSITY may be symbolized by the dropping of say one educational program from the existing curricula. However, the composite mix of this particular hypothetical school's curricula is so similar (in terms of incremental or marginal cost) that no matter which academic area is selected as the candidate for dropping from the existing curricula, the annualized cost reduction related to the loss of 20 FTE students will always be $2,668 x 20 or $53,360. Even more significantly, the identical financial result will persist at all enrollment levels, whether the marginal loss of 20 FTE students were to occur at an enrollment level of 2,257 FTE students, or alternatively, at an enrollment level of only 190 FTE students.

Alternative Interpretations

There are, of course, alternative inferences that can be drawn from the findings presented here. Although, for the most part, these will be left for future researchers to pursue, two possible alternative interpretations, based on a theme central to both, follows.

Even real, as contrasted with perceived, comprehensiveness may exist in an environment where marginal costs are constant. Whereas the marginal cost in the aggregate may be constant, the marginal cost of each individual educational program may nevertheless be nonconstant. While this may appear to be an inconsistent use of the same term, it is theoretically possible to operate a mix of educational programs, each with quite different incremental costs, yet when aggregated, the resulting mix could form a composite marginal cost that might be constant over all enrollment levels.

Within the context of the present study, at least two scenarios are possible. The first is that the 194 small rural community colleges examined herein could have a mix of some very expensive programs, together with some very inexpensive programs, the combination of which nets out, thereby giving the appearance of a very narrow band of educational programs with each having the same marginal cost. If this were the case, as enrollment increased from 190 to 2,257 FTE, each college, on average, and with complete knowledge of the economy of scale dollars available to it, would have to adjust its curricular mix in such a way that real (versus perceived) comprehensiveness would remain unaffected and that the overall marginal cost would remain constant at $2,668/FTE.

A second scenario is that in the face of enrollment changes, from say 190 to 2,257 FTE, real (versus perceived) comprehensiveness is maintained, not by adding or deleting curricula, but by adjusting organizational complexity (i.e., hiring or laying off administrative staff) or by adjusting the quality of existing curricula (i.e., by increasing/decreasing class size). For example, in the illustration cited earlier, the loss of 20 FTE, which at a constant MC of $2,668/FTE equates to $53,360, could be absorbed by (1) increasing the average class size of all existing curricula, thereby decreasing faculty and increasing the student/faculty ratio, or by (2) reassigning administrative responsibilities and reducing administrative staff. While both strategies are undoubtedly utilized in practice as preferable to a reduction in comprehensiveness, the findings reported herein indicate that as FTE either increases or decreases, so too will DIVERSITY increase or decrease. Moreover, this response can be expected across all institutional types.

Conclusions

Based on the findings presented in Chapter III, the following are the conclusions of the present study:

1. Economies of scale are achievable by the two-year public college, irrespective of institutional type or size. However, how these economies are spent may differ by institutional size.

2. The predicted mean average cost of delivering educational programs at 194 small rural colleges is $3,192 per FTE or 26 percent more than that at 64 large two-year public colleges. Even more importantly, the predicted mean marginal cost, that is, the cost of educating the last or next student, at 194 small rural colleges is $2,668 per FTE or 31 percent more than that at 64 large two-year public colleges. Faced with the magnitude of such average and marginal cost disparities as these, small rural colleges clearly do not have the same economic ability to offer the same degree of comprehensiveness as their large counterparts. Size alone produces economic savings that enable the larger colleges to become more comprehensive than smaller colleges.
3. The marginal cost per FTE for 194 small rural colleges is $2,668, over all enrollment levels--from 190 FTE to 2,257 FTE. The constancy of its MC over all enrollment levels may itself be an indicator of just how small rural colleges spend their economies of scale achievable through enrollment growth, for there are only three possibilities available: a) improving existing educational programs, and /or b) adding new

educational programs and/or c) increasing organizational complexity.

Allowing for the possibility that a portion of these achievable economies of scale may be siphoned off into increasing organizational complexity rather than into the expansion of curricula, a constant MC indicates that as small rural colleges grow larger, both their curriculum and their organizational complexity are expanded together at a cost per FTE that is incrementally the same over all enrollment levels. Consequently, a constant MC may mean that as enrollment increases, the small rural college does <u>not</u> add new educational programs having different incremental cost than its existing programs. Since different educational programs may have different educational costs associated with them, the linearity of its total cost curve indicates that the small rural two-year public college may not convert its achievable economies of scale into increased comprehensiveness.

4. In contrast, with the singular exception of 25 medium large two-year public colleges (whose results are not generalizable to the larger population of 174 medium large colleges because of sample size), the marginal cost per FTE of every

other institutional type tested is nonconstant, indicating that all other two-year public colleges, including small nonrural colleges, have the opportunity to convert their achievable economies of scale into increased comprehensiveness by adding educational programs having different educational costs. While these same other institutional types may also convert a portion of their achieved economies of scale into either improving existing programs and/or increasing organizational complexity, their nonconstant MC means that larger schools also spend their economies of scale by adding programs having different (not the same cost). Hence, all schools, other than small rural (and medium large) schools, may spend a portion of their achieved economies of scale by increasing the comprehensiveness of their educational programs. While the present study did not attempt to determine what proportion of achieved economies of scale were channeled into making curricular changes versus increasing organizational complexity, lest it be forgotten, the mission of the community college can best be achieved by increasing comprehensiveness, not by increasing organizational complexity.

5. While the small rural colleges (N = 194) reflect a constant MC ($2,668 per FTE) over all enrollment levels, the small nonrural colleges (N = 51) exhibit a nonconstant MC (from $3,690 at 135 FTE to $204 at 1,859 FTE), indicating that small nonrural colleges respond to enrollment changes by adding or deleting educational programs having different costs, whereas small rural colleges add or delete programs having the same costs. Why is the small nonrural college's marginal cost pattern (i.e., the slope of their TC curve) different from that of the small rural college? Assuming that Bowen's (1980) revenue theory of cost is a valid assumption in an educational setting--that educational costs are driven by the revenue made available to the delivery system--a tentative answer to the question just posed can be found by comparing the state-by-state distribution of the respective data bases (N = 194 vs. N = 51) of the present study (see Appendix G) with the previous research of Ten Hoeve (1981). Although Ten Hoeve identified those states that compensate for smallness from those that do not (p. 18), the application of his research to the data bases of the present study provided only a tentative and inconclusive explanation. Ten

Hoeve's research did not define the extent of the additional support provided by some 13 states which he labeled rather loosely as granting "miscellaneous consideration" in recognition of smallness (p. 18). Subject to this limitation, however, 22 of 51 small nonrural two-year public colleges (or 43 percent) included in the present study were located in states which Ten Hoeve (1981) identified as having some recognition of smallness, including "miscellaneous consideration," in their funding formulas. In contrast, 136 of 194 small nonrural two-year public colleges (or 70 percent) were domiciled in states which Ten Hoeve (1981) identified as having either no recognition or only "miscellaneous consideration" of smallness in their funding formulas.[41] Accordingly, with such additional revenue, the median average cost of 51

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[41] Thirteen of 25 or 52 percent of medium large colleges--the only other institutional type to reflect a linear total cost function--were located in states which Ten Hoeve (1981) identified as having either no recognition or only "miscellaneous consideration" of smallness in their funding formulas. Of these 13 medium large colleges, 11 or 85 percent were located in the same states as those small rural community colleges also identified as either receiving no recognition or only "miscellaneous consideration" of smallness in their funding formulas. To the extent that costs are a function of revenue, this finding simply substantiates that linear funding formulas produce linear total cost curves and constant marginal cost curves, irrespective of either size or type of institution.

small nonrural colleges was found to be $3,310 per FTE or $283 per FTE higher than that of 194 small rural colleges. The tentative conclusion, subject to much needed additional research, is that small two-year public colleges receiving differential funding are in a better financial position to convert their achievable economies of scale into increased comprehensiveness by adding educational programs having different, not the same, costs. Conversely, those small two-year public colleges that do not receive differential funding support may not be financially able to convert their achievable economies of scale into increased comprehensiveness. Accordingly, in response to enrollment changes, such colleges add or delete educational programs having the same, not different, costs. Whereas the 51 small nonrural colleges of the present study tend to identify with the former group (43 percent), the 194 small rural colleges overwhelmingly identify with the latter group (70 percent).

Recommendations

Recommendations for future research

Whereas the present study indicated that FTE was a far more significant predictor of IEG than DIVERSITY (see Table

37), the research of McLaughlin et al. (1980) indicated that enrollment alone does not provide a sufficient explanation of cost variations between educational institutions--that organizational complexity and curricular diversity account for far more significant effects (p. 60). The present study indicated that if curricular diversity is related to IEG, then additional research on the development of a reliable and valid measure of comprehensiveness is needed for two-year public colleges. While INDEXCOMP was a noble, first-effort attempt at developing such a measure, its future use as either a predictor or a co-predictor of IEG has been seriously impaired by so simplistic a rival as DIVERSITY in the present study.

A second area of much needed additional research generated by the present study is to provide a conclusive explanation as to why small rural colleges spend their achievable economies of scale in the way they do. While the present study infers that the small rural college does not expand comprehensiveness as enrollment increases, it is still conjecture as to why this is so. The explanation offered here is that the small rural college not only does not, but more importantly cannot, offer additional educational programs at different cost in response to enrollment increases, unless it receives differential funding support from the state in which it is situated. To test this explanation, what is needed is a follow-up research study wherein these same 194 small rural colleges would be systematically placed into two sub-groups--those that receive differential funding from those that do not. A suggested future research hypothesis would be that the TC function of those receiving differential funding would be nonlinear, whereas those without differential funding would be linear.

A third area of suggested additional research is to search for a predictive model that would allow small rural colleges to attain equity in terms of achievable economies of scale and degree of comprehensiveness. The models presented here indicated that inequities exist in the areas of average cost, marginal cost, and economies of scale. By inference, it has been suggested that economy of scale differences may result in small rural community colleges being less comprehensive than other community colleges. A logical extension of the present research would be to develop an equitable model that, by compensating the small rural community college, would eliminate both the observed and inferred inequities.

Recommendations for policy makers

The research done by Ten Hoeve (1981) indicated that nearly half the states fail to make any adjustment in their funding formulas for economy of scale differentials. While no attempt was made here to separate institutions by state between those that compensate for differences in achievable economy of scale from those that do not, the findings of the present study indicate that the small rural community college may not be able to spend its achievable economies of scale by expanding comprehensiveness.

The recommendation offered here is that differential funding should be considered to compensate the small rural college for differences in achievable economies of scale attributed to disparities that exist in the marginal cost between the small rural college and its larger counterpart. These marginal cost and economies of scale differences are summarized as follows:

1. Marginal cost

   The small rural two-year public college operates at a much higher marginal cost ($2,668) throughout all enrollment levels than does its larger counterparts, ($2,368) for medium large colleges and ($566 at 14,507 FTE to $2,668 at 5,333 FTE) for very large colleges.

2. Economies of scale

The total area under the AC curve and above the MC curve is a comparative measure of the relative magnitude of the cumulative difference in economies of scale achievable by each institutional type. This total area between AC and MC can be approximated by multiplying the average achievable economy of scale by the average enrollment level for each institutional type. The small rural two-year public college can achieve economies of scale ranging from $194 to $2,310 per FTE, or an average of $359 per FTE at a median enrollment level of 1,222 FTE, for a total of $438,698. In contrast, the medium large two-year public college can generate economies of scale ranging from $325 to $870 per FTE, or an average of $480 per FTE at a median enrollment level of 2,072 FTE, for a total of $994,560. And finally, the very large two-year public college, once it achieves an enrollment level of 4,926 FTE, benefits from economies of scale ranging upwards to $1,458 per FTE, or an average of $603 per FTE at a median enrollment level of 8,222 FTE, for a total of $4,957,866.

In the face of such disparities between large and small, the role of policy makers is to judge how equitable such disparities are, and how achieved economies of scale should be spent. The very large two-year public college has nonlinear total cost and marginal cost functions, indicating that the very large college responds to enrollment changes by adding, or deleting, educational programs having different costs. In contrast, the small rural two-year public college has linear total cost and marginal cost functions. Hence, the small rural college responds to enrollment changes by adding, or deleting, educational programs having the same, not different, costs. Comprehensiveness may imply educational programs having different, not the same, costs. Whereas the larger college has an opportunity to use its vastly superior economies of scale to expand its mix of comprehensiveness as enrollment increases, the small rural college may not because it does not have the same economic resources at its disposal to do so.

The apparent refusal of nearly half the states (Ten Hoeve, 1981) to compensate smallness for economy of scale differentials of the magnitude confirmed by the present study, may well deny equality of educational opportunity to all those served by small rural two-year public colleges.

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APPENDIX A

Table A-1

Derivation of Useable Observations Included in Data Base

	Gross	Eliminations[2]	Net
Finance Tape:			
Total observations[1]	944	(45)	= 899
Adjustments[3]		2	= 2
Unuseable observations[4]	(15)		= (15)
Useable observations	929	(43)	= 886
Enrollment Tape:			
Total observations[1]	940	(45)	= 895
Adjustments[3]		2	= 2
Unuseable observations[4]	(11)		= (11)
Useable observations	929	(43)	= 886
Degree Tape:			
Total (and useable) observations[1]	929	(43)	= 886

[1]An "observation" is represented by a reporting unit (or "FICE," *i.e.* Federal Interagency Committee on Education, number), which has been identified on the respective HEGIS tapes with a control code of "public" and an institution type code of "2-year" (excluding U.S. military schools and foreign branches of American schools).

[2]Eliminations: For purposes of this analysis, 43 observations common to all three tapes had to be eliminated for a variety of reasons. For a complete listing of the 43 observations eliminated from the data base (and their associated reasons) see Table A-3 of Appendix A.

[3]Adjustments: Two FICE numbers (3330 and 3381) were on the Finance and Enrollment tapes but were not on the Degree tape. Additionally, these same two schools had to be eliminated on other grounds, since they (along with 20 other observations common to all three tapes) represented 2-year branches of 4-year schools that were not AACJC members.

[4]Unuseable observations: Only observations common to all three tapes (Finance, Enrollment and Degree) were used in this analysis. Thus, some otherwise valid observations had to be discarded from one or more tapes in order to arrive at a data base common to all three tapes. For a complete listing of unuseable observations by tape, see Table A-2 of Appendix A.

Table A-2

Analysis of Unuseable Observations

			Observations		
FICE	State	Institution	On Finance Tape?	On Enrollment Tape?	On Degree Tape?
3079	OH	Miami U.- Hamilton CAM	Yes	Yes	No
3080	OH	Miami U.- Middletown CAM	Yes	Yes	No
3092	OH	Ohio State U- Lima BR	Yes	Yes	No
3093	OH	Ohio State U- Mansfield BR	Yes	Yes	No
3094	OH	Ohio State U- Marion BR	Yes	Yes	No
3095	OH	Ohio State U- Newark BR	Yes	Yes	No
3330	PA	PA State U- Allentown CAM	Yes	Yes	No
3381	PA	U of Pitt- Greensbg CAM	Yes	Yes	No
4816	NY	Suffolk Co. CC- Estn CAM	Yes	No	No
6881	NM	U of NM- Gallvp BR	Yes	Yes	No
10684	NY	Erie CC- City CAM	Yes	No	No
10687	OH	Ohio State U- Agri Tech Inst	Yes	Yes	No
12179	DE	Del. Tech & CC- Wilmington	Yes	Yes	No
12427	NY	Erie CC- South CAM	Yes	No	No
13204	NY	Suffolk Co. CC- Wstn CAM	Yes	No	No
Total unuseable observations (yes)			15	11	0

Table A-3

Analysis of 43 Two-Year Schools Excluded From Data Base

1. 2-Year branches of 4-year schools not AACJC members (N = 20):

FICE	State	Institution
1811	IN	Indiana University East
3319	PA	Clarion State Col Venango Campus
3331	PA	PA State Univ Altoona Campus
3332	PA	PA State Univ Beaver Campus
3334	PA	PA State Univ Berks Campus
3335	PA	PA State Univ DU Bois Campus
3336	PA	PA State Univ Fayette Campus
3338	PA	PA State Univ Hazleton Campus
3339	PA	PA State Univ McKeesport Campus
3340	PA	PA State Univ Mont Alto Campus
3341	PA	PA State Univ New Kensington Campus
3342	PA	PA State Univ Ogontz Campus
3343	PA	PA State Univ Schuylkill Campus
3344	PA	PA State Univ Wrthgtn-Scrtn Campus
3345	PA	PA State Univ Shenango Vly Campus
3346	PA	PA State Univ Wilkes Barre Campus
3347	PA	PA State Univ York Campus
692	PA	PA State Univ Delaware Campus
3383	PA	Univ of Pitt Titusville Campus
3707	VA	Richard Bland Col Wm & Mary

2. 2-year technical schools not AACJC members (N = 2):

FICE	State	Institution
9271	LA	St. Bernard Parish CC
11157	MA	Essex Agri-Tech Inst

3. 2-year schools supported only by Bureau of Indian Affairs (N = 4):

FICE	State	Institution
10438	KS	Haskell Indian Jr. College
11011	NM	Institute of American Indian Arts
8246	AZ	Navajo Community College
29156	SD	Oglala Sioux College

Table A-3 (Continued)

4. <u>2-year technical school reporting no public support</u> ($\underline{N} = \underline{1}$):

FICE	State	Institution
8677	OH	Northwest Technical College

5. <u>2-year schools not reporting any transfer degrees</u> ($\underline{N} = \underline{2}$):

FICE	State	Institution
29029	MO	Pioneer Community College
29245	AL	U. of Alaska Northwest CC

6. <u>2-year schools reporting only transfer degrees</u>: ($\underline{N} = \underline{14}$):

FICE	State	Institution
10997	GA	Emanuel Co. Jr. College
11167	VT	CC of Vermont
29242	AZ	So. Mountain CC
1309	CA	Taft College
1901	KS	Allen Cty Cmty JC
1924	KS	Independence CC
1938	KS	Pratt CC
2656	NM	NM Military Inst.
3101	OH	Ohio U Belemont Cty Br
3103	OH	Ohio U Ironton Br
3450	SC	U of SC at Beaufort
3454	SC	U of SC at Salkehatchie
12112	SC	U of SC at Sumter
3897	WI	U of Wisconsin Central System

APPENDIX B

Table B

Institutions Included on Finance, Enrollment and Degree Tapes, But Not on Salary/Fringe Benefits Tape

1. Small and rural (N=6):

Fice	State	Institution
1857	IA	Southwestern CC
1921	KS	Highland CC
2430	MS	Pearl River JRC
2867	NY	Fulton-Montgomery CC
2870	NY	Jefferson CC
6789	NY	Columbia-Greene CC

2. Small technical (N=1):

Fice	State	Institution
12954	NJ	Hudson Co CC (Commission)

3. Medium large (N = 1):

Fice	State	Institution
2861	NY	Cayuga Co CC

4. Very large (N=3):

Fice	State	Institution
1219	CA	Long Beach CC
2270	MI	Henry Ford CC
2864	NY	Dutchess CC

APPENDIX C

Table C: Listing of HEGIS Data Bases Used in Present Study as Primary Sources[1]

Fiscal Year	HEGIS Survey	Statistical Analysis System (SAS) Tape Label on Tape GG57S	Statistical Analysis System (SAS) Data Set Name	Virginia State Council of Higher Education (SCHEV) Tape Label
1980-81	Financial Statistics of Institutions of Higher Education for Fiscal Year Ending 1981 (HEGIS XVI)	A529E9.FI80	FINAN80	HEG.FIN16.SIGNED.A80-81' VOL=SER=02479 Label = 1
1980-81	Degrees and Other Formal Awards Conferred Between July 1, 1980 and June 30, 1981 (HEGIS XVI)	A529E9.DE80	ADJDEG80	.HEG.ERD16.A80-81 VOL=SER=E13480 Label = 1
1980-81	Fall Enrollment in Institutions of Higher Education: Fall 1980 (HEGIS XV)	A529E9.EN80	ENROL80	EG.OFE15.V.A80-81 Vol=SER=E08637 Label = 1 and EG.OFE15.V.A80-81 VOL=SER=EE11595 Label = 1
1980-81	Salaries, Tenure, and Fringe Benefits of Full-Time Instructional Faculty, 1980-81 (HEGIS XV)	A529E9.SA9M080 and A529E9.SA12M080	SAL9M080 and SAL12M80	HEG.EMP15.E.A80-81 VOL=SER=026863 Label = 1

[1] The National Center for Educational Statistics (NCES), under the auspices of the Department of Human Resources of the United States Government, each year conducts surveys as to the condition of higher education - Higher Education General Information Survey (HEGIS). NCES provides subscribers with the results of each year's surveys on magnetic tape for ease of computer analysis. The State of Virginia's State Council of Higher Education (SCHEV) is one such subscriber. VPI&SU is currently the repository for SCHEV's tapes. SCHEV's tape labels of all NCES tapes used in the present study are given, as well as the related tape labels of all tapes created by the present researcher in SAS format. Currently both tapes (SCHEV's tapes of "raw"-formatted data and the present researcher's tapes of SAS-formitted data) are in the custody of the VPI&SU tape librarian.

APPENDIX D

Data Base Field Definitions[1]

Primary Source	Field ID	Field Definition
ALL HEGIS	STATE	Domicile of reporting institutions.
HEGIS: Degrees	NUMBER	The total number of different degree and non-degree categories (out of a possible 70, excluding "other" classifications) reported by responding institutions in Part C, Sections 1-3, columns 4-9 of HEGIS XVI: Degrees and Other Formal Awards Conferred Between July 1, 1980 and June 30, 1981.
HEGIS: Degrees	DIVERSTY	An index of diversity first developed by Kaplan (1983) and later reported by Atwell and Sullins (1984). DIVERSTY = NUMBER/70.
HEGIS: Salaries and Fringe Benefits	INDXCOMP	An index of comprehensiveness first developed by Kaplan (1983) and later reported by Atwell and Sullins (1984) - see Appendix E for a brief description of its features.
HEGIS: Degrees	DEGCOUNT	The total number of different degree categories (out of a possible 70, excluding "other" classifications) reported by responding institutions in Part C, Sections 1-3, columns 4 and 5 of HEGIS XVI: Degrees and Other Formal Awards Conferred Between July 1, 1980 and June 30, 1981.
HEGIS: Degrees	NONCOUNT	The total number of different non-degree categories (out of a possible

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[1]Each of the fields described herein represent variable names on a data base maintained on magnetic tape currently in the custody of the VPI & SU tape librarian. This tape is referenced as tape number GG57S and carries the tape label of 'A529E9.Bruce5' and the related SAS (Statistical Analysis System) data set name of 'ADJBRUCE'.

Primary Source	Field ID	Field Definition
		70, excluding "other" classifications reported by responding institutions in Part C, Sections 1-3, columns 6-9 of HEGIS XVI: Degrees and Other Formal Awards Conferred Between July 1, 1980 and June 30, 1981.
All HEGIS	FICE	A six-digit identification number assigned to each reporting institution as defined by the Federal Interagency Committee on Education (FICE).
All HEGIS	OBEREG	A one-digit identification number assigned to each reporting institution. Values range from 1-8, as values of "9" and "0" have been eliminated from the present study. 1-NEW ENGLAND: CT ME MA NH RI VT 2-MID EAST: DE DC MD NJ NY PA 3-GREAT LAKES: IL IN MI OH WI 4-PLAINS: IA KS MN MO NE ND SD 5-SOUTHEAST: AL AR FL GA KY LA MS NC SC TN VA WV 6-SOUTHWEST: AZ NM OK TX 7-ROCKY MOUNTAINS: CO ID MT UT WY 8-FAR WEST: AK CA HI NV OR WA 9-OUTLYING AREAS; AQ CZ GU PR TQ VI 0-US SERVICE SCHOOLS
All HEGIS	INAME	Short name of reporting institution.
HEGIS: Enrollment	HEAD	Full and part-time men and women reported by responding institutions on lines 14 and 28, columns 13 and 14 of HEGIS XV: Fall Enrollment in Institutions of Higher Education, 1980.
HEGIS: Enrollment	FTE	Full-time men and women + 1/3 part-time men and women reported by responding institutions on lines 14 and 28, columns 13 and 14 of HEGIS XV: Fall Enrollment in Institutions of Higher Education, 1980.

Primary Source	Field ID	Field Definition
All HEGIS	CITYSZ	A one-digit identification code indicating the Standard Metropolitan Statistical Area (SMSA) or Standard Consolidated Statistical Area (SCSA) in which the reporting institution is located. The range of values is as follows: 0 = Not identified 1 = Outside any SMSA 2 = SMSA of less than 250,000 3 = SMSA of 250,000-499,999 4 = SMSA of 500,000-999,999 5 = SMSA of 1,000,000-1,999,999 (outside Ctr City) 6 = SMSA of 1,000,000-1,999,999 (within Ctr City) 7 = SMSA (or SCSA) of 2,000,000+ (outside Ctr City) 8 = SMSA (or SCSA) of 2,000,000+ (within Ctr City)
HEGIS: Finance	TUIT_FEE	Tuition and fees revenue reported by responding institutions in Part A, line 1 of HEGIS XVI: Financial Statistics of Higher Education for Fiscal Year Ending 1981.
HEGIS: Finance	FEDERAL	Federal government appropriations revenue reported by responding institutions in Part A, line 2 of HEGIS XVI: Financial Statistics of Higher Education for Fiscal Year Ending 1981.
HEGIS: Finance	LOCAL	Local government appropriations revenue reported by responding institutions in Part A, line 4 of HEGIS XVI: Financial Statistics of Higher Education for Fiscal Year Ending 1981.
HEGIS: Finance	STATES	State government appropriations revenue reported by responding institutions in Part A, line 3 of HEGIS XVI: Financial Statistics of Higher Education for Fiscal Year

Primary Source	Field ID	Field Definition
		Ending 1981.
HEGIS: Finance	IEG	Total INSTRUCTIONAL educational and general expenditures and mandatory transfers as reported by responding institutions in Part B, line 12 LESS line 2 (research expenditures) and LESS line 3 (public service expenditures) of HEGIS XVI: Financial Statistics of Higher Education for Fiscal Year Ending 1981.
Present Study	N	An internally assigned number used to identify a reporting institution as belonging to a major grouping of similar institutions. The range of values is: 257 = small and rural cc 80 = small, but not rural cc 92 = small (technical only) cc 100 = large cc
Present Study	NUMBR	A number assigned sequentially to all institutions responding to a nation-wide survey conducted by the present researcher. Range of values is as follows:

Reserved for Responses From 1st Request	Second Request Responses		
1-257	0	=	small and rural cc
258-338	400	=	small, but non-rural cc
401-492	500	=	small technical cc*
501-599	600	=	large cc

Present Study	TARGET	The reporting institutions target or service region population. The range of values represent institutional responses to the following question in a nation-wide survey conducted by the present researcher:

*i.e., no transfer degrees - HEGIS 5600 classification.

Primary Source	Field ID	Field Definition
		SERVICE REGION POPULATION: What is the approximate population of the Institutional Service Region? If the institution has no clearly defined service region, please indicate the approximate population of the area within a 50 mile radius of the institution.
Present Study	MARKET	TARGET/HEAD
HEGIS: Salaries	TOTNUM9	The total number of men and women paid salaries under 9-month contracts as reported by responding institutions in Part 1A, lines 1-6, columns 1 and 5 of HEGIS XV: Salaries, Tenure, and Fringe Benefits of Full-Time Instructional Faculty, 1980-81.
HEGIS: Salaries	AVE_SAL9	The weighted average salary under 9-month contracts, 1980-81, calculated as follows: The sum of all the salaries reported in Part 1A, lines 1-6, columns 2 and 6 (HEGIS XV) was divided by TOTNUM9.
HEGIS: Salaries	AV9_SAL12	The annualized (i.e. 12-month equivalent) weighted average 9-month salary, 1980-81, calculated as follows: (12 months)(AVE_SAL9/9 months)
HEGIS: Salaries	TOTNUM12	The total number of men and women paid salaries under 12-month contracts as reported by responding institutions in Part 1B, lines 1-6, columns 1 and 5 of HEGIS XV: Salaries, Tenure, and Fringe Benefits of Full-Time Instructional Faculty, 1980-81.

Primary Source	Field ID	Field Definition
HEGIS: Salaries	AVE_SAL12	The annualized weighted average salary under 12-month contracts, calculated as follows: The sum of total salaries reported in Part 1B, lines 1-6, columns 2 and 6 (HEGIS XV) was divided by TOTNUM12.
HEGIS: Salaries	AV12SAL9	The 9-month equivalent weighted average salary of 12-month contracts, 1980-81, calculated as follows: (9 months)(AVESAL12/12 months)
HEGIS: Salaries	AVE_SAL	The combined weighted average salary of 9 month contracts and 9-month equivalent of 12 month contracts calculated as follows:

(TOTNUM9 x AVE_SAL9) + (TOTNUM12 x AVE12SAL9) / (TOTNUM9 + TOTNUM12)

U.S. Dept. of Labor	CPI	The 1980-81 average consumer price index applicable to each institution according to its (a) region and (b) population within that region (i.e., its SMSA) as reported by the U.S. Department of Labor, Bureau of Labor Statistics.
Present Study	N1	An internally assigned number used to identify those institutions initially thought to quality for inclusion in the present study, but subsequently excluded for one or more reasons as outlined in foot-note 2 to Table A-1 of Appendix A. Those observations with an N1 value of 1 were thus excluded from the study and are among those itemized in Table A-3 of Appendix A for the specified reasons cited therein.

APPENDIX E

INDEXCOMP

The index of comprehensiveness (INDEXCOMP) "was derived by calculating separate indices for the transfer and occupational-technical (O-T) components of a curriculum. The separate measures then were weighted by assigning a value of 40 percent to the transfer index and 60 percent to the O-T index. The adjusted or weighted indices then were combined to form the total comprehensiveness index [INDEXCOMP]" (Atwell and Sullins, 1984, p. 33).

With respect to the development of the transfer index, values of either 5 or 10 points were arbitrarily assigned to each of 10 transferable program areas. The calculation of the O-T index was considerably more complex. Following the six O-T program areas of the HEGIS taxonomy, Atwell and Sullins (1984) describe this complexity as follows:

> The first program in a cluster was given a value of ten points, the second separate program within the same cluster was worth five points, the third, three points, and each subsequent new curriculum, one point. If an institution offered a diploma in a curriculum in which a degree had already been counted, or vice versa, it received one point for having a second level of curricular offering. Once the point values were calculated for each of the six occupational clusters, each cluster value was adjusted to reflect the wide variation in program options (from 5 to 19) points in each cluster. (p. 7-8 of Appendix A).

APPENDIX F

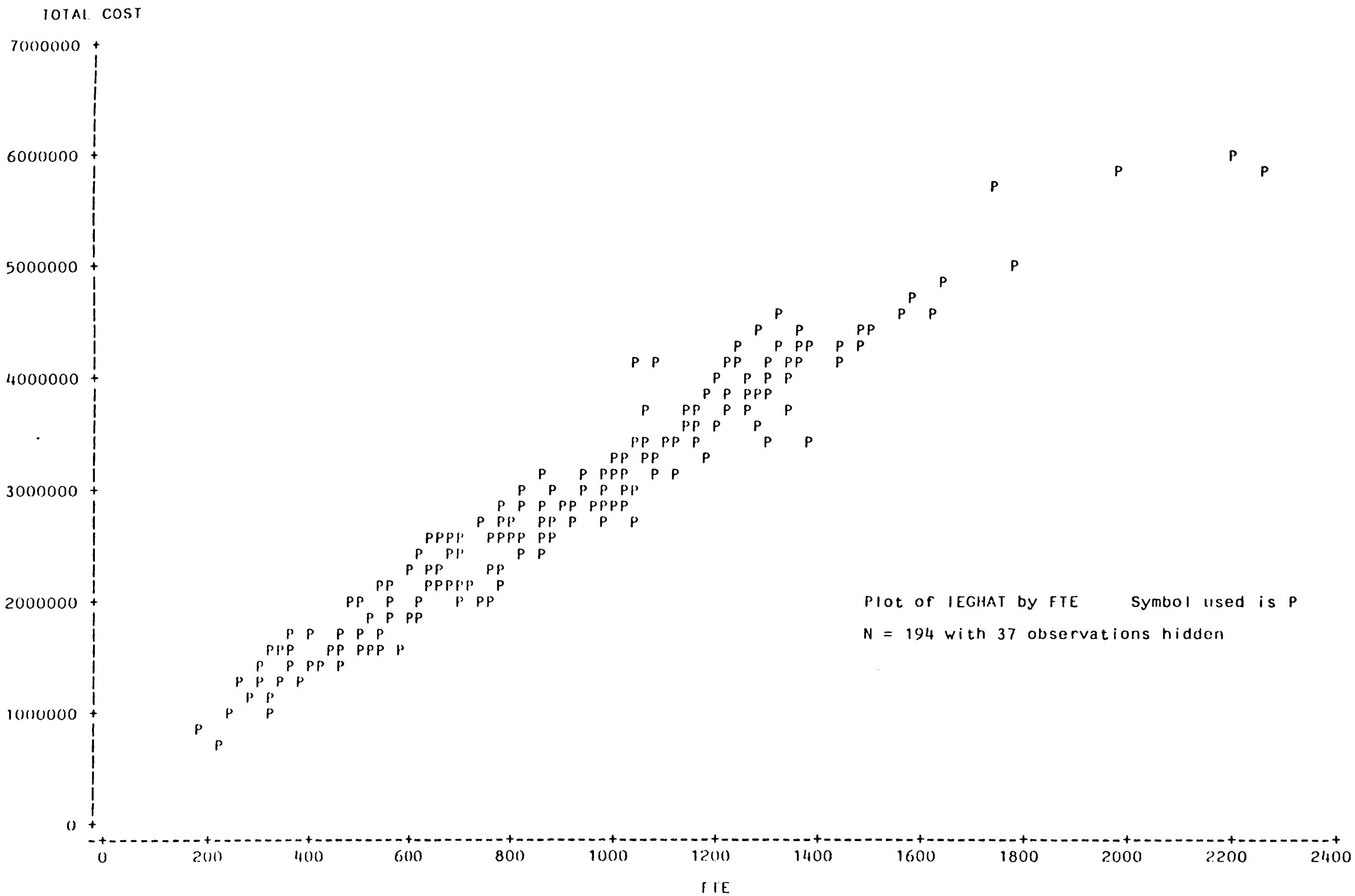

Figure F-1. Predicted (TEGHAT) total cost: Equation (5.1) linear model for small rural 2-year public colleges.

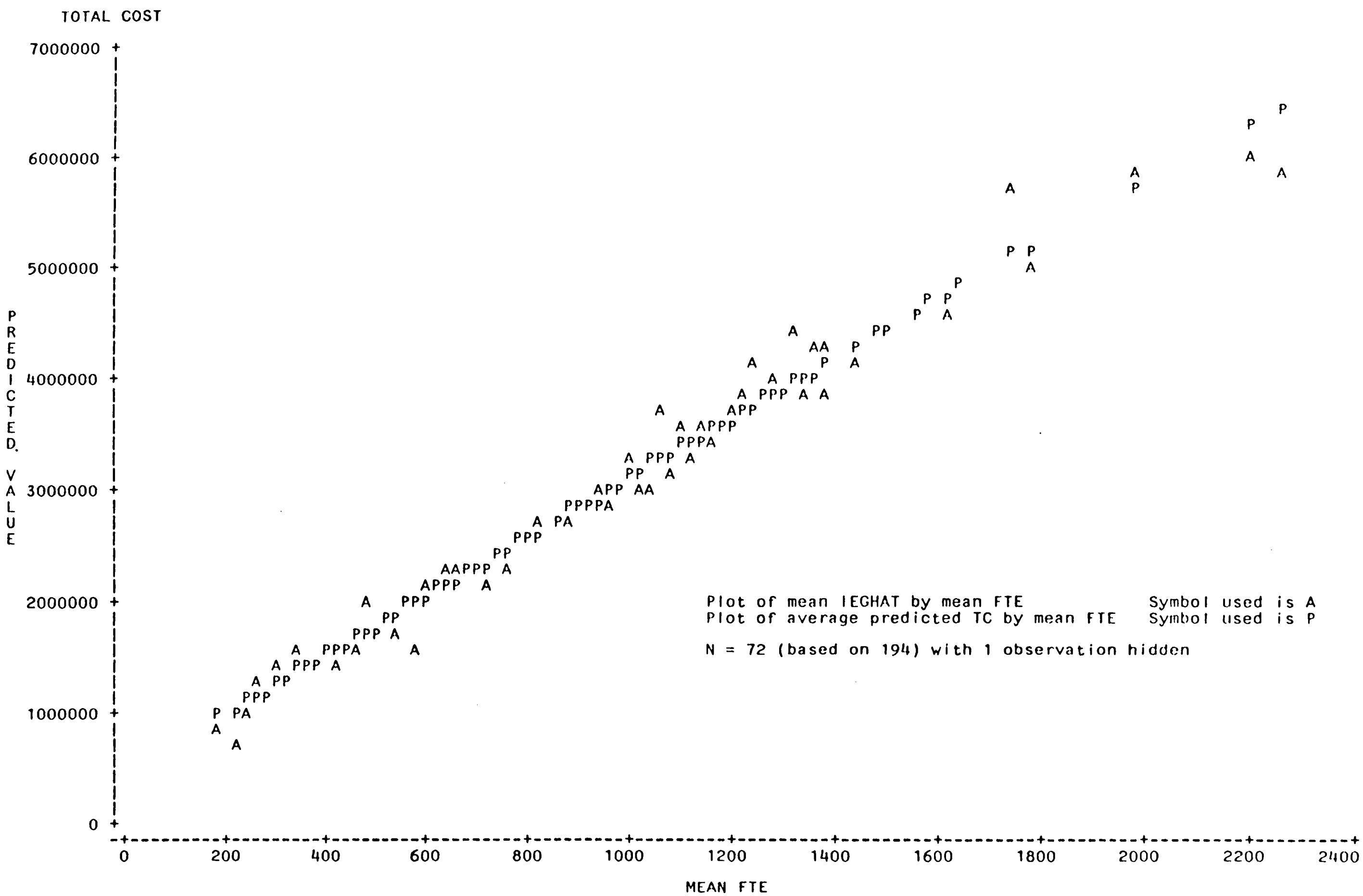

Figure F-2. Mean IEGHAT vs. average predicted total cost: Equation (5.1.1) linear model for small rural 2-yr public colleges.

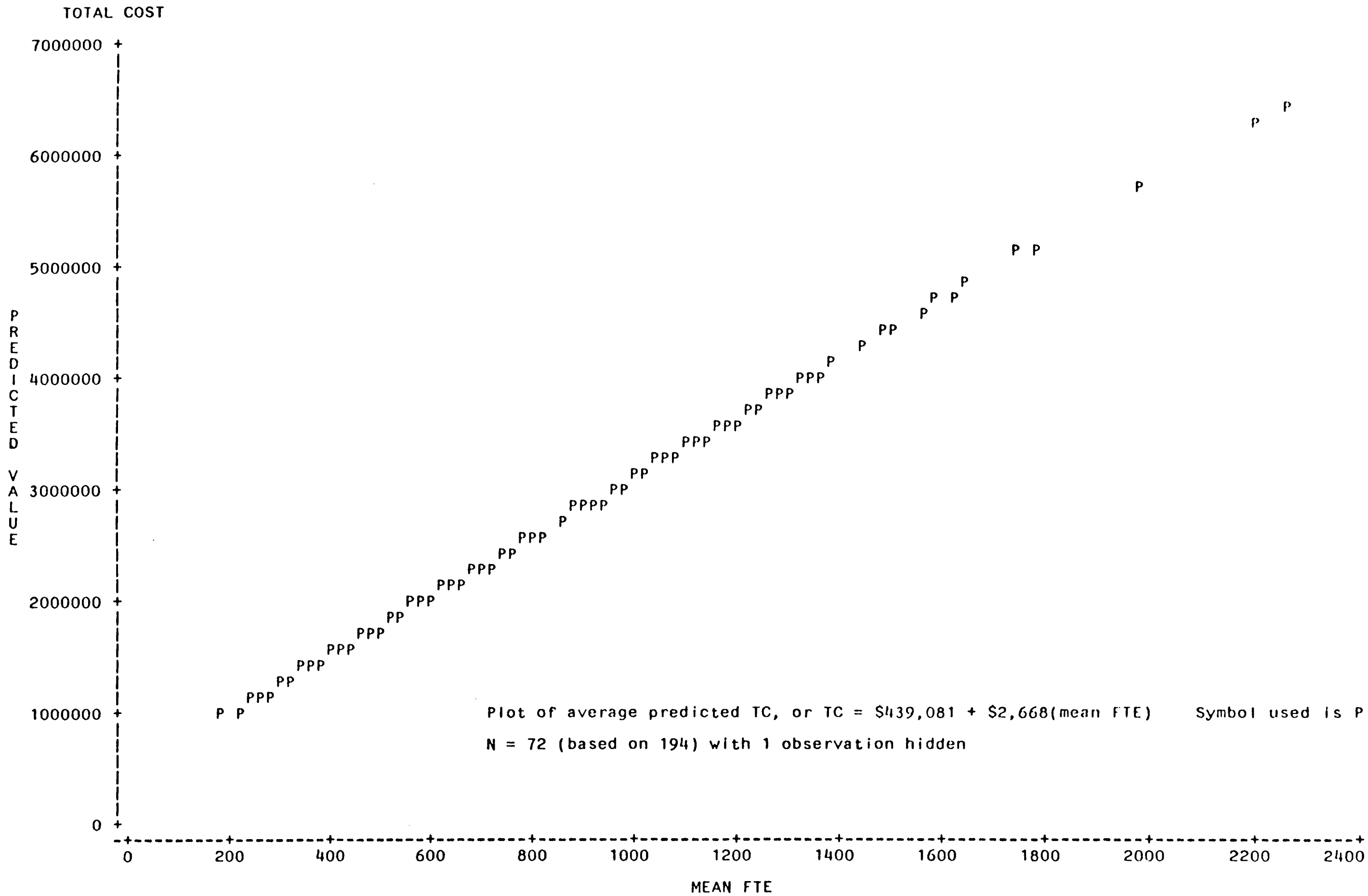

Figure F-3. Average predicted total cost: Equation (5.1.1) linear model for small rural 2-year public colleges.

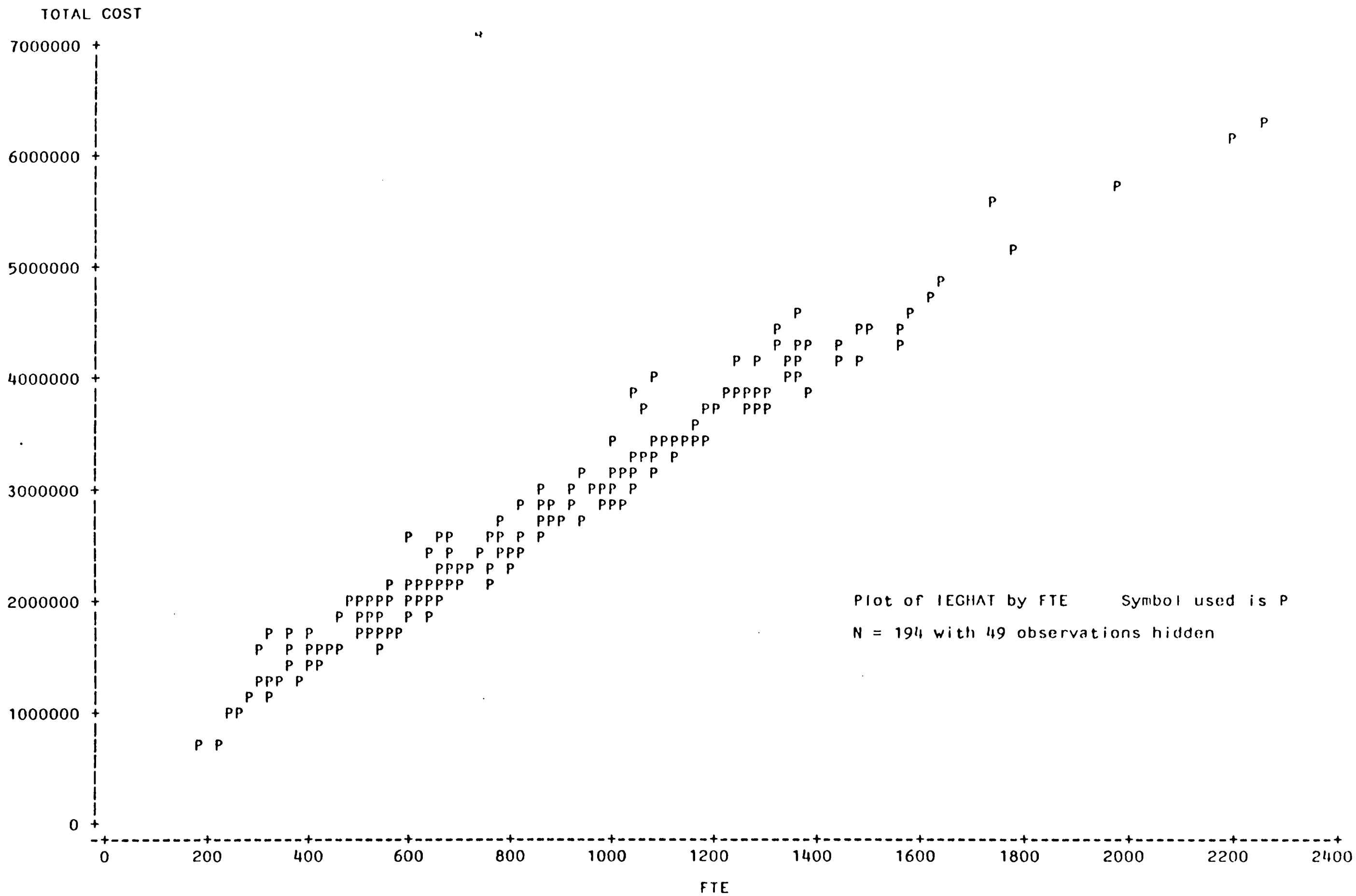

Figure F-4. Predicted (IEGHAT) total cost: Equation (5.2) linear model with INDEXCOMP for small rural 2-year public colleges.

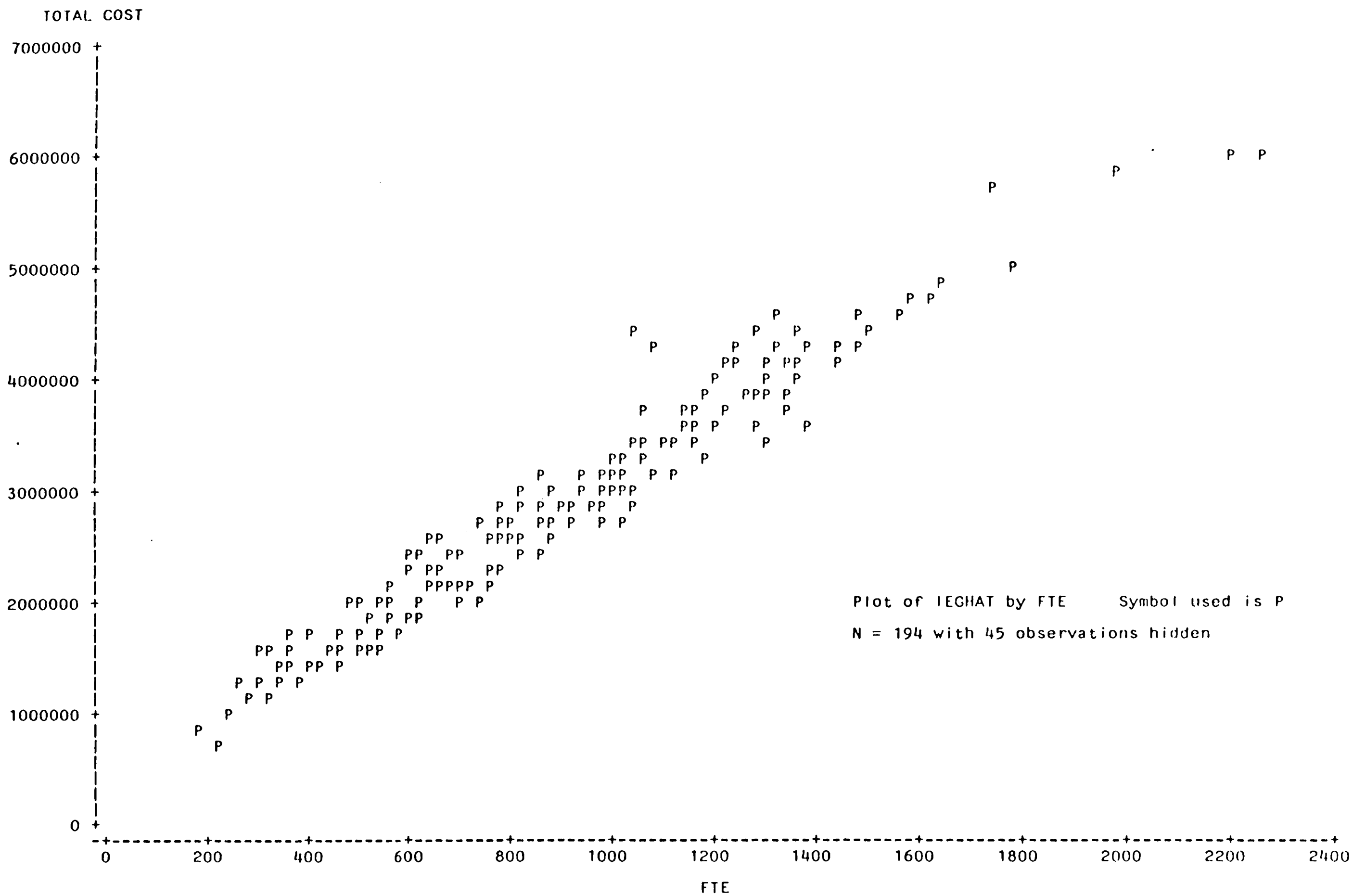

Figure F-5. Predicted (IEGHAT) total cost: Equation (6.1) quadratic model with DIVERSITY for small rural 2-year public colleges.

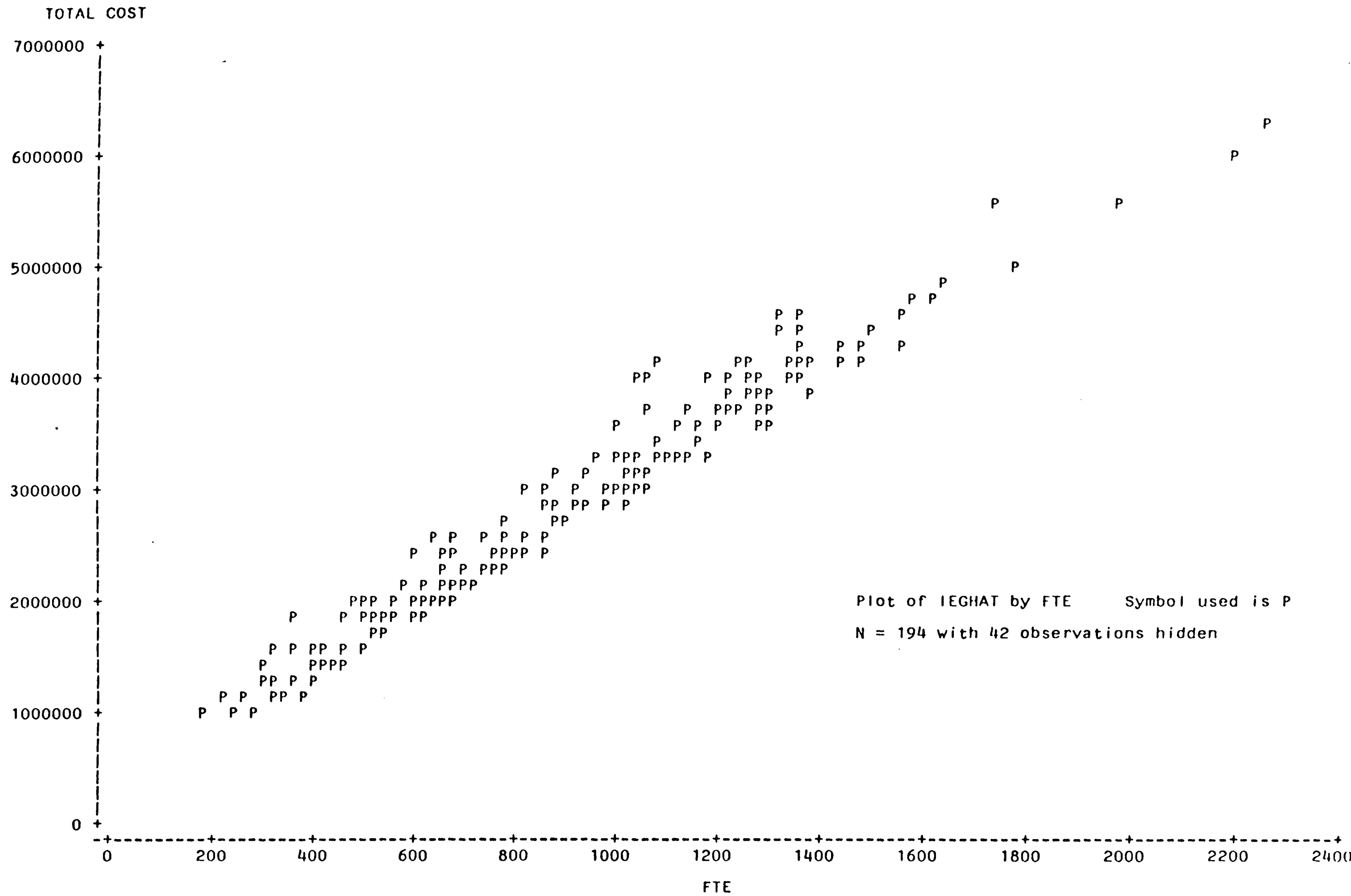

Figure F-6. Predicted (IEGHAT) total cost: Equation (6.2) quadratic model with INDEXCOMP for small rural 2-year public colleges.

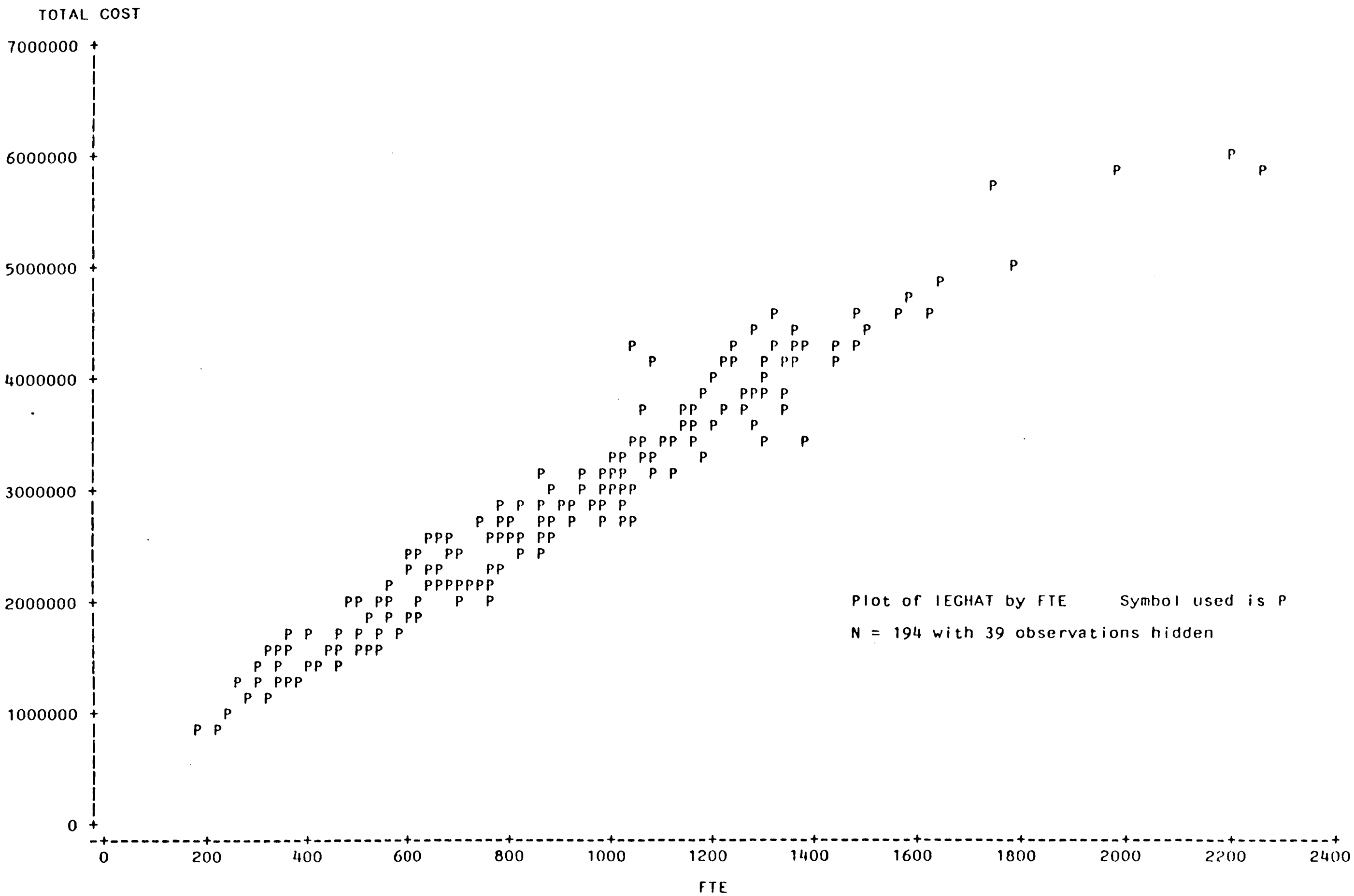

Figure F-7. Predicted (IEGHAT) total cost: Equation (6.1A) quadratic model with DIVERSITY for small rural 2-year public colleges.

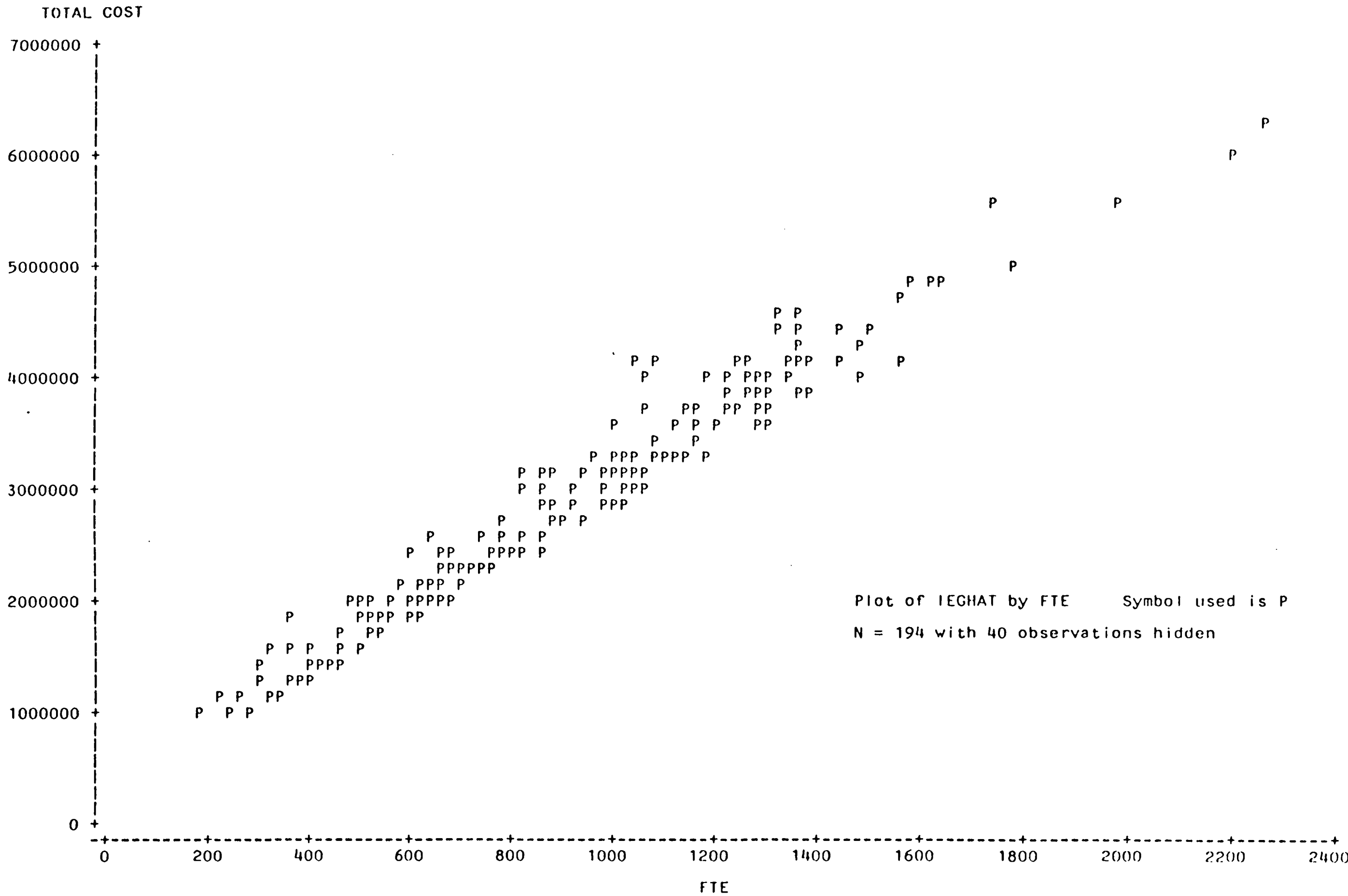

Figure F-8. Predicted (IEGHAT) total cost: Equation (6.2A) quadratic model with INDEXCOMP for small rural 2-year public colleges.

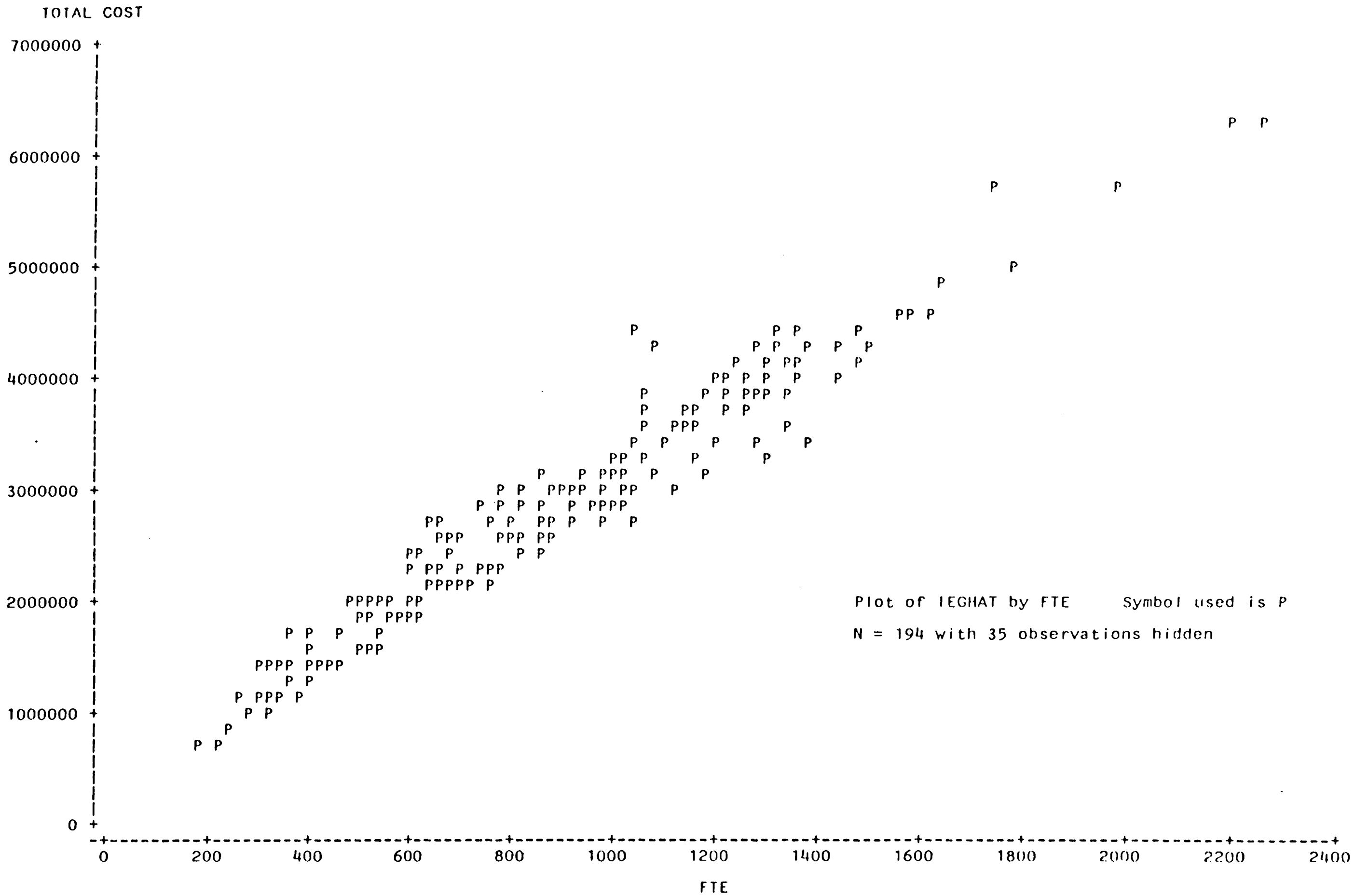

Figure F-9. Predicted (IEGHAT) total cost: Equation (7.1) cubic model with DIVERSITY for small rural 2-Year public colleges.

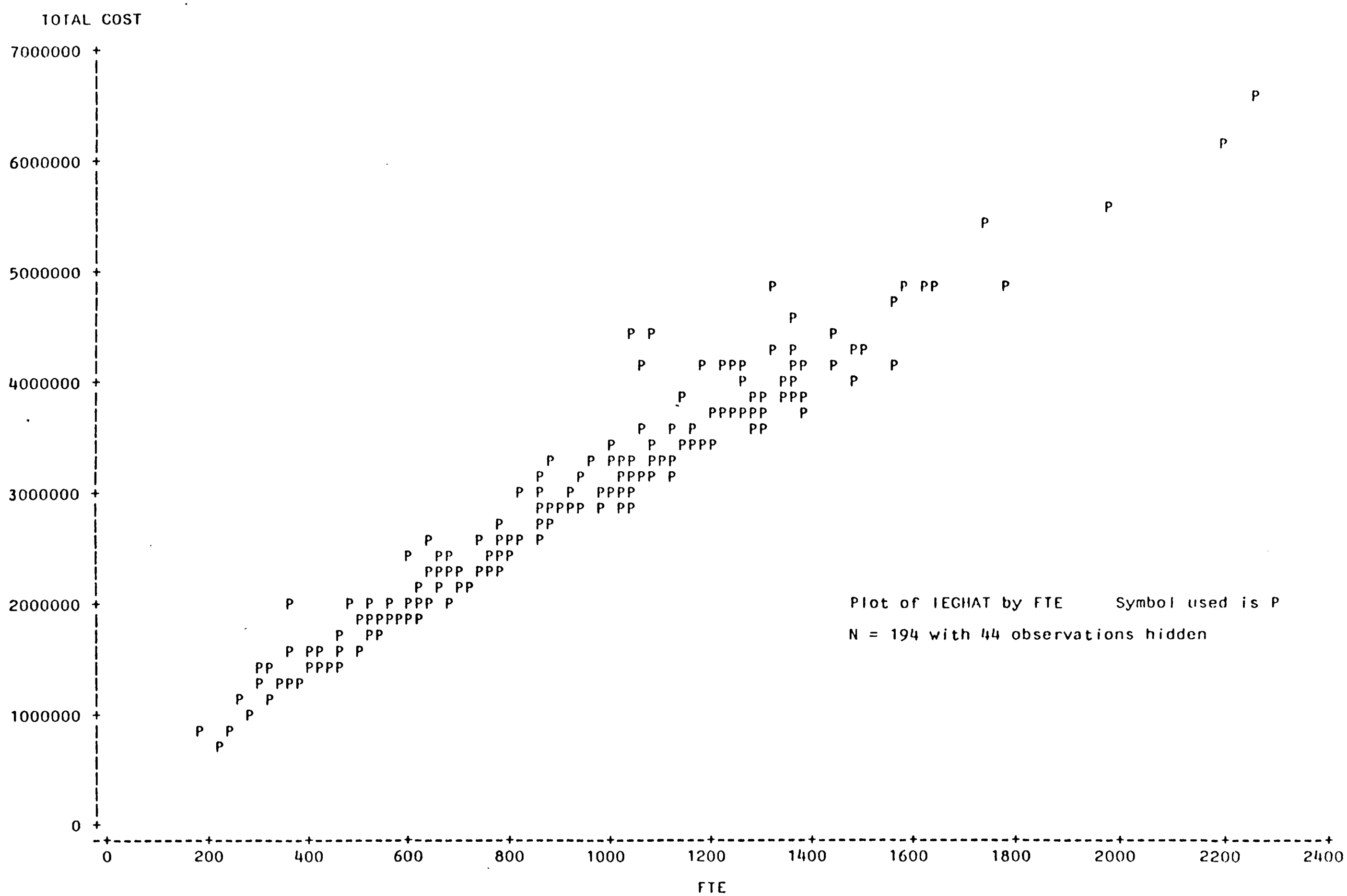

Figure F-10. Predicted (IEGHAT) total cost: Equation (7.2) cubic model with INDEXCOMP for small rural 2-year public colleges.

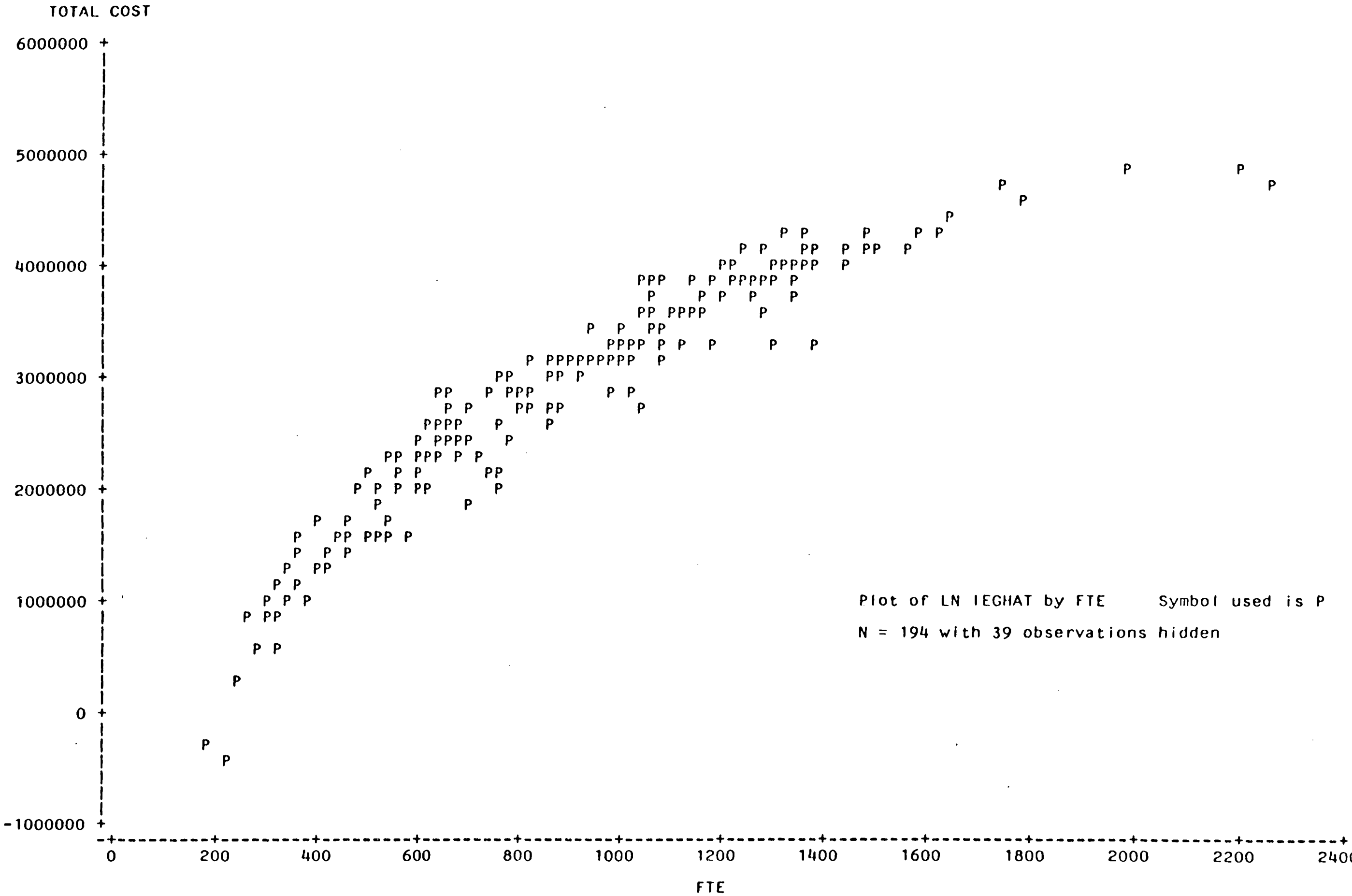

Figure F-11. Predicted (LN IEGHAT) total cost: Equation (8.1) multicative with DIVERSITY for small rural 2-year public colleges.

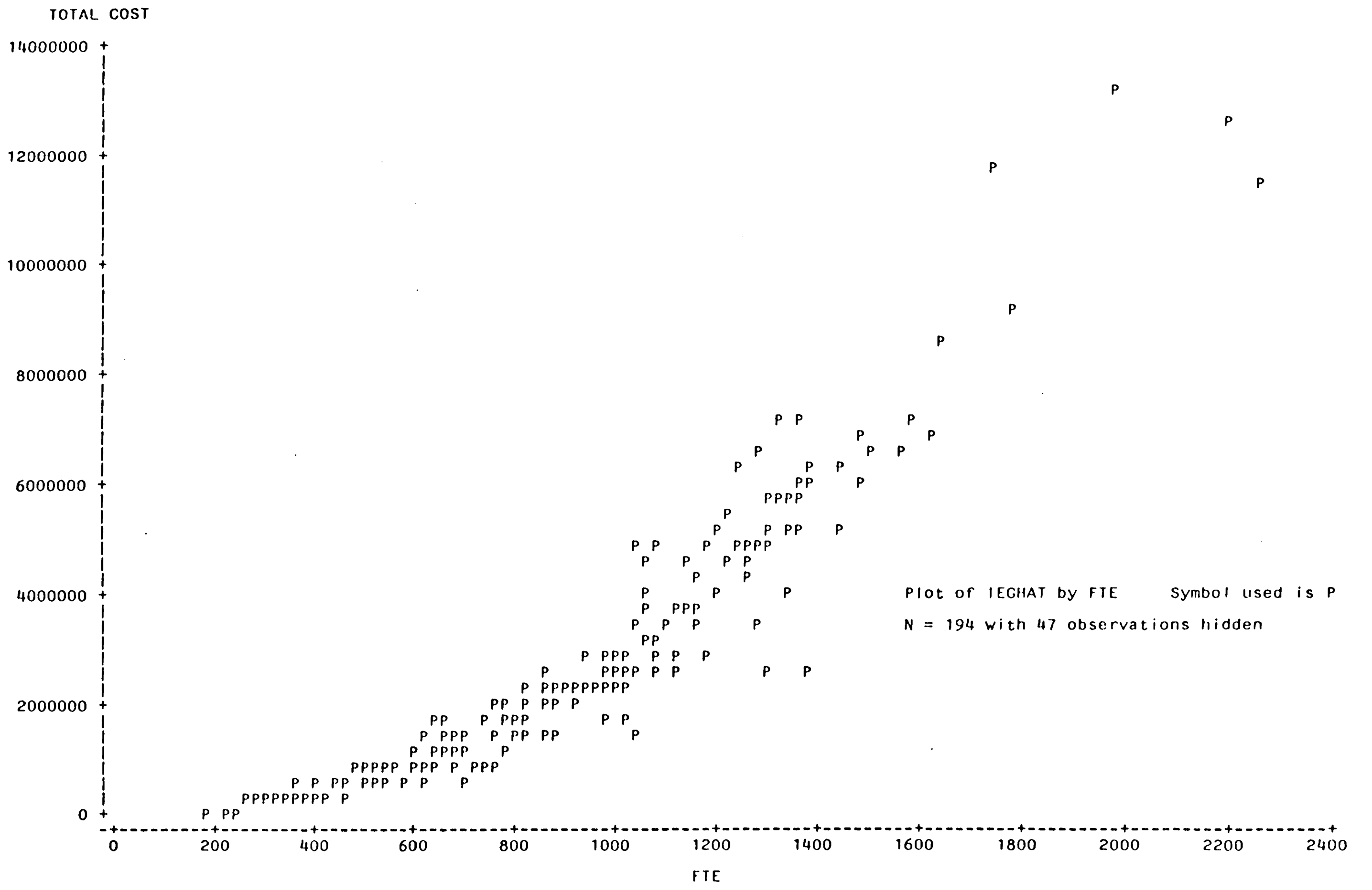

Figure F-12. Predicted (IEGHAT) total cost: Equation (8.1) multicative with DIVERSITY for small rural 2-year public colleges.

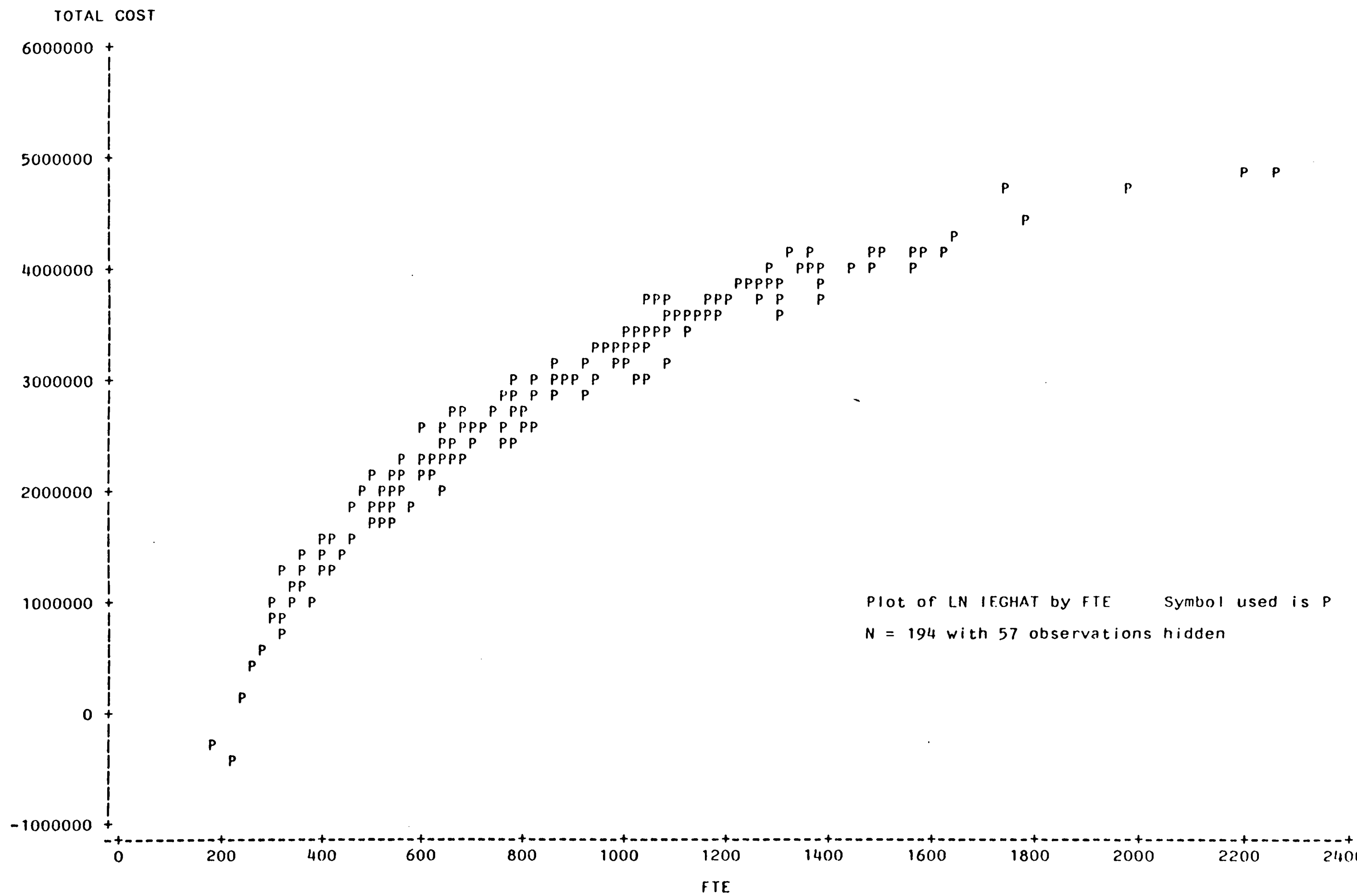

Figure F-13. Predicted (LN IEGHAT) total cost: Equation (8.2) multicative with INDEXCOMP for small rural 2-year public colleges.

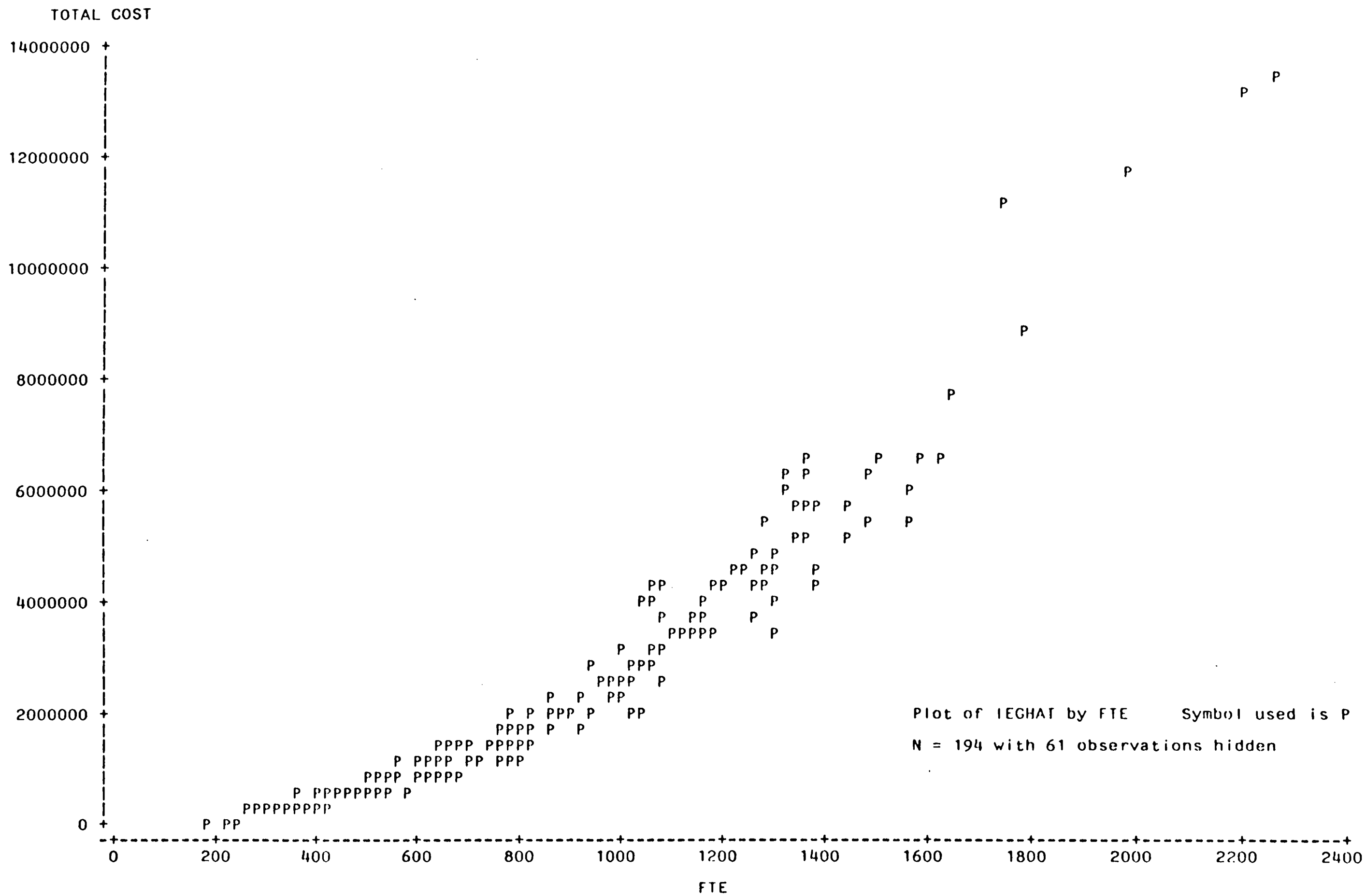

Figure F-14. Predicted (IEGHAT) total cost: Equation (8.2) multicative with INDEXCOMP for small rural 2-Year public colleges.

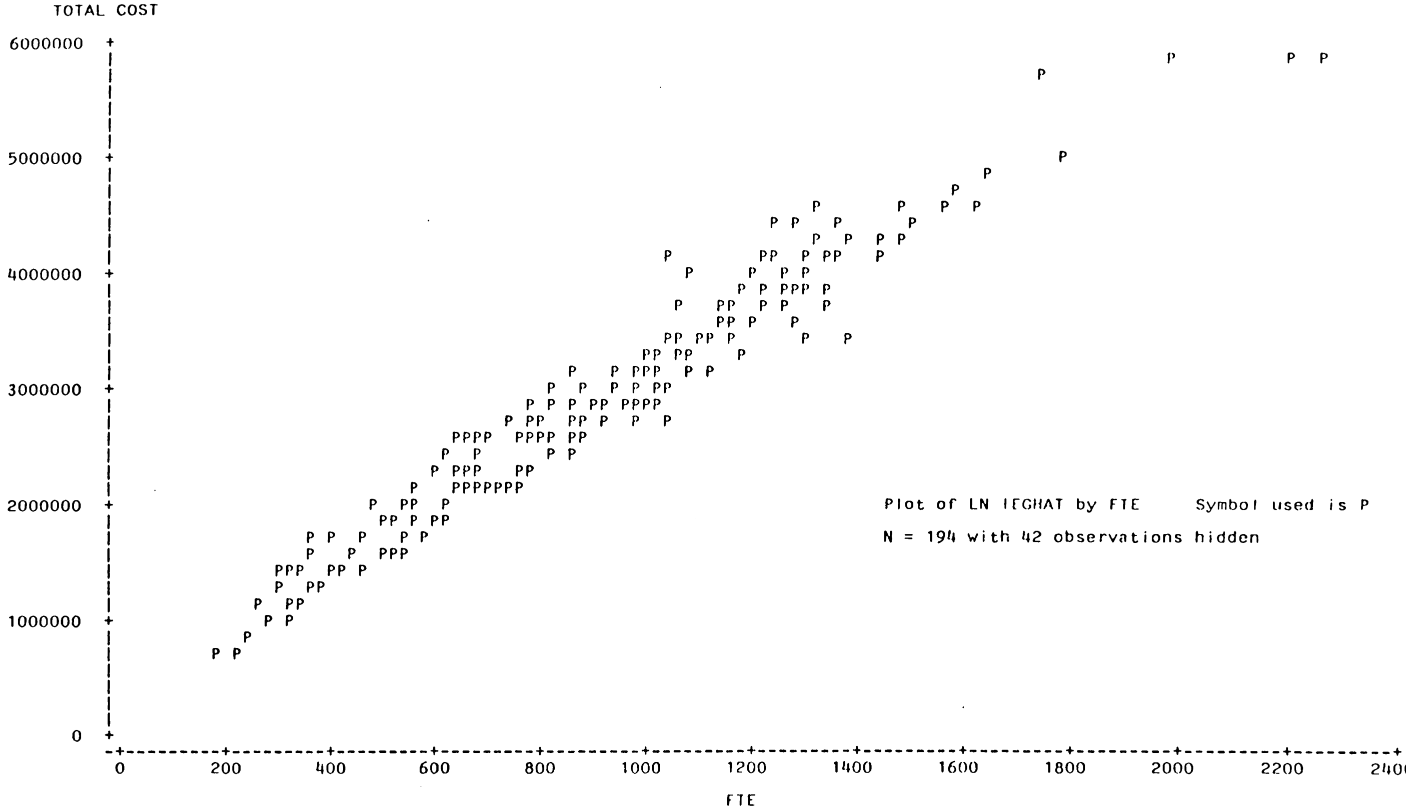

Figure F-15. Predicted (LN IEGHAT) total cost: Equation (9.1) trans-log with DIVERSITY for small rural 2-year public colleges.

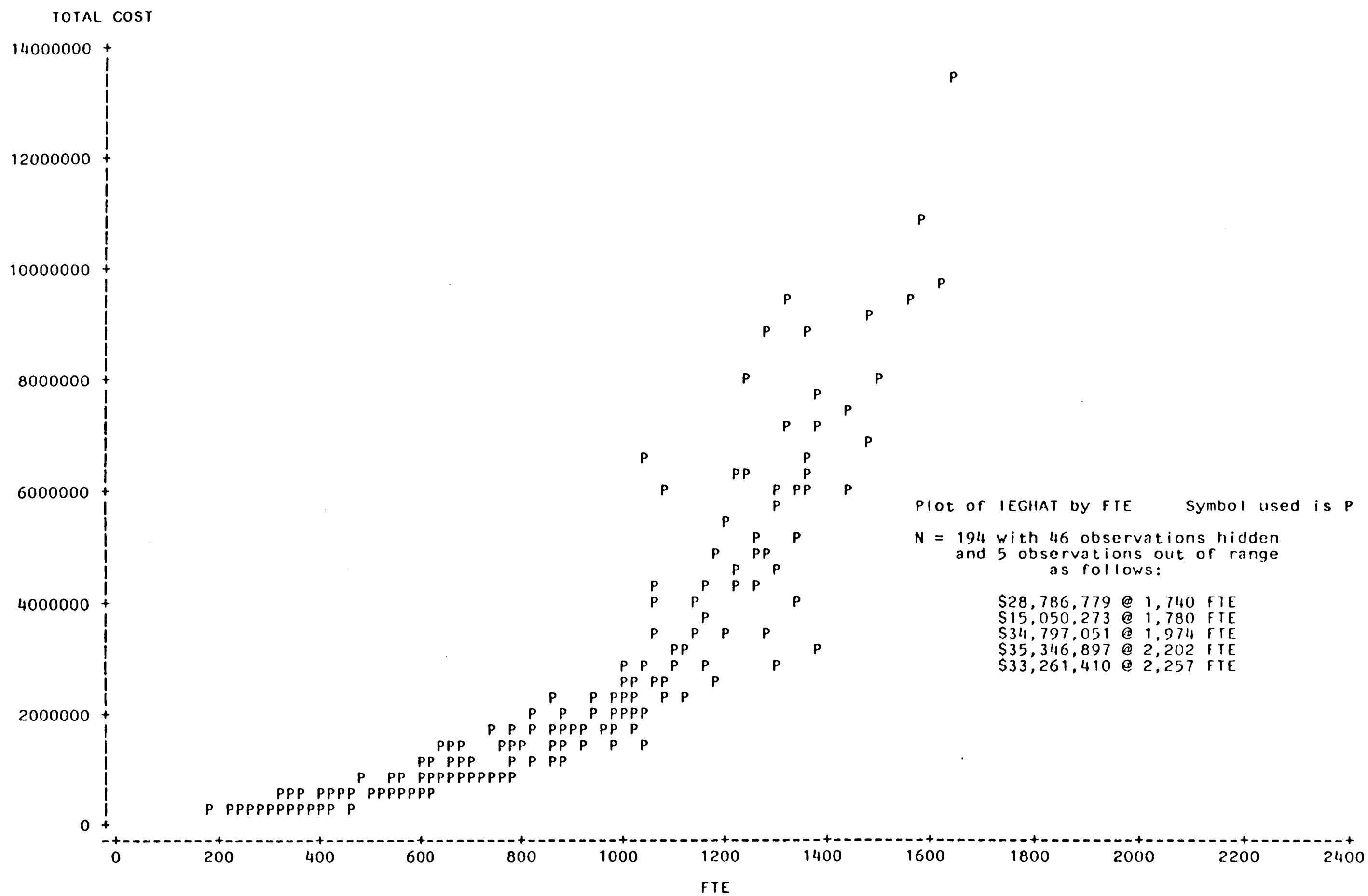

Figure F-16. Predicted (IEGHAT) total cost: Equation (9.1) trans-log with DIVERSITY for small rural 2-year public colleges.

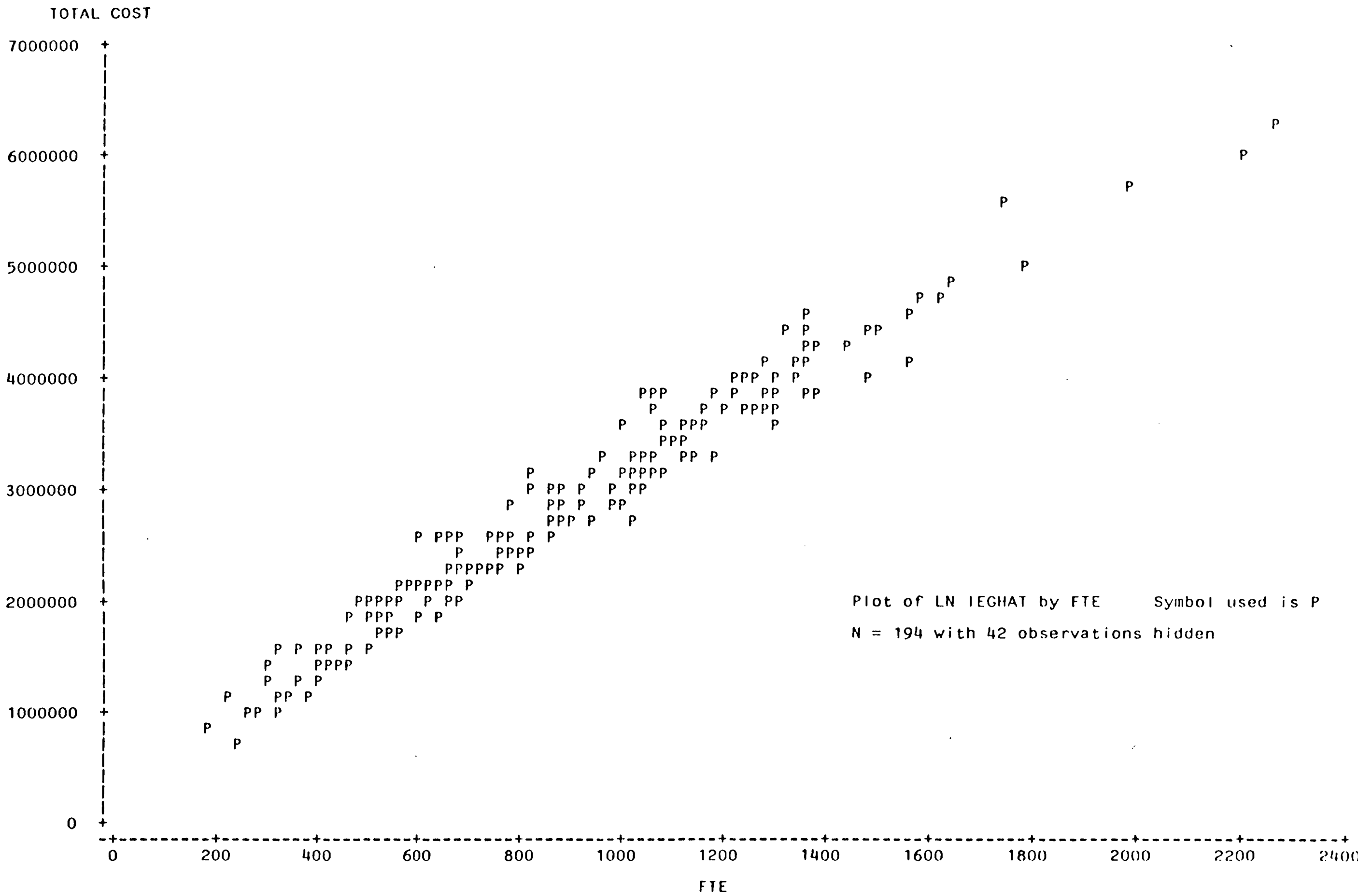

Figure F-17. Predicted (LN IEGHAT) total cost: Equation (9.2) trans-log with INDEXCOMP for small rural 2-year public colleges.

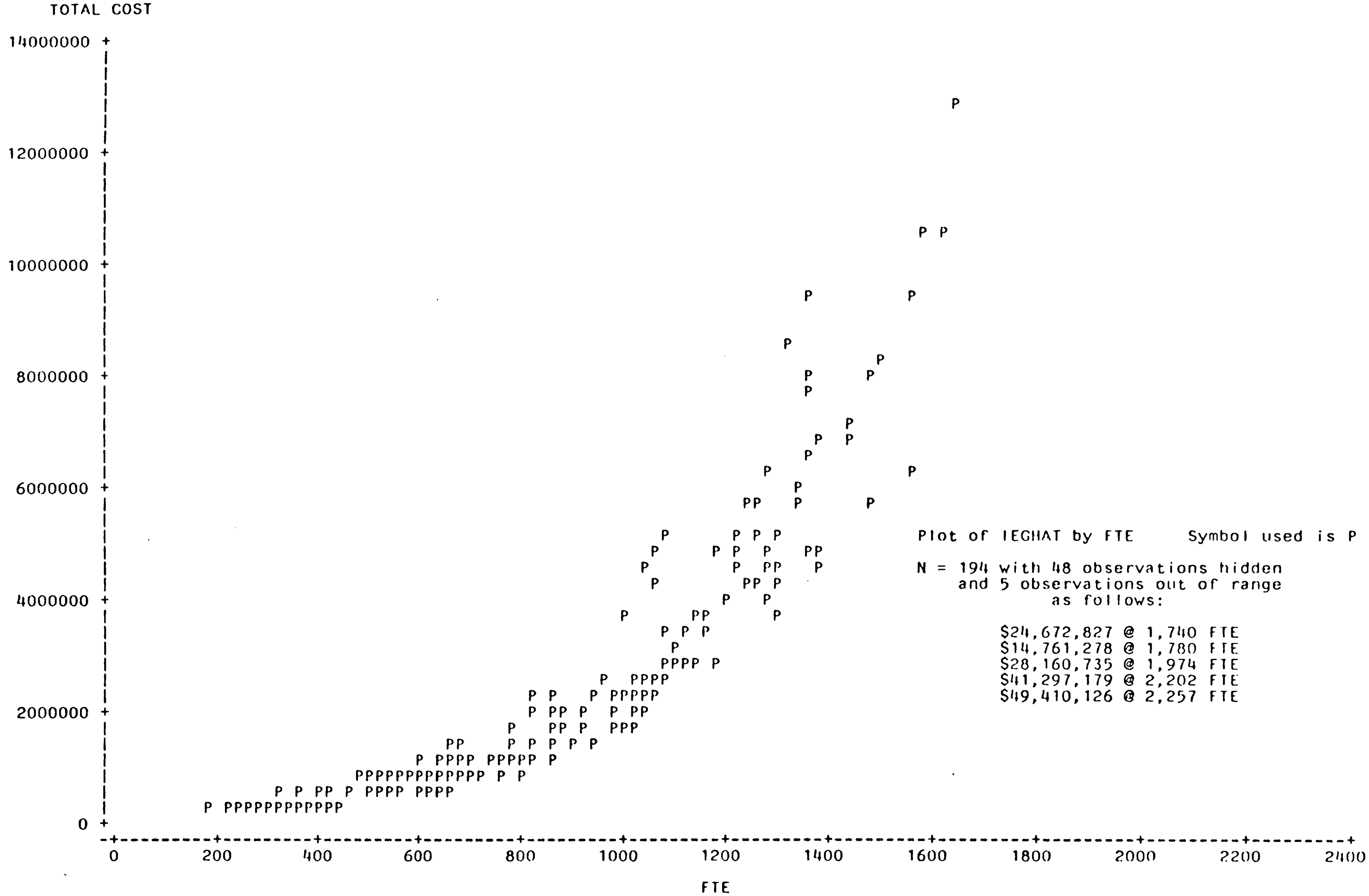

Figure F-18. Predicted (IEGHAT) total cost: Equation (9.2) trans-log with INDEXCOMP for small rural 2-year public colleges.

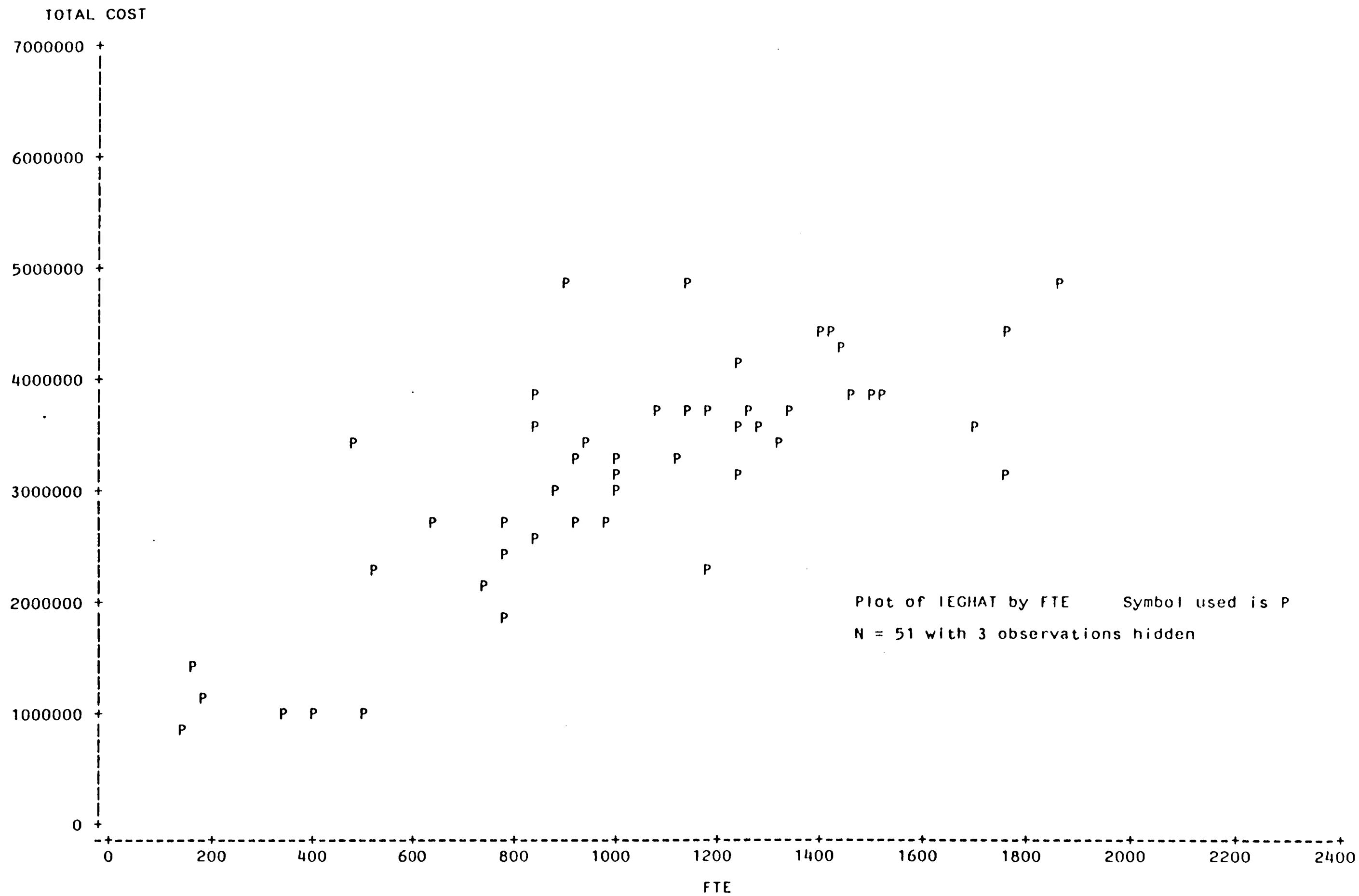

Figure F-19. Predicted (IEGHAT) total cost: Equation (6.1) quadratic model for small nonrural 2-year public colleges.

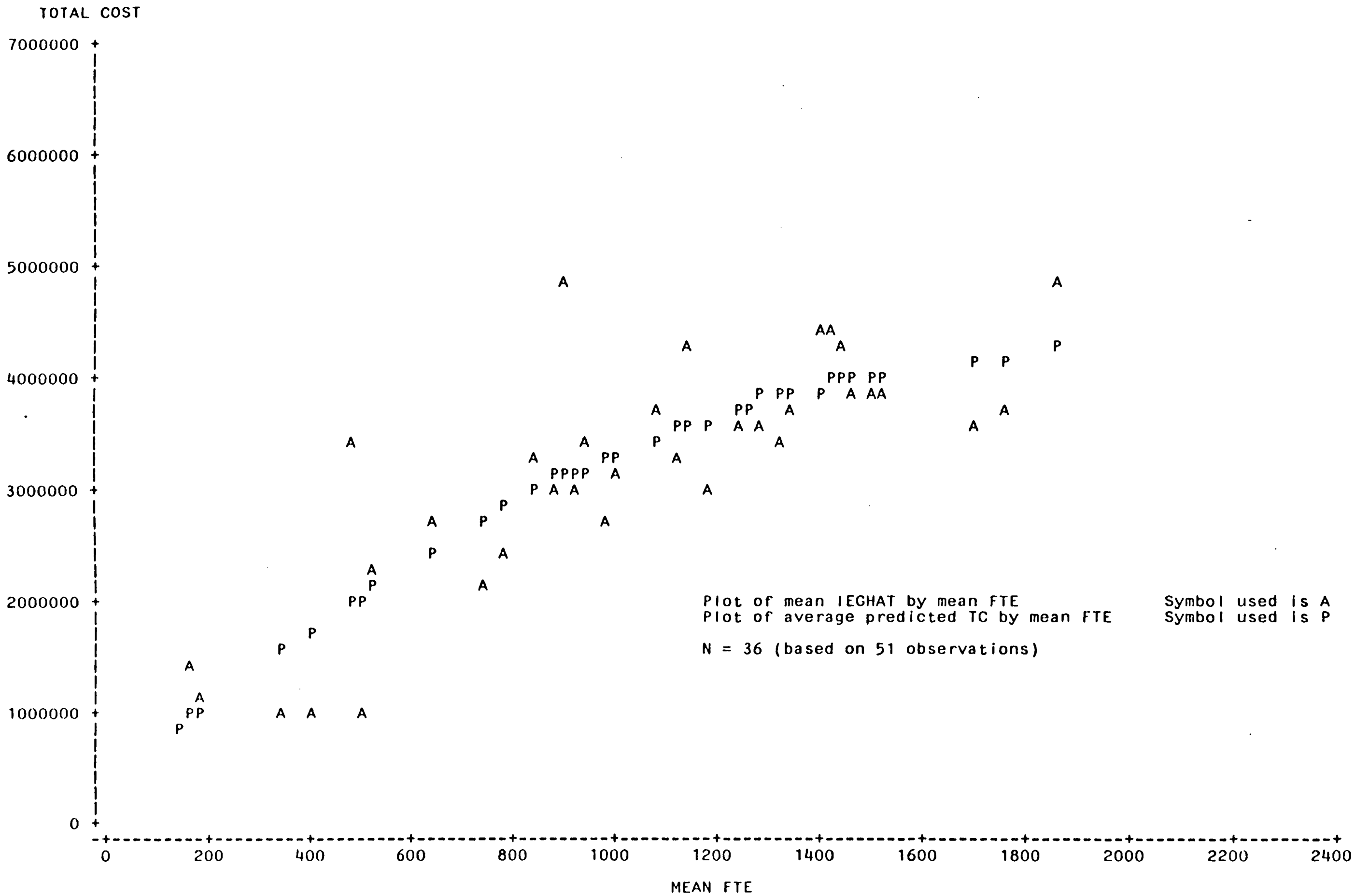

Figure F-20. Mean IEGHAT vs. average predicted total cost: Equation (6.1.1) quadratic model for small nonrural 2-year public colleges.

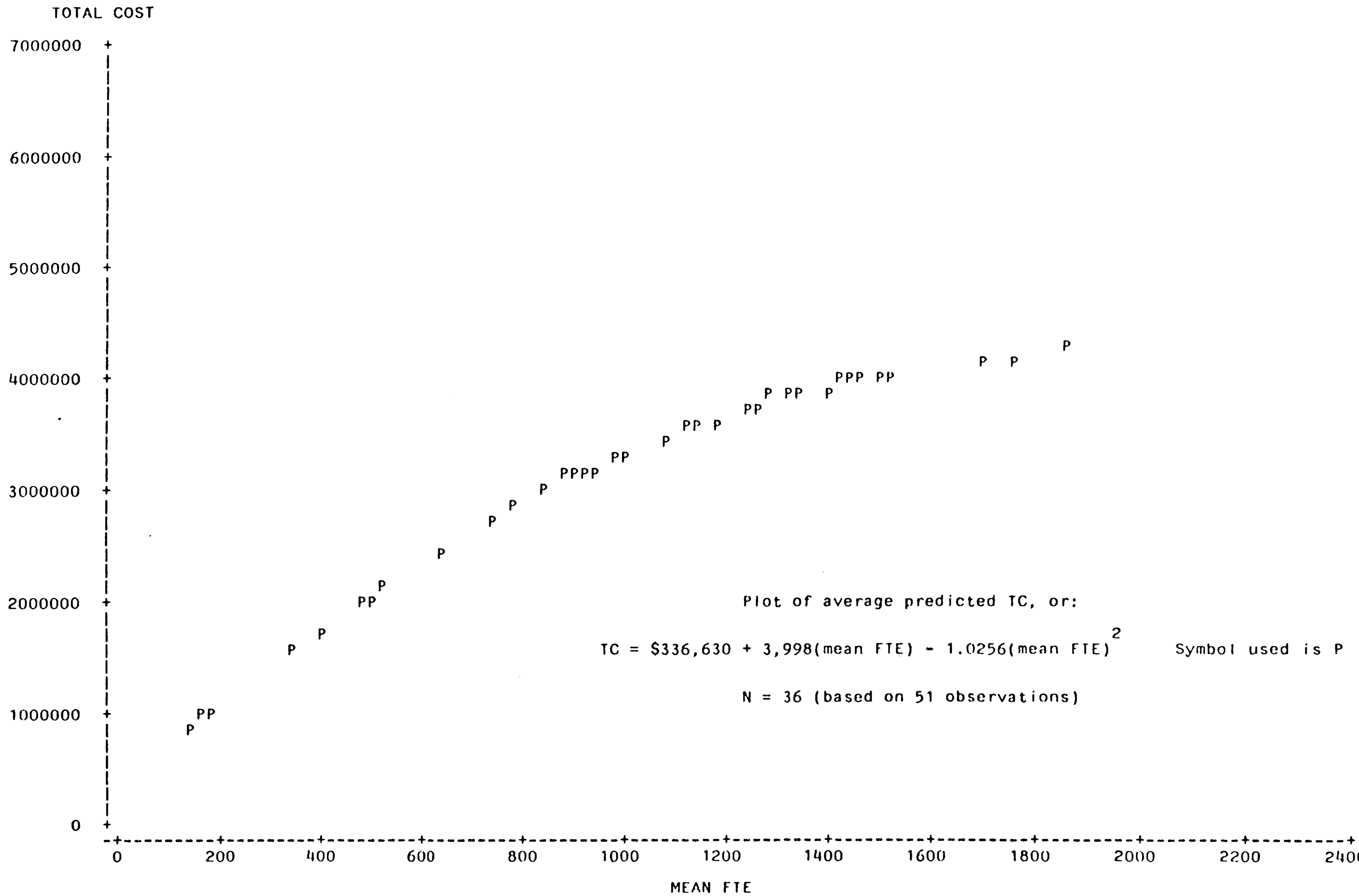

Figure F-21. Average predicted total cost: Equation (6.1.1) quadratic model for small nonrural 2-year public colleges.

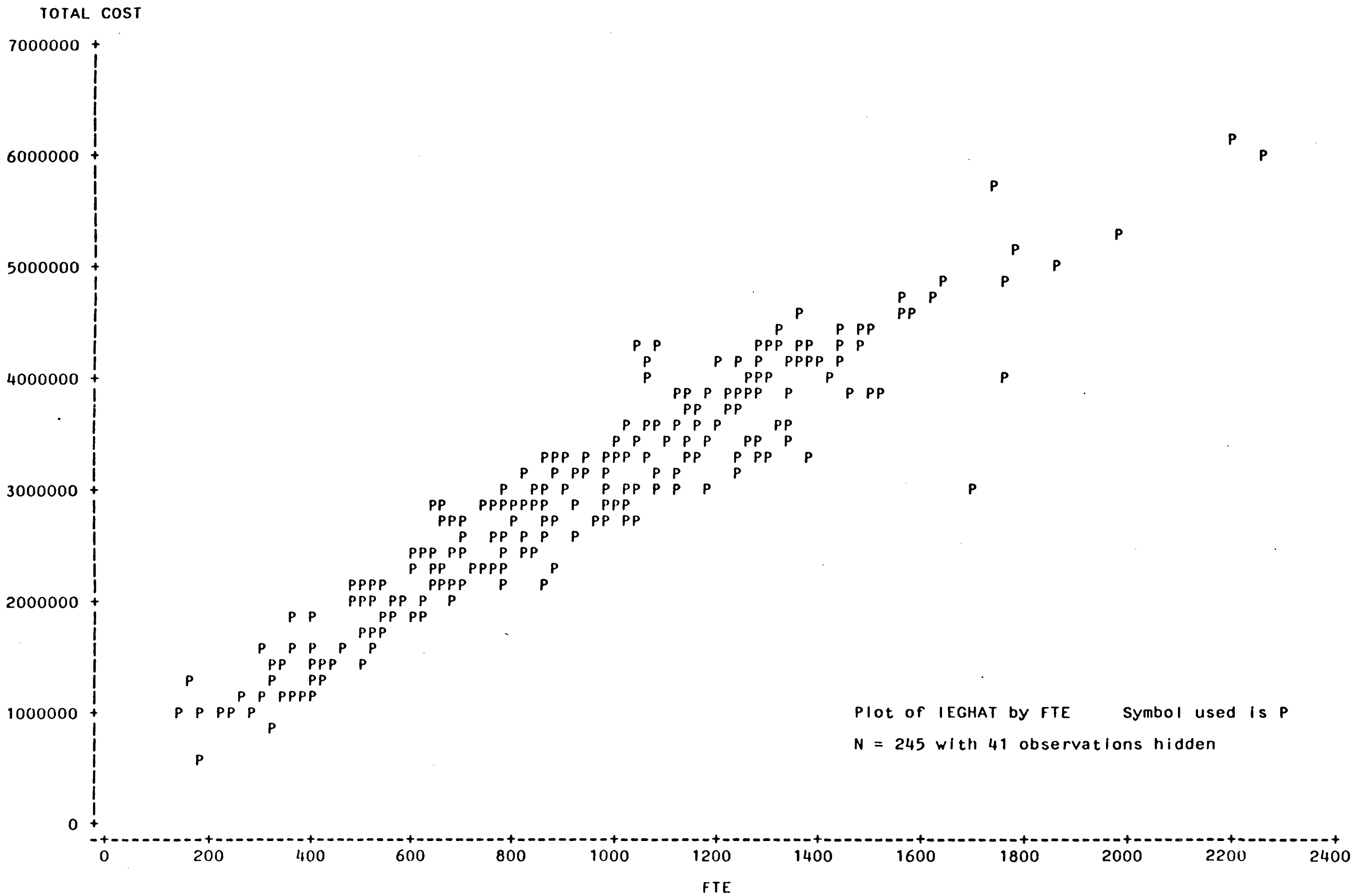

Figure F-22. Predicted (IEGHAT) total cost: Equation (7.1) cubic model for total small 2-year public colleges.

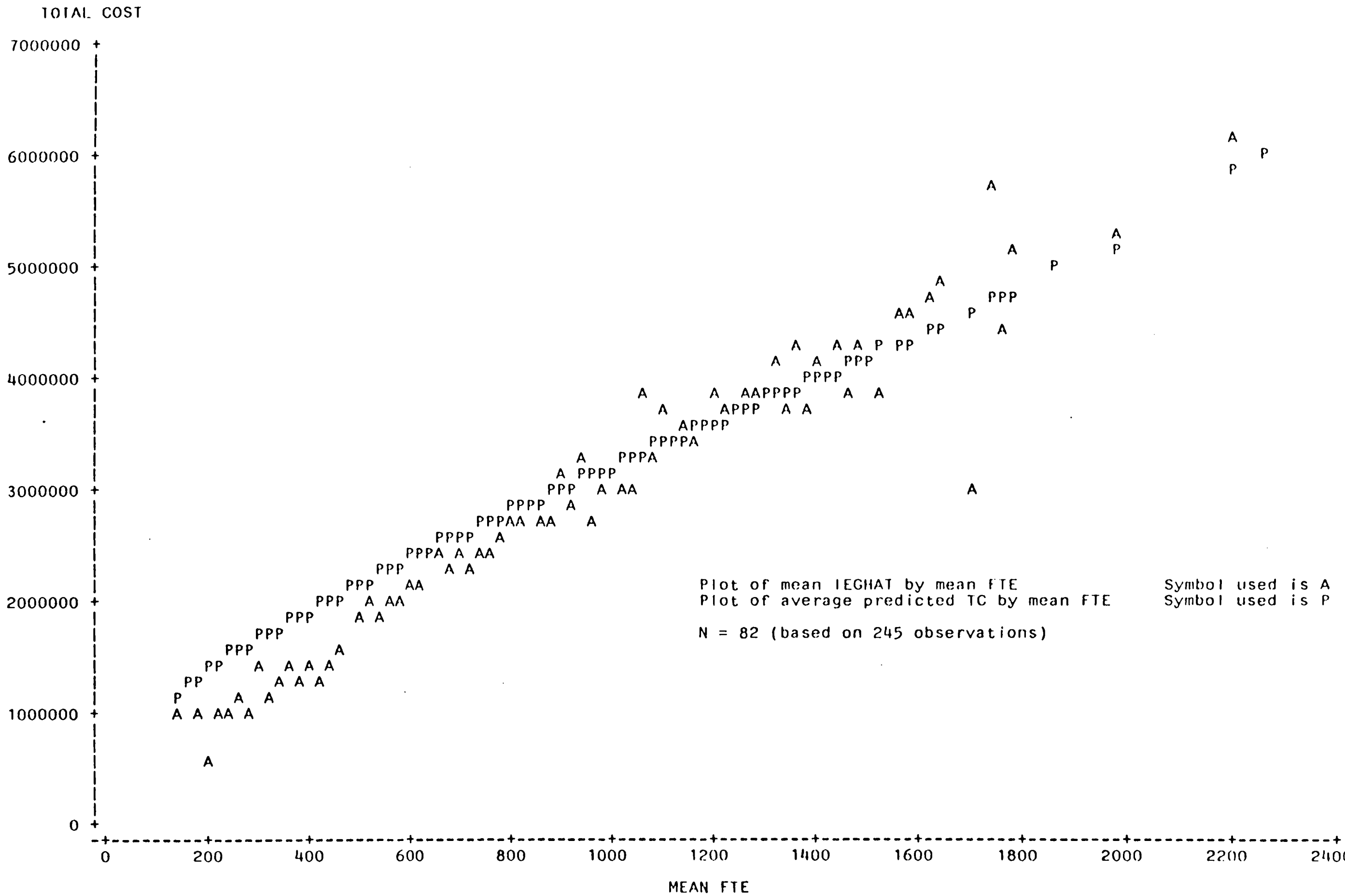

Figure F-23. Mean IEGHAT VS. average predicted total cost: Equation (7.1.1) cubic model for total small 2-year public colleges.

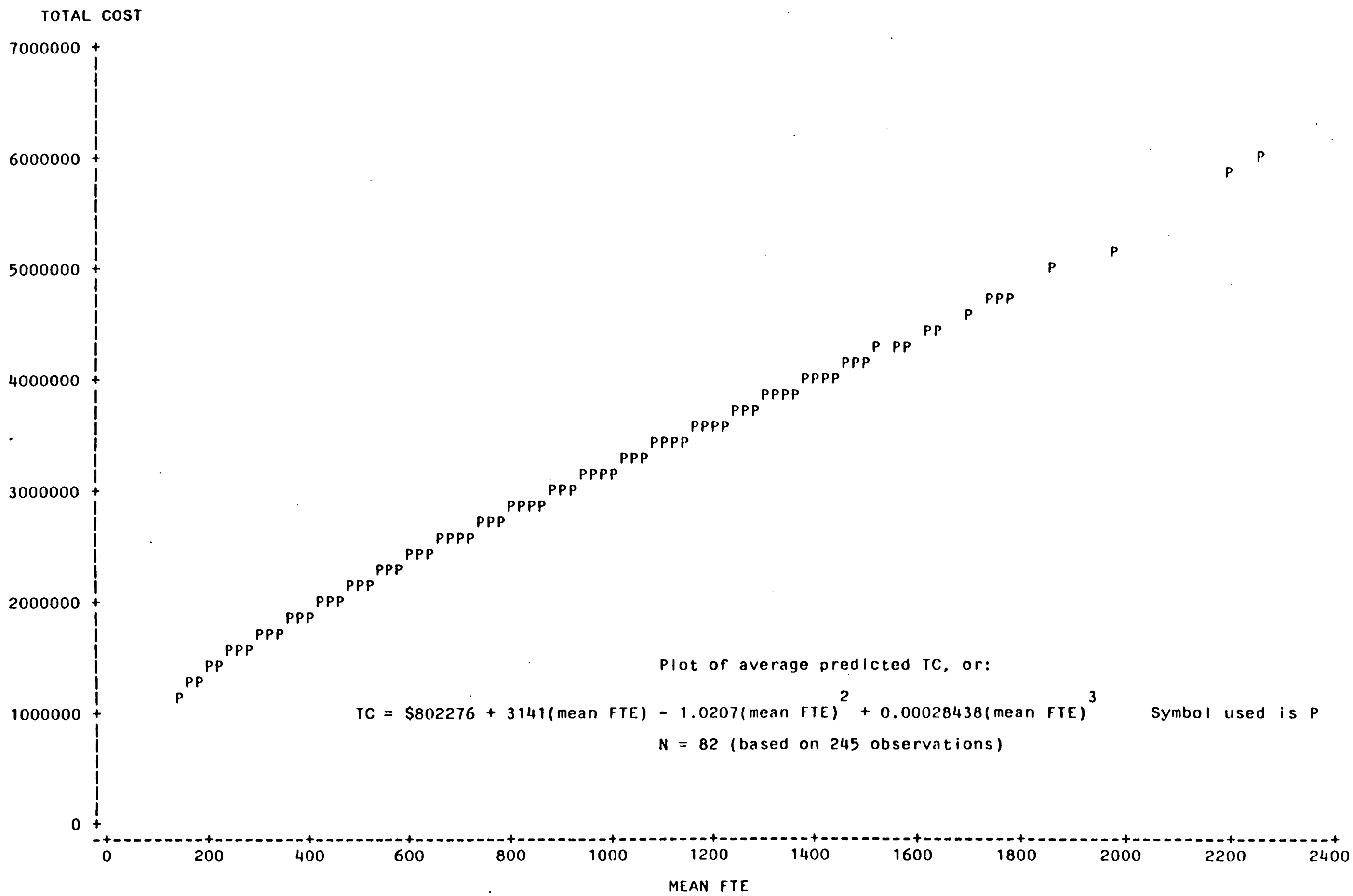

Figure F-24. Average predicted total cost: Equation (7.1.1) cubic model for total small 2-year public colleges.

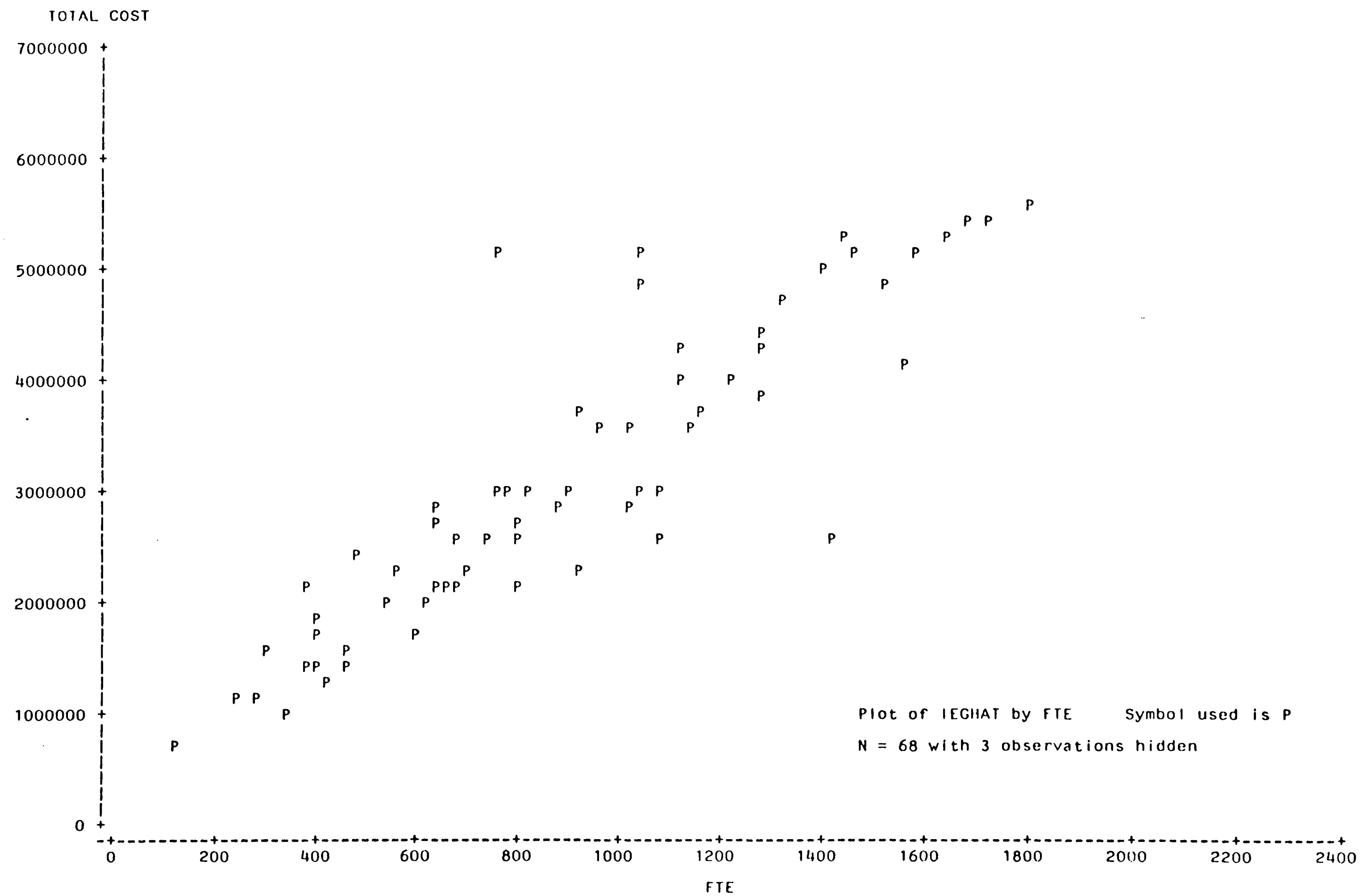

Figure F-25. Predicted (IEGHAT) total cost: Equation (7.1) cubic model for small technical 2-year public colleges.

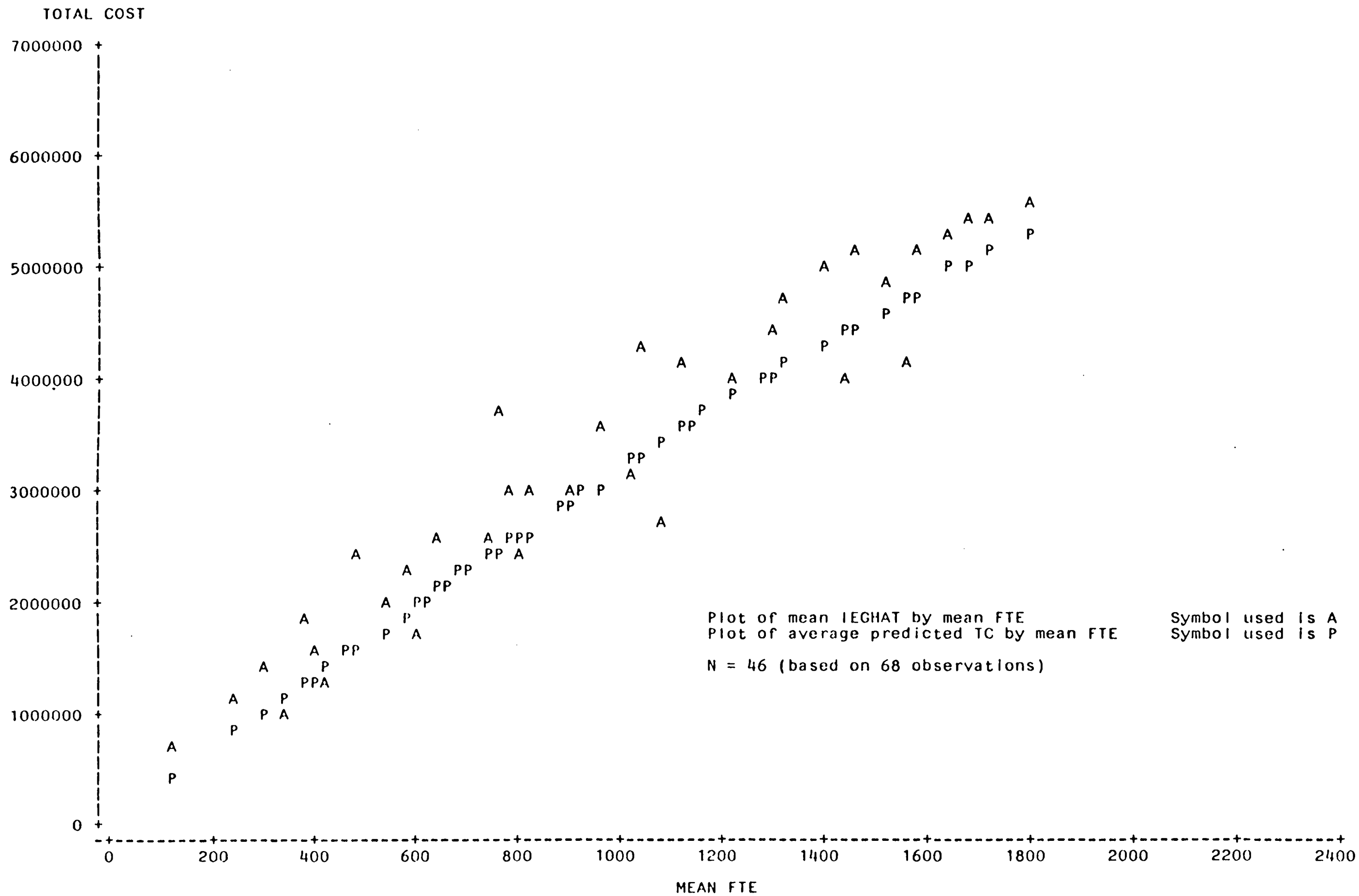

Figure F-26. Mean IEGHAT vs. average predicted total cost: Equation (7.1.1) cubic model for small technical 2-year public colleges.

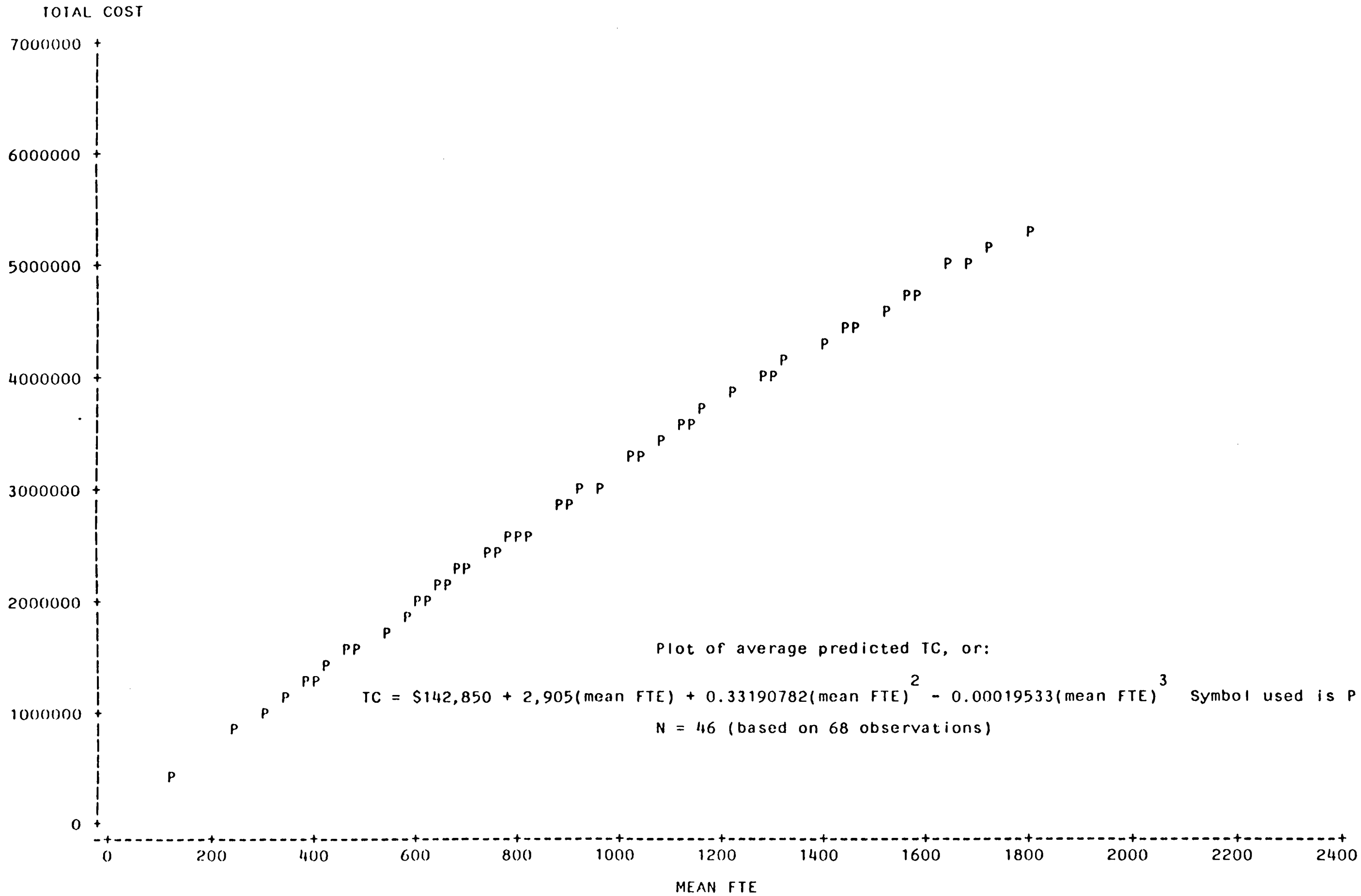

Figure F-27. Average predicted total cost: Equation (7.1.1) cubic model for small technical 2-year public colleges.

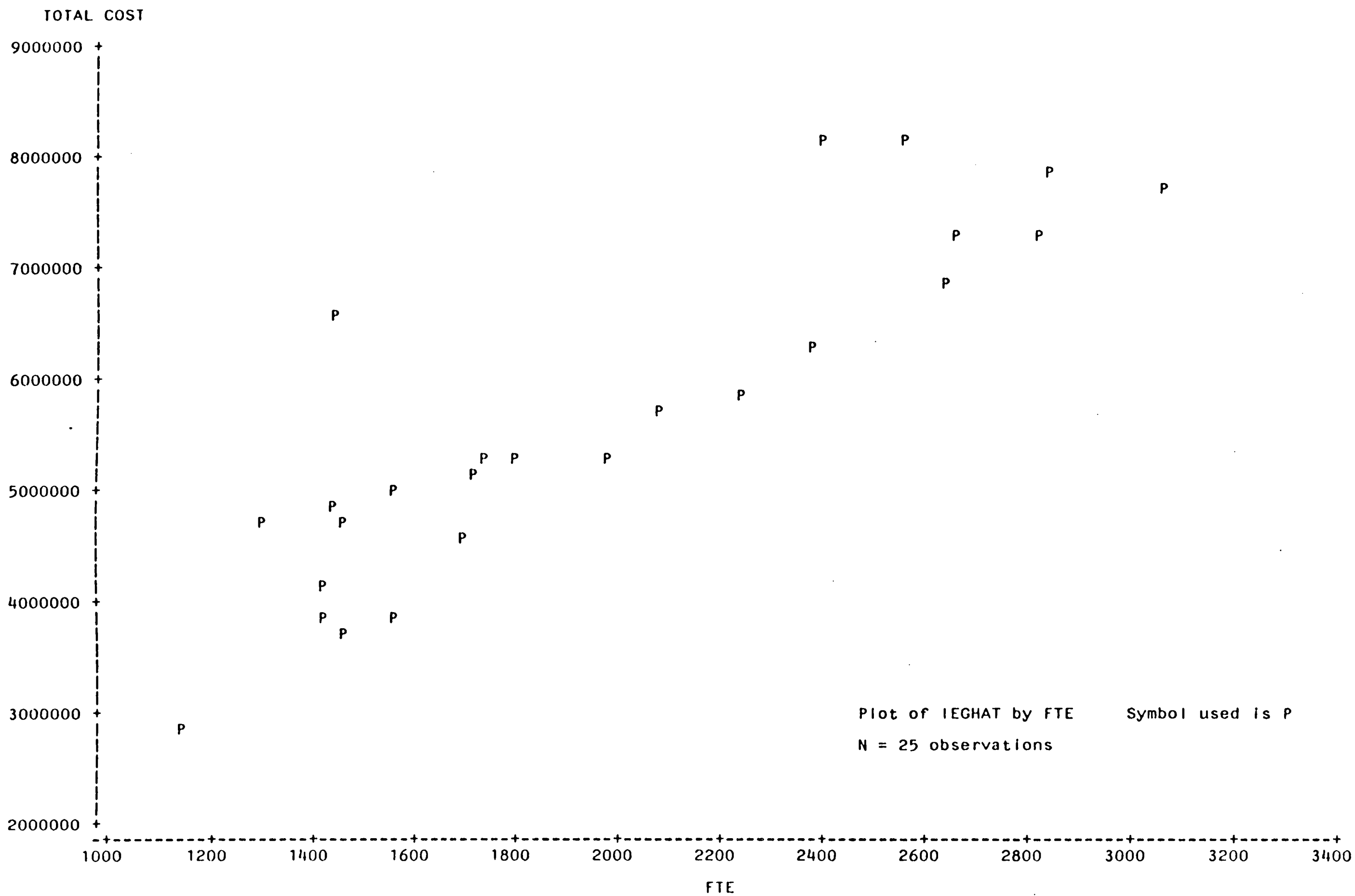

Figure F-28. Predicted (IEGHAT) total cost: Equation (5.1) linear model for medium large 2-year public colleges.

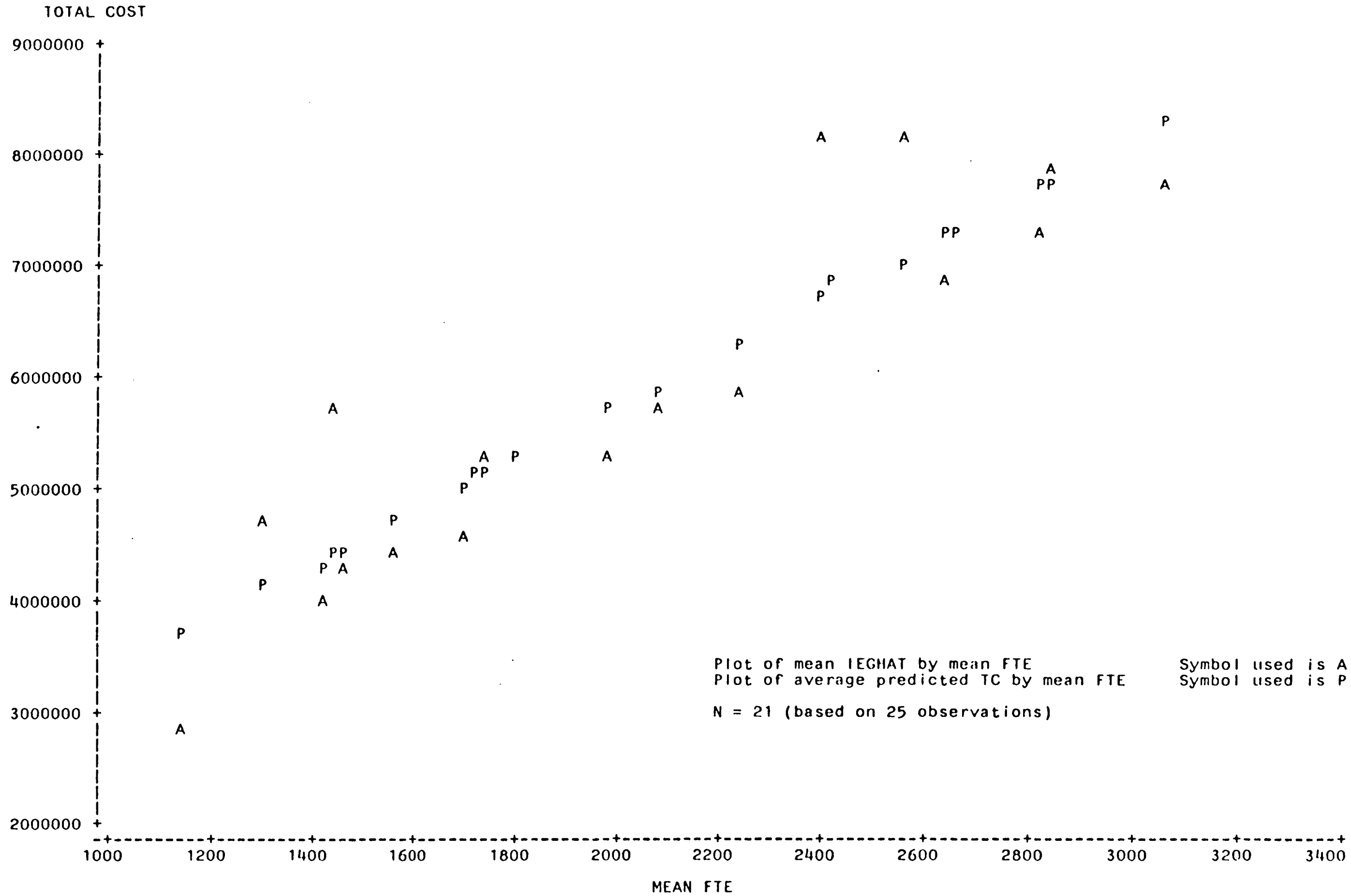

Figure F-29. Mean IEGHAT vs. average predicted total cost: Equation (5.1.1) linear model for medium large 2-year public colleges.

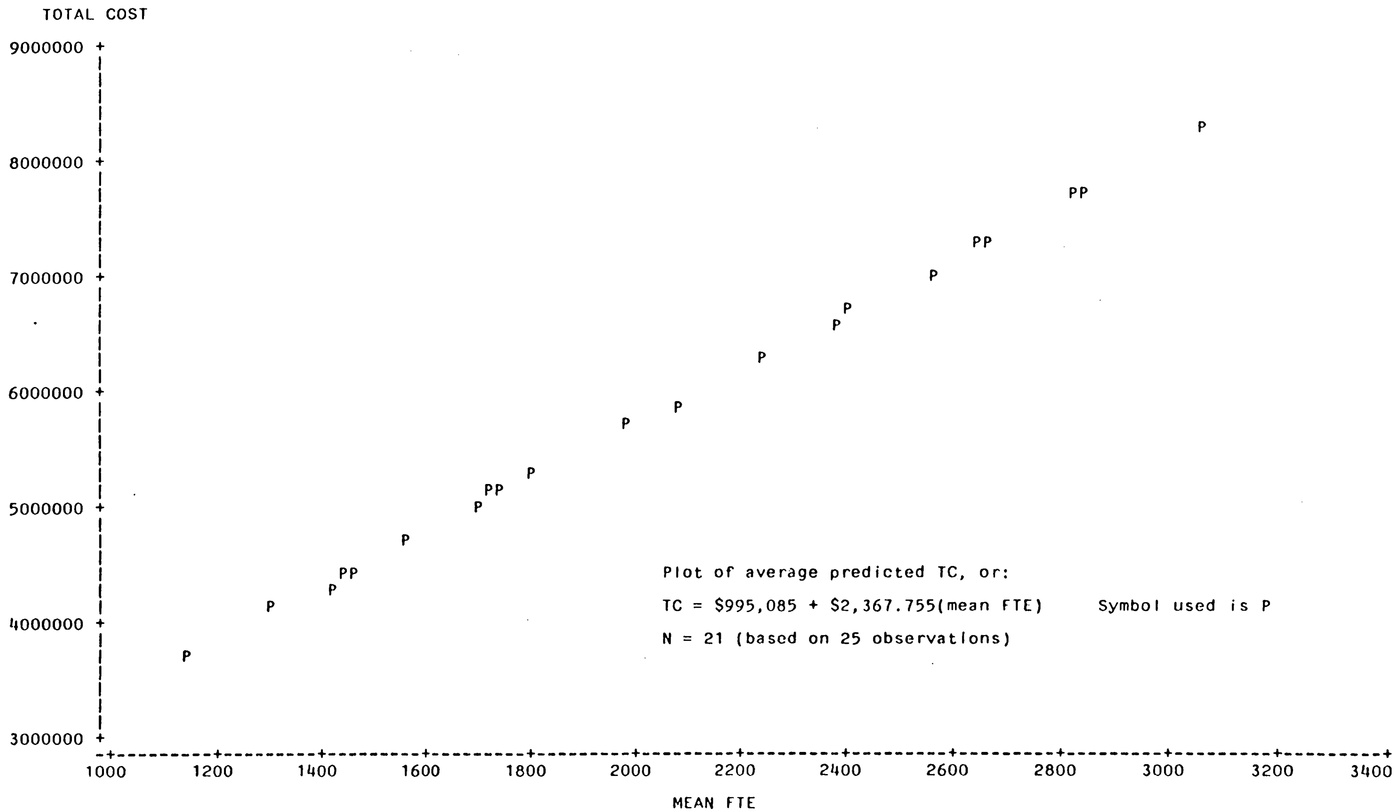

Figure F-30. Average predicted total cost: Equation (5.1.1) linear model for medium large 2-year public colleges.

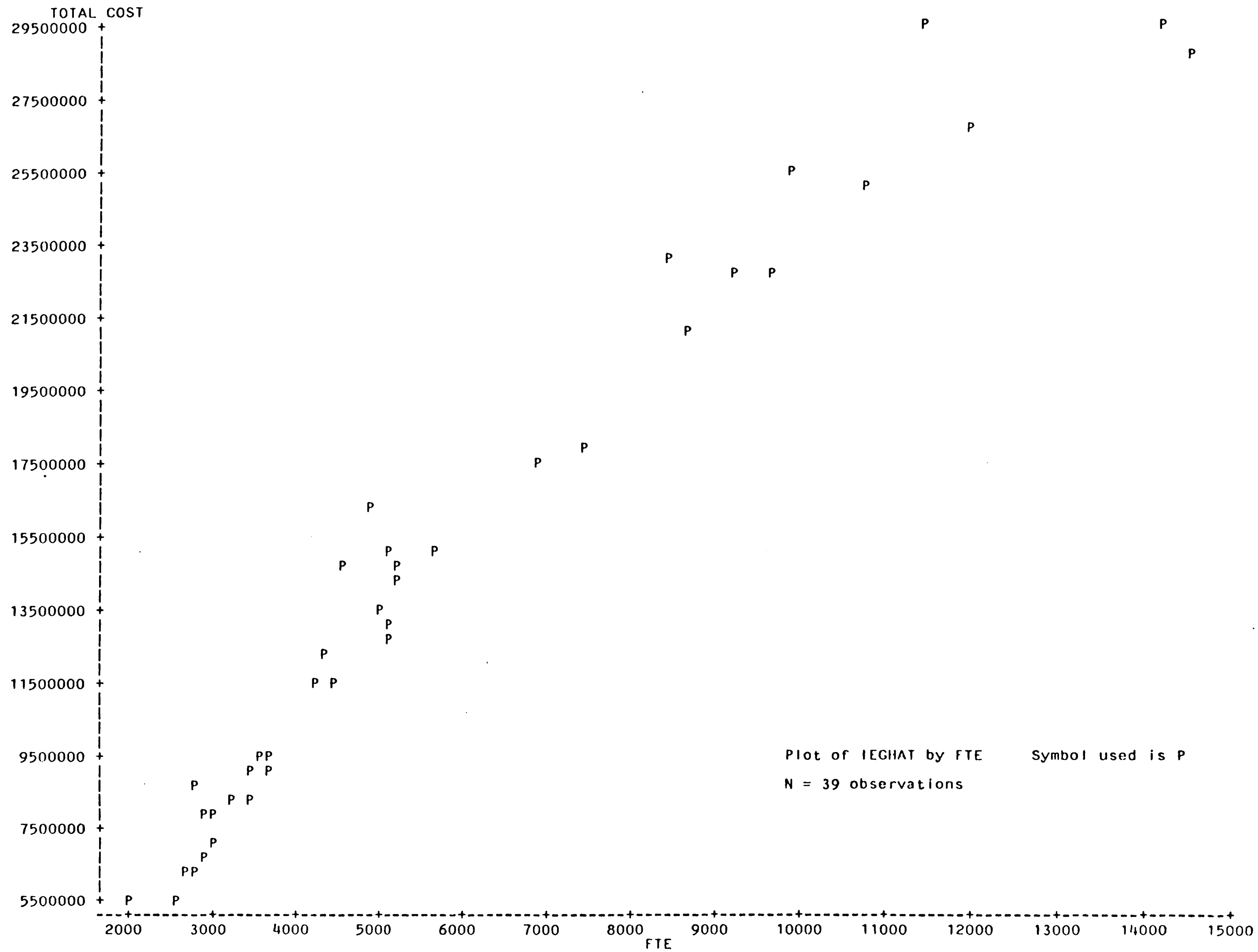

Figure F-31. Predicted (IEGHAT) total cost: Equation (6.1A) quadratic model for very large two-year public colleges.

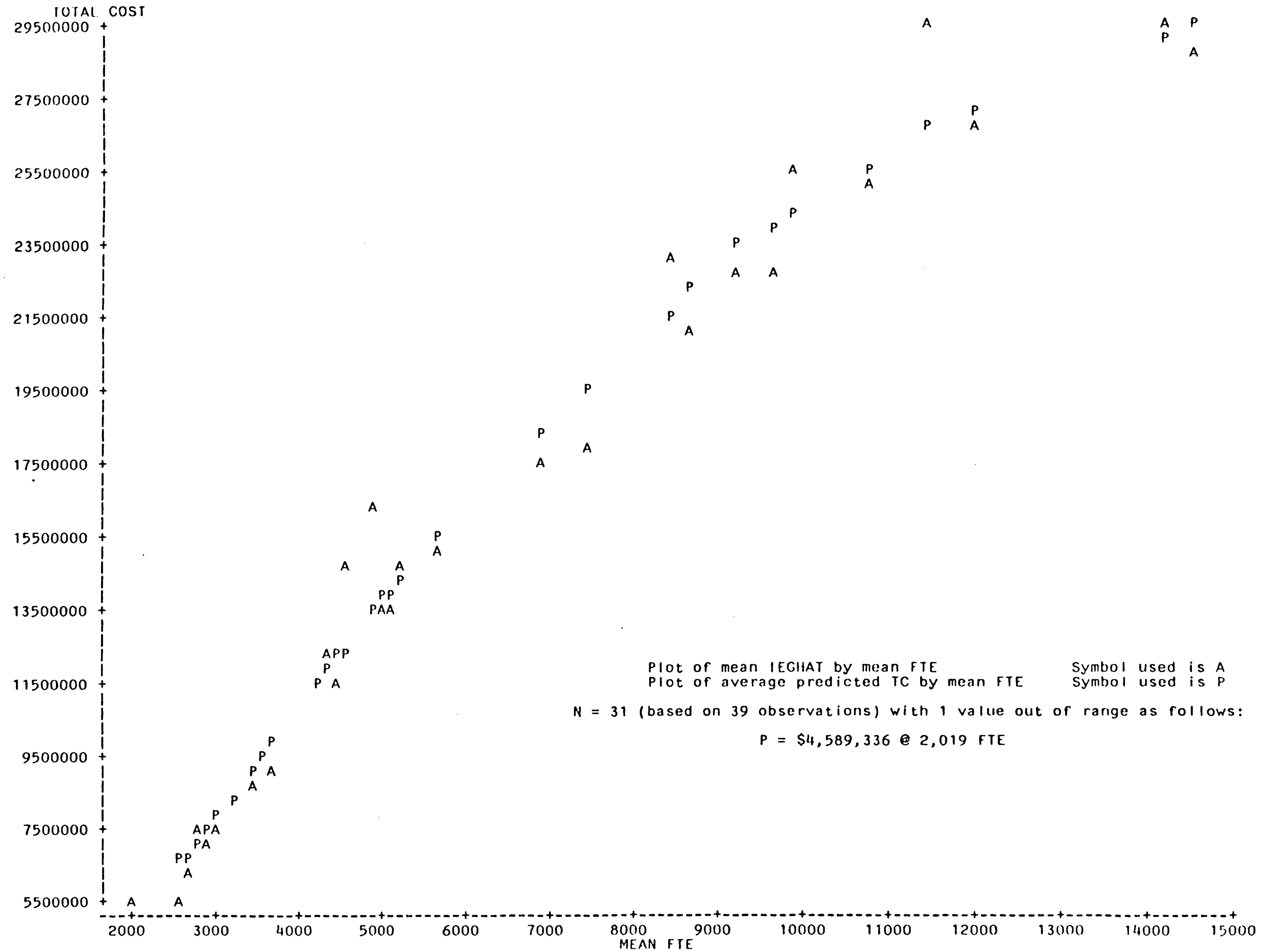

Figure F-32. Mean IEGHAT vs. average predicted total cost: Equation (6.1A.1) quadratic model for very large two-year public colleges

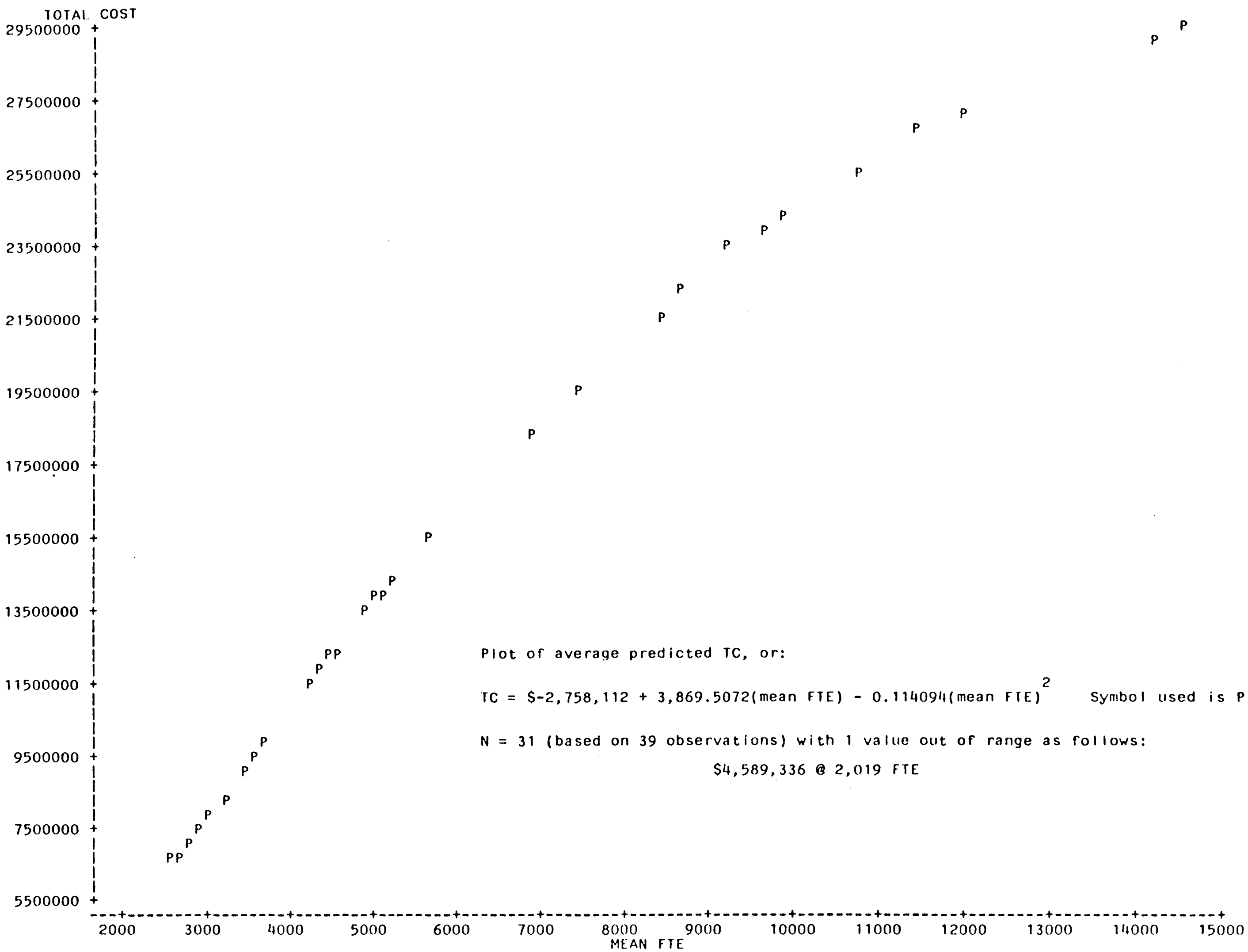

Figure F-33. Average predicted total cost: Equation (6.1A.1) quadratic model for very large two-year public colleges.

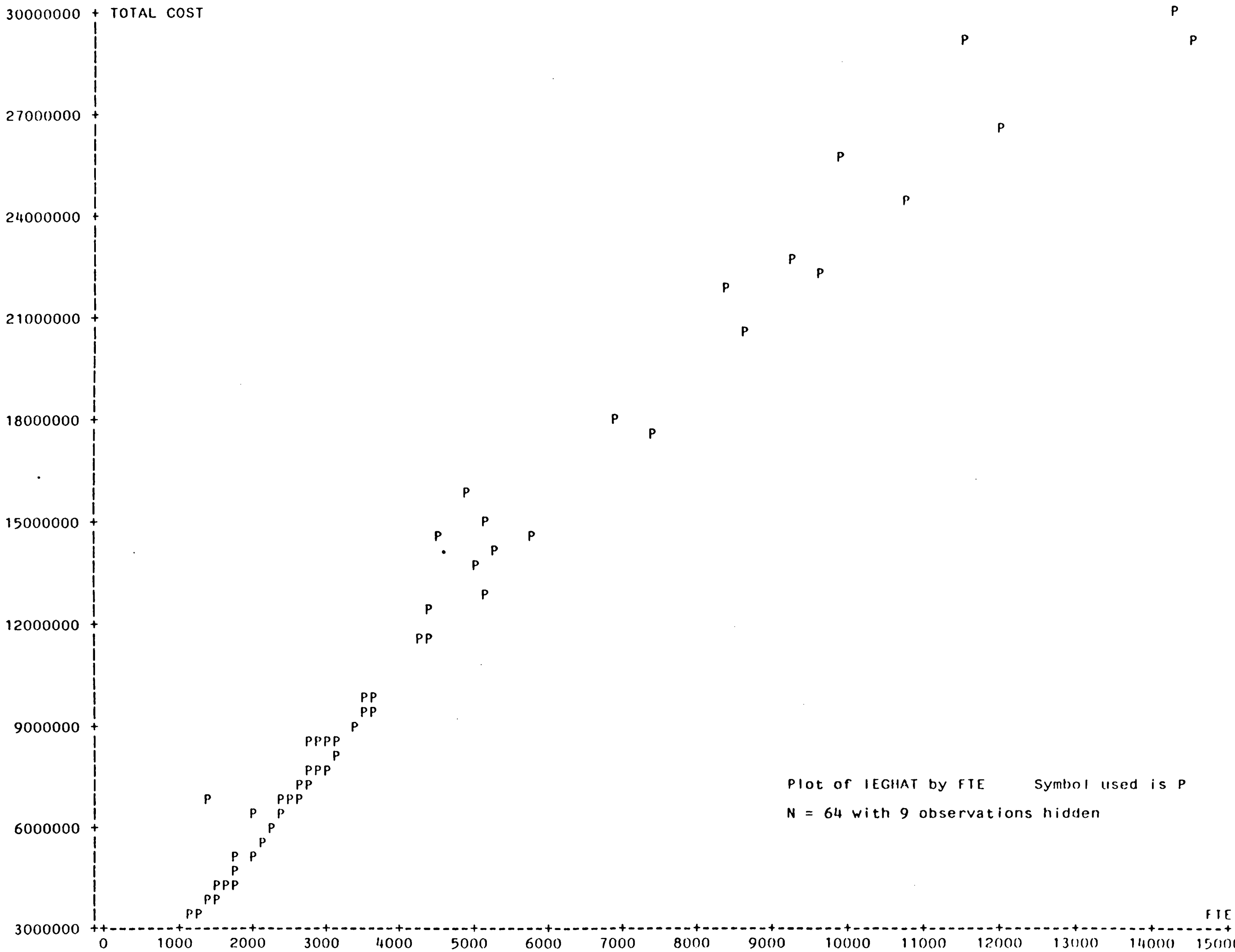

Figure F-34. Predicted (IEGHAT) total cost: Equation (6.1A) quadratic model for total large two-year public colleges.

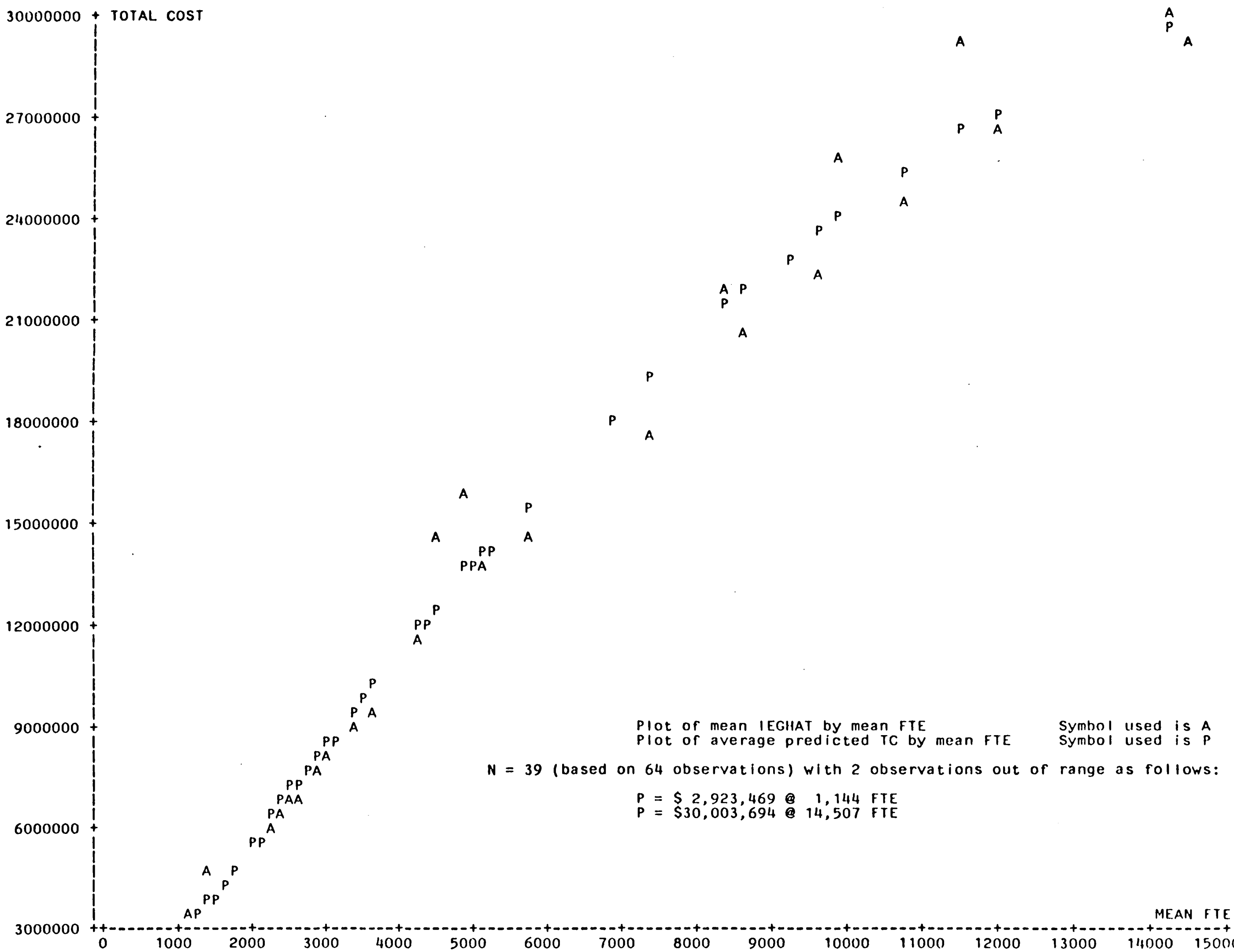

Figure F-35. Mean IEGHAT vs. average predicted total cost: Equation (6.1A.1) quadratic model for total large two-year public college

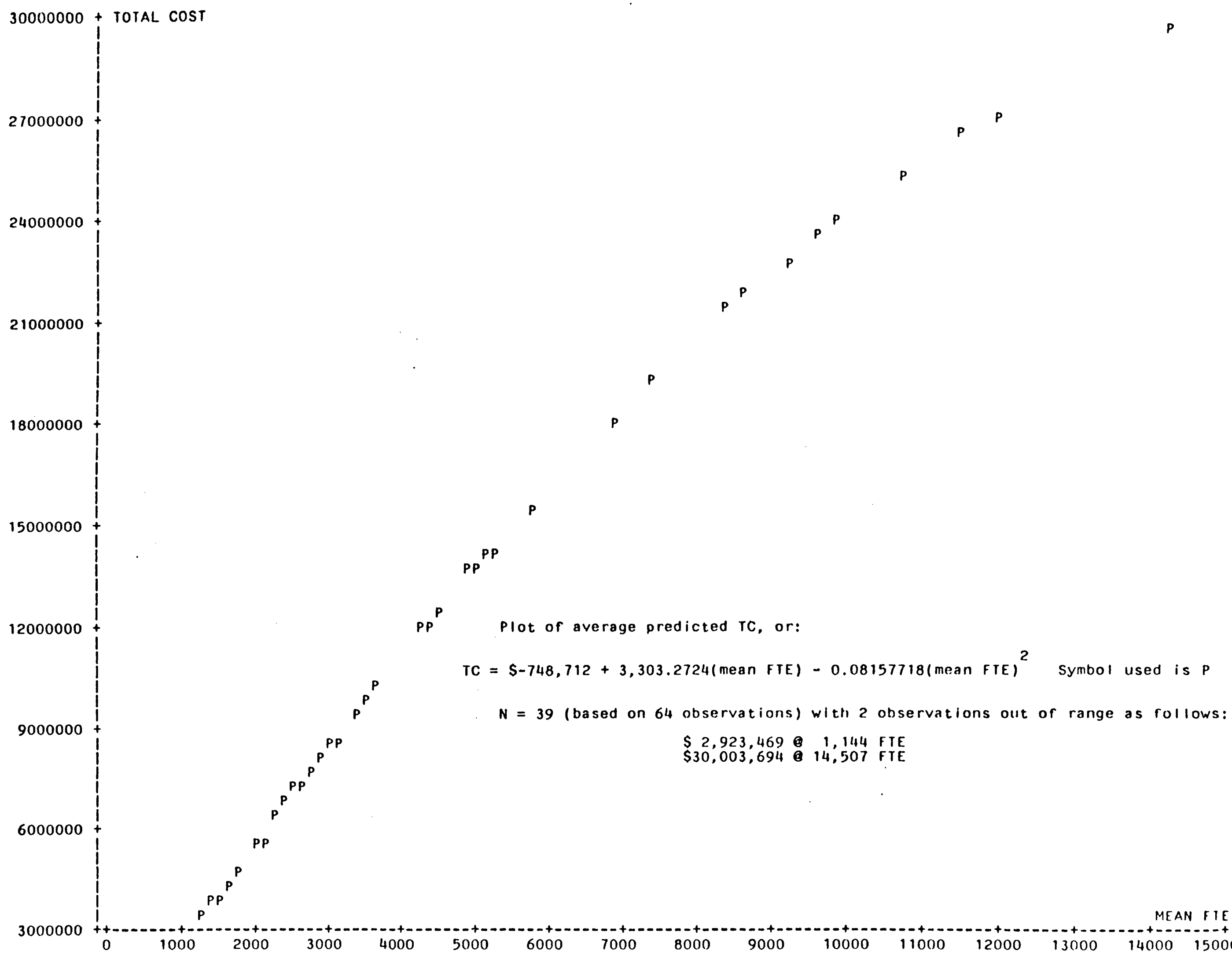

Figure F-36. Average predicted total cost: Equation (6.1A.1) quadratic model for total large two-year public colleges.

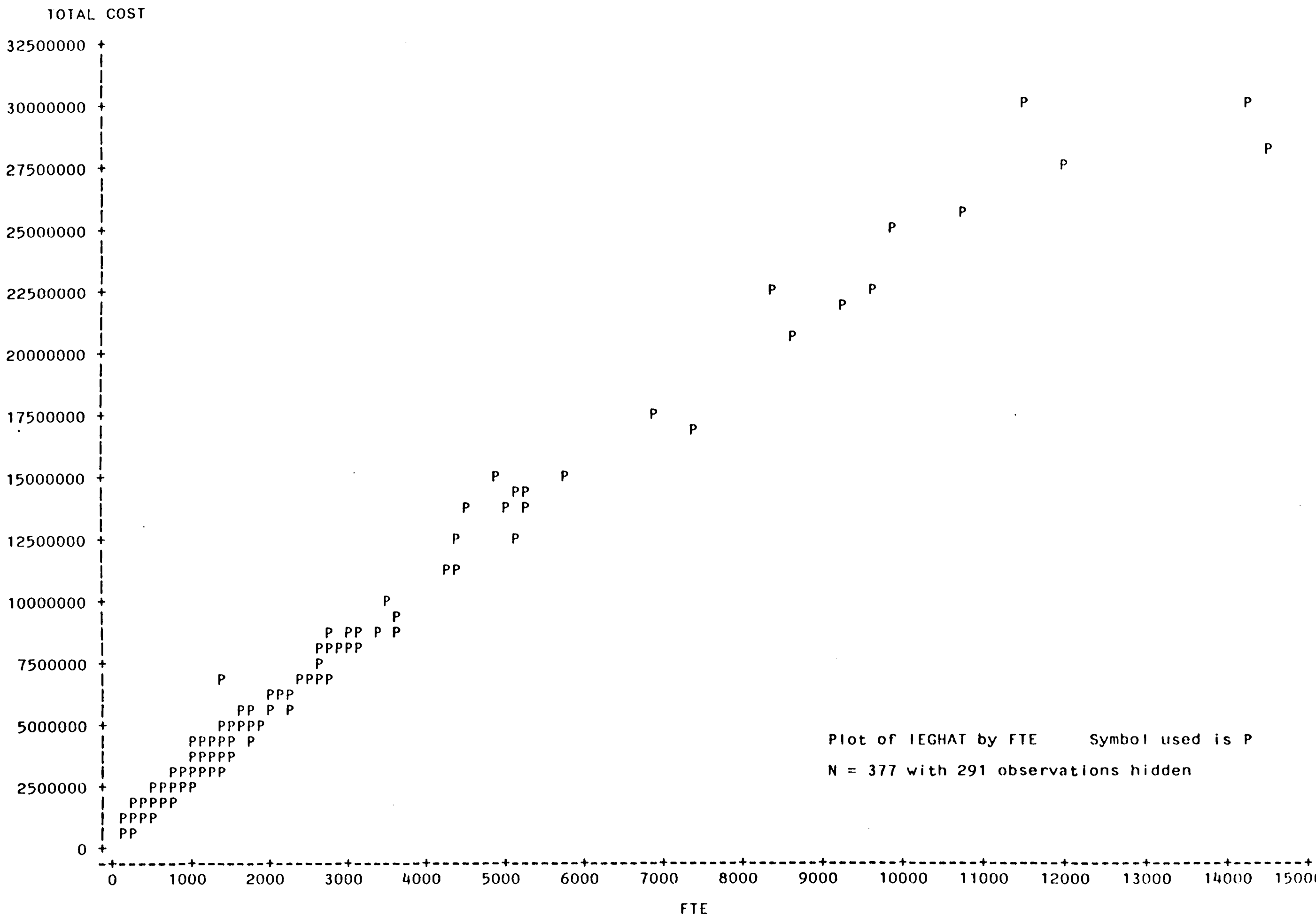

Figure F-37. Predicted (IEGHAT) total cost: Equation (6.1) quadratic model for COMPOSITE I 2-year public colleges.

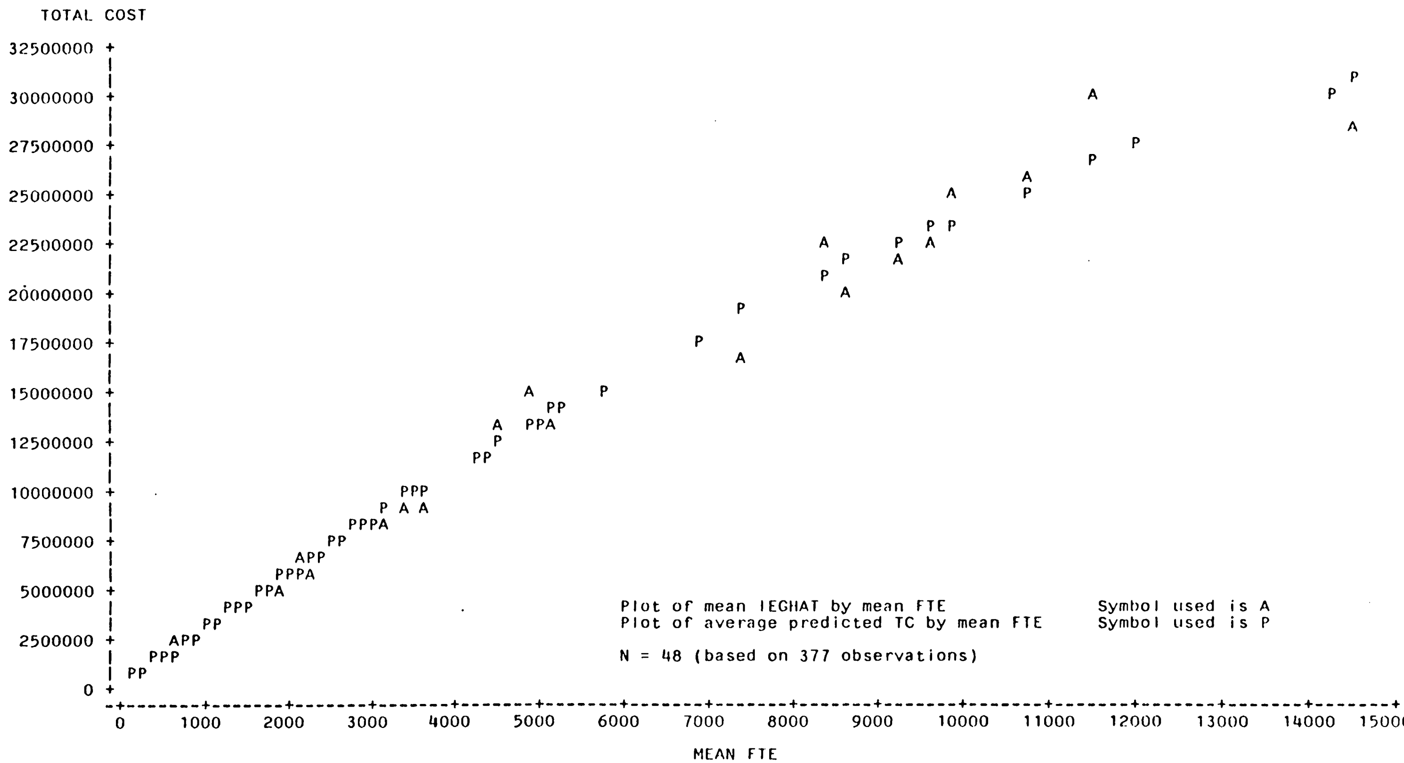

Figure F-38. Mean IEGHAT vs. average predicted total cost: Equation (6.1.1) quadratic model for COMPOSITE I 2-year public colleges.

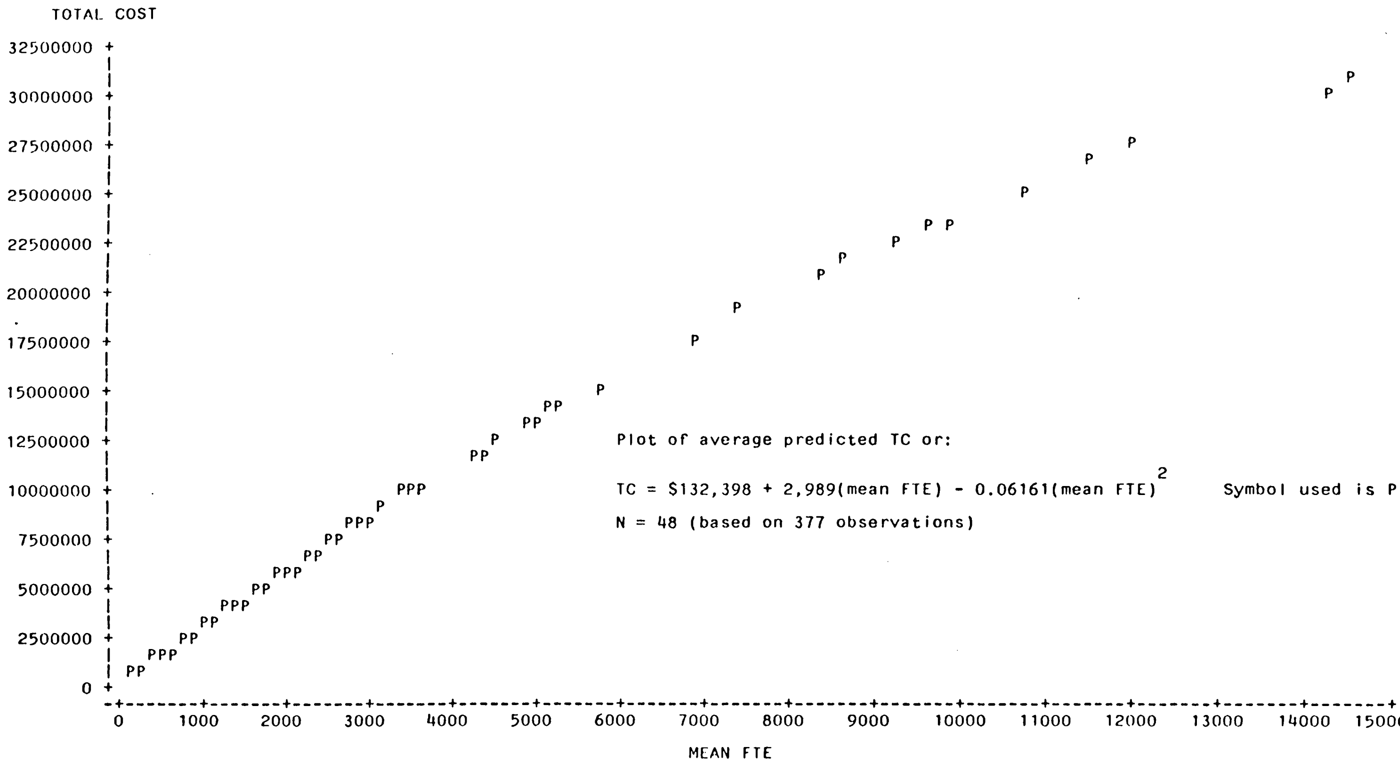

Figure F-39. Average predicted total cost: Equation (6.1.1) quadratic model for COMPOSITE I 2-year public colleges.

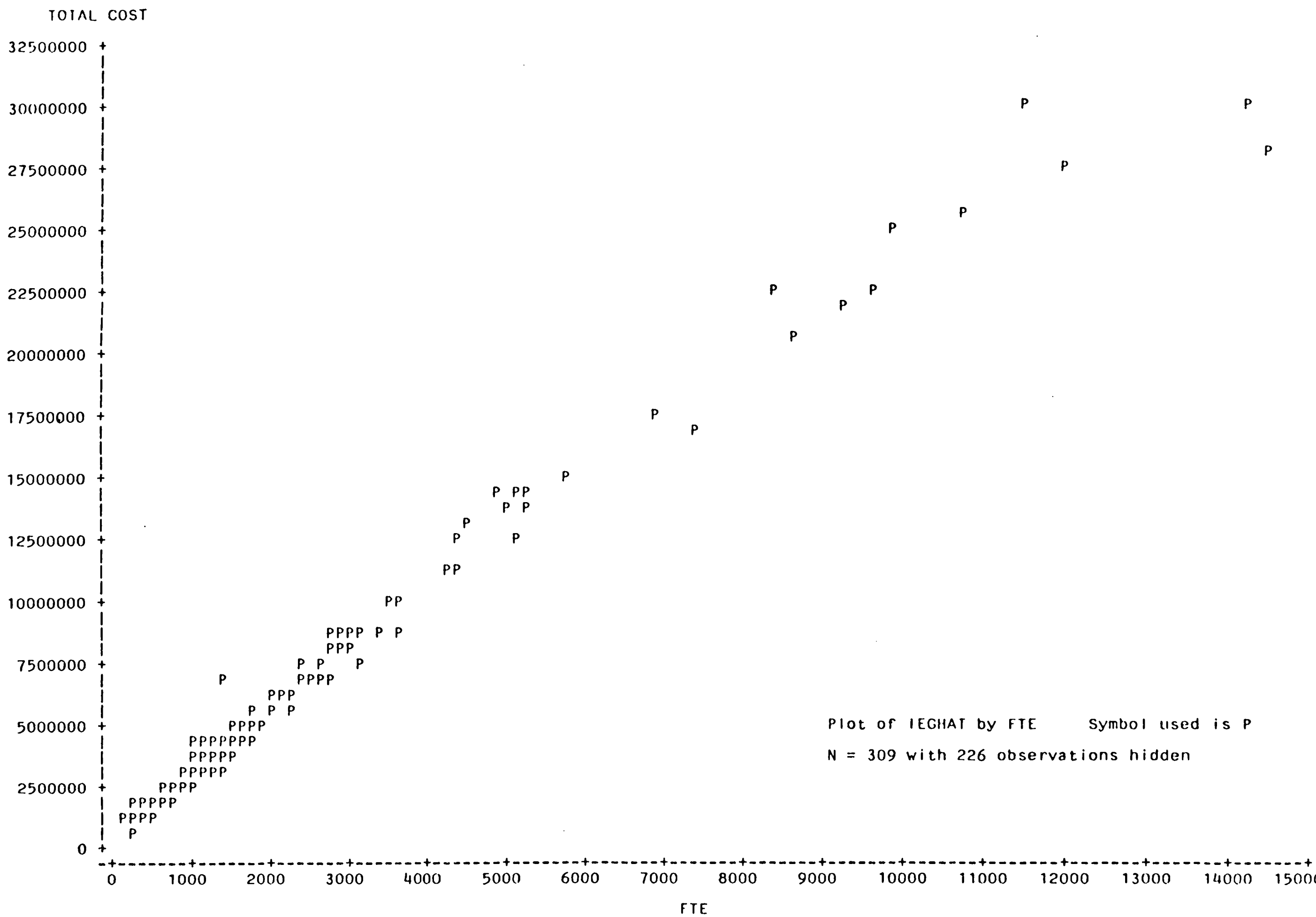

Figure F-40. Predicted (IEGHAT) total cost: Equation (6.1) quadratic model for COMPOSITE II 2-year public colleges.

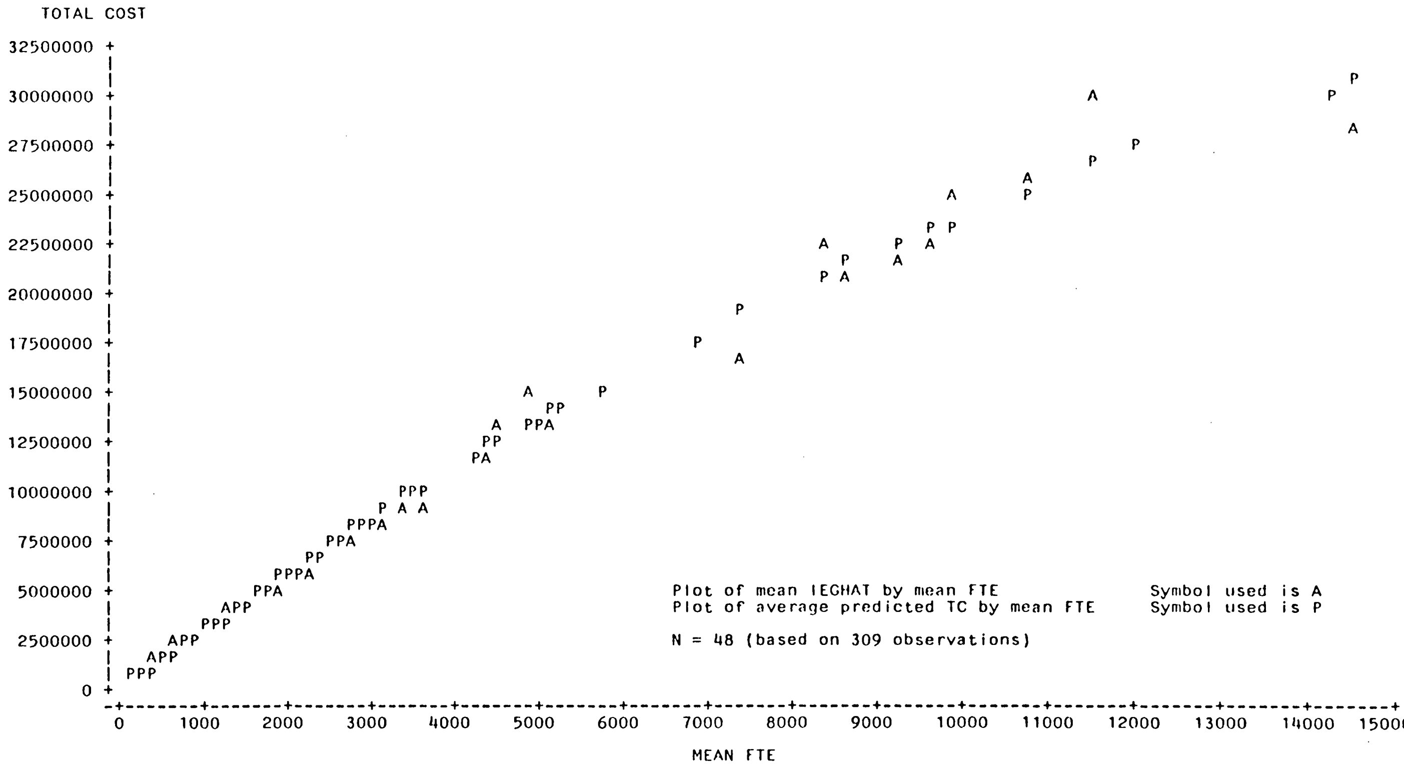

Figure F-41. Mean IEGHAT vs. average predicted total cost: Equation (6.1.1) quadratic model for COMPOSITE II 2-year public colleges.

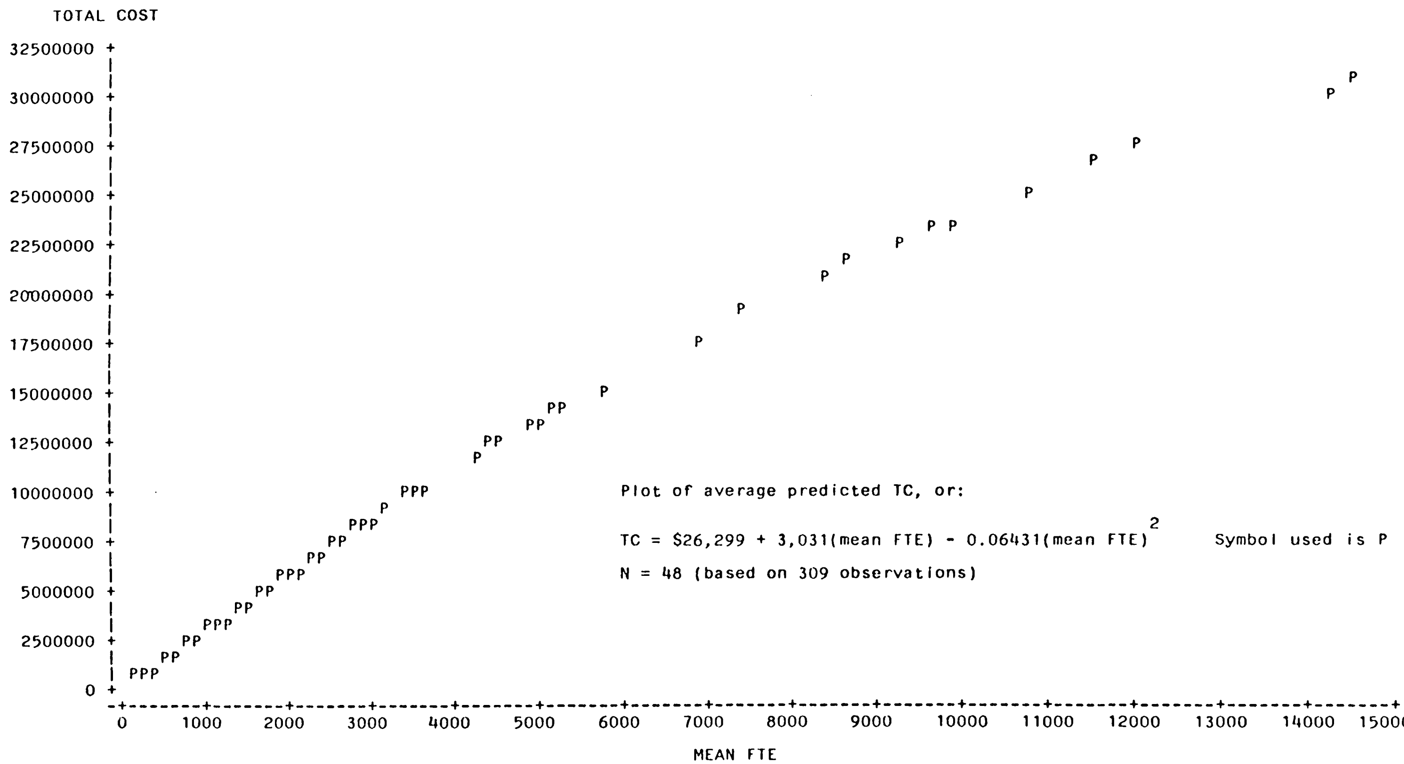

Figure F-42. Average predicted total cost: Equation (6.1.1) quadratic model for COMPOSITE II 2-year public colleges.

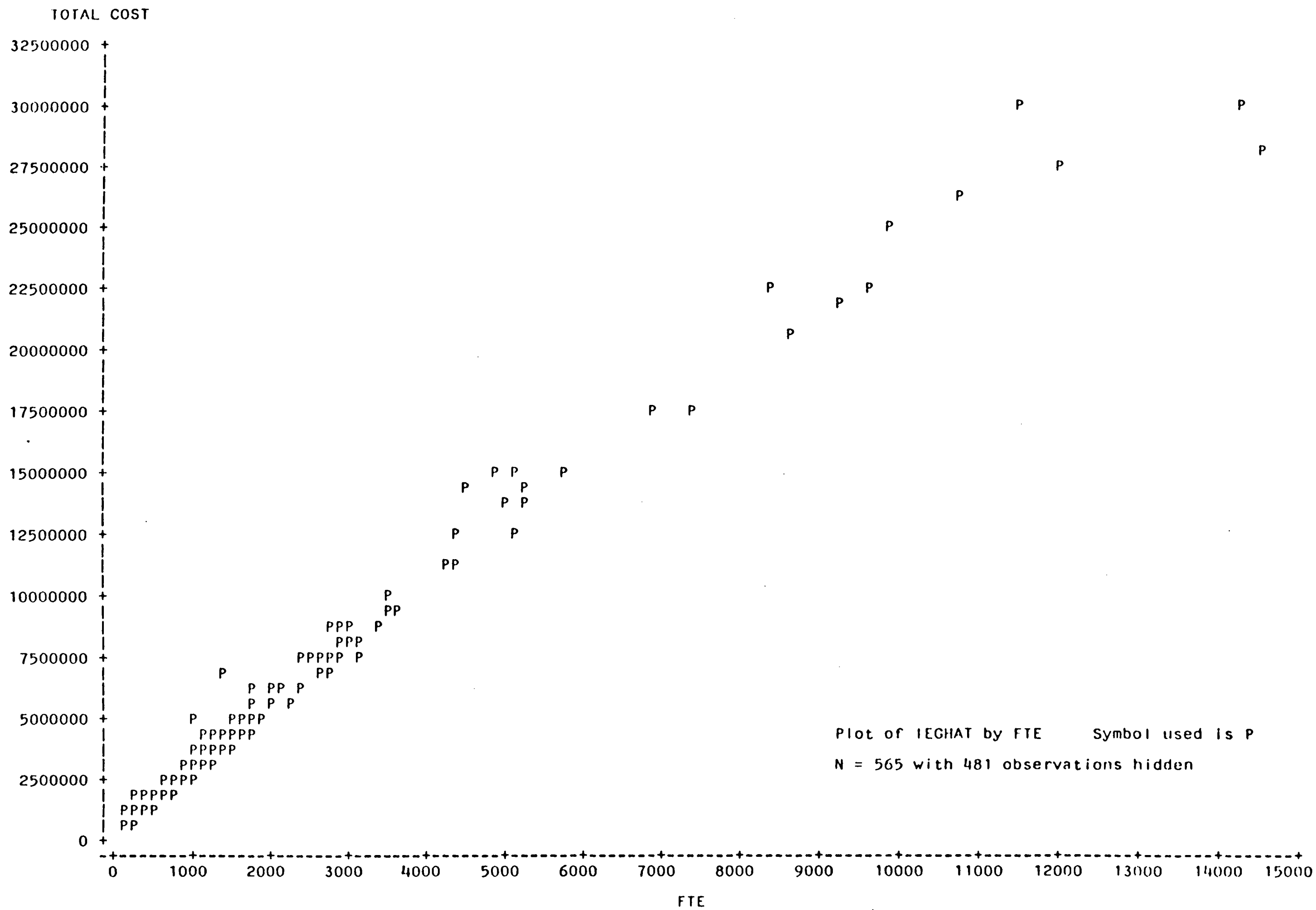

Figure F-43. Predicted (IEGHAT) total cost: Equation (6.1) quadratic model for COMPOSITE III 2-year public colleges.

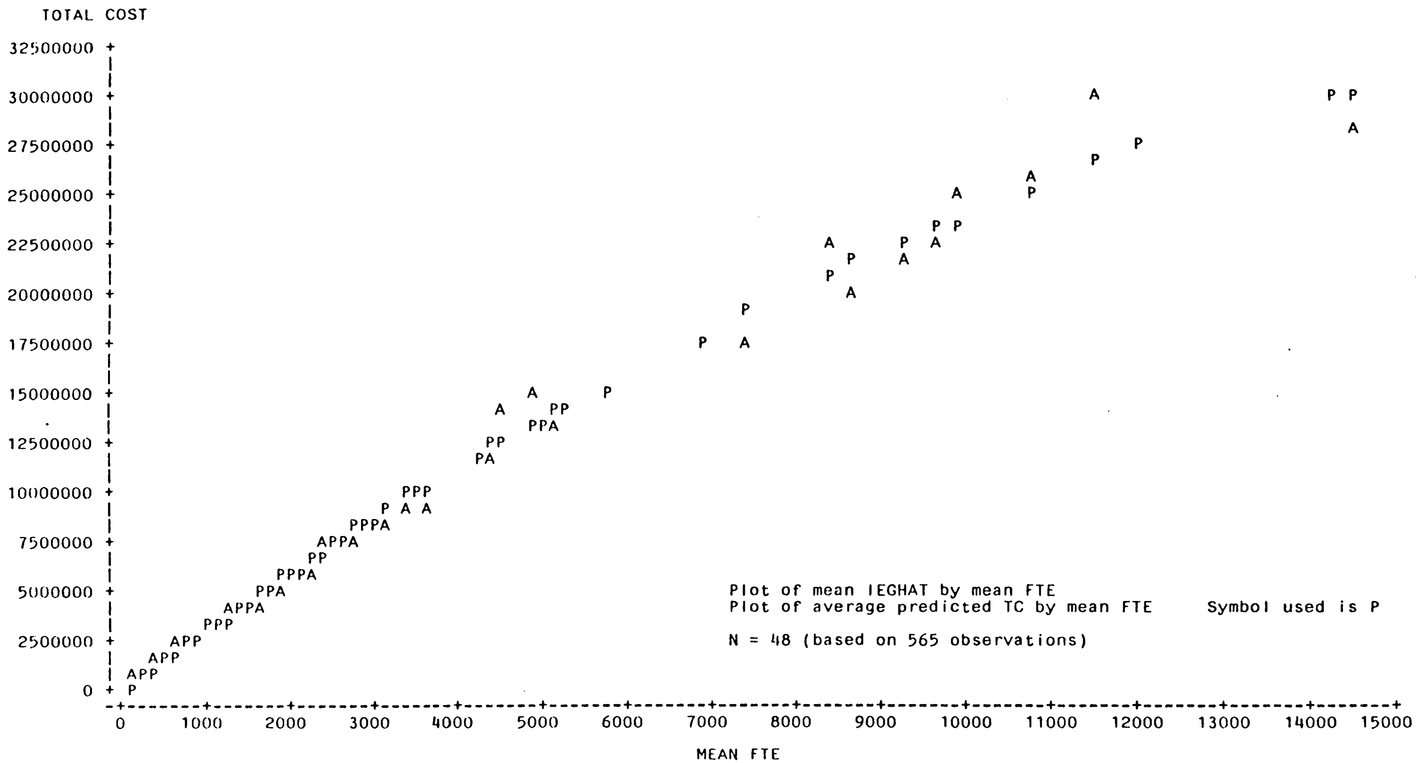

Figure F-44. Mean IEGHAT vs. average predicted total cost:Equation (6.1.1) quadratic model for COMPOSITE III 2-year public colleges.

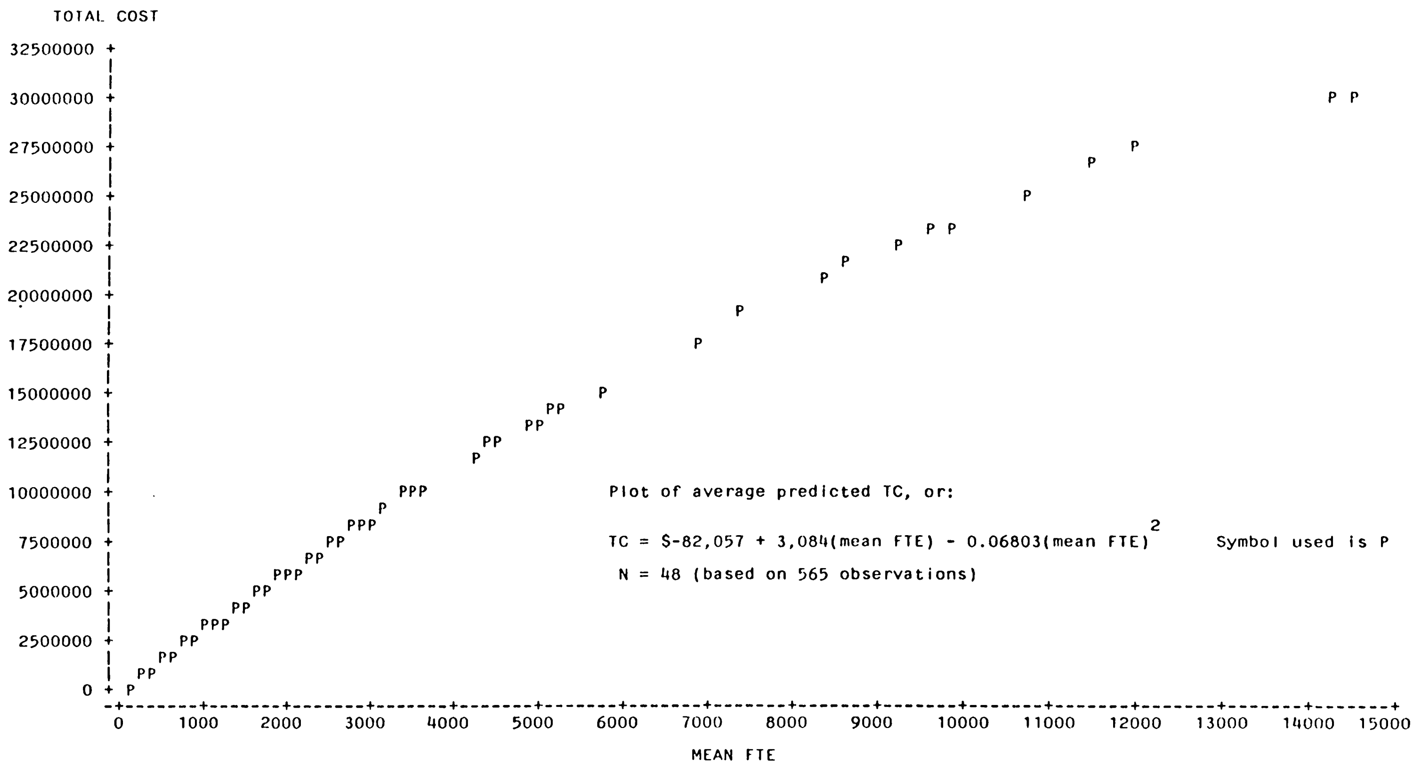

Figure F-45. Average predicted total cost: Equation (6.1.1) quadratic model for COMPOSITE III 2-year public colleges.

APPENDIX G

TABLE G-1: DATA BASE OF SMALL RURAL 2-YEAR PUBLIC COLLEGES (N=194).

STATE=ALABAMA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
1	1007	ALEXANDER CITY STATE JC	1229	2439408	931	0.0098320	0.185714	5.858	2574
2	9134	BREWER STATE JR COLLEGE	611	1327461	498	0.0061100	0.071429	15.703	3242
3	1015	ENTERPRISE ST JR COLLEGE	1922	2949645	1505	0.0167500	0.214286	20.627	2826
4	1060	FAULKNER STATE JR COLLEGE	1167	2337057	984	0.0058350	0.085714	18.383	2194
5	1021	JEFFERSON DAVIS STATE JC	850	1592164	695	0.0170000	0.028571	15.256	1687
6	8988	LURLEEN B WALLACE ST JC	839	2421895	734	0.0139833	0.042857	14.646	1791
7	1031	NTHEST ALA ST JR COLLEGE	998	2597207	777	0.0285143	0.114286	20.260	1799
8	1032	NTHWST ALA ST JR COLLEGE	922	1721044	641	0.0040978	0.157143	5.804	2631
9	1034	PATRICK HENRY STATE JC	658	1511352	534	0.0126538	0.042857	16.726	2552
10	1040	STHN UNION ST JR COLLEGE	1591	2497668	1195	0.0212133	0.157143	18.170	2398

STATE=ARKANSAS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
11	1091	ARKANSAS STATE U BEEBE BR	701	1794378	587	0.0065652	0.042857	1.837	-28
12	12260	EAST ARK CMTY COLLEGE	851	1924589	516	0.0085100	0.071429	15.120	-462
13	12860	MISS CO CMTY COLLEGE	1190	2363113	698	0.0148750	0.114286	16.897	-1080
14	12261	NORTH ARKANSAS CC	899	1994721	616	0.0082485	0.071429	14.929	-570

STATE=CALIFORNIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
15	1119	BARSTOW COLLEGE	1643	3617886	935	0.0410750	0.128571	4.759	7978
16	1187	COLLEGE OF THE SISKIYOUS	1842	4039067	1066	0.0438571	0.214286	24.462	7862
17	8597	FEATHER RIVER COLLEGE	1293	2021657	608	0.0517200	0.085714	16.510	1047
18	12907	LAKE TAHOE CMTY COLLEGE	1455	1844695	656	0.0415714	0.128571	16.959	7486
19	1259	PALO VERDE COLLEGE	586	1475485	295	0.0418571	0.057143	7.597	4514
20	1268	PORTERVILLE COLLEGE	2078	5901897	1236	0.0593714	0.185714	6.671	-5154

STATE=COLORADO

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
21	1359	COLORADO NORTHWESTERN CC	1038	2360668	567	0.0346000	0.100000	14.463	798
22	1355	LAMAR COMMUNITY COLLEGE	453	1880358	352	0.0181200	0.085714	13.427	-334
23	9981	MORGAN COMMUNITY COLLEGE	516	1229999	268	0.0103200	0.142857	3.480	1222
24	1361	NORTHEASTERN JR COLLEGE	1701	3569985	1221	0.0243000	0.185714	20.194	1389
25	1362	OTERO JUNIOR COLLEGE	881	2497327	648	0.0281686	0.214286	22.161	1832
26	1368	TRINIDAD STATE JR COLLEGE	1865	4358648	1050	0.0777083	0.242857	8.793	1071

STATE=CONNECTICUT

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
27	9765	MOHEGAN COMMUNITY COLLEGE	2271	1888474	1186	0.01514	0.114286	9.795	-6309
28	10530	QUINEBAUG VALLEY CC	930	903183	398	0.01240	0.085714	9.144	-3536

TABLE G-1: DATA BASE OF SMALL RURAL 2-YEAR PUBLIC COLLEGES (N=194).

STATE=FLORIDA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
29	1472	CHIPOLA JUNIOR COLLEGE	1122	3207830	889	0.0130465	0.214286	23.413	-1113
30	1502	LAKE-SUMTER CMTY COLLEGE	2021	3225519	1117	0.0161680	0.100000	17.318	1500
31	1523	SAINT JOHNS RIVER CC	1562	2773953	1010	0.0092976	0.142857	6.567	-1224
32	1522	SOUTH FLORIDA JR COLLEGE	995	2594521	562	0.0110556	0.142857	6.580	1083

STATE=GEORGIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
33	1541	ABRAHAM BALDWIN AGRL C	2447	6148273	2257	0.0143941	0.185714	24.152	-2301
34	11074	BAINBRIDGE JUNIOR COLLEGE	560	1888432	429	0.0040694	0.100000	17.797	-1839
35	3956	DALTON JUNIOR COLLEGE	1409	3334767	1023	0.0093933	0.171429	19.409	-2918
36	9507	FLOYD JUNIOR COLLEGE	1197	3202627	824	0.0079800	0.142857	6.771	-4087
37	1581	MIDDLE GEORGIA COLLEGE	1478	3919361	1305	0.0036950	0.100000	20.601	-2210
38	1592	SOUTH GEORGIA COLLEGE	1137	3808928	956	0.0189500	0.142857	22.812	-5889
39	29028	WAYCROSS JUNIOR COLLEGE	415	1280085	321	0.0041500	0.057143	17.511	1517

STATE=IDAHO

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
40	1623	NORTH IDAHO COLLEGE	2193	6391224	1642	0.018275	0.271429	23.179	1479

STATE=ILLINOIS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
41	7538	BLACK HAWK C EAST CAMPUS	1069	2049627	657	0.0164462	0.157143	15.593	1109
42	1681	HIGHLAND CMTY COLLEGE	1868	3817500	1140	0.0224760	0.228571	9.732	3172
43	1742	ILL ESTN CC OLNEY CEN C	2381	2632724	1349	0.0214331	0.114286	19.269	-2117
44	9786	ILL ESTN LINCOLN TRAIL C	1795	1922898	1085	0.0051286	0.171429	19.760	-3109
45	8076	JOHN A LOGAN COLLEGE	2061	3642329	1444	0.0137400	0.242857	20.483	2762
46	7684	KISHWAUKEE COLLEGE	2098	3922447	1357	0.0262250	0.228571	24.458	1036
47	1757	SOUTHEASTERN ILL COLLEGE	2064	3502493	1247	0.0332903	0.314286	9.613	-7
48	1643	SPOON RIVER COLLEGE	2417	3077072	1333	0.0274659	0.157143	19.386	3051

STATE=IOWA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
49	1882	MUSCATINE CMTY COLLEGE	881	2308555	684	0.0220250	0.100000	18.852	-22
50	1877	N IOWA AREA CMTY COLLEGE	2163	5843380	1780	0.0166385	0.228571	19.725	2591

TABLE G-1: DATA BASE OF SMALL RURAL 2-YEAR PUBLIC COLLEGES (N=194).

STATE=KANSAS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
51	4608	BARTON CO CMTY COLLEGE	2142	4084671	1185	0.0225474	0.257143	24.281	427
52	1910	COFFEYVL CMTY COLLEGE	1474	2026855	825	0.0491333	0.100000	3.621	-743
53	1911	COLBY COMMUNITY COLLEGE	1490	2974260	913	0.0212857	0.100000	17.207	-739
54	1902	COWLEY CO CMTY COLLEGE	1917	3097224	1012	0.0042600	0.257143	9.938	541
55	1913	DODGE CTY CMTY COLLEGE	1650	4276647	1004	0.0471429	0.157143	19.801	-7250
56	1919	GARDEN CITY COMMUNITY C	1057	4848098	864	0.0234889	0.057143	2.175	2646
57	1930	LABETTE CMTY COLLEGE	1555	2111156	887	0.0259167	0.114286	5.516	-263
58	1936	NEOSHO CO CMTY COLLEGE	839	1549145	462	0.0067120	0.071429	14.479	448
59	8228	SEWARD CO CMTY COLLEGE	1115	1922766	552	0.0278750	0.071429	3.980	-359

STATE=KENTUCKY

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
60	29207	ELIZABETHTOWN CMTY C	1930	2931584	1371	0.0089767	0.071429	17.160	-5953
61	29219	HAZARD COMMUNITY COLLEGE	326	493161	240	0.0036236	0.100000	16.129	371
62	29208	HENDERSON CMTY COLLEGE	811	1232908	548	0.0041168	0.100000	4.046	-264
63	29214	MAYSVILLE CMTY COLLEGE	513	767143	350	0.0102600	0.071429	13.373	-74
64	29216	PRESTONBURG CMTY COLLEGE	751	1150714	536	0.0062583	0.057143	16.869	-847
65	29217	SOMERSET CMTY COLLEGE	982	1479815	809	0.0056114	0.185714	7.081	-3783
66	29218	SOUTHEAST CMTY COLLEGE	578	876736	374	0.0055577	0.085714	9.467	-2618

STATE=LOUISIANA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
67	2011	LA STATE U ALEXANDRIA	1408	3750759	1049	0.0042156	0.085714	15.343	-5778
68	2012	LA STATE U EUNICE	1418	3158720	871	0.0141800	0.114286	18.662	-7561

STATE=MARYLAND

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
69	8308	CECIL COMMUNITY COLLEGE	1184	2400417	604	0.0197333	0.071429	16.298	-2172
70	4650	CHESAPEAKE COLLEGE	1634	3168391	863	0.0134405	0.171429	21.547	-5280
71	2071	FREDERICK CMTY COLLEGE	2103	3337208	1168	0.0168240	0.142857	21.405	1568
72	10014	GARRETT COMMUNITY COLLEGE	653	2310344	454	0.0225172	0.114286	18.995	-1611

STATE=MASSACHUSETTS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
73	2167	BERKSHIRE CMTY COLLEGE	1818	4769823	1483	0.01818	0.185714	20.687	1295
74	2169	GREENFIELD CMTY COLLEGE	2363	3890717	1230	0.02780	0.200000	20.090	-2613

TABLE G-1: DATA BASE OF SMALL RURAL 2-YEAR PUBLIC COLLEGES (N=194).

STATE=MICHIGAN

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
75	2237	ALPENA COMMUNITY COLLEGE	2097	3593122	1358	0.0233000	0.214286	6.911	5482
76	2263	GLEN OAKS CMTY COLLEGE	1224	2402925	763	0.0122400	0.100000	3.561	1883
77	2264	GOGEBIC COMMUNITY COLLEGE	1121	2867963	826	0.0249111	0.214286	22.284	1428
78	7171	KIRTLAND CMTY COLLEGE	1699	3129450	1206	0.0346029	0.228571	7.866	2451
79	6768	MID MICHIGAN CMTY COLLEGE	2007	3180724	1286	0.0401400	0.300000	19.119	1358
80	2294	MONROE CO CMTY COLLEGE	2251	5597859	1278	0.0167985	0.214286	20.810	2929
81	2295	MONTCALM CMTY COLLEGE	1544	2476324	986	0.0154400	0.157143	15.985	4661
82	2299	NORTH CEN MICH COLLEGE	1879	2617657	1072	0.0289077	0.100000	4.699	803
83	2317	SOUTHWESTERN MICH COLLEGE	2135	4479329	1566	0.0071167	0.257143	9.443	1404
84	7950	WEST SHORE CMTY COLLEGE	1013	2613767	664	0.0168833	0.242857	14.208	2933

STATE=MINNESOTA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
85	2335	AUSTIN COMMUNITY COLLEGE	894	2602594	717	0.0081273	0.071429	16.703	4933
86	2352	FERGUS FALLS CMTY COLLEGE	588	1519160	498	0.0117600	0.171429	19.302	5163
87	2355	HIBBING COMMUNITY COLLEGE	813	1589629	628	0.0203250	0.085714	4.262	3341
88	2356	ITASCA COMMUNITY COLLEGE	996	1940802	666	0.0226364	0.085714	4.165	3896
89	2385	NORTHLAND CMTY COLLEGE	574	1268254	405	0.0229600	0.057143	17.130	3154
90	6775	RAINY RIVER CMTY COLLEGE	516	1185877	370	0.0303529	0.085714	17.456	2799
91	2350	VERMILION CMTY COLLEGE	545	1762704	484	0.0419231	0.100000	4.490	2005
92	2392	WILLMAR CMTY COLLEGE	868	1905079	753	0.0045684	0.042857	16.050	5150
93	2395	WORTHINGTON CMTY COLLEGE	657	1416209	451	0.0082125	0.085714	18.519	3319

STATE=MISSISSIPPI

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
94	2402	COPIAH-LINCOLN JR COLLEGE	1617	4401922	1264	0.0161700	0.228571	22.997	-1549
95	2404	EAST CENTRAL JR COLLEGE	785	2057303	762	0.0071364	0.057143	3.357	-1201
96	2405	EAST MISS JUNIOR COLLEGE	899	3190830	672	0.0048333	0.271429	21.426	-2144
97	2411	JONES CO JUNIOR COLLEGE	2402	6081525	2202	0.0144699	0.228571	22.672	219
98	2445	UTICA JUNIOR COLLEGE	1005	3611342	993	0.0067000	0.242857	22.751	-1298

STATE=MISSOURI

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
99	2459	CROWDER COLLEGE	1183	1818929	856	0.0236600	0.171429	21.198	-2140
100	7102	JEFFERSON COLLEGE	2361	4671859	1484	0.0152323	0.271429	9.083	407
101	8080	STATE FAIR CMTY COLLEGE	1543	3098704	1044	0.0308600	0.185714	6.292	-1796
102	4713	THREE RIVERS CMTY COLLEGE	1252	3158162	978	0.0187268	0.157143	6.856	-1587
103	2514	TRENTON JUNIOR COLLEGE	612	1158073	403	0.0068764	0.114286	18.248	-1702

STATE=MONTANA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
104	2529	DAWSON COMMUNITY COLLEGE	432	1047717	293	0.0154286	0.128571	19.078	-193

TABLE G-1: DATA BASE OF SMALL RURAL 2-YEAR PUBLIC COLLEGES (N=194).

STATE=MONTANA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
105	6777	FLATHEAD VLY CMTY COLLEGE	1768	2562445	915	0.03536	0.1	4.775	2380

STATE=NEBRASKA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
106	2552	MCCOOK COMMUNITY COLLEGE	516	1189515	361	0.0103200	0.200000	24.288	978
107	11667	NORTHEAST TECHNICAL CC	1616	5523591	1252	0.0089778	0.228571	21.800	73

STATE=NEW MEXICO

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
108	2655	NEW MEXICO JUNIOR COLLEGE	1746	3557389	1015	0.0174600	0.057143	14.091	3459
109	2658	NM STATE U ALAMOGORDO	1183	1271318	683	0.0236600	0.071429	15.453	-1993
110	2659	NM STATE U CARLSBAD	746	943689	427	0.0186500	0.071429	14.929	-5881
111	8854	NM STATE U GRANTS BRANCH	391	722622	190	0.0130333	0.057143	2.675	-5578
112	2660	NM STATE U SAN JUAN	1444	2428924	851	0.0167907	0.085714	16.489	-6357
113	29087	NTHN NM COMMUNITY COLLEGE	1363	4051368	810	0.0132664	0.185714	9.870	-2132

STATE=NEW YORK

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
114	6787	CLINTON COMMUNITY COLLEGE	1510	2897625	1023	0.018875	0.128571	16.257	-6655
115	7111	N COUNTRY CMTY COLLEGE	1449	3385992	981	0.019320	0.128571	5.676	2434

STATE=NORTH CAROLINA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
116	7985	ANSON TECHNICAL COLLEGE	637	1597103	347	0.0098000	0.171429	12.101	-3287
117	8558	BEAUFORT CO CMTY COLLEGE	1146	2532672	772	0.0191000	0.242857	7.789	-2321
118	7987	BLADEN TECHNICAL INST	415	1431924	344	0.0138333	0.157143	12.777	-3402
119	9684	BLUE RIDGE TECHNICAL C	945	2279272	602	0.0105000	0.100000	13.398	-614
120	4835	CALDWELL CC AND TECH INST	1928	3982415	1170	0.0192800	0.242857	20.451	-1830
121	5449	CEN CAROLINA TECH C	2069	4687883	1390	0.0147786	0.271429	8.247	-1537
122	8082	CLEVELAND TECH COLLEGE	1331	2970228	1061	0.0177467	0.242857	14.473	-1612
123	2917	COLLEGE OF THE ALBEMARLE	1253	2796130	904	0.0156625	0.185714	5.797	-2372
124	2919	DAVIDSON CO CMTY COLLEGE	2357	3961470	1582	0.0117850	0.271429	24.169	148
125	7986	HALIFAX CMTY COLLEGE	975	2591892	746	0.0121875	0.257143	20.410	-2031
126	7687	JAMES SPRUNT TECH COLLEGE	746	2688380	621	0.0186500	0.214286	13.004	-3296
127	11197	MAYLAND TECHNICAL C	603	1914681	408	0.0134000	0.185714	15.450	-1745
128	2947	MITCHELL CMTY COLLEGE	1412	2746379	913	0.0056480	0.214286	22.103	-1295
129	8557	NASH TECHNICAL INSTITUTE	1192	1995074	697	0.0183385	0.200000	10.458	-1781
130	5447	RANDOLPH TECHNICAL C	1013	2248353	704	0.0111319	0.214286	11.554	-1794
131	8612	ROBESON TECHNICAL C	1130	3310512	858	0.0111881	0.200000	10.155	-311
132	2958	ROCKINGHAM CMTY COLLEGE	1351	3232610	1004	0.0135100	0.200000	19.065	-845
133	7892	SAMPSON TECHNICAL C	810	2277566	591	0.0162000	0.200000	7.442	-2258
134	2961	SANDHILLS CMTY COLLEGE	1729	4744349	1388	0.0247000	0.257143	20.480	-212

TABLE G-1: DATA BASE OF SMALL RURAL 2-YEAR PUBLIC COLLEGES (N=194).

STATE=NORTH CAROLINA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
135	2964	SOUTHEASTERN CMTY COLLEGE	1907	3985407	1252	0.0254267	0.228571	23.524	-1491
136	2970	SURRY COMMUNITY COLLEGE	1585	3141519	1115	0.0166842	0.214286	21.312	-1956
137	9430	TRI-COUNTY COMMUNITY C	653	1492961	558	0.0197879	0.157143	16.055	-2402
138	9903	VANCE-GRANVL CMTY COLLEGE	1131	2773506	794	0.0104722	0.200000	17.088	-2115
139	2980	WAYNE COMMUNITY COLLEGE	2403	5517929	1974	0.0264066	0.314286	21.866	-556
140	2982	WESTERN PIEDMONT CC	1726	3612339	1101	0.0172600	0.185714	18.179	-583
141	2983	WILKES COMMUNITY COLLEGE	2006	3987406	1222	0.0221413	0.300000	23.522	319

STATE=NORTH DAKOTA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
142	2991	LAKE REGION JR COLLEGE	615	1593348	513	0.0094615	0.171429	19.208	796
143	2995	ND STATE U BOTTINEAU	358	1627377	324	0.0358000	0.085714	18.628	1360
144	3007	U OF ND WILLISTON BRANCH	646	1353423	523	0.0040375	0.171429	20.498	-497

STATE=OHIO

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
145	7856	BOWLING GRN ST U FIRELDS	1195	1918411	786	0.0029875	0.128571	18.941	-469
146	12270	EDISON STATE CMTY COLLEGE	1978	2426281	974	0.0104105	0.214286	20.670	207
147	3061	KENT ST U SALEM REG CAM	524	998966	317	0.0131000	0.100000	11.329	-9554
148	3102	OHIO U CHILLICOTHE BR	1264	1822680	777	0.0105333	0.071429	16.002	1540

STATE=OKLAHOMA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
149	3176	CARL ALBERT JR COLLEGE	1856	2456862	1038	0.0154667	0.128571	19.295	680
150	3155	EASTERN OKLA ST COLLEGE	1951	3226518	1292	0.0291194	0.228571	9.435	2413
151	3158	MURRAY STATE COLLEGE	1469	2615650	984	0.0097933	0.142857	19.504	1954
152	3162	NORTHERN OKLAHOMA COLLEGE	2000	2730668	1334	0.0200000	0.228571	21.751	1671
153	3178	SEMINOLE JUNIOR COLLEGE	1606	2982861	1027	0.0094471	0.171429	22.034	2283
154	3146	WESTERN OKLAHOMA STATE C	1925	2236674	1072	0.0278986	0.128571	19.649	1798

STATE=OREGON

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
155	3186	BLUE MTN CMTY COLLEGE	2454	5067703	1353	0.0395806	0.257143	20.818	3553
156	3188	CENTRAL OREG CMTY COLLEGE	2131	5922904	1368	0.0266375	0.185714	19.666	2779
157	3189	CLATSOP COMMUNITY COLLEGE	2373	4091971	1090	0.0765484	0.185714	9.488	4283
158	3221	TREASURE VLY CMTY COLLEGE	1772	3352559	1052	0.0506286	0.200000	19.837	1152

STATE=PENNSYLVANIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL

TABLE G-1: DATA BASE OF SMALL RURAL 2-YEAR PUBLIC COLLEGES (N=194).

STATE=PENNSYLVANIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
159	3240	BUTLER CO CMTY COLLEGE	1863	3877931	1142	0.01242	0.214286	23.755	425

STATE=SOUTH CAROLINA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
160	7602	CHESTERFLD-MARLBORO TECH	585	1672057	439	0.0083571	0.114286	14.917	-1591
161	4926	TRI-COUNTY TECH COLLEGE	2353	5462484	1740	0.0672286	0.271429	18.623	179
162	4927	U OF SC AT UNION	290	766631	218	0.0019333	0.042857	1.455	-177
163	3996	YORK TECHNICAL COLLEGE	1788	3009576	1299	0.0119200	0.271429	10.046	-170

STATE=TENNESSEE

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
164	6836	MOTLOW STATE CMTY COLLEGE	2179	3030012	1287	0.0145267	0.114286	19.17	-493

STATE=TEXAS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
165	6661	ANGELINA COLLEGE	2035	3164319	1277	0.0203500	0.200000	12.640	783
166	3546	BEE COUNTY COLLEGE	1976	4281336	1564	0.0079040	0.257143	23.540	169
167	3568	FRANK PHILLIPS COLLEGE	835	2023307	502	0.0334000	0.042857	16.858	2386
168	3574	HOWARD C AT BIG SPRING	1076	3764247	656	0.0077525	0.142857	6.721	1456
169	3600	PANOLA JUNIOR COLLEGE	973	1756620	650	0.0194600	0.142857	7.907	-198
170	3601	PARIS JUNIOR COLLEGE	2116	5711928	1435	0.0105800	0.200000	23.419	-738
171	3614	SOUTHWEST TEX JR COLLEGE	2185	3658670	1368	0.0546250	0.128571	19.993	346
172	3664	WEATHERFORD COLLEGE	1543	2405274	1012	0.0205733	0.057143	18.378	-646
173	9549	WESTERN TEXAS COLLEGE	1163	3190302	783	0.0145375	0.214286	20.407	-1206
174	3668	WHARTON CO JR COLLEGE	2011	4780605	1618	0.0088303	0.228571	23.487	2704

STATE=UTAH

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
175	3676	COLLEGE OF EASTERN UTAH	1112	3673396	685	0.0370667	0.100000	17.966	1114
176	3671	DIXIE COLLEGE	1689	4370314	1320	0.0603214	0.157143	17.959	2402
177	3679	SNOW COLLEGE	1283	4661729	1118	0.0128300	0.114286	17.324	2467

TABLE G-1: DATA BASE OF SMALL RURAL 2-YEAR PUBLIC COLLEGES (N=194).

STATE=VIRGINIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
178	6819	BLUE RIDGE CMTY COLLEGE	2273	2669275	1308	0.0135298	0.200000	21.318	1640
179	4996	DABNEY S LANCASTER CC	1060	2989232	693	0.0137686	0.114286	15.189	-515
180	3748	ESTN SHORE CMTY COLLEGE	481	1438823	277	0.0102340	0.071429	14.415	1221
181	8660	GERMANNA CMTY COLLEGE	1218	1734348	687	0.0065838	0.128571	13.936	-6722
182	8659	LORD FAIRFAX CMTY COLLEGE	1966	2368682	1049	0.0140429	0.128571	15.658	-492
183	3751	PATRICK HENRY CC	1605	2301808	880	0.0160500	0.128571	17.355	1052
184	9159	PAUL D CAMP CMTY COLLEGE	1089	2279575	642	0.0114632	0.185714	16.052	-8035
185	9160	RAPPAHANNOCK CMTY COLLEGE	1403	2640667	822	0.0122000	0.142857	17.773	-638
186	8661	SOUTHSIDE VA CMTY COLLEGE	1809	2927448	984	0.0110982	0.142857	14.030	35
187	7099	VA HIGHLANDS CMTY COLLEGE	1491	2948864	1107	0.0186375	0.185714	18.006	792
188	3761	WYTHEVILLE CMTY COLLEGE	1912	3995097	1157	0.0165384	0.228571	19.428	-4033

STATE=WEST VIRGINIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
189	3816	STHN W VA CC	1876	1980840	1063	0.0134	0.185714	18.174	-637

STATE=WISCONSIN

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
190	8919	NICOLET COLLEGE-TECH INST	1117	5233195	767	0.0159571	0.185714	18.083	3514

STATE=WYOMING

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
191	7289	CENTRAL WYOMING COLLEGE	854	3189760	536	0.0212169	0.157143	17.632	2330
192	3929	EASTERN WYOMING COLLEGE	803	2271719	519	0.0200750	0.100000	19.341	531
193	9259	LARAMIE CO CMTY COLLEGE	2492	6187989	1312	0.0383385	0.300000	25.295	3792
194	3930	SHERIDAN COLLEGE	1290	2817799	853	0.0516000	0.142857	6.092	2081

TABLE G-2: DATA BASE OF SMALL NONRURAL 2-YEAR PUBLIC COLLEGES (N=51).

---------- STATE=ALABAMA ----------

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
1	12182	CHATTAHOOCHEE VALLEY CC	1491	3738193	1134	0.0066267	0.157143	6.639	1133
2	9980	GEO C WALLACE ST CC-SELMA	1554	3206627	1239	0.0084000	0.185714	17.566	772
3	1059	LAWSON STATE CMTY COLLEGE	1056	6509396	898	0.0014080	0.228571	9.463	1666
4	1038	SNEAD STATE JR COLLEGE	1017	2101565	843	0.0084750	0.100000	18.837	1972
5	7871	WALLACE ST CC-HNCV	2227	2255399	1708	0.0222700	0.385714	24.062	1124

---------- STATE=ALASKA ----------

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
6	1068	U ALAS MATANUSKA-SUSITNA	407	1501661	186	0.0169583	0.100000	12.905	6767
7	1066	U OF ALASKA KENAI CC	967	3016861	477	0.0299381	0.057143	15.255	13927
8	1067	U OF ALASKA KETCHIKAN CC	396	1451269	165	0.0226286	0.042857	12.010	13050
9	1069	U OF ALASKA SITKA CC	359	1101142	135	0.0239333	0.028571	12.978	2536

---------- STATE=ARKANSAS ----------

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
10	12105	GARLAND CO CMTY COLLEGE	1365	2092766	788	0.0170625	0.157143	6.834	-900
11	1104	PHILLIPS CO CMTY COLLEGE	1467	3502702	1125	0.0293400	0.242857	23.269	-1037
12	13176	STHN ARK U EL DORADO BR	542	920071	337	0.0120444	0.100000	14.526	-2096

---------- STATE=CALIFORNIA ----------

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
13	1176	WEST HILLS COLLEGE	2228	4919744	1145	0.0327647	0.1	15.539	7398

---------- STATE=CONNECTICUT ----------

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
14	11150	ASNUNTUCK CMTY COLLEGE	1729	1317900	742	0.0144083	0.071429	12.363	1434
15	8037	SOUTH CEN CMTY COLLEGE	2046	2608749	1231	0.0068200	0.128571	18.473	-126

---------- STATE=GEORGIA ----------

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
16	1543	ALBANY JUNIOR COLLEGE	1976	4051741	1501	0.0263467	0.142857	18.510	-5083
17	12165	ATLANTA JUNIOR COLLEGE	1344	3890506	1007	0.0008960	0.114286	20.581	653
18	1558	BRUNSWICK JUNIOR COLLEGE	1120	3121765	847	0.0112000	0.257143	23.733	-3888
19	1567	GAINESVILLE JR COLLEGE	1530	3204432	1233	0.0076500	0.128571	20.739	-6202
20	7728	MACON JUNIOR COLLEGE	2447	4008270	1523	0.0122350	0.128571	20.299	-194

TABLE G-2: DATA BASE OF SMALL NONRURAL 2-YEAR PUBLIC COLLEGES (N=51).

STATE=HAWAII

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
21	1614	U OF HAWAII KAUAI CC	1060	3368465	649	0.0240909	0.114286	5.079	2958
22	1615	U OF HAWAII MAUI CC	1869	3580131	1174	0.0263808	0.214286	15.230	2850
23	10390	U OF HAWAII WINDWARD CC	1436	2489427	911	0.0179500	0.071429	3.639	1556

STATE=ILLINOIS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
24	9332	STATE COMMUNITY COLLEGE	1826	3818484	1237	0.0231139	0.214286	21.799	-619

STATE=IOWA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
25	1864	IOWA LAKES CC	1413	5462972	1264	0.0173079	0.128571	17.768	2551
26	4074	SCOTT COMMUNITY COLLEGE	2056	5420088	1448	0.0128500	0.242857	15.564	-471

STATE=KENTUCKY

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
27	29206	ASHLAND COMMUNITY COLLEGE	1472	2219235	995	0.0122667	0.128571	19.369	723
28	29209	HOPKINSVILLE CMTY COLLEGE	1089	1643878	775	0.0136125	0.085714	3.755	-5596
29	29213	MADISONVILLE CMTY COLLEGE	845	1287706	494	0.0070417	0.085714	17.051	-7255
30	29215	PADUCAH COMMUNITY COLLEGE	1850	2794595	1289	0.0102579	0.142857	19.073	-640

STATE=MARYLAND

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
31	2057	ALLEGANY CMTY COLLEGE	1844	4903072	1396	0.0097053	0.228571	10.371	-727
32	2074	HAGERSTOWN JUNIOR COLLEGE	2242	3961426	1315	0.0149467	0.185714	16.254	-6892

STATE=MISSOURI

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
33	8862	EAST CENTRAL MO DIST JC	2060	3242502	1288	0.0274667	0.228571	10.068	-677

STATE=NEW MEXICO

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
34	2661	EASTERN NM U ROSWELL	1204	3160384	975	0.0218909	0.171429	17.335	-8564

TABLE G-2: DATA BASE OF SMALL NONRURAL 2-YEAR PUBLIC COLLEGES (N=51).

STATE=NEW YORK

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
35	4788	HERKIMER CO CMTY COLLEGE	2199	4239893	1859	0.0314143	0.157143	6.509	531

STATE=NORTH CAROLINA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
36	8086	CRAVEN COMMUNITY COLLEGE	1491	2984284	948	0.0149100	0.228571	18.394	-1518
37	2934	ISOTHERMAL CMTY COLLEGE	2089	3094078	1082	0.0321385	0.185714	18.155	-1743
38	7988	MARTIN COMMUNITY COLLEGE	737	1988043	515	0.0184250	0.200000	17.146	-1948
39	4062	PITT CMTY COLLEGE	2455	4434107	1760	0.0272778	0.357143	18.026	-1900
40	4845	WILSON CO TECHNICAL INST	1356	3322721	885	0.0214788	0.257143	13.175	-1940

STATE=NORTH DAKOTA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
41	2988	BISMARCK JUNIOR COLLEGE	2273	4227955	1755	0.0151533	0.2	7.614	1577

STATE=OHIO

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
42	3054	KENT ST STARK CO REG CAM	1946	3272162	1172	0.00513696	0.028571	1.22	1145
43	12870	STHN ST GEN-TECH COLLEGE	1406	1720724	780	0.00937333	0.142857	17.51	-1063

STATE=OKLAHOMA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
44	3168	CLAREMORE JUNIOR COLLEGE	1828	2844054	1335	0.00292480	0.114286	19.567	709
45	3156	EL RENO JUNIOR COLLEGE	1388	1729067	783	0.00699421	0.100000	18.832	1556

STATE=PENNSYLVANIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
46	6807	CMTY COLLEGE OF BEAVER CO	2092	3982060	1420	0.0104600	0.285714	19.215	-6334
47	10388	READING AREA CMTY COLLEGE	1441	3713592	831	0.0045031	0.228571	19.969	-6079

STATE=TEXAS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
48	29065	CEDAR VALLEY COLLEGE	1886	4446528	995	0.0157167	0.114286	14.875	2838
49	3554	CLARENDON COLLEGE	625	1077708	402	0.0113636	0.085714	4.264	-1990
50	6662	GALVESTON COLLEGE	1555	3682733	926	0.0239231	0.185714	5.578	1825
51	3662	VICTORIA COLLEGE	2362	4057729	1453	0.0118100	0.128571	18.515	2253

TABLE G-3: DATA BASE OF SMALL TECHNICAL 2-YEAR PUBLIC COLLEGES (N=68).

STATE=ALASKA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
1	29093	U OF ALASKA TANANA VLY CC	1936	5548285	769	0.0339649	0.142857	7.867	13066

STATE=COLORADO

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
2	29166	PUEBLO VOCATIONAL CC	754	2555519	636	0.00685455	0.185714	5.06	1420

STATE=CONNECTICUT

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
3	29170	GREATER NEW HAVEN TECH C	810	1043495	458	0.0015577	0.100000	4.182	40
4	1400	NORWALK ST TECH COLLEGE	1788	2206642	1088	0.0022350	0.128571	5.959	4792
5	1413	THAMES VLY STATE TECH C	1823	1859641	1076	0.0182300	0.128571	5.404	3328
6	1423	WATERBURY ST TECH COLLEGE	1715	2081688	1011	0.0063519	0.100000	5.463	5064

STATE=DELAWARE

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
7	11387	DEL TECH & CC STANTON CAM	2457	4295000	1434	0.0061716	0.357143	12.643	3905
8	7053	DEL TECH & CC STHN CAM	1808	5522700	1323	0.0196783	0.271429	11.644	4073
9	11727	DEL TECH & CC TERRY CAM	1188	2855600	754	0.0247500	0.200000	7.896	3586

STATE=INDIANA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
10	13146	IND VOC TECH C-EAST CEN	2228	2674104	1560	0.00466011	0.214286	8.163	-1316
11	10039	IND VOC TECH C-LAFAYETTE	1015	1702973	648	0.00406000	0.214286	5.223	-1861
12	13144	IND VOC TECH C-SOUTHEAST	517	887187	290	0.00517000	0.100000	5.158	-1582
13	10109	IND VOC TECH C-STHCEN	1231	1906759	886	0.00492400	0.185714	5.431	-1724
14	13140	IND VOC TECH C-WHITEWATER	925	1190657	597	0.00513889	0.128571	6.141	-1643
15	8547	IND VOC TECH-WABASH VLY	1355	2102102	957	0.00504891	0.228571	7.096	-437

STATE=IOWA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
16	4595	HAWKEYE INST TECHNOLOGY	1708	7890901	1681	0.00817894	0.328571	8.698	569
17	4600	NTHWST IOWA TECH C	489	2482672	488	0.00679167	0.185714	5.013	444

STATE=KANSAS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
18	4611	KANSAS TECHNICAL INST	455	1665058	382	0.00892157	0.114286	5.749	-279

TABLE G-3: DATA BASE OF SMALL TECHNICAL 2-YEAR PUBLIC COLLEGES (N=68).

STATE=LOUISIANA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
19	12033	BOSSIER PARISH CC	1470	1960650	662	0.0042	0.0571429	3.395	1379

STATE=MAINE

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
20	5276	CENTRAL ME VOC-TECH INST	436	2011726	429	0.00109000	0.114286	3.789	-1106
21	5277	EASTERN ME VOC-TECH INST	642	2372899	570	0.00535000	0.171429	8.075	-62
22	5525	SOUTHERN ME VOC TECH INST	1572	5134552	1131	0.00449143	0.200000	8.213	16

STATE=MARYLAND

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
23	29053	WOR-WIC TECH CMTY COLLEGE	627	1965393	348	0.00737647	0.128571	5.107	-5782

STATE=MINNESOTA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
24	4069	U MINN TECH COL CROOKSTON	1178	4704206	1038	0.0336571	0.228571	10.986	-1939
25	10225	U OF MINN TECH C-WASECA	1123	4629895	926	0.0056150	0.100000	9.072	633

STATE=NEW HAMPSHIRE

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
26	5291	NH VOC-TECH C BERLIN	401	891216	391	0.0080200	0.157143	6.075	-171
27	7560	NH VOC-TECH C CLAREMONT	388	1414097	380	0.0097000	0.200000	5.508	-1727
28	7555	NH VOC-TECH C LACONIA	248	916383	247	0.0053913	0.085714	4.693	-2132
29	9236	NH VOC-TECH C NASHUA	1001	1039334	541	0.0040040	0.142857	6.560	639

STATE=NORTH CAROLINA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
30	4033	ASHEVL BUNCOMBE TECH C	2318	4702232	1724	0.0092720	0.342857	11.283	-44
31	5320	CAPE FEAR TECHNICAL INST	1871	6054058	1285	0.0143923	0.228571	9.715	89
32	8081	CARTERET TECHNICAL INST	988	2334272	697	0.0247000	0.185714	9.093	-1617
33	5318	CATAWBA VALLEY TECH C	2271	4244875	1572	0.0075700	0.285714	9.121	180
34	8855	EDGECOMBE TECH COLLEGE	1000	2886941	687	0.0175439	0.185714	7.017	-2142
35	8083	HAYWOOD TECHNICAL INST	875	4075396	779	0.0087500	0.214286	9.825	-1593
36	8085	MCDOWELL TECHNICAL INST	568	1411731	400	0.0160000	0.157143	5.168	-1841
37	7031	PAMLICO TECHNICAL C	155	864109	113	0.0155000	0.128571	7.309	-2090
38	9646	PIEDMONT TECHNICAL C	868	2767048	633	0.0144667	0.185714	8.537	-1897
39	8613	ROANOKE-CHOWAN TECH INST	554	2407658	402	0.0079143	0.157143	7.732	-1344
40	5754	ROWAN TECHNICAL COLLEGE	1891	3907601	1290	0.0094550	0.257143	8.646	213
41	8466	SOUTHWESTERN TECH C	985	3182257	680	0.0182407	0.214286	10.632	-924
42	5463	TECH C OF ALAMANCE	1780	3831015	1213	0.0148333	0.242857	10.837	443

TABLE G-3: DATA BASE OF SMALL TECHNICAL 2-YEAR PUBLIC COLLEGES (N=68).

STATE=NORTH CAROLINA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
43	4844	WAKE TECHNICAL COLLEGE	1806	4661671	1514	0.00602	0.271429	9.551	-1073

STATE=OHIO

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
44	9941	BELMONT TECHNICAL COLLEGE	1264	1719944	799	0.0093630	0.200000	7.684	-4194
45	11046	CENTRAL OHIO TECHNICAL C	1167	2085244	802	0.0077800	0.171429	7.106	888
46	7275	JEFFERSON TECHNICAL C	1533	2276647	1040	0.0170333	0.200000	7.871	390
47	10736	MARION TECHNICAL COLLEGE	1263	1864505	818	0.0126300	0.200000	8.369	2231
48	8133	MUSKINGUM AREA TECH C	1518	2295382	1015	0.0216857	0.257143	11.646	-1824
49	10818	U AKRON WAYNE GEN-TECH C	916	1178337	457	0.0045800	0.057143	6.916	-1653
50	10453	WASHINGTON TECH COLLEGE	796	1219957	535	0.0106133	0.157143	6.105	380

STATE=SOUTH CAROLINA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
51	10056	AIKEN TECHNICAL COLLEGE	1269	2605068	896	0.0084600	0.185714	4.242	603
52	9910	BEAUFORT TECH COLLEGE	1185	2711603	792	0.0091860	0.142857	5.817	-1089
53	5363	DENMARK TECHNICAL COLLEGE	669	1827343	617	0.0148667	0.157143	5.690	634
54	3990	FLORENCE DARLINGTON TECH	2234	5635879	1795	0.0055850	0.300000	9.895	133
55	4925	HORRY-GEORGETOWN TECH C	1465	2966253	1169	0.0101034	0.214286	9.132	364
56	6815	ORANGEBURG CALHOUN TECH C	1455	3521364	1129	0.0161667	0.300000	11.084	-460
57	3992	PIEDMONT TECH COLLEGE	1773	4049326	1402	0.0086277	0.285714	8.180	763
58	3994	SPARTANBURG TECH COLLEGE	1931	4938059	1465	0.0064367	0.314286	10.224	-474
59	9322	WILLIAMSBURG TECH C	503	2075472	398	0.0131586	0.142857	6.576	-901

STATE=TENNESSEE

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
60	12693	STATE TECH INST KNOXVILLE	2458	2847674	1430	0.006145	0.142857	6.929	-6909

STATE=TEXAS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
61	9933	TEX ST TECH AMARILLO CAM	792	4171038	743	0.00226286	0.200000	5.607	-2961
62	9225	TEX ST TECH-HARLINGEN CAM	1422	4204540	1277	0.00646364	0.242857	8.375	-947
63	9932	TEX ST TECH-SWEETWATER	332	1928066	291	0.00221333	0.157143	5.138	-1326

STATE=VERMONT

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
64	3698	VERMONT TECHNICAL COLLEGE	793	3221208	767	0.03172	0.1	4.847	-203

TABLE G-3: DATA BASE OF SMALL TECHNICAL 2-YEAR PUBLIC COLLEGES (N=68).

STATE=WISCONSIN

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
65	5390	BLACKHAWK TECHNICAL INST	2148	5436077	1647	0.0126777	0.271429	9.584	3541
66	5299	GATEWAY TECH INST-RACINE	2131	7416488	1113	0.0058065	0.228571	11.280	1710
67	5380	MID-STATE TECHNICAL INST	1334	6460019	1035	0.0088638	0.314286	10.052	2927
68	7669	STHWST WIS VOC TECH INST	1066	4001957	929	0.0083997	0.228571	6.674	848

TABLE G-4: DATA BASE OF MEDIUM LARGE 2-YEAR PUBLIC COLLEGES (N=25).

STATE=ARIZONA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
1	11864	MOHAVE COMMUNITY COLLEGE	3380	3208716	1307	0.0482857	0.171429	6.323	-861

STATE=CALIFORNIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
2	7707	COLUMBIA COLLEGE	2986	4428534	1417	0.039813	0.171429	8.112	5599
3	9272	CRAFTON HILLS COLLEGE	3268	4057905	1567	0.010893	0.300000	24.232	4980
4	29246	CUYAMACA COLLEGE	2568	2891408	1144	0.007950	0.142857	18.289	2188
5	1217	LASSEN COLLEGE	2762	6679490	1436	0.125545	0.171429	7.128	5679

STATE=COLORADO

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
6	9543	CC DENVER RED ROCKS CAM	4663	8197201	2632	0.00310867	0.314286	21.013	-1488
7	7933	CC OF DENVER NORTH CAMPUS	4758	8197201	2811	0.00858845	0.300000	25.522	-926

STATE=CONNECTICUT

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
8	4513	HOUSATONIC REGIONAL CC	2600	3596849	1420	0.00577778	0.157143	19.367	-2296

STATE=HAWAII

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
9	1612	U OF HAWAII HONOLULU CC	4493	7682253	3064	0.00561625	0.271429	9.155	517

STATE=ILLINOIS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
10	1705	ILLINOIS VLY CMTY COLLEGE	4250	5401230	2661	0.0283333	0.242857	9.219	1345
11	7644	LAKE LAND COLLEGE	4093	6360117	2843	0.0227389	0.314286	11.270	-947

STATE=MAINE

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
12	6760	U OF MAINE AT AUGUSTA	3420	5310610	1694	0.0105122	0.1	4.525	-2281

STATE=MARYLAND

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL

TABLE G-4: DATA BASE OF MEDIUM LARGE 2-YEAR PUBLIC COLLEGES (N=25).

STATE=MARYLAND

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
13	8175	HOWARD COMMUNITY COLLEGE	3042	4670161	1464	0.038025	0.114286	19.05	-1386

STATE=MICHIGAN

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
14	2302	NORTHWESTERN MICH COLLEGE	3389	6633899	2395	0.06778	0.314286	25.297	-2211

STATE=MINNESOTA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
15	2373	ROCHESTER CMTY COLLEGE	3106	5305856	2241	0.0207067	0.185714	19.66	1747

STATE=NEW YORK

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
16	2860	ADIRONDACK CMTY COLLEGE	2770	4837483	1798	0.02770	0.214286	22.961	-692
17	2857	SUNY AGRL & TECH C DELHI	2713	11675912	2554	0.05426	0.271429	8.385	-2841

STATE=OHIO

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
18	4868	U CINCIN RAYMND WALTERS C	3479	5105183	1986	0.006958	0.228571	7.112	-1076

STATE=OKLAHOMA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
19	3160	NTHESTN OKLA AGRL-MECH C	2892	5658306	2373	0.0141695	0.271429	23.958	-437

STATE=OREGON

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
20	3220	STHWSTN OREG CMTY COLLEGE	3013	4559584	1552	0.0424366	0.242857	9.568	1277

STATE=PENNSYLVANIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
21	6811	LUZERNE CO CMTY COLLEGE	3423	6489037	2072	0.00997729	0.3	21.9	-1966

TABLE G-4: DATA BASE OF MEDIUM LARGE 2-YEAR PUBLIC COLLEGES (N=25).

STATE=TEXAS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
22	12713	SAN JACINTO C NORTH CAM	2827	4022373	1466	0.0014135	0.185714	21.684	-128

STATE=VIRGINIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
23	5223	NEW RIVER CMTY COLLEGE	3151	4838849	1722	0.0212403	0.228571	17.379	-1979
24	9928	PIEDMONT VA CMTY COLLEGE	3558	3635783	1736	0.0244086	0.200000	19.012	-3145

STATE=WASHINGTON

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
25	3770	BIG BEND CMTY COLLEGE	2815	7408055	1446	0.0469167	0.171429	7.501	1328

TABLE G-5: DATA BASE OF VERY LARGE 2-YEAR PUBLIC COLLEGES (N=39).

STATE=ARIZONA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
1	7283	CENTRAL ARIZONA COLLEGE	6098	8597333	2893	0.0635208	0.342857	24.577	-1150
2	11862	NORTHLAND PIONEER COLLEGE	5030	3832616	2019	0.0838333	0.157143	19.588	-2921

STATE=CALIFORNIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
3	9552	AMERICAN RIVER COLLEGE	22837	19008647	12001	0.0285462	0.471429	28.720	5218
4	1113	ANTELOPE VALLEY COLLEGE	6239	6398620	3011	0.0499120	0.342857	21.284	998
5	1124	CABRILLO COLLEGE	9566	14023810	5229	0.0478300	0.371429	10.458	2394
6	1181	COLLEGE OF SAN MATEO	16144	20532693	8631	0.0274092	0.385714	13.274	5814
7	1182	COLLEGE OF THE DESERT	6204	11429095	2972	0.0413600	0.271429	24.259	412
8	1197	EL CAMINO COLLEGE	30530	28318697	14507	0.0555091	0.500000	12.011	4237
9	1206	GOLDEN WEST COLLEGE	20675	21896525	9681	0.0275667	0.400000	25.120	5194
10	1209	HARTNELL COLLEGE	6095	10118326	3184	0.0641579	0.185714	8.145	1803
11	1227	LOS ANG TR TECH COLLEGE	15824	26462180	8391	0.0098900	0.457143	13.848	5327
12	1223	LOS ANGELES CITY COLLEGE	19800	28667822	10745	0.0044000	0.414286	12.288	4683
13	1250	ORANGE COAST COLLEGE	28351	32548889	14229	0.0436169	0.528571	29.145	5986

STATE=CONNECTICUT

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
14	1392	MANCHESTER CMTY COLLEGE	6615	5567516	3400	0.02646	0.257143	7.437	-344

STATE=FLORIDA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
15	1475	DAYTONA BCH CMTY COLLEGE	8011	18023460	4926	0.0291309	0.5	13.373	-1209

STATE=HAWAII

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
16	4549	U OF HAWAII LEEWARD CC	5535	8191107	3671	0.01107	0.185714	22.245	-553

STATE=ILLINOIS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
17	1638	BLACK HAWK C QUAD-CITIES	6381	10760539	3475	0.0159525	0.328571	24.938	-1567
18	6753	ILLINOIS CENTRAL COLLEGE	13081	15578062	6834	0.0348827	0.414286	25.833	-5454
19	7118	PARKLAND COLLEGE	7606	11259095	4517	0.0338044	0.485714	12.966	-1176
20	6931	WAUBONSEE CMTY COLLEGE	6015	5625257	2864	0.0325135	0.271429	19.422	95

TABLE G-5: DATA BASE OF VERY LARGE 2-YEAR PUBLIC COLLEGES (N=39).

STATE=MICHIGAN

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
21	2267	GRAND RAPIDS JR COLLEGE	8871	14577047	5696	0.0077139	0.328571	9.775	-1394
22	2278	LANSING COMMUNITY COLLEGE	18884	27928100	9841	0.0429182	0.542857	13.083	-7009
23	2297	MUSKEGON CMTY COLLEGE	5171	8260448	2724	0.0295486	0.214286	21.541	1614
24	2328	WASHTENAW CMTY COLLEGE	8452	14409492	4259	0.0318943	0.342857	11.489	2668

STATE=MISSISSIPPI

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
25	8763	MISS GULF CST JC	6326	14162989	4358	0.0210166	0.4	24.454	-3328

STATE=MISSOURI

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
26	2484	PENN VALLEY CMTY COLLEGE	5096	7149742	2800	0.010192	0.385714	25.238	532

STATE=NEBRASKA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
27	29007	CEN TECH CMTY C AREA	5203	8760265	2620	0.0177899	0.342857	22.531	-6491

STATE=NEVADA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
28	29231	TRUCKEE MEADOWS CC	6693	4722078	2601	0.0317414	0.2	14.746	-1691

STATE=NEW JERSEY

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
29	6865	CAMDEN COUNTY COLLEGE	8360	8656358	5105	0.0176000	0.285714	9.876	199
30	4740	MERCER CO CMTY COLLEGE	8963	14553984	4993	0.0291136	0.385714	23.092	-852

STATE=NEW YORK

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
31	2877	ROCKLAND CMTY COLLEGE	7798	14997169	5089	0.0299923	0.3	24.44	-254

STATE=NORTH CAROLINA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
32	2915	CEN PIEDMONT CMTY COLLEGE	18933	21222569	9274	0.0454029	0.457143	25.112	-3628

TABLE G-5: DATA BASE OF VERY LARGE 2-YEAR PUBLIC COLLEGES (N=39).

STATE=OREGON

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
33	3213	PORTLAND CMTY COLLEGE	20458	28402403	11472	0.0255725	0.585714	30.335	-1427

STATE=PENNSYLVANIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
34	4452	MONTGOMERY CO COMMUNITY C	7410	10589577	4421	0.0117619	0.257143	9.64	3

STATE=RHODE ISLAND

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
35	3408	CMTY COLLEGE RHODE ISLAND	11844	21907450	7421	0.011844	0.285714	21.91	-1326

STATE=TEXAS

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
36	3563	DEL MAR COLLEGE	8207	15975277	5120	0.0273567	0.442857	10.534	-1405

STATE=VIRGINIA

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
37	6871	THOMAS NELSN CMTY COLLEGE	6379	7736215	3526	0.0185252	0.357143	22.69	-3326

STATE=WASHINGTON

OBS	FICE	INSTITUTION	HEAD	IEG	FTE	MARKET	DIVERSITY	INDEXCOMP	ADJAVSAL
38	3791	SHORELINE CMTY COLLEGE	7969	11548787	5231	0.0053127	0.371429	25.074	-457
39	3805	YAKIMA VALLEY CC	6204	7206650	3618	0.0294028	0.300000	26.033	-208

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