The Supply of University Enrollments: University Administrators as Utility Maximizing Bureaucrats

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Abstract

The supply of enrollments in higher education has received relatively little attention in both theoretical and empirical economic research. To address this, we formulate and test a model of the supply of enrollments in higher education in which administrators are modeled as utility maximizing bureaucrats. We find evidence that individual presidents and provosts have a significant effect on enrollment supply and faculty demand in a panel of eleven public colleges and universities in Maryland from 1988 to 1996, implying that institutions have enough market power to permit the preferences of administrators to influence enrollment supply and faculty demand.

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1 Introduction

William Niskanen (1971) developed a model of bureaucratic behavior in which a government official attempted to maximize the budget of his or her particular agency. In the Niskanen model, the budget of the agency served as a proxy for a variety of issues of importance to the bureaucrat. For example, the greater the agency budget, the more prestige associated with heading up that agency. Using his model, Niskanen derived results on the extent to which government services were over supplied.

The provision of higher education is an important government service. Interestingly, the supply of higher education, which we take here to be the enrollment in colleges and universities, is not often studied. Moreover, studies of the supply of higher education rarely focus on the decision-making of the college or university administration, the bureaucrats, who, if Niskanen's model applies, will attempt to maximize the public funding for the campus, leading to excess supply of enrollments.

In this paper, we adopt the Niskanen framework to analyze the decisions of college administrators. In particular, we are interested in how college or university administrators select the level of enrollment for their institutions; we focus on the supply of enrollments, whereas much of the existing literature has focused on the demand for enrollments.[1] In particular, we adopt the framework used in Niskanen (1975), and assume that bureaucrats maximize utility, which depends upon enrollments and the quantity and quality of faculty and facilities.

One study of the supply of enrollments in higher education by Garvin (1980) examined the behavior of universities, specifically considering the enrollment decision, as well as decisions on allocation of resources between departments. He mentioned the bureaucratic model of university decision-making and his analysis began by treating the university as a unitary actor with a well-defined utility function. However, he described this utility function as resulting from consensus or, at least, from politicking within the faculty, students and administrators. Essentially, the preferences of administrators have no more bearing on the decisions than do those of a student or Assistant Professor. Garvin did not, in other words, allow for individual specific

[1]See Manski and Wise (1983), Paulsen (1990), Manski (1993), Hauser (1993), Cook and Frank (1993), Savoca (1990), Hoenack and Weiler (1979), Hoenack and Pierro (1990), Betts and McFarland (1995), and McPherson and Schapiro (1991) among others.

tastes or preferences to influence university behavior. Our analysis assumes that the administrator is the only individual whose preferences matter in making decisions for the university. If this assumption is valid, we should find, and we do, that enrollment decisions at the various campuses depend upon which administrator is in office at the time.

In another supply side study Ehrenberg, Rees and Brewer (1993) examined the effects of increased federal support for graduate students on the behavior of universities. This issue was addressed using a regression model explaining the number of full time science and engineering graduate students supported by institutional funds. Explanatory variables included the number of undergraduates, the number of science and engineering faculty, and the number of science and engineering graduate students supported by outside funds such as governmental grants. If the coefficient on the number of students supported with outside funds is negative, the university response to greater government support of graduate education is to use less of its own funds that way. The university diverts funds from supporting graduate students in science and engineering to other types of activities. Ehrenberg, et al. found support for the hypothesis that universities reallocate their own source funds away from the support of graduate students as outside support for those students increases.

Interestingly, Ehrenberg, et al., assumed that there was an institution specific error that is constant over time, and they took first differences to control for this effect. However, if our model is correct and university administrators act like Niskanen style bureaucrats, then for the institution specific error to be constant over time requires that the administrators of the university not change over time. If administrators do change over time, then first differencing does not control for the fixed effects. Finally, if there is correlation between the administration effect and the explanatory variables, as would be the case if administrators are influential in making the resource allocation decisions, then coefficients on those variables are biased and inconsistent.

In the following section we develop theoretical implications of the Niskanen-style bureaucratic supply model for the enrollment decisions of universities and colleges. By contrast, we also develop implications for the enrollment decision of profit maximizing behavior on the part of the university administrator. The key distinction is that under the latter objective the role of the university administrator should be minimal. In section 3 we describe the empirical approach to testing the theoretical implications, and in appendix A we describe our data. Section 4 reports and discusses our results. Conclusions are provided in section 5.

2 Models of Enrollment Supply

Colleges and universities, especially those supported by state and local governments, are generally not-for-profit organizations. As such, it is not natural or reasonable to model them as profit maximizing institutions. In this section we model the decision-making of the president, provost, chancellor or chief officer of the campus assuming that individual seeks to maximize his or her own utility subject to revenues from the operation of the college being at least as large as costs. Nonetheless, a useful benchmark against which the decisions of the college administrator may be compared is the decisions that would result if the institution were a profit maximizer. Consequently, in this section we examine the first-order-conditions for both the profit maximization and the utility maximization problems.

In either context the college or university may be either a price-taker or a price-setter. That is, tuition and fees may be set outside the institution, by the market or within the state or local political system, or they may be set by the institution. We compare the theoretical implications under these two tuition (price) formation assumptions.

Garvin's (1980) model of university behavior is similar to ours. In Garvin's model the university is, implicitly, an organic entity with preferences of its own. Our model differs from his because we assume that it is the campus president or provost whose preferences matter for determining the direction of the school and its resource allocations.[2] We do not formally analyze the Garvin model, but we do draw comparisons between his model and ours.[3]

We begin by analyzing the model of a price-taking university or college administrator's behavior. The individual, who can be thought of as a president or provost,

[2]A second difference is that Garvin does not do any formal comparative static analysis.

[3]Freeman (1975) also developed and estimated a similar model, although Freeman assumed that the university behaved like a profit maximizing firm when making supply and factor demand decisions, and then distributed the residual profits to maximize institutional utility.

has a utility function which depends upon the level of enrollment, the number and quality of faculty, the quality of the library and laboratory facilities, the success of the university athletic teams, the success of the university's graduates, and his or her own income.[4] The administrator's utility function exhibits the usual curvature, except that we will assume it is separable in income, and is expressed as

$$U = \mu(E, F, L, S; I) = \phi(E, F, L, S) + f(I). \tag{1}$$

We have assumed separability in income for two reasons. First, the administrator's income (I) is not discretionary to the administrator, but is set by the Board of Regents, the College's trustees or the state. Second, for the empirical work that follows we have been unable to obtain income information for presidents and provosts. Our assumption of separability means that the level of an administrator's income has no impact on his or her choices of enrollment, faculty, or facilities.

In our model it is key that the administrator maximizes his or her own utility by selecting the enrollment (E), the quantity and quality of the faculty (F), and the quality of the library and the laboratories (L) of the university. In this first model, the administrator does not get to select the tuition, fees and state appropriation that constitute the "price" an enrollee must pay to be enrolled. Rather, after the legislature sets tuition, etc., at each campus, the university administrator offers enrollment. The enrollment figures for a campus reflect the quantity demanded for education by that campus at the going tuition and fees, but also reflect the administrator's desired mix of faculty, facilities, and students.

The success of athletics and, especially, of the graduates (S) is a function of the quality and quantity of faculty and laboratories and library materials.[5] For simplicity,

[4]Alternatively, one could hypothesize that the university administrator's utility depends upon the number of graduates, which is an increasing function of the number of enrollees. While making the comparative static expressions messier, this alternative approach does not materially affect the implications.

[5]Garvin distinguished the prestige of the university and the prestige of departments within the university. He stated that "the university will respond to the change in price by increasing the prestige of that department" in response to an outside source increasing the level of research funding in a particular area. But the university is incapable of changing a department's prestige. All the university can do is allocate more faculty to that department and offer higher salaries to faculty

S is dropped and its effects on utility are captured via F and L. Choices of enrollment, faculty and labs are subject to constraint. In particular, the college cannot run a (current account) budget deficit, so that its spending is constrained by the level of support via tuition and fees and state support, and the funding from outside sources such as the federal government and other grant making institutions. The tuition and fees (TF) and at least some state assistance (SA) are each collected by the institution on a per enrollee basis. Hence, $(SA + TF)E$ is one source of funding. G represents the non-enrollment dependent funds the university receives from the state. Outside funding (OF) is a function of enrollment, the quantity and quality of faculty, and the quality of the laboratories and other facilities, $OF(E, F, L)$. The first partial derivatives of the outside funding function are assumed to be positive.

The costs incurred by the university or college depend upon the salaries paid to faculty and staff (W_f), the quantity and quality of faculty (F), the number of students (E), and the laboratories and libraries (L). The university's costs are $C(W_f, F, E, L)$ with each of the first partial derivatives positive. The nature of the cost function is, however, highly complex. For public institutions, Cohn, Rhine and Santos (1989) found economies of scale with respect to research and graduate teaching at any size public institution. However, they found economies of scale with respect to undergraduate teaching at any of these institutions below the average size but diseconomies of scale at institutions at or above average size. Additionally, Cohn, Rhine and Santos found ray diseconomies of scale starting about the average size.[6] In other words, whether marginal costs of undergraduate enrollment are rising or falling seems to depend upon the size of the institution. However, for stability no marginal costs can

in that area to attract better researchers. If the university is successful, then the prestige of the department will rise, but this is a long term process. Moreover, the prestige of an institution or one of its departments is not solely a function of the research performed there. Teaching activities and the uniqueness and success of academic programs are also sources of prestige for the campus. Whatever the source of the prestige, it is clear that the university cannot increase its own prestige or that of individual departments quickly or unilaterally.

[6] A ray economy of scale is based on increasing all outputs by a given proportion rather than only a single output by that proportion. Formally, ray economies of scale are based on the ratio of the total cost of a vector of outputs to the sum of the output-weighted marginal costs of the individual outputs. If this ratio is greater than 1 then ray economies of scale exist; if it is less than one, ray diseconomies of scale exist.

be decreasing too fast. Consequently, in the analysis below we implicitly assume that if marginal costs are falling with respect to enrollment, faculty or facilities, they are doing so more slowly than marginal revenues from those variables.

The university administrator then maximizes

$$\begin{aligned} &\phi(E, F, L, I) + \lambda((SA + TF)E + G \\ &\quad + OF(E, F, L) - C(W_f, F, E, L)) \end{aligned} \tag{2}$$

through the choice of E, F, L, and λ. The first-order-conditions for this problem are:

$$\phi_E + \lambda[(SA + TF) + OF_E - C_E] = 0 \tag{3}$$

$$\phi_f + \lambda[OF_f - C_f] = 0 \tag{4}$$

$$\phi_l + \lambda[OF_l - C_l] = 0 \tag{5}$$

$$(SA + TF)E + G + OF(E, F, L) - C(W_f, F, E, L) \geq 0 \tag{6}$$

$$\lambda \geq 0 \tag{7}$$

$$\lambda((SA + TF)E + G + OF(E, F, L) - C(W_f, F, E, L)) = 0 \tag{8}$$

The bracketed term in each of the first-order-conditions can be interpreted as the net marginal revenue to the university from increasing each of the three choice variables. Satisfaction of these conditions implies in each case that marginal cost of enrolling an additional student, hiring an additional faculty member, or expanding the library and laboratory facilities each exceeds the marginal revenue of that action. For example, adding a student raises costs by more than the tuition, fees and state appropriations plus any outside funding that student will generate. That this is true results because the added enrollment, faculty or facilities provide more than just financial benefits to the university administrator. Each also generates utility benefits.

$$\phi_E + \lambda[(SA + TF) + OF_E] = \lambda C_E. \tag{9}$$

In equation (9) the first-order-condition (3) is revised to put all the benefits from added enrollment together on one side of the equality, and all the costs on the other side. In other words, the marginal benefit of added enrollment is comprised of both additional revenues and additional utility. The optimizing university president equates the sum of these two components of additional benefits to the marginal costs, so enrollment (and faculty and laboratories) are each expanded beyond the level at which marginal revenues equal marginal costs. This is an important point to which we return below.

Niskanen examined two cases in his model of bureaucratic behavior, when revenues or the budget exceeded the costs of providing the services and when revenues just met costs of providing the services. A similar dichotomy can be used here. Suppose that revenues from fees, tuition, state assistance and outside funding exceed the costs incurred by the university. In other words, suppose the institution earns a profit. In this instance, the Lagrange multiplier (λ) must equal zero. The only way for the first-order-conditions to be met in this case is for the first derivatives of the utility function, ϕ_E, ϕ_f, and ϕ_l, to each equal zero. In other words, the additional utility the administrator derives from raising enrollment, improving faculty quality or quantity, or improving the labs or libraries is, in every case, zero. If the university is taking in more revenue than it needs to cover the costs of its teaching and research mission, then the administrator will not have any interest in raising enrollments, faculty quality or laboratory and library resources. Neither increases in tuition and fees nor small increases in costs would have any impact on the administrator's most desired bundle of enrollment, faculty and facilities.

This analysis is problematic, however, because it begs the question of who is the residual claimant of those profits. Moreover, since the institutions are not-for-profit, they cannot earn profits in this way. Consequently, we consider the case in which revenues exactly match costs; that is, the case in which $\lambda > 0$ and $(SA+TF)E+G+OF(E,F,L)-C(W_f,F,E,L)=0$. In this case, an increase in revenues results in an increase in one or more of the choice variables in the administrator's utility function.

Notice that SA and TF enter the model in the same way, as multipliers of the enrollment E. This model structure implies that an increase in either of these variables has the same comparative static effects on enrollment. In other words, from the university or college administrator's point of view, whether additional funding comes from the state, on a per student basis, from tuition or from increased student fees is immaterial in the decision of how to allocate that money. This is, quite simply, little more than the notion that the composition of the per enrollee receipts is unimportant to college or university administrators.[7] The total of those receipts is, however, very important. This does provide us with a hypothesis that is testable, at least in principle. Namely, the coefficients on state assistance, fees and tuition are equal in the enrollment equation.[8] They are also equal in the faculty and lab equations. They are not, of course, equal across equations. The effects on enrollment are the same for a change in any of the three SA, T or FE, the comparative static expression for which, after simplification, is given by:

$$\frac{\partial E}{\partial(SA+TF)} = \frac{E\partial E}{\partial G} + \left(\frac{\partial E}{\partial(SA+TF)}\right)_{\phi=\phi^*}. \tag{10}$$

For the university administrator, enrollments are a good to be offered for sale. The comparative statics expression confirms this as it indicates that the quantity of enrollments selected by the administrator will rise as the tuition and fees per enrollee rise. The best analogy is to interpret the relationship like a labor supply curve. The distinction between this enrollment supply curve and a labor supply curve is that the typical approach is to think of labor as providing disutility whereas here enrollment provides utility. Consequently, while the labor supply curve has an income and a price effect that work in opposite directions, the typical enrollment supply curve has an income and a price effect that work in the same direction.[9] The first term in equation (10) is analogous to the income effect. An increase in any of the per-enrollment sources of revenue enables the university to increase the

[7] This is a different point than the result of Ehrenberg, Rees and Brewer (1993). In our model funds from the state per enrollee or from tuition and fees are not ear-marked for support of students. Those funds are provided on the basis of the number of students, but may be used for any purpose.

[8] In the empirical section below this hypothesis cannot be tested because the data does not separate revenues into tuition and fees, and state appropriations per student.

[9] There is also the possibility that an increase in lump sum grants leads to reduced enrollments, faculty or labs, though not all three. That is, any of these may be an inferior good to university presidents and provosts. It seems highly unlikely that any of these is inferior and in what follows we assume that they are normal goods. However, the possibility of inferiority does suggest that increased tuition and fees has an ambiguous effect on the level of enrollments, faculty and facilities. We make this point again when discussing other comparative statics results.

number of students and the faculty and labs simultaneously. This effect is like a receipt of a lump sum grant by the campus unencumbered by restrictions on its use. The second term of the expression is the price effect of the change in tuition, fees or state appropriations per student. Intuition suggests that this price effect will be positive, indicating that university administrators will respond to higher tuition and fees per student by offering more enrollments, all other things equal. Naturally, we hypothesize that enrollments supplied rise as tuition, fees and state appropriations rise.

Notice that this comparative static result depends upon the utility function of the administrator. That is, the institutional responses to higher tuition and fees will vary by administrative regime. A difference between our model and Garvin's (1980) is, therefore, that we predict that differences in enrollment supplies, faculty and facilities, arise not simply because the institutions differ, but because administrations differ. In other words, a finding that university administrators have individual specific effects on enrollment, faculty, and facilities is support for the bureaucracy model of universities over both Garvin's (1980) unitary actor model of university behavior and the profit-maximization model.[10] Our model is rejected in favor of Garvin's if institutional effects matter but individual administrator effects do not.

Finally, though we do not report them, comparative static effects for faculty and facilities may be derived. The direction of the effects on either of these of an increase in lump sum funding or tuition, fees and state appropriations per student is ambiguous. First, note that the effect of lump sum funding may be positive or negative as faculty or facilities are normal or inferior goods to the administrator. Second, the effects of tuition, fees and state appropriations on faculty and facilities can be split into an income (or lump sum) effect and a substitution effect. We have already pointed

[10]A referee noted that significance of the administrator specific effects might arise from other factors, such as economic circumstances or programmatic changes, that coincide with the tenure of a specific president or provost. In other words, there is a spurious correlation problem. While that is true for a specific administrator, we are not convinced that such a spurious correlation could generate significance of large numbers of administrator specific effects. The provosts and presidents at the different campuses change at different times and stay in their positions for varying durations. A pattern of outside events that corresponds closely with the pattern of changes in provosts and presidents we observe, and which explains the effects we find, seems a low probability event.

out the ambiguity in the sign of the lump sum effect. The substitution effect is also ambiguous because the effect is generated from a change in the "price" of another good. That is, the substitution effect is a cross-price effect whose sign will indicate whether enrollments are complements or substitutes for faculty and facilities. We have no reason to assert one or the other relationship a priori.

The foregoing has assumed that university presidents and provosts are utility maximizers, but this is not their only possible motivation. In his analysis, Garvin (1980) discusses criticisms of the utility maximization assumption. He admits that the unitary actor model, in which the university is assumed to be an organic entity with preferences of its own, neglects the ways with which decisions are made inside the university. He also admits that the university may have multiple, and not necessarily consistent, goals which the utility maximization assumption does not allow. However, he contends that the evidence does not support profit or revenue maximization as the likely goals of the university. Nonetheless, we derive simple implications from a profit maximization model of university behavior, enabling comparisons between this and the bureaucratic model developed above.

Assuming profit maximization, the university would maximize $(SA+TF)E+G+OF(E,F,L)-C(W_f,F,E,L)$ by choosing enrollment, faculty and laboratories. We assume that W_f, faculty salaries, is determined in largely competitive markets and thus beyond the control of the institutions. The first-order conditions of the profit maximization model are:

$$(SA+TF)+OF_E-C_E = 0 \tag{11}$$

$$OF_{FE}-C_{FE} = 0 \tag{12}$$

$$OF_L-C_L = 0 \tag{13}$$

Note that the lump sum payment to the institution does not appear in any of these first-order conditions. The implication of this is that under profit maximization lump sum funding (G) has no impact on the enrollment, faculty size or laboratory facility decisions. Lump-sum revenues clearly do influence the decision-making of the university president, provost or other bureaucratic head. The intuition behind the profit-maximizing case is clear. Lump sum revenues do not depend upon the quantities of any of the decision variables. Consequently, lump sum revenues have no impact on what the profit maximizing institution chooses to do.

A second implication of equations (11), (12) and (13) is that at the solutions to these equations, the first-order-conditions for the the bureaucratic case, equations (3) - (5), would be greater than zero. Recall equation (9) in which marginal benefits to the university administrator were a combination of utility and revenue. In the profit maximization case, the only benefit from additional enrollment is the revenue the enrollment generates. The profit maximizer stops increasing enrollment at a lower level of enrollment than does the bureaucrat because the marginal costs catch up to marginal revenues before they would catch up to marginal revenues plus marginal utility. Consequently, the bureaucratic model with price-taking behavior implies more of each of enrollment, faculty and laboratories, than would profit maximization.

Finally, deriving comparative static effects of changes in the state appropriation, tuition and fees, a further implication of profit maximization is that an increase in any of the per student sources of revenues unambiguously results in increased enrollment. While this is the most likely event in the bureaucratic model, it is not a necessary result. In the bureaucracy model, the effects of the change in state appropriations, tuition, and fees are ambiguous for the choices of faculty and laboratories. In the profit maximization model the effects of tuition and fees on faculty and facilities are also of ambiguous sign. However, under the natural assumption that increases in faculty or laboratories raise the marginal net revenues from enrollments, then both faculty and laboratories will increase in response to an increase in tuition, fees and state appropriations per enrollee. Such a clean result is not possible under the bureaucracy model.

Suppose now that enrollment is a function of tuition and fees. That is, suppose that the relevant actors are price-setters rather than price-takers. We model this by letting $E = E(TF)$ with $E_{TF} < 0$. This simply indicates that demand for enrollments falls as tuition and fees rise, the usual downward sloping demand curve.

Under this formulation the first-order-condition for the choice of tuition and fees in the bureaucratic model is:

$$\phi_E E_{TF} + \lambda[E(TF) + E_{TF}[(SA + TF) + OF_E - C_E]] = 0$$

and under the profit-maximizing model is:

$$E(TF) + E_{TF}[(SA + TF) + OF_E - C_E] = 0$$

The first-order-conditions for the choices of the other variables, F and L, are the same as in the price-taking model discussed above.[11] At the optimal values of the choice variables in the profit-maximizing model, the first-order-condition for the choice of tuition and fees in the bureaucratic model would not be zero. Indeed, given the assumptions, this expression would be less than zero. In other words, the price-setting profit maximizer would raise tuition and fees beyond the level that the price-setting university president or provost would choose. Said differently, the price-setting bureaucrat selects greater enrollment than does the price-setting profit-maximizer. This is an interesting result because it suggests that bureaucratic control of colleges and universities may be beneficial, at least compared to profit-maximization by price-setting institutions.[12] The intuition of this result is also clear. An increase in tuition and fees carries with it marginal revenues, but also lower enrollments. For the bureaucratic institution the additional revenues are offset, in part, by the lower utility associated with fewer students. In the profit maximizing institution the reduction in students carries no influence independent of the revenue impact.

As before, unambiguous comparative statics results are uncommon. It is clear, however, that the lump-sum funding influences the choices of the bureaucratic organization but does not alter those of the profit maximizing institution. This is exactly what was found for the case of price-takers. In addition, it is clear that an increase in lump sum funding has an ambiguous affect on tuition and fees and, hence, on enrollments. This is also what was found for the price-taking university administrators.[13]

It is also clear that an increase in state appropriations on a per enrollee basis carries an ambiguous effect on tuition and fees and, therefore, on enrollment. Again,

[11] The statement in the text is true accounting for the obvious exception that enrollment depends upon tuition and fees.

[12] Perhaps this result explains the tendency for public institutions to be larger than their private sector counterparts, holding constant all other things.

[13] As above, the effects of the lump sum increase in funding have ambiguous effects on faculty and facilities. At least one of tuition, faculty and facilities must have a positive lump sum grant effect, and we assume that all three do.

just as in the price-taking model, there are two effects which are analogous to the well-known income and substitution effects. And these effects work opposite one another, creating the ambiguity regarding the direction of the effect. This ambiguity can be seen in the following equation.

$$\frac{\partial TF}{\partial SA} = \frac{E\partial TF}{\partial G} + \left(\frac{\partial TF}{\partial SA}\right)_{\phi=\phi^*} . \tag{14}$$

The increase in state appropriations per enrollee carries both a substitution effect and an income effect. All else constant, higher state appropriations raise the revenues of the institution at the given level of enrollment and tuition and fees. This is the first term in the equation, the income effect of the increase in state assistance per enrollee. The greater income enables the campus to lower its tuition and fees to purchase higher enrollments. At the same time, the higher state allocation per student allows the campus to push its tuition rates higher, knowing that the effects on financial resources resulting from the loss in enrollments will be mitigated by the higher state appropriations per student. This is the substitution effect. The result of these countervailing influences is that whether an increase in state appropriations per enrollee induces higher or lower tuition and fees is ambiguous, and so too is the effect of higher state appropriations on enrollments. Recall that in the price-taking case, an increase in state assistance per student had an unambiguously positive effect on enrollments as long as enrollments were normal goods.

This section developed two alternative types of models of university behavior: bureaucratic models and profit maximizing models. The bureaucratic models assume utility maximizing behavior of an agent or group of agents; while Garvin (1980) characterized universities as a unitary actor with a well-defined utility function representing the preferences of many individuals, we explicitly model the utility function of an individual decision maker. Profit maximizing models require no such consideration of who makes the decisions; under profit maximization individual decision makers can be treated as homogeneous.

The predictions emerging from these two types of models differ in several ways. In the empirical analysis described in the following section, we focus on two key differences between bureaucratic and profit maximizing models. First, lump sum grants affect the behavior of universities in bureaucratic models but not in profit maximizing models. Thus a statistically significant impact of lump sum grants on enrollment supply or faculty demand can be interpreted as evidence in favor of the bureaucratic model of university behavior. Second, individual presidents or provosts should have no statistically evident impact on enrollment supply or faculty demand under the profit maximizing model *and* the bureaucratic unitary actor model. Any evidence that individual presidents or provosts have statistically significant impacts on enrollment supply or faculty demand can be interpreted as evidence in favor of the bureaucratic model with individual utility functions.

We also examined the effects of two different market structures on the outcomes of both types of models. In particular, we contrasted price-taking and price-setting behavior. This distinction also provides a way to contrast bureaucratic and profit maximizing models of university behavior. Under price-setting, bureaucratic models imply a greater supply of enrollment than profit maximizing models. However, the differences between price-setting and price-taking behaviour do not have implications for the empirical work that follows.

3 Empirical Analysis

The model developed in the previous section is not an identified econometric model. We cannot directly estimate the entire structural model as specified and the assumptions about specific functional forms necessary to specify such a model would likely lead to mis-specification bias in the empirical estimation. As an alternative, we estimate the supply and demand functions implied by the model. Although we cannot explicitly test the restrictions on the structural parameters implied by the model using this framework, we can specify and estimate complete demand and supply functions for inputs and outputs, including the relevant input and output prices.[14]

A university can be thought of as an organization that uses multiple inputs like classrooms, computers, textbooks, and a wide variety of other factors to produce multiple outputs like scholarly research, educated students, etc. The first-order conditions from the model developed above could be manipulated to show an inter-related set of

[14] Freeman (1975) formulated and estimated a similar model, although the focus of that analysis was the faculty labor market.

demand functions for inputs and supply functions for outputs. The supply functions take the general form

$$Y_{it} = f(\Phi_{it}, W_{it}, \Gamma_{s,it}) \tag{15}$$

where Y_{it} is a vector of outputs for institution i in period t, Φ_{it} is a vector of prices for the outputs produced by institution i in period t, W_{it} is a vector of input prices for institution i in period t and $\Gamma_{s,it}$ is a vector of other factors that shift supply at institution i in period t. The demand functions take the general form

$$X_{it} = g(W_{it}, \Phi_{it}, \Gamma_{d,it}) \tag{16}$$

where X_{it} is a vector of inputs for institution i in period t, Φ_{it}, W_{it} are vectors of output and input prices defined above and $\Gamma_{d,it}$ is a vector of other factors that shift demand at institution i in period t.

Our empirical analysis focuses on an enrollment supply function which shows how the enrollment decisions made by a utility-maximizing college or university administrator are affected by the price of each student who enrolls at an institution - the financial benefit from each additional student - as well as how the quantity supplied will be affected by other input prices and state government appropriations, and a faculty demand function which shows how decisions about the number of faculty at an institution are affected by these factors. The empirical enrollment supply function is

$$E_{it} = \beta_{i,s} + \alpha_{1,s}TF_{it} + \alpha_{2,s}G_{it} + \gamma_{1,s}W_{op,it} + \gamma_{2,s}W_{ser,it} + \gamma_{3,s}W_{fac,it} + \eta_{s,it} \tag{17}$$

and the empirical faculty demand function is

$$F_{it} = \beta_{i,d} + \alpha_{1,d}TF_{it} + \alpha_{2,d}G_{it} + \gamma_{1,d}W_{op,it} + \gamma_{2,d}W_{ser,it} + \gamma_{3,d}W_{fac,it} + \eta_{d,it}. \tag{18}$$

The interpretation of each function is straightforward. [15] Enrollment supply E_{it}

[15] Although the demand for labs and libraries was discussed in the context of the behavioral model developed in section 2 above, we chose to omit this input from the empirical analysis. This decision was made primarily because of the poor quality of the physical plant data in the IPEDS data; only book value data are available for buildings, labs, and other real property.

is expressed as a function of its own price, TF_{it}, input prices, and the government subsidy to each institution, G_{it}. Faculty demand F_{it} is expressed as a function of its own price, $W_{fac,it}$, other input prices, the price of output, and the government subsidy to each institution. G_{it} works through an income-type effect, so increased government appropriation to an institution should increase the supply of enrollment and demand for faculty at that institution other things equal. The behavioral model predicts that higher input prices should reduce the supply of enrollments, other things equal.

Table 1: Variable Descriptions

Variable	Description
E	Total Fall Headcount Enrollment
FTE	Total Fall Full-time-equivalent Enrollment
F	Total Number of Faculty
TF	Price of Enrollment (from Tuition and Fees)
G	Lump-Sum State Appropriation
W_{op}	Cost of Operating and Maintaining Academic Buildings/Equipment
W_{ser}	Cost of Operating Dorms, Dining Halls, other Student Services
W_{fac}	Average Faculty Salary
$HSGRAD$	Number of High School Graduates in Maryland
$RATFCC$	Average Tuition and Fees at MD Community Colleges

The variables in these equations are described on Table 1. Detailed information about the sources and construction of these variables can be found in the data appendix. Careful readers will note that the behavioral model contains a term for government appropriation per enrollee (SA) and a term for lump-sum government appropriation (G) while the empirical specifications do not. We chose to include only G in the empirical model because Maryland does not make appropriations to higher education based on strict enrollment-funding formulas.

Table 2 shows the means of the key variables that appear in the system of equations, enrollment, tuition and fees, state government appropriation in 1,000's of dollars, and average faculty salary in real 1996 dollars for each of the eleven institutions in the sample from 1988 to 1996. Considerable variation exists across the institutions in the sample. The University of Maryland College Park (UMCP) is a comprehensive public land-grant university and has the largest student body, faculty, and state appropriation by far. Average faculty salaries are highest at the University of Baltimore because this relatively small institution has both a law school and a business school as well as no freshman or sophomore students.

Table 2: Summary Statistics

School	E	FTE	TF	G	W_{fac}	F
University of Baltimore	5431	3391	2908	19876	64596	168
Bowie State	4668	3139	2198	16526	45246	130
Coppin State	3049	2293	1998	14457	47341	107
Frostburg State	5253	4515	2650	21010	46644	238
UMBC	10285	7999	3217	48647	53763	360
UMCP	33629	27912	4245	253070	64350	1352
UMES	2541	2288	3215	16829	43556	115
Morgan State	5365	4703	2943	35474	50490	226
Salsbury State	5881	4866	2671	20953	45280	241
St. Mary's College	1578	1413	4114	11581	46780	97
Towson	14952	11625	2739	50830	50020	480

We control for the effects of unobservable institution-specific factors on the supply and demand function by allowing the constant terms in each equation ($\beta_{i,s}$ and $\beta_{i,d}$) to vary. Three types of institution-specific effects are considered. The first is simply a separate intercept for each institution. These institution-specific effects proxy for unobserved factors related to differences in the missions of each institution, location, general composition of the student body, academic reputation, and other factors that are unique to each campus but do not change over the sample period. Statistical significance of these institution-specific effects is evidence against the competitive markets model of university behavior.

The behavioral model developed above implies that utility-maximizing administrators effect enrollment supply, faculty demand, and the other outputs and inputs of the institution. In this case, differences in the preferences of the decision makers will affect their decisions, which will have an impact on the inputs and outputs. To account for these effects we constructed a series of dummy variables capturing the tenure of different presidents on each campus. This "presidential effects" specification is nested in the institution-specific effects specification mentioned above under the assumption that each president on a given campus had the same effect on enrollment supply and faculty demand, or alternatively under the assumption that presidents have identical preferences. In all there were 19 separate presidential dummy variables. Six institutions had the same president in every year of the sample. In these cases, it is impossible to distinguish presidential effects from institution specific effects.

As an alternative to the presidential effects specification, we also explored the idea that provosts have more influence on enrollment supply and faculty demand than presidents. It may be possible that university presidents are primarily concerned with lobbying state legislators and higher education regulators, and with off-campus fundraising efforts, and are less involved than provosts in short-term decision making on campus. If this is the case, then the tenure of provosts, the chief academic officers, may do a better job of explaining variation in enrollment supply and faculty demand. We also constructed a series of dummy variables capturing the tenure of different provosts on each campus. There were 30 different provosts during our sample, and only two campuses had the same provost in each year. The "provost effects" specification is also nested in the institution-specific effects specification under the assumption that all of the provost effects on each campus are equal over time.

The key implication of our model is that either the president or the provost specific effects will be statistically significant in tests against either the institution-specific effects or the common intercept models. Recall that a lack of significant institutional or administrator effects reflects perfectly competitive markets; significant institution-specific effects reflect oligopolistic or monopolistically competitive markets in which institutions compete on brand name; significant administrator-specific effects reflect a bureaucratic model where administrator's preferences affect enrollments and faculty demand at institutions.

Finally, we confront a simultaneity problem in estimating the system of equations (17) and (18) because the enrollment price variable is an *ex post* average price and depends on enrollment. Consequently, OLS estimates of the response of enrollment supply and faculty demand to changes in TF will be biased. To correct for this problem, we use three-stage least squares to estimate the system of equations [see Greene (1997) for complete details]. The instruments used in the first stage regressions are the W's and G along with two variables that reflect shifts in the demand for enrollment in higher education, the number of high school graduates in the state of Maryland in year t ($HSGRAD_t$) and the average tuition and fees at community colleges in Maryland in year t ($RATFCC_t$), and a time trend.[16] We assume that institutions are price takers in labor markets, implying that the faculty salary variable should be treated as exogenous.

4 Empirical Results

Table 3 shows the results of estimating equations (17) and (18) using three-stage least squares. The top panel uses total headcount enrollment E as the dependent variable in the supply equation and the bottom panel uses total FTE enrollment as the dependent variable in the supply equation. It is clear from the table that the results do not differ between headcount and FTE enrollment. The first two columns show the results for the institution-specific effects specification, the second two columns show the results for the provost-specific effects specification, and the final two columns show the results from the president-specific effects specification. The estimates of the various intercepts are discussed separately below.[17]

The estimated parameters on the price variable are positive and significant across all specifications, implying that the higher the real tuition and fees per student, the larger the enrollment and the larger the faculty, other things equal. The price elasticity of supply at the mean values of E and TF implied by the point estimates on the top panel are 1.94 for the provost effects specification and 0.97 for the president effects specification on average across all institutions. For individual institutions, the largest price elasticities of supply are for the three largest institutions (UMBC, UMCP

[16]Some readers have suggested that factors like the average tuition at public universities in nearby states belong in the empirical model. If they are included, it clearly would be as an instrument, as these variables shift demand for public education in Maryland. We included a weighted average of the out of state tuition at large public universities in states near Maryland as an instrument. The states were New Jersey, Delaware, Pennsylvania, Virginia and West Virginia and the weights were based on total out of state undergraduate enrollment at the public universities. The inclusion of this instrument did not change the empirical results. These results are available on request.

[17]We do not report the results from the "no fixed effects" specification; these results are available on request.

and Towson) across all three specifications; the smallest price elasticity of supply is for St. Mary's College, which ranges between 0.13 and 0.27. The interaction of location and capacity probably explains much of this difference. St. Mary's College is located in a rural part of the state and probably cannot attract many more students than it can house. The three large institutions are all located in the suburbs of large cities and probably have a greater ability to attract nonresident students.

The estimated parameters on the two input prices related to the operation of academic buildings (W_{op}) and dorms, dining halls and student services (W_{ser}) are negative and significant in the enrollment supply functions and statistically insignificant in the faculty demand functions across all specifications. These results are quite plausible. It seems reasonable that enrollment decisions are more sensitive than demand for faculty to operating costs.

The estimated parameters on the faculty salary variables are negative and significant in the faculty demand functions and statistically insignificant in the enrollment supply functions. The implied wage elasticity of demand for faculty is small for all three specifications. Calculated at the mean values of W_{fac} and F the (absolute) values of the elasticity are 0.30, 0.31, and 0.33, respectively.[18] Finally, our finding that faculty salaries have no effect on enrollment supply has intuitive appeal.

The estimated parameter on the state government appropriation variable is statistically significant in ten of the twelve specifications, and correctly signed in all twelve cases. According to the model described above, government appropriation works through an income-effect type mechanism, and the point estimates from this variable generally support this effect in both the enrollment supply and faculty demand functions. Moreover, the theory suggests that this lump sum appropriation variable will only be significant in the unitary-actor or bureaucratic models of university behavior. It should not be significant if the setting is one of a competitive or profit maximizing institution. Hence, significance of this variable is evidence in favor of the Garvin (1980) or bureaucracy models.[19]

[18]These elasticities are close to the wage elasticity for college and university faculty (0.26) reported by Freeman (1975), using aggregate time series data from 1920-1970.

[19]The provost-specific effects for UMCP were set equal to each other in the enrollment supply function. College Park had six provosts during the nine year sample period, but these individual effects were not jointly significant. Inclusion of the UMCP provost variables caused the parameter

4.1 Fixed Effects Specifications

As was mentioned above, we are interested in empirically testing the hypothesis that the preferences of specific administrators have an observable effect on the inputs and outputs of an institution of higher education. In order to capture these effects, we created sets of dummy variables that reflect the tenure of different presidents and provosts on each campus, and included these dummy variables in (17) and (18). Tables 4 and 5 contain the estimated president and provost effects for the FTE enrollment specification. The vast majority of these effects are statistically significant. In some cases, changes in administrators have a large effect on enrollment. For example, the difference between provosts at Coppin State College was over 400 FTE students.

F-tests on the joint significance of the three fixed effects specifications (institution-specific, president-specific, and provost-specific effects) provide a convenient method for distinguishing among the different fixed effects specifications. In this case, the three fixed effects specifications are nested, providing an interesting test of the differences among them. The F-statistics, P-values, and degrees of freedom for these tests are shown on the top panel of Table 6 for headcount enrollment and on the third panel of Table 6 for FTE enrollment.

The null hypothesis for the first set of F-tests, shown on panels one and three of Table 6, is that there are no statistically significant fixed effects; the institution-specific effects are all equal, the president-specific effects are all equal, and the provost-specific effects are all equal for each specification. In each case, the F-tests reject this null in favor of the alternative hypothesis, that the institution-, provost-, or president-specific effects are not all equal. Rejection of this null hypothesis can be interpreted as evidence that the market for public higher education in Maryland does not resemble a perfectly competitive market. The alternatives include either monopolistic competition or a market composed of institutions where the preferences of administrators affect enrollments and faculty demand.

The second set of F-tests compares the provost- and president-specific effects to the institution-specific effects specification. The results of these tests are shown on the

on G in the enrollment supply function to become negative and significant but had no effect on the other parameter estimates.

second and fourth panels on Table 6 for headcount and FTE enrollment, respectively. Institution-specific effects are rejected in favor of provost-specific effects for both the enrollment supply and faculty demand functions, but the institution-specific effects are rejected in favor of the president-specific effects only for the enrollment supply function when headcount enrollment is used as the dependent variable. When FTE enrollment is used as the dependent variable, institution-specific effects are rejected in favor of provost-specific effects but there is no difference between the institution-specific effects and the president-specific effects. The preferences of provosts are clearly distinguishable from the preferences of presidents when FTE enrollments are the dependent variable.

Presidential effects are indistinguishable from institutional effects in the faculty demand equation. One interpretation of this result is that although presidents and provosts both play a role in making decisions relating to enrollment, provosts play a larger role than do presidents in decisions regarding the number of faculty employed by the institution. These results are also supportive of the hypothesis that the preferences of college or university administrators affect the inputs and outputs of these institutions.[20] In the case of enrollment supply, both sets of F-tests support the bureaucratic model over the monopolistically competitive market hypothesis.

5 Summary and Conclusions

The supply of enrollments in higher education has received little attention relative to the demand side of this market, even though the provision of higher education is an important function of government. We set out to explore the influence that administrators have on the supply of enrollments and demand for inputs to the education process. In the context of a Niskanen-style model of bureaucratic behavior,

[20] Some might argue that we have the causality reversed in the case of provosts, in that undesirable changes in enrollments cause provosts to be replaced. Although this hypothesis is at odds with our personal experiences in higher education, if correct it implies that changes in enrollment should be a good predictor of changes in provosts. To test this hypothesis, we regressed a variable that took a value of one in years when there was a new provost on a campus on lags of the change in enrollment. The coefficients on one and two year lags of changes in enrollment were not statistically significant in this regression.

college or university administrators can be thought of as utility maximizing agents who choose the level of inputs and outputs of an institution, subject to constraint, based on individual preferences. We develop a behavioral model which shows that the preferences of individual administrators will affect the inputs and outputs of the institution.

We assembled a panel of data on public colleges and universities in Maryland from 1988 to 1996 and tested the implications of the behavioral model using this data. The simultaneous estimation of a system of two equations, a supply function for enrollment and a demand function for faculty, revealed evidence that individual presidents and provosts had a significant effect on the supply of enrollments and demand for faculty; these president- and provost-specific effects were statistically distinct from unobservable institution-specific effects. In the context of our model, these results suggest that the market for public higher education in Maryland more closely resembles a collection of institutions whose enrollment supply and faculty demand are affected by the preferences of individual administrators than a perfectly or monopolistically competitive market.

These results also suggest that presidents and provosts play distinctly different roles in determining the supply of enrollments and demand for faculty in colleges and universities in Maryland. While both presidents and provosts had an important effect on the supply of enrollments, only provosts were found to have an important effect on faculty demand. This difference is consistent with the widely-held perception that college and university presidents are primarily concerned with off-campus activities like fundraising, public relations, and lobbying while provosts are primarily involved with on-campus decision making.

Our research suggests several interesting and important future lines of research. If individual administrators affect the supply of enrollments in higher education, and the preferences of these administrators are different from those of the government, then an important principle-agent problem may exist. A better understanding of the nature and extent of this problem would increase our understanding of the effectiveness of educational policy. In particular, society's goal of wide access to quality higher education may not be compatible with administrator's goals of running a prestigious institution. Also, given the size of public subsidies to higher education, and the importance of human capital accumulation to long-run growth, any factor that affects access to higher education warrants additional attention. For example, additional analysis of educational outcomes as they relate to administrator's preferences would help to assess the overall impact of public higher education.

A Data Description

Our empirical analysis focuses on public four-year colleges and universities in Maryland. The eleven public institutions of higher education used in this study are shown on Table 1. In 1988 the Maryland legislature formed the University of Maryland System, which was renamed the University System of Maryland in 1997. The UMS is a collection of public institutions of higher education charged by the Maryland legislature with the goals of fostering the development of a consolidated university system, improving the quality of higher education, extending the benefits of higher education to all Marylanders and encouraging the economical use of the State's resources. Oversight of higher education in the state of Maryland is performed by the Maryland Board of Regents and the Maryland Higher Education Commission. UMS can be viewed as a consortium of public institutions of higher education pursuing a common set of goals and increasing mutual benefits. The UMS collectively represents the member institutions before the Maryland legislature; individual institutions cannot directly lobby the state legislature for funding. In practice, this restriction on direct lobbying is not well-enforced, as UMCP was able to obtain direct funding from the state legislature in fiscal year 1997.

The member institutions in the UMS represent a diverse collection of institutions of higher education. Among the eleven institutions in the sample are four historically black institutions (Coppin State, Bowie State, the University of Maryland Eastern Shore and Morgan State University), an institution that enrolls only juniors, seniors and graduate students, the University of Baltimore, and a comprehensive land-grant university, UM College Park. With the exception of Frostburg State University, these institutions are located in a relatively small geographic region with a high population density.

Nine UMS member institutions are included in this data; the excluded UMS institutions include the University of Maryland Biotechnology Institute, and the University of Maryland Center for Environmental Science, which are primarily research institutes, the University of Maryland at Baltimore, a free-standing graduate and professional school consisting of a medical school, a dental school and a law school, and the University of Maryland University College, an institution with nearly 10,000 part-time students and about 20 full-time faculty that focuses primarily on continuing education both in Maryland and overseas and distance education. At the time the UMS was founded, two other public institutions of higher education, Morgan State University and St. Mary's College of Maryland, declined to join the UMS. These two institutions still receive state support, although they are governed by separate boards of regents and lobby the state legislature for funding separately. Because they are public institutions of higher education in Maryland we have included these two schools in our sample.

The data used in this paper were taken from the Integrated Postsecondary Education Data System (IPEDS) which is collected and published by the U.S. Department of Education; before 1986, this survey was called the Higher Education General Information Survey (HEGIS). The data used in this paper were taken from two of the six surveys that make up IPEDS: the Fall Enrollment Survey and the Finances Survey. Each of these surveys is conducted annually; all postsecondary institutions in the United States and outlying areas that are eligible for Title IV federal financial aid programs are surveyed. Enrollment and Finance data are available for academic year 1988-1989 through 1996-1997.

Fall enrollment is the most commonly used measure of access to higher education. The IPEDS fall enrollment data is based on reported enrollment for the first week of October in the fall semester or quarter. There are many possible measures of enrollment. In this paper, we use both total (or headcount) enrollment and FTE enrollment as measures of the number of students attending an institution of higher education. Using a broad measure of enrollment has several advantages over narrower measures like full-time undergraduate enrollment. Universities have different missions, and administrators have different goals. Full-time undergraduate enrollment would not reflect the impact of an administrator attempting to increase graduate enrollment or the impact of an administrator attempting to increase undergraduate offerings to working adults who enroll in one or two courses per semester. Broad measures of enrollment, like total headcount, should reflect a wide variety of changes in enrollment policies.

However, institutions with many part-time students will have large headcount enrollments and very different needs in terms of capital, faculty and other infrastructure than institutions with large numbers of 18-24 year old full-time students. In order to control for these differences, we estimate the empirical model using FTE enrollment as the dependent variable.

A considerable amount of institution-specific budget data are available in the IPEDS Finances Survey. We used data from the Finances Survey to construct the output price measure as well as measures of the costs of student services like dorms, dining halls, and intercollegiate athletics, the cost of operation and maintenance of buildings and equipment, and the state government appropriation variables which were used in this analysis. TF_{it}, our measure of the price of enrollments, is defined as total revenues from tuition and fees divided by total enrollment. Public universities price discriminate in many different ways. In-state students, out-of-state students, full-time students, part-time students, undergraduates, and graduate students are all charged different tuition. Differing need-based and merit-based financial aid packages further differentiate charges to students. Because of this, we chose to use an *ex post* measure of the price of enrollments. This variable will reflect the effect of differences in the composition of the student body on revenues earned by the university.

G_{it} is revenue from state government appropriations. W_{op} is expenditure on maintenance and operation of plant and equipment relative to the book value of buildings and equipment. W_{sup} is expenditure on auxiliary enterprises, which are defined as operations that furnish some service to students, faculty, and staff. Examples of auxiliary enterprises are residence halls, food services, student health services, intercollegiate athletics and student unions.

W_{fac} measures the average faculty salary. This variable was constructed by dividing the total salary outlay for all contract categories on each campus by the total number of faculty employed in each contract category.

Maryland also has an extensive public community college system, consisting of fourteen campuses. Because a community college education may be a substitute for education at a four-year public college or university, we have included a measure of the average tuition and fees at twelve of the fourteen community colleges in Maryland. Data from the other two community colleges were not available for the entire sample period, and they were excluded. The average tuition and fees for community colleges variable was constructed from a weighted average of the revenues from tuition and fees per student enrolled at each of the twelve community colleges in the sample. The weights were the fraction of total community college enrollment at each campus.

All variables expressed in dollars were deflated using the Higher Education Price Index (HEPI) published annually in the *Handbook of Educational Statistics.* Deflating with the Consumer Price Index had little effect on the empirical results.

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Table 3: Empirical Results - Estimation of Equations (17) and (18)

	Headcount Enrollment					
Fixed Effect:	Institution		Provost		President	
Variable	E Supply	F Demand	E Supply	F Demand	E Supply	F Demand
TF	0.548*	0.018*	0.529*	0.018*	0.345*	0.015*
	(0.139)	(0.007)	(0.169)	(0.008)	(0.137)	(0.007)
G	0.019*	0.0009*	0.018*	0.0004	0.018*	0.0009*
	(0.006)	(0.0003)	(0.004)	(0.0005)	(0.005)	(0.0003)
W_{op}	-0.480	0.001	-0.859*	0.004	-0.559**	-0.0009
	(0.366)	(0.018)	(0.324)	(0.014)	(0.341)	(0.0193)
W_{ser}	-0.058*	0.0004	-0.065*	-0.0007	-0.056*	0.0004
	(0.017)	(0.0009)	(0.014)	(0.0007)	(0.015)	(0.0009)
W_{fac}	-0.001	-0.0020*	-0.004	-0.0019*	-0.005	-0.0021*
	(0.009)	(0.0005)	(0.010)	(0.0005)	(0.009)	(0.0005)
	FTE Enrollment					
TF	0.474*	0.015*	0.586*	0.017*	0.390*	0.013*
	(0.094)	(0.006)	(0.128)	(0.007)	(0.100)	(0.007)
G	0.020*	0.0009*	0.020*	0.0006	0.019*	0.0009*
	(0.005)	(0.0003)	(0.004)	(0.0005)	(0.004)	(0.0003)
W_{op}	-0.627*	0.001	-0.872*	0.0006	-0.613*	-0.003
	(0.301)	(0.019)	(0.277)	(0.0141)	(0.294)	(0.020)
W_{ser}	-0.046*	0.0004	-0.056*	-0.0007	-0.045*	0.0004
	(0.014)	(0.0009)	(0.012)	(0.0006)	(0.013)	(0.0009)
W_{fac}	-0.009	-0.0019*	-0.009	-0.0019*	-0.011	-0.0021*
	(0.008)	(0.0005)	(0.009)	(0.0005)	(0.008)	(0.0005)

Standard Errors in parentheses.

**: Significant at 5% level.*

***: Significant at 10% level.*

Table 4: Provost Specific Estimates

	Enrollment Supply		Faculty Demand	
Institution	Parameter	P-Value	Parameter	P-Value
UMBC1	6971.3	.000	452.3	.000
UMBC2	6754.8	.000	455.4	.000
UMBC3	6825.3	.000	454.2	.000
BSU1	2410.7	.000	158.0	.000
BSU2	3121.0	.000	198.4	.000
BSU3	2929.3	.000	179.4	.000
BSU4	2630.4	.003	203.0	.000
TU1	11499.1	.000	582.3	.000
TU2	11861.3	.000	551.6	.000
TU3	10951.3	.000	524.0	.000
TU4	11819.8	.000	513.9	.000
FSU1	4014.8	.000	302.3	.000
FSU2	4101.8	.000	286.1	.000
FSU3	4080.7	.000	286.6	.000
CSC1	1973.6	.006	173.9	.000
CSC2	2401.7	.000	149.5	.000
CSC3	2706.4	.000	148.9	.000
UB1	2029.0	.016	245.0	.000
UB2	885.9	.369	223.9	.000
SSU	4376.1	.000	290.9	.000
UMES1	1050.0	.159	183.8	.000
UMES2	1389.9	.085	188.7	.000
MSU	3489.0	.000	282.3	.000
SMC	505.6	.473	145.3	.000

Table 5: President Specific Estimates

	Enrollment Supply		Faculty Demand	
Institution	Parameter	P-Value	Parameter	P-Value
UMCP	27000.0	.000	1234.9	.000
UMBC1	7600.5	.000	450.5	.000
UMBC2	7705.6	.000	458.4	.000
BSU1	2939.6	.000	189.6	.000
BSU2	3562.0	.000	216.2	.000
BSU3	3381.0	.000	210.5	.000
TU	11845.0	.000	525.5	.000
FSU1	4389.9	.000	312.8	.000
FSU2	4499.3	.000	311.7	.000
FSU3	4588.5	.000	298.1	.000
CSC	2541.6	.000	183.4	.000
UB	2474.9	.002	266.5	.000
SSU1	4851.6	.000	291.0	.000
SSU2	4905.7	.000	297.4	.000
SSU3	4929.1	.000	301.5	.000
UMES1	1799.9	.007	203.5	.000
UMES2	2219.6	.003	205.6	.000
MSU	4154.2	.000	290.9	.000
SMC	617.4	.353	157.9	.000

Table 6: F-tests on Fixed Effects Specifications

H_a:	Institution-specific		Provost-specific		President-specific	
	E Supply	F Demand	E Supply	F Demand	E Supply	F Demand
	Dependent Variable: Headcount Enrollment					
H_o: None	75.3	15.7	68.3	13.5	49.5	8.5
P-value	0.00	0.00	0.00	0.00	0.00	0.00
Degrees of Freedom	11,72	11,72	30,53	30,53	19,64	19,64
H_o: Institution	-	-	2.10	4.32	2.03	0.30
P-value	-	-	0.05	0.00	0.02	0.99
Degrees of Freedom	-	-	8,53	8,53	19,64	19,64
	Dependent Variable: FTE Enrollment					
H_o: None	65.72	18.13	40.62	20.53	44.36	11.42
P-value	0.00	0.00	0.00	0.00	0.00	0.00
Degrees of Freedom	11,72	11,72	30,53	30,53	19,64	19,64
H_o: Institution	-	-	7.77	15.55	0.95	0.55
P-value	-	-	0.00	0.00	0.52	0.92
Degrees of Freedom	-	-	8,53	8,53	19,64	19,64

Table 7: Maryland Institutions of Higher Education in Sample

UNITID	Name		Affiliation
161873	University of Baltimore	UB	UM System
162007	Bowie State	BSU	UM System
162283	Coppin State	CSC	UM System
162584	Frostburg State	FSU	UM System
163268	UM Baltimore County	UMBC	UM System
163286	UM College Park	UMCP	UM System
163338	UM Eastern Shore	UMES	UM System
163453	Morgan State	MSU	Public Independent
163851	Salsbury State	SSU	UM System
163912	St. Mary's College	SMC	Public Independent
164076	Towson University	TU	UM System