A Report on Incremental Costs and Benefits Associated with Increasing Enrollment at UMBC

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Preface

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The following pages contain an economic cost/benefit analysis of enrollment growth presented by one of UMBC's economics faculty, Professor Brad Humphreys. The report was prepared for the UMBC Planning Leadership Team (PLT) to provide an economist's perspective on the implications of enrollment growth at UMBC. It is one of two reports commissioned as part of the campus' long-term planning process. The other report, which was prepared by Professor and Vice Provost Marilyn Demorest, examines historical patterns in the hiring of UMBC faculty. This cost/benefit report, as Professor Demorest's report, is technical in nature. To assist the PLT and other readers, a brief summary and discussion of Professor Humphreys' report is presented below.

Over the course of the past few years, UMBC faculty have asked for more information about the actual costs associated with increased student enrollments. For several years, UMBC has admitted more students each fall semester than in each previous year. While the additional numbers of students have enriched the campus in many ways, faculty, and in, particular, members of the campus' Academic Planning and Budget (APB) Committee, have asked for greater detail about the financial implications to the university of this incremental but sustained growth.

There are a number of approaches to providing this information, but it appeared that the best way was to ask an economist who was skilled in cost/benefit analysis to examine the data. We are fortunate at UMBC that Professor Brad Humphreys, who was already familiar with the literature on higher education finance and who also is skilled in cost/benefit analysis, was willing to conduct the study. The project was conducted as a traditional research study with a negotiated budget and design, a technical advisory board, a report deadline, and freedom to pursue this inquiry. The following report is the result of Professor Humphreys' systematic efforts.

Professor Humphreys' technical cost/benefit analysis examined a time period that experienced both growth in enrollments and state support to the university. This allowed the study to examine the implications of enrollment growth and campus expenditures under optimum circumstances. The results can also be used to project the implications of enrollment growth under less favorable financial circumstances. The fiscal years compared for this report were FY01 and FY02. While the results may vary from year to year, Professor Humphreys has provided a structure and a method from which the campus can undertake additional analyses either by examining other historical data or by making projections based on his findings for FY01 and FY02.

The full report will take time to read and digest. It is filled with information that can, at times, become quite detailed. Yet, detailed as it may be, from the perspective of an economist studying a complex organization such as a university, it only scratches the surface. There is much more that can be discussed. With this view in mind and recognizing the multiple readers of the report, here is a brief summary of some of Dr. Humphreys' findings.

The findings for the cost/benefit analysis at both the undergraduate level and graduate level revealed that when scholarships and overall infrastructure costs were considered, tuition and fees paid in FY02 coupled with the growth in the state budget allocation, covered the average incremental cost for each new undergraduate student; and, new out-of-state undergraduate students were advantageous financially to UMBC. Nevertheless, in FY 01 and FY 02, UMBC undertook a variety of strategies to cover additional classes needed by new students. Those financial strategies proved to be prudent in that the financial costs did not exceed benefits. As Professor Humphreys notes, "over this period, adding students made UMBC better off financially." (p. 40).

While additional students generated new revenue, that revenue was allocated in a variety of ways to balance overall university needs. In essence, consideration of only the costs associated with instruction did not reflect the entire marginal costs associated with admitting an additional new student. Like overhead on a grant, beyond a certain threshold there are student services and administrative overhead costs associated with enrollment growth.

One approach to estimating the costs for each new student is to assign to each an average cost. While this approach is useful in explaining associated costs, it does not reflect the reality of budgeting. Non-instructional costs associated with new students are not linear expenditures that increase with each student; they are allocated based on a justified need and assigned as required. In most cases, there is a time lag between need and an actual staff hire. Therefore, where capacity exists, it is possible to enroll a new student without incurring additional staff costs but, at some point, the elasticity of the staff support will reach its maximum and a new staff person will need to be hired in order to maintain quality of services.

This case load concept and its associated cost is an important consideration when discussing the actual costs associated with growth because much of the attention is focused on covering the immediate instructional demands necessitated by the additional students. This is particularly true for new undergraduates or new transfer students. Humphreys argues that in a variety of areas, UMBC has pushed the capacity envelope and needs to factor in the costs associated with expanding infrastructure and student support systems when considering the real costs associated with growth. While his study focused on a year of expanding state resources during which student enrollments and overall revenues increased to cover additional costs, Humphreys also charts what would happen if state funding remained level or declined.

Depending on the degree type and residency status, the projected benefit of adding new students at UMBC may be reduced as the university's ability to absorb more students on existing resources declines. The benefit is further reduced when and if the state per-student allocation declines. If the state were not to provide additional funding for each new student, adding a student whose tuition does not cover the full costs of education, in effect, dilutes the resources available to the existing student body - something akin to going up the down escalator. Adding new students who are not covering their full cost - even with substantially increased tuition in a system that has little excess capacity - will cause additional strain on existing personnel and resources. Adding new students in a strained system without substantial state support or much higher tuition over several years eventually results in a financial loss to the campus. Growing numbers of students may bring additional dollars, but rather than building revenues for maintaining quality, quality in the form of student support services and the ratio of faculty to students is gradually eroded.

The same, but only more so, can be said about doctoral students. They are expensive. However, as Humphreys discusses in detail, they bring other benefits such as national stature, institutional differentiation, and faculty rewards. Masters students, on the other hand, represent a double-edged sword. Masters students on assistantships provide few of the external benefits associated with doctoral students at nearly the same costs. Alternatively, tuition-paying masters students in non-thesis professional programs or non-degree certificate programs, can be a benefit to the campus in a way not ordinarily considered for undergraduates. For example, tuition-paying masters students who are in professional masters programs may be taught best by a balance of practitioners and faculty. Practitioners, who often are subject matter experts in the profession, can be hired on a part-time, course-by-course, basis. While part-time instructors may be viewed by many as detrimental to the advising operation in the undergraduate education setting, these professionals may actually serve as enhancements to quality graduate programs and to the master's learning experience.

Humphreys states, "new masters students lead to relatively larger increases in estimated net revenues." (p. 45) Other institutions have acted on this fact. According to the National Center of Educational Statistics, the number of graduates from masters programs rose by 42% between 1990 and 2000, totaling over 450,000 degrees granted per year, or 4 out 5 post-baccalaureate degrees granted in the United States

(*CGS Communicator*, Jan/Feb, 2003, p.5). In 2000, the fields of education and business dominated Masters education programs reflecting more than 50% of all the masters degrees granted that year. Indeed, nationally, applied masters programs reflect a growth area for graduate education and one that is examined in greater detail in the report.

The data presented by Humphreys in the final chapter indicates that if the university seeks to maintain its quality undergraduate program as defined by adequate support personnel and full-time faculty to nurture the undergraduate student, growth should be approached cautiously if that growth is not associated with significant tuition increases and/or at least a maintenance of effort in per-student funding in state support. The financial underpinnings of the positive cost/benefit of adding students to UMBC is highly sensitive to increased administrative costs and/or declining per-student state allocations.

The bottom line is that UMBC can grow and maintain quality if it receives the full costs associated with each new undergraduate student enrolled. Tuition-paying, in-state students, pay only part of the actual cost of their education. Although not discussed by Humphreys, but gaining national attention, is the proposal put forward by the University of Miami of Ohio in which all undergraduate students, whether in-state or out-of-state, would be charged the full cost of their education, with in-state students receiving a discount based on the FTE value of the state support. This proposal more clearly identifies a financial strategy that serves the academic program and highlights the funding dilemma faced by public universities that are dependent upon state subsidies. In FY02, UMBC received adequate state and tuition support to generate a positive cost/benefit ratio to its enrollment growth. Professor Humphreys cautions that future implications for such growth, even with higher tuition, may not prove beneficial from a financial cost/benefit point of view.

In summary, the reader will find that this report serves as a valuable contribution to the overall long-term planning process at UMBC. We are most appreciative of the thoughtful efforts of Professor Humphreys and the members of the technical advisory board who assisted with the research design and data collection. Members of the technical advisory board include Professor Marilyn Demorest, Ms. Patty Keys, Professor Marvin Mandell, Mr. Mike Morgan, Ms. Nancy Ochsner, Dr. Judith Sunley, and Mr. Tom Taylor.

Introduction

In late September, 2002, I was asked by Scott Bass, Dean of the Graduate School and Vice Provost for Research and Planning, to undertake a study of the financial and economic consequences of the increases in enrollment at UMBC over the past few years. This process was initiated by Provost Arthur Johnson, who requested that Dean Scott Bass direct an effort to examine the issue of enrollment growth at UMBC, assist the Planning Leadership Team, and ultimately identify a target for future enrollment. This report is the first step in responding to Dr. Johnson's request.

UMBC has experienced rapid enrollment growth in the past few years. This increase in enrollment was, in part, brought about in response to the Report of the UMBC Enrollment Management Task Force, issued in January 1999. This report called for the university to reach enrollment of 10,000 undergraduates and 2,000 graduate students by Fall 2007. By Fall 2001, UMBC had 9,243 undergraduates and 1,909 graduate students, and was nearly at the Fall 2007 goals. The rapid rate at which the campus had moved toward meeting the enrollment goals set in 1999 suggests that new enrollment goals should be considered.

Note that this report is not the result of the deliberations of a task force. It is not a policy document nor is it a position paper expressing the goals and opinions of the UMBC administration, and it is not intended to represent the opinions of the UMBC faculty. It is a piece of scholarly research focused on understanding the consequences of increased enrollment at UMBC. Dean Bass asked me to apply the tools of my trade, economics, to this question, in order to provide the campus - administrators, faculty members, and students - with some insight into the consequences of the rapid increases in enrollment on campus.

I have received an enormous amount of help with the data from many administrators and staff members on campus and solicited advice and input from a wider group of faculty, administrators and staff. But I am solely responsible for the analysis and presentation of this report. The report reflects, by and large, the attempt of an applied economist to understand and explain the consequences of the recent increases in enrollment on campus. Economists have a particular way of looking at the world - several colleagues have taken great pains to point this out to me since I embarked on this project - and this report reflects this way of thinking. The report is essentially a detailed accounting of the economic costs and benefits associated with increased enrollment at a university.

In organizations with well-defined goals, like profit-maximizing firms, the relationship between costs and benefits are straightforward: to maximize total net benefits an organization should continue to undertake an action until the incremental cost of that action equals the incremental benefit. But in organizations with complex and multi-faceted goals, like a university, the implications of a cost/benefit analysis are more difficult to determine, although this does not necessarily reduce the effectiveness of this approach as a tool for learning more about the financial and economic implications of changes in enrollment. If UMBC were a profit-maximizing firm, in order to maximize profits, it would need to attract and admit students until the incremental cost of admitting a student equaled the incremental benefit from admitting that student. But the complex and multi-faceted goals of UMBC might make it desirable to enroll students who contribute more to overall costs than to overall benefits. These decisions should be made by the administration after close consultation with the faculty. Although the results of a cost/benefit accounting might help to inform the process, these decisions cannot be made solely on the outcome of an accounting of the overall incremental costs and benefits associated with attracting and admitting an additional student like this one.

Again, I undertook a thorough accounting of the incremental costs and benefits flowing from the enrollment of additional students at UMBC. Economic cost/benefit analysis can provide powerful and useful insights, but it must be carefully implemented and interpreted; the identification of the relevant costs and benefits requires careful thought and data limitations may play an important role in determining these costs and benefits.

The calculation of incremental costs and benefits requires a minimum of two years' data. More years can be considered, but the complexity of the project rises with the number of years studied and the effects of unexamined external or unobservable factors that influence economic costs and benefits become more important as the period of time analyzed increases. In this project, I analyze changes in costs and enrollment from Academic Year 2000 (AY00) to Academic Year 2001 (AY01), or alternatively, Fiscal Year 2001 (FY01) to Fiscal Year 2002 (FY02). Discussions with a number of administrators revealed that many important factors that affect costs but are beyond the scope of this analysis - programmatic offerings, classroom space and physical facilities - were essentially unchanged over this period. Also, the economic environment in which the university operates, in terms of economic performance of the Maryland economy and the effects of outside factors- resources available to state politicians and higher education regulators and their disposition toward higher education in Maryland- was extremely favorable to UMBC over this period. Thus, the results in this report can be interpreted as an upper boundary on the flow of resources to UMBC.

Some Perspective: Average Cost Per Credit Hour 1997-2001

The estimation of incremental costs and benefits in institutions of higher education is a difficult process. A university is a complex organization that produces many different services and has many different, and possibly conflicting, goals. Many of the services produced by a university are produced jointly - they cannot easily be separated into meaningful components. This joint production implies that costs will also be inter-related and difficult to untangle into separate components.

Because of these possible pitfalls, developing a baseline point of comparison for the incremental cost and benefit estimates described later in this report seemed like a good idea. Average cost measures are one convenient point of comparison for marginal costs. Average costs are simply unit costs, a familiar concept to many. If you go into a music store and buy a \$20 CD, a \$18 CD and a \$40 CD, your the average cost per CD is \$26. Average costs are considerably easier to estimate than incremental costs. Economic theory provides a clear link between average and incremental costs, providing another reason for using an estimate of average instructional costs as a benchmark.

In order to provide a benchmark for comparing the estimated incremental costs and benefits associated with changing enrollment at UMBC, I first estimated the average cost per credit hour taught at UMBC, adjusted for inflation, over the period 1997 - 2001. I chose this period because the data needed to estimate this average cost were readily available from the Office of Institutional Research web site.

To estimate the average cost per credit hour at UMBC, I began with the data on the table "UMBC Cost per Credit Hour, by Academic Department" available on the OIR web page. This table has an average cost measure, Salaries and Wages plus Operating Budget for each department per credit hour taught in each department, over the period 1997-2001. I adjusted these figures for inflation over the period using a weighted average of the Bureau of Labor Statistics' Employment Cost Index (ECI) component for wages and salaries at Colleges and Universities and the Producer Price Index (PPI) for Auditing and Bookkeeping Services and Legal Services firms. The ECI is a measure of average salaries for colleges and universities, and I used a weight of 93% - the fraction of UMBC departmental budgets that went to wages and salaries in 2000 and 2001 - for this component. The PPI component captures the prices of inputs like supplies, computers and software, employee travel and other factors, paid by firms. There is no component of the PPI for universities, but I assume that the prices paid for productive inputs other than salaries at accounting and law firms is similar to the prices paid for inputs by universities. Using the total PPI, a broader price measure that includes many input prices paid by firms, had no appreciable effect on the average cost estimates.

After adjusting the reported cost per credit hour for inflation over the past five years, I averaged these department-specific average cost measures to get a university-wide measure of average instructional costs. Care must be used in developing aggregate measures of instructional costs from department specific cost data. Simply averaging across departments is inappropriate. Unless each department teaches the same number of undergraduate and graduate students per faculty member; this assumption is unlikely to

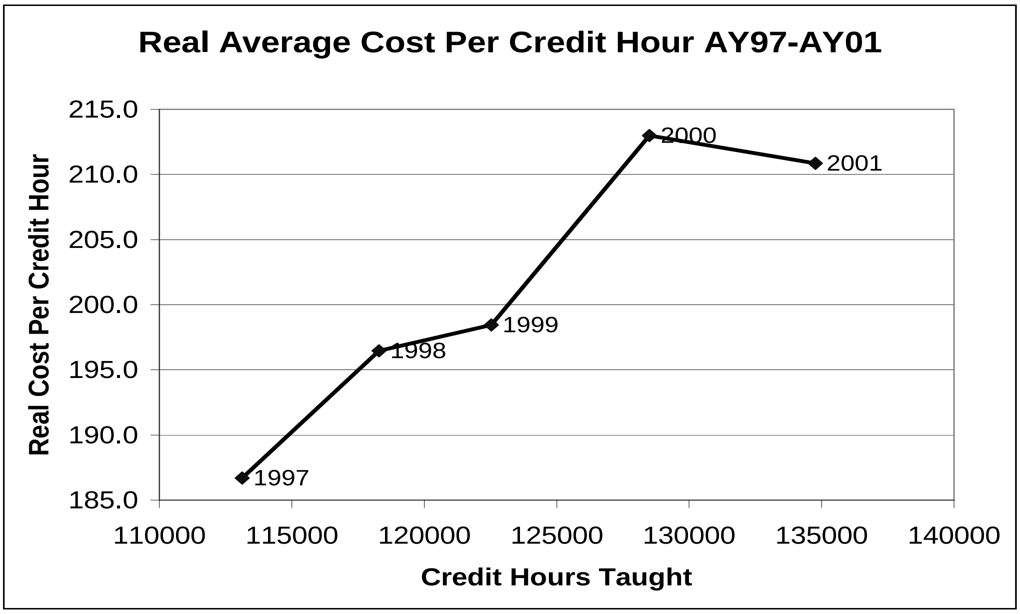

Figure 1: Average Instructional Costs

hold, as undergraduate and graduate enrollments vary widely across departments on campus. Instead, I constructed a weighted average of costs per credit hour where the weights used for each department depended on each department's share of headcount enrollment. This method does not distinguish between graduate and undergraduate credit hours, but it does reflect differences in the number of credit hours taught by faculty in each department.

In order to estimate average instructional costs, I also needed a measure of the output of the university. I simply used average total credit hours taught for this measure. I took the total full time and part time enrollment for each department from the table "Total Majors, by Program: Fall 1997 - Fall 2001" on the OIR web page and multiplied the total full time enrollment in each department by the average credits per full time student in 2000 and 2001 and the total part time enrollment by the average credits per part time student in 2000 and 2001.

Figure 1 shows the real average instructional costs at UMBC over the period 1997 to 2001. The points from left to right correspond to the five years in this sample, reflecting the continuous growth in enrollment at UMBC over the period. The data show a general increase in average instructional costs over the period with a slight decrease in the last two years. In the context of the economic theory of production costs, if the fixed inputs at UMBC remained roughly constant over this period, and if the underlying department specific cost per credit hour data accurately reflect instructional costs, then the data underlying this figure can be interpreted as evidence that the rising average instructional costs at UMBC over this period correspond to a movement along the upward sloping portion of a short run average cost curve (see Appendix 1 for details.) Rising average costs imply that incremental costs also generally rose during this period, although some incremental costs may have fallen in the last year of the period. Rising average and incremental costs can be attributed to an organization producing output beyond the capacity of its fixed factors of production. Enrollments rose during this period, but if core faculty, building space, and other university assets that can be adjusted only slowly did not change much over this period, then incremental and average costs would rise. However, this evidence must be interpreted with care, as it could be the result of other factors.

This measure of instructional costs reflects changes in a broad measure of instructional costs - departmental salaries and budgets - relative to credit hours taught over the past five years at UMBC. It also illustrates some problems inherent with broadly defined measures of instructional costs, and underscores why campus decision-makers should interpret such statistics with care. One important problem with broadly defined measures of instructional costs is that they treat salary increases paid to existing faculty members as increasing instructional costs. From the perspective of economic theory, existing faculty should be treated as quasi-fixed factors of production, like equipment, the library, and other assets that can only be adjusted slowly over time. Costs associated with quasi-fixed assets should be treated as a long-run cost, and not a short-run cost, and average cost measures are typically interpreted as a reflecting short run costs. Also, campus decision-makers may not have much control over salary increases; including these factors in measures of instructional costs mixes factors under the control of campus decision makers with factors they cannot fully control, obscuring the causal relationship between increasing enrollment and costs. Another problem with this measure is that it implicitly treats both graduate and undergraduate instructional costs and instructional costs per credit hour across departments as equal, despite ample evidence and experience suggesting that costs differ in important ways across these dimensions. Finally, this measure of average instructional costs assumes that departmental budgets accurately reflect all relevant instructional costs. The incremental cost estimates developed later in this report reflect a narrower definition of instructional costs.

With this preliminary estimate of changes in real average instructional costs as context for the basic approaches used to estimate instructional costs and illustrative of some problems inherent in estimating instructional costs at a university, I now turn to the estimation of incremental costs and benefits associated with changes in enrollment at UMBC from 2000 to 2001.

Estimating Incremental Economic Costs and Benefits

The estimation of incremental costs in higher education has received a large amount of attention from economists; the estimation of incremental benefits has not received as much attention, but many of the basic cost estimation techniques can also be applied to the estimation of benefits. Those interested in more details on the large literature on estimating costs in higher education should see the Appendix 1: A Primer on Economic Models of Costs in Higher Education and the references in that appendix.

As pointed out, I intended to estimate marginal, or incremental, costs associated with increased enrollment at UMBC. An alternative approach would be to estimate average costs of enrollment. I presented an estimate of average instructional costs earlier in this report and the inherent limitations of average cost estimates. In this instance, incremental costs, not average costs, are an appropriate cost measure for understanding the consequences of UMBC's recent increase in enrollment.

In 1983, Richard Allen and Paul Brinkman published *Marginal Costing Techniques for Higher Education*, a survey of methods for estimating marginal costs at colleges and universities. They identify three alternative methods for estimating marginal costs: the regression method, the fixed-and-variable-cost method, and the incremental cost method. The regression method uses statistical techniques to estimate marginal costs and requires a considerable amount of data. The other two methods use arithmetic computations and require as little as two years of data. Each of these three methods has strengths and weaknesses and none can be identified as the "best" method on purely objective criteria. This type of analysis is as much art as science, as considerable discretion must be used by the researcher.

I decided on a hybrid of the fixed-and-variable cost and incremental cost methods for this analysis. Each of these methods has particular strengths and weaknesses, but similar enough to adopt some elements of each method. These methods are similar in that each is based on a categorization of costs at a very detailed level of analysis. In this way, both methods allow for a considerable degree of heterogeneity in costs. The cost of an additional upper division credit hour taught by the history department can differ from the cost of an additional graduate credit hour in biology in both methods, for example. Both methods are also time consuming to implement because many different categories of costs must be classified in order to generate an estimate of marginal cost.

The difference between these two methods is conceptual, and based on the taxonomy of costs assumed.

As the name implies, the fixed-and-variable-cost method assumes only two types of costs: variable costs (those that change with enrollment) and fixed costs (those that do not change with enrollment). In the incremental cost method, costs are assumed to fall into three different types: costs related to volume (here defined as enrollment), costs related to the environment (inflation is one example of an environmental factor, a mandate from the state government is another) and decision costs, defined as costs related to decisions made by administrators but not related to changes in enrollment. The fixed-and-variable-cost method uses average variable costs as an estimate of marginal costs; the incremental cost method uses the average period-to-period change in costs related to volume as an estimate of marginal cost.

Methodology: Estimating Incremental Costs of Enrollment

The methodology is relatively simple and straightforward:Develop a list of relevant, measurable costs related to enrollment at UMBC and calculate the change in each enrollment-related cost from one period to the next, then calculate the change in enrollment over the same period. The period-to-period average change in these enrollment costs per unit of enrollment represents an estimate of incremental or marginal costs associated with enrollment.

While conceptually simple, implementation of this approach presents some formidable problems. One problem is determining an appropriate unit of observation for enrollment. A second is identifying costs related to enrollment that are both relevant and measurable. A third is the joint nature of costs and production in higher education. A discussion of each of these problems follows. I discuss each of these problems in turn.

There are many different measures of enrollment in institutions of higher education, but in practical terms, the estimation of incremental costs must proceed from existing sources of enrollment data. I had access to two different measures of enrollment at UMBC: headcount enrollment data from the UMBC student data set, and credit hour data from the UMBC faculty workload data set. Both of these data sources are described in detail in the data appendix.

The student-based enrollment data contain a wealth of information about individual students, including major, credit hours, residence status, level, and full-time/part-time status. This is a rich data set, but it has some drawbacks as a measure of enrollment changes for estimating incremental costs. Although these data show how many credits a student signed up for, they do not provide data on the department or departments that provided these credits or the level of these credits. This is a drawback for estimating incremental instructional costs because the expenditure data that form the basis of incremental cost estimates are commonly collected and organized by academic department.

The faculty workload data set contains an alternative measure of enrollment, student credit hours (SCH) generated. These data are collected differently than the enrollment data and measure enrollment at a more disaggregated level. Using SCH as a measure of enrollment has a number of advantages over headcount enrollment data, or the credit hour data in the UMBC student data set. First, the SCH data are reported by department. They reflect the actual classroom activity in each academic department on campus and not simply the number of majors in each department. Because many departments teach "service" courses that enroll large numbers of non-majors - math and English are two notable examples - estimating the effects of enrollment by major and credit hour would greatly underestimate the impact of rising enrollment in these departments. Second, SCH data avoid the difficult issue of comparing full-time and part-time students when estimating enrollment. SCH data reflect the number of students enrolled in the courses offered by each department. A full-time student and a part-time student enrolled in a three-credit class both generate the same instructional costs, and SCH data treat these students identically. Third, the SCH data are disaggregated by level of instruction, capturing enrollment at the lower division undergraduate, upper division undergraduate, and graduate level. Unfortunately, these data do not disaggregate the graduate enrollment data more finely; courses offered at the master's level, doctoral level, and post-baccalaureate certificate level cannot be separately identified. However, many graduate courses are open to all three types of graduate students, making it difficult to untangle these different types of enrollment.

Because of these advantages, I adopted SCH as the basic unit of measurement for calculating incremental enrollment costs. By measuring enrollment changes as changes in student credit hours taught, I could generate incremental cost estimates that vary by level of instruction - that is, these estimates would allow the cost of lower division undergraduate instruction to differ from upper division undergraduate instruction and from graduate instruction - as well as by department.

Clearly, instructional costs vary by level and discipline. The total instructional costs for a 40 student section of principles of an economics course differs from the total instructional costs for a 200 student section of introduction to psychology, and both differ from the total instructional costs for a 100 student section of basic physics. Because of these differences in costs across disciplines, it is important that the methodology allows for variation in costs across departments. If the methodology does not allow for such differences, the cost estimates will not reflect the situation in departments. Wherever possible, I have estimated incremental costs by department and by level of instruction.

Finally, because increased enrollment affects the campus in many different ways, the incremental cost estimates must include a number of different categories of costs related to instruction. The phenomena that economists call "joint production" is widespread in higher education. Joint production refers to the idea that universities produce many different things (education, research, campus and community service to mention a few of the important ones) using essentially the same inputs to production. The production of research and teaching by faculty members are interrelated, and cannot be cleanly separated into teaching output and research output like the production of a dairy can be separated into milk and cheese. This research project attempted to estimate only costs related to enrollment - the cost of a certain type of the educational output of a university - but this type of educational output is produced by faculty simultaneously with other outputs. Thus, the incremental cost estimates presented here should be viewed as only a part of the overall effects of enrollment changes on campus. Depending on the exact nature of the relationship between production of education as captured by SCH and the other things produced by the university, these cost estimates will either overstate or understate the total costs of rising enrollments. Unfortunately, the complex nature of this joint production precludes any adjustment procedure to scale the cost estimates up or down to account for the effects of increasing enrollment on other costs on campus.

To mitigate the extent to which joint production problems distort the cost estimates, I further disaggregated the incremental costs of enrollment into sub-categories that can be identified by their degree of dependence on other jointly produced services on campus. The categories of incremental instructional costs that are relatively independent of other jointly produced services will be less likely to affect other non-instructional costs, and thus will also be less likely to overstate or understate the total costs. These categories of costs associated with enrollment are:

Direct Instructional Costs - Consider the effect of an increase in student enrollments, as measured by an increase in SCH, on the amount of instruction done in an academic department. In part, the effect of this increase in instruction depends on the amount of instruction performed by the department before the increase occurred. If there were vacant seats in the courses taught by the department prior to the increase in enrollment, and the number of vacant seats were greater then or equal to the number of additional SCH, then the additional SCH could be accommodated by the same number of course sections. If there were few vacant seats in the department's courses before the increase, then the department would have to add additional courses to its offerings. These additional courses could be staffed by existing tenured/tenure track faculty or existing full-time instructional faculty, or by hiring additional tenure/track faculty, additional full-time instructional faculty, additional part-time faculty. Existing faculty could teach additional courses on an overload basis or allow more students into sections than the capacity listed in the catalog. Alternatively, graduate students on teaching assistantships could teach additional courses.

Any additional SCH will always raise total costs, but if these additional SCH are taught by existing faculty, there is no observable incremental direct instructional cost to the additional SCH. If additional tenured/tenure track, full-time instructional or part-time faculty are hired, then the incremental direct instructional cost of the additional SCH is the salary of the new faculty.

Note that direct instructional costs may vary greatly across departments, both because academic salaries vary across departments and because there are other direct instructional costs related to the instructional methods employed in different disciplines. The average faculty salaries for different types of faculty can be calculated for each department from the faculty data files. But accounting for differences in the instructional methods is more complex. In economic terms, departments are producing SCH, as well as other things. Departments use different production technologies and different inputs to production to produce SCH. I assume that the "basic" production function for departments is the standard "chalk and talk" method of lecture instruction in which an instructor teaches a section containing up to 40 students in a standard classroom. The main alternative to this production process would be a large 100 to 200 seat lecture section taught by an instructor and aided by some number of teaching assistants. Clearly the large lecture section will involve lower faculty salary costs than the smaller sections. Although there may be important quality differences in these two methods of instruction, I ignore these differences in my cost estimates.

Beyond these two basic production processes, I considered four alternative production methods or techniques that differ from the standard lecture format and thus may also lead to differences in instructional costs. Although some departments utilize one or more of these techniques in a small subset of courses taught, it is more important to identify those departments that make extensive use of one or more of these.

1. Labs and Other Specialized Facilities. Many disciplines use labs as part of instruction. Specialized facilities like labs are costly to maintain and place important constraints on the number of SCH that can be taught in any given semester. Departments that use labs and other specialized facilities will generally have higher direct instructional costs, and thus higher incremental direct instructional costs than departments who do not.

2. Use of Technology, Including Computer Labs. UMBC emphasizes technology, and the use of technology in education can be much more costly than standard lecture courses. The use of technology includes not only computer labs for instruction and assignments, but also the use of high-end computer workstations in the arts and super computer time to run complex simulations or other computationally intensive exercises.

3. Supervised Field Research. Many departments on campus make use of internships and other field research and experiential learning. These techniques can require a considerable amount of faculty oversight, making them more time intensive than standard lecture courses.

4. Individualized Instruction, Small Sections, Group Instruction, Seminars. These instructional techniques require more faculty time and effort than a standard lecture course. Examples include small group instruction that takes place in the Dance or Music department, seminar type courses offered to undergraduates, and individual research projects focused in cartography that take place in Geography.

Each of these factors may increase the production process used in a department and thus also affect direct instructional costs in that department. In developing and discussing the incremental cost estimates, I have paid attention to the use of these techniques by departments at UMBC and their possible effects on the incremental cost estimates.

I did not include graduate teaching assistants as part of the direct instructional costs. Although many departments employ graduate teaching assistants, teaching assistants account for a relatively small number of courses taught at UMBC, almost exclusively in Modern Languages and Linguistics, Math and Information Systems. But I could not link teaching assistants directly to courses given the existing data, and ignore this component of teaching costs in my incremental cost estimates. This clearly lead to an understatement in the total instructional costs. These costs are understated primarily in Modern Languages and Linguistics, Math and Information Systems, where graduate students teach courses. Costs will also be understated in departments that use teaching assistants as graders, as section leaders, and in labs.

Indirect Instructional Costs - In addition to additional course sections, increased enrollment can also increase other costs within academic departments. Photocopying for handouts, quizzes and exams, exam books, and other supplies are used in direct proportion to the number of SCH taught in a department. The expenditures for these items by a department are listed under the budget items Supplies and Materials and Contract Services. The Contract Services budget category contains expenditure for any good or service contracted for by an academic department. Some photocopying expenses are contained in this category, as are any other contracted goods or services related to instruction. The departmental budget data also contain spending for equipment (Equipment Replacement and Additional Equipment), but these expenditure categories may reflect research equipment and not instructional materials.

Administrative Costs Linked to Enrollment - Increasing enrollment also places demands on many academic support units, thereby increasing costs. These costs are not directly tied to the additional course sections that must be offered to educate additional students. Some are incurred in administrative units like the Comptrollers Office and the Office of Financial Aid – the additional students must be billed for tuition and fees and the money must be collected from these students – and additional students also lead to increased wear and tear on the physical plant of the university, generate additional trash that must be cleaned up and disposed of, increase the need for security services on campus, and so on. Like the direct instructional costs, the size of these incremental administrative costs depends in part on the level of administrative staffing in these units.

There are many possible units on campus that could be affected by additional enrollment. Presently, I am surveying administrative units on campus in order to determine which units have costs that are affected by additional enrollment. This survey process has not been completed at this time.

Capacity and Costs

The discussion above, about the relationship between prior levels of staffing in departments, raises the issue of the effect of capacity on costs. Capacity refers to the optimum amount of activity that can be supported by some fixed quantity of resources. Anyone who commutes to and from work by car has a good idea of the practical implications of capacity. At any point in time, there are a fixed number of miles of highway in a metropolitan area. Based on this fixed quantity of roads, and the driving habits and abilities of the residents of a metropolitan area, there is a maximum carrying capacity, in terms of number of cars that can use the roads at any time. When the number of cars on the road is below or equal to the level of capacity, traffic moves smoothly at or near the posted speed limit. But when the number of cars trying to use these roads exceeds the capacity, traffic slows to a crawl. In the extreme case, gridlock occurs and cars do not move at all. This happens during "rush hour" in many metropolitan areas.

Economic theory recognizes the importance of the relationship between capacity and both average and incremental costs and formalizes this relationship. Average costs - or costs per unit - have a U-shape when graphed. The bottom of the U is the point of optimum capacity. The existing resources are used efficiently at this point. Beyond this point, average costs rise, because the marginal cost of each additional unit is greater than the average cost of the preceding units. See Appendix 1 for a detailed discussion of this point.

In terms of enrollment costs, over some given period of time a university has a fixed number of parking spaces, buildings, classrooms, laboratories, administrative staff, faculty, and other fixed resources. Each of these fixed resources on campus has a point of capacity. When these areas are operating at or below their capacity, the incremental cost of increased enrollment is small, but when these areas operate above their individual point of capacity, incremental costs increase, sometimes dramatically. The process of educating students places demands on these fixed resources. As additional students are admitted to the university, each type of fixed resource moves closer to its point of capacity and at some point the number of students may exceed the point of capacity. Capacity can only be increased by acquiring more of the fixed resources that limit capacity.

In my conversations with a number of faculty and administrators, the point that UMBC is operating beyond the point of capacity in many areas came up frequently. Many faculty and staff members on campus believe that the increased enrollment UMBC has experienced over the past several years has led to capacity problems on campus. Although I have tried to address this issue, the incremental cost estimates in this report may not reflect this effect. This is in part because these costs associated with too many students for the existing capacity on campus are incurred in areas treated as fixed in this methodology, a limitation of this methodology that is important to recognize. Incremental Cost Estimates

The first step in estimating incremental costs associated with enrollment is to determine how much enrollment changed in departments at different levels. Total headcount enrollment - the total number of students enrolled at UMBC regardless of the level or number of credits taken - increased from 10,759 in Fall 2000 to 11,237 in Fall 2001. However, this aggregate number, while indicative of more students on campus, does not tell us much about increases in costs associated with this increase in enrollment because this number implicitly weights each student equally. In headcount enrollment, a part-time graduate student taking a single three-credit class in a post-baccalaureate certificate program counts the same as a full-time undergraduate in a lab-intensive science major. Clearly, these two students would place different burdens on campus resources and have a different impact on costs.

Table 1: Changes in Student Credit Hours Generated, AY00 - AY01

	Change in Student Credit Hours Generated				Change in Total Generated by				
Department	Total	Lower Division	Upper Division	Graduate	Tenure/Track	FT Instruct.	FT Res.	Other Fac.	TAs
ECON	1956.0	975.0	981.0	0.0	1548.0	612.0	0.0	-219.0	0.0
IFS	1777.0	267.0	609.0	901.0	-1039.0	893.0	0.0	1708.0	162.0
MLL	1630.5	1403.5	251.0	-24.0	839.5	-382.0	0.0	1114.0	68.0
BIOL	1238.8	586.8	610.0	42.0	808.6	840.2	1.0	-367.2	0.0
MUSC	1008.0	608.0	400.0	0.0	870.0	-103.0	0.0	-159.0	0.0
ENGL	890.6	31.6	807.0	52.0	291.6	1066.5	0.0	-617.5	0.0
AMST	748.5	567.0	139.5	42.0	-351.6	45.6	0.0	1197.0	0.0
GEOG	678.0	719.0	-43.0	2.0	-451.0	1024.0	-9.0	477.0	0.0
THTR	545.0	718.0	-173.0	0.0	548.0	-106.0	0.0	87.0	0.0
EDUC	523.5	-744.0	503.5	764.0	-1284.0	1062.0	0.0	710.5	0.0
POLI	514.5	429.0	40.5	45.0	682.0	0.0	0.0	-51.5	0.0
MENG	404.7	192.0	240.7	-28.0	123.4	0.0	0.0	5.3	0.0
ANCS	308.0	143.0	162.0	3.0	456.0	0.0	0.0	-132.0	0.0
SOCY	279.1	375.5	-136.0	39.6	-379.9	321.0	0.0	309.0	0.0
PHIL	209.0	-8.0	221.0	-4.0	-175.0	411.0	0.0	-30.0	0.0
SOWK	196.0	-86.0	282.0	0.0	-369.0	156.0	0.0	387.0	0.0
DANC	168.0	227.0	-59.0	0.0	-115.0	163.0	-90.0	291.0	0.0
CENG	166.4	111.0	-68.0	123.4	29.8	501.0	0.0	-381.4	0.0
EHS	51.0	-20.0	-12.0	83.0	42.0	-1.0	0.0	6.0	0.0
PHYS	-15.0	61.0	-176.0	100.0	-419.0	-915.0	1780.0	-466.0	0.0
POSI	-42.0	0.0	30.0	-72.0	-136.5	-8.5	0.0	128.0	0.0
CHEM	-69.0	-664.0	410.0	185.0	548.0	-461.0	0.0	-47.0	0.0
MATH	-88.8	898.8	-828.3	-159.3	1575.1	-781.0	0.0	-356.9	-479.0
AFST	-115.0	-348.0	239.0	-6.0	212.0	-45.0	0.0	-300.0	0.0
PSYC	-167.4	231.0	-481.4	83.0	-2658.7	2031.0	0.0	821.3	-198.0
VART	-176.0	-450.0	187.5	86.5	-961.5	-222.0	0.0	994.5	13.0
HIST	-323.5	-140.5	-163.0	-20.0	251.5	96.0	0.0	-960.0	0.0
CSEE	-582.5	-1580.7	476.2	522.0	1060.5	-2013.7	-8.0	392.7	-30.0
UMBC	11713.4	4503.0	4450.2	2760.2					

Table 1 provides detailed information on the change in enrollment, measured by student credit hours, over these two years. The source of the data on this table is the faculty workload report data set provided by the UMBC Office of Institutional Research. This data set is described in detail in the data appendix. Notice that the data summarized in Table 1 are based on Student Credit Hours (SCH) generated, and not on headcount enrollment. That means these data are based on the number of students enrolled in a class and the number of credits awarded to students for completing the class, and not on the status of the students enrolled in the class. Part-time students and full-time students are treated equally in this measure of enrollment, as each is counted by the number of credit hours generated, not by enrollment status. This makes SCH a more accurate measure of instructional resource requirements than headcount enrollments.

Table 1 provides quite a bit of detailed information about the distribution of SCH across levels of instruction and departments. The first column on this table shows the change in SCH generated from AY00 to AY01 for each UMBC department. The departments are sorted by the size of the increase in SCH generated, from largest to smallest. From the last row of this table, SCH generated at UMBC increased by 11,713 from AY00 to AY01; this increase in SCH is equivalent to 390 additional full-time students each taking 15 credits per semester for two semesters.

Notice that the increase in enrollment from AY00 to AY01 was not evenly distributed over all UMBC departments. In fact, five departments - Economics, Information Systems, Modern Languages and Linguistics, Biology and Music - accounted for 65% of the increase in total SCH generated. Three of these five - economics, music and modern languages - are primarily undergraduate departments. Also, note that nine departments experienced declines in SCH generated, although in several of these the decrease was quite small. This decline in SCH could be due to a large number of majors graduating in AY00 and not replaced by new majors in AY01, or simply due to changes in the composition of elective courses taken by undergraduates.

The next three columns show how the changes in total SCH shown in the first column were distributed across three levels of instruction - lower division undergraduate, upper division undergraduate, and graduate - within each department. The final row shows the total SCH changes across all UMBC departments. The overall distribution of increases in SCH across levels was roughly a 40% increase in lower division undergraduate credit hours, primarily attributable to new freshmen, a 40% increase in upper division undergraduate credit hours, due to additional transfer students and relatively more undergraduates taking upper level courses than graduating, and a 20% increase in graduate credit hours. The majority of additional SCH generated were at the undergraduate level. Turning to the distribution of changes for individual departments, the increase in enrollment over this period was not evenly distributed across levels within UMBC departments. For individual departments, no clear pattern emerges in terms of where the AY00 to AY01 increases in enrollment took place, except that in the five departments with the largest increases in SCH, the increases were mainly at the undergraduate level; IFS, which experienced a relatively large increase in graduate level SCH is one exception to this pattern.

The final five columns on this table show how the total changes in SCH were distributed across five different types of faculty in UMBC departments: tenured and tenure track faculty, full-time instructional faculty, full-time research faculty, part-time faculty (referred to as "other" faculty in the workload data) and teaching assistants. For example, the Economics Department - shown on the top row of the table - taught 1956 more SCH in AY01 than in AY00. The five rightmost columns show that tenured and tenure track faculty in Economics taught an additional 1548 SCH, or about 80% of the increase, full-time instructors taught an additional 612 SCH, or about 30% of the increase, and part-time faculty taught 219 fewer SCH, a decrease of about 10% relative to the previous year. So the economics department responded to the increase in primarily by increasing SCH generated by tenured and tenure track faculty as well as by increasing SCH generated by full-time instructors. Graduate teaching assistants taught very few of the additional SCH generated in AY01.

Examining the change in the distribution of SCH across types of faculty for other UMBC departments shows a wide variety of responses to the increased enrollment from AY00 to AY01. Because the instructional methods vary across departments, these widely different changes in SCH generated are to be expected.

The comparability of SCH across levels of instruction and across departments is not clear. A lower division SCH offered in a department that teaches principles level courses in large lecture sections may not be comparable to an upper division SCH in the same major that is taught in a small discussion section; this same lower division SCH also may not be comparable to a lower division SCH generated in another department that teaches principles level courses in 40 student sections.

Incremental Direct Instructional Costs

This increase in SCH also does not tell the entire story about the effects of enrollment changes on total costs over this two-year period. Increases in SCH can be met by increases in the number of students enrolled in each class, if there were excess seats in the previous year, by offering additional classes taught by existing faculty, or by offering additional classes taught by new faculty. Some of these changes increase the instructional burden of existing faculty while others add to costs without increasing the instructional burden of existing faculty. The faculty workload data provide some valuable information about the way in which departments responded to the changes in SCH documented on the previous table. The workload data set contains information about the number of course units taught by each department as well as the number of faculty in each department by rank. These data allow for estimates in the change in course units offered and the change in total staffing in each department. In terms of the methodology described above, the change in the number of courses offered, and the type of faculty who staffed these additional courses are called direct instructional costs.

Table 2: Change in Course Units Taught, Headcount Faculty AY00 to AY01

	Change in Course Units Taught				Change in Headcount Faculty		
Department	Total	Tenure/Track	Full-Time	Part-Time	Tenure/Track	Full-Time	Part-Time
MUSC	40	2	12	22	1	0	-3
IFS	35	-5	11	25	-2	2	11
MLL	20	9	-6	15	1	-1	4
ENGL	19	7	18	-7	-1	2	0
PHYS	19	2	3	4	1	0	0
CSEE	17	16	1	2	1	-1	3
MATH	16	18	-1	2	2	0	1
ECON	12	12	7	-6	-1	1	-4
AMST	11	-1	-1	11	0	0	4
EDUC	9	0	9	0	0	-1	-2
CENG	7	2	4	-2	-3	1	0
SOWK	6	3	6	-3	-1	1	3
THTR	6	-1	4	1	0	0	0
GEOG	6	-2	6	3	0	1	3
SOCY	6	-6	4	5	-1	1	-3
CHEM	4	4	-1	2	0	0	0
VART	3	-15	-4	22	0	0	5
PSYC	3	-6	6	6	-1	1	4
ANCS	2	4	0	-1	0	0	-1
EHS	2	3	0	-1	0	-1	3
PHIL	2	-6	7	1	-1	1	-1
DANC	2	-5	6	5	0	1	2
MENG	1	0	0	-2	0	0	-4
POLI	-3	6	0	-9	1	0	-4
POSI	-4	-4	-2	1	0	0	0
BIOL	-5	4	-6	-3	0	2	-2
AFST	-5	2	-2	-4	0	0	0
HIST	-11	0	3	-13	2	1	-3
Total	223	44	86	74	-2	11	16

Table 22 provides detailed information about how departments responded to the changes in SCH documented above in terms of courses taught and the number of instructional faculty in each department. This table shows the change in class sections - Course Units in the terminology of the workload data - and the change in the number of faculty members in each department from AY00 to AY01. On this table "Tenure/Track" refers to tenured and tenure-track faculty, "Full-Time" refers to full-time instructional faculty and "Part-Time" refers to part-time instructional faculty. The teaching done by full-time research faculty and teaching assistants is omitted from this table. Full-time research faculty taught 10 courses in AY00 and 13 courses in AY01; teaching assistants taught 54 courses in AY00 and 56 courses in AY01. These instructors clearly accounted for very few of the additional courses offered in AY01. The departments on this table are sorted in descending order based on changes in courses offered from AY00 to AY01. The rows do not sum to the figure shown in the total column because I omitted the small number of course sections taught by full-time research faculty and TAs from this table.

The first four columns show the changes in course sections offered. Nearly every department on campus offered more courses in AY01 than in AY00, although in many cases the number of additional courses offered was small. The change in courses offered in music was a 36%, The largest increase in percentage terms; IFS (18%), PHYS (31%), AMST (28%) and CENG (24%) also saw large changes in percentage terms. In general, many of the changes near the top of this table represent 10% or more increases. Among the departments with increases of 1 to 6 courses, the change is small in percentage terms - typically under 5%. Of the handful of departments who offered fewer courses, nearly all the courses eliminated were taught by part-time faculty.

The pattern that emerges from these data on the changes in courses offered is that the three departments with the largest increases in courses offered (recall that these three also had among the five largest increases in SCH over this period) offered mostly courses taught by full-time instructional faculty and part-time instructors. Three other departments with large increases in courses offered - CSEE, ECON and MATH - staffed these additional courses with tenured and tenure-track faculty; CSEE and MATH had additional tenured and tenure-track faculty available in AY01, but ECON did not. Also, these three departments did not have similar increases in SCH. ECON had a large increase in SCH at the undergraduate level, MATH had an overall decrease in SCH, and CSEE had a very large decrease in SCH taken by lower division undergraduates and a relatively large increase in graduate SCH.

Beyond these patterns, the data on changes in courses offered show a great deal of department-level heterogeneity, but little in the way of large changes in absolute or percentage terms. One exception is VART, which offered a lot of additional courses taught by part-time faculty and many fewer courses taught by tenured and tenure-track faculty. While the 22 additional courses taught by part-time faculty represents a 47% increase over AY00, the 15 course decline in courses taught by tenured and tenure-track faculty is only a 10% decline from AY00, a change small enough to be accounted for by an anomalous event like a relatively small number of faculty on leave in a given academic year. Furthermore, total SCH declined by less that 2% in this department in AY01.

The three rightmost columns on Table 2 show the change in headcount tenure and tenure-track, full-time instructional and par-time faculty in each department. One factor stands out in these columns. The increase in SCH and courses offered from AY00 to AY01 was carried out using two fewer tenured or tenure track faculty. Although there were more full-time instructors and part-time faculty, in some respects this increase in teaching represents an increase in the cost of teaching borne by tenured or tenure-track faculty members at UMBC, as these faculty members also have research responsibilities in addition to service and teaching. Regular tenured and tenure-track faculty bear a larger portion of the hidden day-to-day costs of running an academic department at a research university than instructors or part-time faculty. The cost estimates in this report must underestimate the total costs associated with higher enrollments, as there is no way to estimate the internal costs borne by individual tenured and tenure-track faculty members at UMBC.

The data shown on these tables represent a roadmap for the estimation of direct incremental instructional costs associated with increased enrollment at UMBC. These tables show how many additional SCH were generated by each department, how the distribution of SCH generated changed by the type of instructor in each department, how the courses offered by each department changed, and the number of additional faculty available to teach courses. The actual estimation of direct instructional costs involved a detailed examination of the data on the following two tables, as well as other data from the workload files, to determine exactly how departments met the increases in SCH shown on Table 1.

This estimation process also requires some assumptions about the exact interpretation of increases in enrollment in a department. From Table 1, 19 departments experienced increases in SCH from AY00 to AY01. But among the departments where total SCH declined, some departments experienced an increase in graduate SCH despite a decline in total SCH. Because graduate credits require more faculty and departmental resources than undergraduate credits, total instructional costs might have increased even though SCH generated decreased. Because of this possibility, I treated graduate SCH and undergraduate SCH separately when calculating incremental direct instructional costs. Departments with no increase in total SCH and no increase in graduate SCH were assumed to have had no increase in direct instructional costs over this period. Data from these departments were not used to calculate incremental direct instructional costs.

I also restricted the incremental instructional cost estimates to those departments that taught additional courses with additional faculty at the lower division undergraduate, upper division undergraduate, and graduate level. In other words, I examined the SCH and courses taught by either tenured or tenure track faculty, full-time instructional or research faculty, and part-time faculty at each of the three levels of instruction and calculated incremental direct instructional costs for only those departments that taught additional SCH in additional sections staffed by additional faculty. If a department taught additional SCH using the same number of sections at that level, the incremental direct instructional costs are zero for the additional SCH. If a department taught additional SCH using the same number of faculty teaching additional sections, the incremental direct instructional costs are zero for the additional SCH.

Table 3: Staffing Changes and Changes in Student Credit Hours

	Δ Total	Δ Lower	%Δ Lower Division SCH				%Δ Faculty		
Department	SCH	Div. SCH	Tenure/Track	FT Inst.	FT Rsrch.	Part Time	Tenure/Track	Full Time	Part Time
AMST	749	567	-21%	36%	0%	**92%**			4
ANCS	308	143	194%	0%	0%	-84%			
BIOL	1239	587	133%	**68%**	0%	-90%		2	
CENG	166	111	0%	**392%**	0%	-292%		1	
DANC	168	227	-35%	**85%**	-13%	**85%**		1	2
ECON	1956	975	82%	40%	0%	-21%			
GEOG	678	719	-43%	**146%**	0%	36%		1	
IFS	1777	267	-1%	-19%	0%	60%			11
MENG	405	192	19%	0%	0%	48%			
MLL	1631	1404	**40%**	-13%	0%	68%	1		4
MUSC	1008	608	**43%**	36%	0%	-9%	1		
POLI	515	429	**66%**	0%	0%	59%	1		
SOCY	279	376	-47%	0%	0%	147%			
THTR	545	718	85%	-12%	0%	17%			

	Δ Total	Δ Upper	%Δ Upper Division SCH				%Δ Faculty		
Department	SCH	Div. SCH	Tenure/Track	FT Inst.	FT Rsrch.	Part Time	Tenure/Track	Full Time	Part Time
AMST	749	140	-164%	-114%	0%	**484%**			4
ANCS	308	162	106%	0%	0%	-7%			
BIOL	1239	610	19%	**79%**	0%	-3%		2	
ECON	1956	981	75%	**22%**	0%	-2%		1	
EDUC	524	504	10%	163%	0%	-70%			
ENGL	891	807	0%	**92%**	0%	-10%		2	
IFS	1777	609	-246%	**141%**	0%	**205%**		2	11
MENG	405	241	60%	0%	0%	-48%			
MLL	1631	251	**113%**	-75%	0%	**63%**	1		4
MUSC	1008	400	**153%**	-81%	0%	-27%	1		
PHIL	209	221	-105%	**81%**	0%	92%		1	
POLI	515	41	**960%**	0%	0%	-846%	1		
SOWK	196	282	62%	**40%**	0%	-11%		1	

		Δ Grad.	%Δ Graduate SCH				%Δ Faculty		
Department		SCH	Tenure/Track	FT Inst.	FT Rsrch.	Part Time	Tenure/Track	Full Time	Part Time
CENG		123	51%	0%	0%	43%			
CHEM		185	90%	0%	0%	1%			
CSEE		522	**143%**	-4%	-7%	-32%	1		
EDUC		764	76%	0%	0%	186%			
EHS		83	76%	18%	0%	6%			
ENGL		52	100%	6%	0%	-6%			
IFS		901	51%	9%	0%	**34%**			11
PHYS		100	**56%**	0%	51%	-12%	1		
PSYC		83	84%	76%	0%	**134%**		1	4
VART		84.5	98%	0%	0%	2%			

In order to arrive at an estimate of incremental direct instructional costs, the changes in SCH need to be matched to changes in faculty in each department. Where possible, I distinguished the changes in SCH by level of course and type of faculty. Table 3 shows the detailed matching of additional SCH and staffing of additional courses by department and by level of SCH for those departments identified as meeting additional SCH with additional courses staffed by additional faculty.

Table 3 contains quite a bit of detailed information about how staffing changed in response to the increases in SCH. The top panel contains information on lower division undergraduate (LD) SCH, the middle panel contains information on upper division undergraduate (UD) SCH and the bottom panel contains data on graduate (GR) SCH. The first two columns simply show the change in SCH by level for the departments that experienced increases. The next three columns show the distribution of these changes in SCH across different types of faculty for each level. "Tenure/Track" refers to tenured and tenure track faculty, "FT Instr" to full-time instructional faculty, and "FT Rsrch" to full-time research faculty. The percentages in bold are the largest category of percent changes in SCH that can be explicitly linked to a change in headcount faculty in a department. The final three columns show the change in headcount faculty in each category for these departments.

Reading across the top row of the top panel, the American Studies Department (AMST) taught an additional 749 SCH in AY01 relative to AY00 and 567 of these SCH were taught at the lower division level. Of these 567 additional lower division SCH, 92% of the additional SCH were in classes taught by part-time faculty, and there were 4 additional part-time faculty in the American Studies Department in AY01. Tenured and tenure track faculty taught fewer LD SCH in AY01 than in AY00 and full-time instructional faculty taught 36% more LD SCH in AY01, but there were no additional faculty in these categories in AY 01, so these changes in SCH are estimated to have zero incremental direct instructional cost. The incremental direct instructional costs for this department will be attributed to additional part-time faculty. Reading the top row of the second panel, American Studies taught 140 more upper division SCH in AY01 than in AY00. These additional SCH were taught entirely by part-time faculty - the only category of faculty who taught more upper division SCH in AY01.

The bottom panel of Table 3 shows the changes in graduate SCH and the associated changes in headcount faculty in the departments that generated additional SCH in AY01. Recall that some of these departments may have generated fewer total SCH in AY01, but because graduate credit hours place different burdens on faculty time and other resources relative to undergraduate credit hours, I treated graduate instruction separately. The columns contain the same information as in the undergraduate panels above. Again, the bold percentages indicate increases in graduate SCH generated by particular types of faculty that can be matched directly to increases in headcount faculty in that department, and are assumed to indicate graduate SCH taught by additional faculty, and thus incremental direct instructional costs.

Table 3 contains much of the information needed to estimate incremental direct instructional costs. The departments that generated additional lower division undergraduate, upper division undergraduate, and graduate SCH in AY01, as well as those departments that responded to this increase by adding sections taught by new faculty of some type, are identified on this table. All that remained was to estimate the cost of the additional faculty, in terms of salary. The UMBC faculty data set contains detailed information about the rank, salary, and full-time/part-time status for all UMBC faculty. I could not match individuals in the faculty data set to the changes in headcount faculty by department shown above; I could calculate the average salary of UMBC faculty in each of the three categories shown on Table 3. Using this average salary, I estimated the incremental direct instructional costs for the additional SCH generated in AY01.

I calculated a weighted average of tenured and tenure track, full-time instructional and full-time research, and part time faculty for each department at UMBC. I assumed that all additional tenured or tenure track faculty in departments in AY01were assistant professors and that they were paid the average salary for all assistant professors in the department. Note that this probably understates the actual salary of these new faculty. New assistant professors typically earn more than assistant professors hired in the previous years, and if the new faculty member was an associate or full professor, the actual salary will be much higher. However, as I was unable to identify new faculty from the existing data, I made this assumption for computational convenience. Full-time instructional or research faculty can be

Table 4: Incremental Cost Estimates

Department & Level	Total SCH	SCH by Type: Lower Division	SCH by Type: Upper Division	SCH by Type: Graduate	Change in Staffing, Actual: Tenure/Track	Actual: Full Time	Actual: Part Time	Change in Staffing, Allocated: Tenure/Track	Allocated: Full Time	Allocated: Part Time	Incremental Cost per SCH	Incremental Cost
ECON LD	1956	975			0	0	0	0.0	0.0	0.0	0	0
ECON UD	1956		981		0	1	0	0.0	1.0	0.0	48	47112
IFS LD	1777	267			0	0	11	0.0	0.0	1.7	26	6837
IFS UD	1777		609		0	2	11	0.0	2.0	3.8	150	91578
IFS GR	1777			901	0	0	11	0.0	0.0	5.6	26	23071
MLL LD	1631	1404			1	0	4	0.8	0.0	3.4	38	53546
MLL UD	1631		251		1	0	4	0.2	0.0	0.6	49	12391
BIOL LD	1239	587			0	2	0	0.0	1.0	0.0	70	40884
BIOL UD	1239		610		0	2	0	0.0	1.0	0.0	80	48878
MUSC LD	1008	608			1	0	0	0.6	0.0	0.0	55	33491
MUSC UD	1008		400		1	0	0	0.4	0.0	0.0	46	18571
ENGL UD	1956	807			0	2	0	0.0	2.0	0.0	92	74096
ENGL LD	1956		32		0	0	0	0.0	0.0	0.0	0	0
AMST LD	749	567			0	0	4	0.0	0.0	3.2	21	12038
AMST UD	749		140		0	0	4	0.0	0.0	0.8	21	2962
GEOG LD	678	719			0	1	0	0.0	1.0	0.0	70	50652
THTR LD	545	718			0	0	0	0.0	0.0	0.0	0	0
EDUC UD	524		504		0	0	0	0.0	0.0	0.0	0	0
POLI LD	515	429			1	0	0	0.9	0.0	0.0	102	43593
POLI UD	515		41		1	0	0	0.1	0.0	0.0	94	3813
MENG LD	405	192			0	0	0	0.0	0.0	0.0	0	0
MENG UD	405		241		0	0	0	0.0	0.0	0.0	0	0
ANCS LD	308	143			0	0	0	0.0	0.0	0.0	0	0
ANCS UD	308		162		0	0	0	0.0	0.0	0.0	0	0
SOCY LD	279	376			0	0	0	0.0	0.0	0.0	0	0
PHIL LD	209	221			0	1	0	0.0	1.0	0.0	0	0
SOWK LD	196	282			0	1	0	0.0	1.0	0.0	305	59792
CENG LD	166	111			0	1	0	0.0	1.0	0.0	234	39006
CENG GR	166			123	0	0	0	0.0	0.0	0.0	0	0
EDUC GR	524			764	0	0	0	0.0	0.0	0.0	0	0
EHS GR	51			83	0	0	0	0.0	0.0	0.0	0	0
PHYS GR	-15			100	1	0	0	1.0	0.0	0.0	568	56753
CHEM GR	-69			185	0	0	0	0.0	0.0	0.0	0	0
PSYC GR	-167			83	0	1	4	0.0	1.0	4.0	546	45320
VART GR	-176			85	0	0	0	0.0	0.0	0.0	0	0
CSEE GR	-583			522	1	0	0	1.0	0.0	0.0	129	67085

identified by their rank and full-time/part-time status in the faculty data files. To estimate the average part-time salary in each department, I constructed a weighted average of the salaries of all part-time faculty where the weights depended on the percent time worked and the number of faculty at each rank in the department.

Table 4 shows the detailed incremental direct instructional costs estimates for each department by level of incremental SCH generated. The first column shows the department and level of the SCH. The next six columns repeat the information shown on Table 3 for incremental SCH and associated staffing by level for each department. The next three columns allocate these staffing changes by level within each department. In some cases, specific changes in staffing could be associated with specific changes in SCH at a given level. For example, there were two additional full-time instructors in IFS in AY01, and incremental SCH at the upper division undergraduate level were the only incremental SCH in IFS taught by full-time instructional faculty. Thus, these two faculty members can be allocated solely to upper division SCH in IFS. In some instances I could not directly link additional faculty to additional SCH, either because the additional faculty taught students at multiple levels or the data are not rich enough to allow for this detailed identification. In these cases, the estimated incremental direct instructional costs are the same for different levels, although the incremental cost differs as the number of additional SCH differs.

The final two columns show the estimated incremental direct instructional cost per SCH and the total estimated incremental direct instructional costs broken down by department and by level of instruction. These estimates were obtained by multiplying the allocated faculty in each department at each level by the appropriate average faculty salary for each department. The incremental cost per SCH estimates vary from a low of \$21 per SCH to a high of \$568 per SCH. An estimated incremental direct instructional cost of zero means that the department taught the additional SCH at that level with the same number of faculty as in the previous year.

The average estimated incremental direct instructional cost per SCH at UMBC was $77 per SCH. This implies that the average cost of an additional 40- student lecture section for a 3- credit course was $9,235 in AY01. Keep in mind that this average reflects additional courses at all levels taught by additional tenure track, full-time and part-time faculty. The average for graduate credit hours was $141 per SCH and the average for undergraduate credit hours was $56 per SCH. Total estimated incremental direct instructional costs were $831,468 for the additional SCH generated at UMBC in AY01. Broken down by level, $192,229 was accounted for by graduate SCH and $639,239 was accounted for by undergraduate SCH.

The high cost departments in these estimates met increased enrollment by hiring new full time faculty during this period. But because these incremental cost estimates are based on one year changes in staffing, this does not mean that the incremental instructional costs in these high cost departments would continue to be high in the future. The additional new full time faculty hired in this period might be enough to meet some future enrollment increases - in which case future incremental instructional costs would be low or zero - or future enrollment increases could be met using new part time faculty. Future incremental instructional costs would only remain high in these departments if future enrollment increases were met by hiring additional full-time faculty.

Differences in SCH Production Techniques in Departments

The methodology section contains a discussion of possible sources of differences in the production of SCH across departments. The four factors identified were: use of specialized facilities like labs, use of technology including computer labs, supervised field research, and individualized and small group instruction. Because the use of any or all of these factors can make it difficult to compare and add up incremental direct instructional costs across departments, some information about the use of these factors is important.

In order to determine the extent to which departments use these instructional methods, I surveyed the department chairs. The survey asked about extensive use of these factors. Most departments on campus integrate technology into the curriculum in a number of ways, often including a small subset of courses that make some use of computer labs. Graduate education necessarily involves much more than lecture-based courses, as part of the supervision of master's theses and doctoral dissertations. However, the intent of the survey was to learn more about the use of these alternative production technologies by departments and to identify intensive use (defined broadly as out of the ordinary, or well above average) of these factors in departments. The term "intensive use" was not specifically defined in the survey, but the narratives and discussions with the respondents, along with my judgment, were used to help define intensive use.

Table 5 summarizes the results from this survey of departmental instruction technology; a detailed narrative summary of the positive responses shown on this table can be found in Appendix 4. On the table, an "X" in a column means that the department reported use of a specialized instructional technique and a blank means that no use was reported. The shaded areas represent departments with no program at that level. The three leftmost columns contain information about graduate education and the four rightmost columns contain information about undergraduate education. Although it appeared on the survey, I do not report the "alternative instruction" results for graduate education because nearly all graduate departments teach graduate classes by methods differing from standard "chalk and talk" lectures.

Table 5 reveals quite a bit of heterogeneity in the educational process across departments at UMBC. The most common source of this heterogeneity is non-traditional teaching methods in undergraduate courses. Forty-four percent (44%) of the departments with undergraduate programs on campus reported extensive use of small sections, seminar-style courses, individualized instruction, or other alternative instructional models in undergraduate courses. The second most common source of heterogeneity is the extensive use of technology, extensively used by 38% of the departments with undergraduate and graduate

Table 5: Alternative Instruction Technologies

	Graduate Education			Undergraduate Education			
Department	Specialized Facilities	Technology	Alternative Instruction	Specialized Facilities	Technology	Field Research	Alternative Instruction
AFST							
AMST							X
ANCS							X
BIOL	X	X		X	X		X
CENG	X			X			
CHEM	X			X			X
CSEE					X		
DANC				X			X
ECON							
EDUC		X			X	X	
EHS						X	X
ENGL							
GEOG					X		X
HIST							
IFS		X			X		
MATH		X					
MENG	X	X		X	X		
MLL					X		X
MUSC				X	X		X
PHIL							X
PHYS	X	X		X	X		
POLI							
POSI							
PSYC							
SOCY							
SOWK						X	
THTR				X			X
VART		X			X		X

programs on campus; the third is extensive use of specialized facilities like labs, reported by 28% of the departments with graduate programs and 30% of the departments with undergraduate programs.

Among the departments extensively using specialized facilities are a group of "laboratory" disciplines - Biology, Chemical Engineering, Chemistry, Mechanical Engineering and Physics - as well as a group of humanities departments - Dance, Music and Theatre - that use specialized facilities like studio and performance spaces. Within the "laboratory" departments, graduate education takes place in faculty labs, but undergraduate education tends to take place in dedicated instructional labs that also have high materials and staffing costs.

The extensive use of technology frequently involved the use of specialized department-maintained computer labs. These labs typically require cutting-edge computers and specialized software; they tend to be smaller and more expensive than the general use computer labs maintained by University Computing Services.

Three departments - Education, Emergency Health Services, and Social Work - reported extensive use of field research. These faculty monitoring that takes place in these programs makes intensive use of faculty time and requires a lower student/faculty ratio than standard "chalk and talk" courses.

The survey uncovered extensive use of alternate instructional methods in many departments; only eight departments rely primarily on lecture-based instruction. Note that among these eight departments are three departments that experienced large increases in SCH from AY00 to AY01 (ECON, IFS, ENGL). MLL reported significant use of alternative instructional methods (advanced undergraduate courses are taught in small sections in this department) but the increase in enrollment in MLL was primarily in lower division undergraduate SCH. Music and Biology also reported significant use of alternative instructional methods and experienced large increases in SCH.

This survey indicated a large amount of heterogeneity in instructional methods at UMBC. Many departments make extensive use of instructional techniques different from traditional "chalk and talk" lectures; technology, in the form of specialized computer labs is relatively common; a significant subset of departments, including three in the humanities, use specialized facilities; a smaller subset make extensive use of faculty supervised field research. This heterogeneity in instruction means that the university-wide marginal cost estimates presented above may not fully capture the actual marginal cost of increasing enrollment at UMBC. It also means that some care must be taken when comparing incremental cost estimates across departments. For example, the estimated incremental cost of additional upper division undergraduate SCH for Music ($46/SCH) and Economics ($48/SCH) shown on Table 4 are quite similar. However, the Music Department makes extensive use of specialized facilities and alternative instructional techniques but the Economics Department does not. The actual marginal instructional costs for these two departments may not be as similar as the estimates suggest, because of the differences in the underlying instructional technologies used by these departments.

Finally, the heavy use of specialized facilities and technology in the form of departmental computer labs has important capacity implications. Increasing enrollment in departments that make use of these factors is more likely to lead to more than proportionate increases in the instructional costs that are not reflected in the incremental instructional costs reported above. These capacity effects are discussed in detail later in the report.

Incremental Indirect Instructional Costs

Incremental Indirect Instructional Costs are related to the costs of additional materials and supplies, photocopying, lab equipment and chemicals, and other factors not directly related to the cost of paying an instructor. Incremental indirect instructional costs are estimated using departmental budget data. Because department budget data are not broken down by level of instruction, I could not estimate separate indirect instructional costs for each level of instruction.

The estimation of incremental instructional costs is not difficult, as long as the assumption that departmental expenditure on Contractual Services and Materials and Supplies reflect these costs. The change in expenditure in these categories is adjusted to account for inflation - the change in the general price level - from 2000 to 2001 and then the inflation adjusted change in expenditure per SCH is calculated. This represents an estimate of the incremental indirect instructional cost per SCH. But because departmental funds are fungible, expenditure on these budget items may not reflect indirect instructional costs. In any case, I know of no better source of information on these costs.

I adjusted the FY2001 budget data for Supplies and Materials and Contracted Services using the CPI component for educational supplies. This would appear to be the most appropriate price index for deflating expenditures on materials and supplies in higher education. The deflator for FY2001 was 0.945, implying a 5.5% rate of inflation on educational books and supplies over this period.

Real budget expenditure in these two categories increased in only six departments: Theatre, Chemistry, Biology, Modern Languages and Linguistics, Visual and Performing Arts and Music. These departments probably use specialized supplies and materials in instruction, so it may be inappropriate to compare these costs to the indirect instructional costs in other departments. Further complicating the estimation, in two departments (Chemistry and Visual and Performing Arts) there was an increase only in graduate SCH, not in total SCH. Because of these complications, the estimates of indirect instructional costs may not be applicable to other departments.

For these six departments, the estimated incremental indirect instructional cost per SCH was $95 per SCH. The highest estimated incremental cost was $218 per graduate SCH in chemistry and the lowest was $6 per total SCH in Music. The total estimated incremental indirect instructional cost per SCH for these six departments was $210,527.

The lack of increase in departmental expenditures for supplies, even though many of these departments saw significant increases in SCH generated, can be interpreted in a number of ways. Perhaps the existing FY01 expenditure on these items was more than adequate to provide for the existing SCH generated. In this case, the department was running a surplus in expenditure on instructional supplies and did not need to increase expenditure to meet the increased demands in FY02. Alternatively, the increase in SCH meant the overall quality of instruction decreased, as the instructors did not have access to enough instructional supplies to teach with the same effectiveness as they had in the previous year. A third alternative is that these expenditure categories do not reflect the indirect instructional costs incurred by departments. Finally it is possible that departments are able to shift some or all of these increased costs onto students. As SCH rise, departments could stop supplying class hand-outs to students and instead sell these hand-outs through the bookstore or charge students directly for the photocopying.

Recall that the average cost per student credit hour estimated earlier was just over $210 per student credit hour. This average cost is higher than the incremental direct instructional cost average of $103 per student credit hour reported here. This may explain why average costs per credit hour dropped from AY00 to AY01. If the additional credit hours generated in AY01 had a marginal or incremental cost less than the credit hours generated before, then average costs would drop. Put simply, marginal costs always pull average costs toward them. If UMBC was able to generate additional SCH at a lower incremental cost in AY01, then average instructional costs would be expected to drop. In this sense, the incremental direct instructional cost estimates presented here are consistent with the average cost estimates presented earlier. Note that even if the $95 per SCH indirect instructional cost were added to all of the additional SCH generated in AY01, the incremental instructional costs would still be less than the average cost estimate in AY00. Even this larger incremental cost estimate is consistent with the change in estimated average costs from AY00 to AY01

Robustness Checks

The relationship between average cost and incremental direct instructional costs discussed above provides some confirmation that the incremental cost estimates are consistent with widely accepted measures of instructional costs. However, these incremental cost estimates can be placed more fully in context. As a robustness check, I calculated incremental direct instructional costs under some additional assumptions about the staffing of additional courses, in order to determine how sensitive the cost estimates are to the staffing pattern.

Table 6 shows some estimated incremental direct instructional costs based on alternative staffing assumptions. These estimates represent a check on the sensitivity of the results reported on Table 4 to alternative assumptions. The first three columns on this table repeat the numbers from Table 4 - the department and level along with the incremental SCH generated by each department at each level. The Courses Required column shows how many additional courses would be required assuming that all additional courses taught were three credit undergraduate course enrolling 30 students or three credit graduate course enrolling 15 students. The Faculty Required columns show the hypothetical number of additional tenure track faculty (TT) and full-time instructional faculty (FT) required to staff these additional courses assuming a five course load per year for tenure track faculty and a six course per load year for full-time instructional faculty. The final four columns show the estimated cost per student credit hour from Table 4 along with the estimated cost per student credit hour for three alternative staffing scenarios: additional courses taught entirely by part-time faculty paid the average part-time instructor's salary in each department (PT), additional courses staffed only by new tenure track faculty paid the average assistant professor's salary in each department (TT), and additional courses staffed only by additional full-time instructors paid the average full-time instructor's salary in each department (FT). The detailed average salary data by department used to calculate these costs can be found in Appendix 2: Details on Cost Estimates. At the bottom are the average estimated incremental instructional costs per SCH for graduate and undergraduate courses; the first averages are the actual estimates - these reflect

Table 6: Robustness Checks on Incremental Cost Estimates

Department & Level	Total SCH	Lower Division	Upper Division	Graduate	New Courses Required	Additional Faculty Required: On Track	Additional Faculty Required: FT Inst.	Incremental Cost per SCH: Estimated Table 4	Incremental Cost per SCH: Part Time	Incremental Cost per SCH: Full Time	Incremental Cost per SCH: Tenure Track
ECON LD	1956	975			11	2	2	0	26	89	129
ECON UD	1956		981		11	2	2	48	26	89	129
IFS LD	1777	267			3	1	0	26	46	94	177
IFS UD	1777		609		7	1	1	150	46	94	177
IFS GR	1777			901	20	4	3	26	92	188	354
MLL LD	1631	1403			16	3	3	38	41	45	106
MLL UD	1631		251		3	1	0	49	41	45	106
BIOL LD	1239	586			7	1	1	70	50	70	112
BIOL UD	1239		610		7	1	1	80	50	70	112
MUSC LD	1008	608			7	1	1	55	18	69	98
MUSC UD	1008		400		4	1	1	46	18	69	98
ENGL UD	1956	807			9	2	1	92	40	69	106
ENGL LD	1956		32		0	0	0	0	40	69	106
AMST LD	749	567			6	1	1	21	42	87	109
AMST UD	749		139		2	0	0	21	42	87	109
GEOG LD	678	719			8	2	1	70	36	85	119
THTR LD	545	718			8	2	1	0	27	72	102
EDUC UD	524		503		6	1	1	0	26	84	123
POLI LD	515	429			5	1	1	102	20		115
POLI UD	515		40		0	0	0	94	20		115
MENG LD	405	192			2	0	0	0	57	79	141
MENG UD	405		240		3	1	0	0	57	79	141
ANCS LD	308	143			2	0	0	0	22		161
ANCS UD	308		162		2	0	0	0	22		161
SOCY LD	279	375			4	1	1	0	19		107
PHIL LD	209	221			2	0	0	0	80	85	88
SOWK LD	196	282			3	1	1	305	15	111	122
CENG LD	166	111			1	0	0	234	46	75	128
CENG GR	166			123	3	1	0	0	91	150	256
EDUC GR	524			764	17	3	3	0	51	168	247
EHS GR	51			83	2	0	0	0	53	186	208
PHYS GR	-15			100	2	0	0	568		149	252
CHEM GR	-69			185	4	1	1	0	39	123	216
PSYC GR	-167			83	2	0	0	546	27	150	229
VART GR	-176			84	2	0	0	0	80	150	229
CSEE GR	-583			522	12	2	2	129	61	192	298
						Average Undergraduate		56	38	81	127
						Average Graduate		141	62	162	254

how UMBC departments actually responded to the increase in SCH from AY00 to AY01 - and the next three represent what the average would have been under the three alternative scenarios.

As an example of how to interpret the information on this table, examine the first two rows of the table that show what actually happened as well as three alternative staffing scenarios for the Economics department in AY01. This department taught 1,956 more SCH in AY01 than in AY00, 975 more lower division undergraduate SCH and 981 more upper division SCH. If taught in three credit courses with an average of 30 students per course, this would have required 11 additional lower division undergraduate courses and 11 additional upper division undergraduate courses. Staffing these 11 additional lower division courses would have taken 2.2 additional tenure track faculty teaching a 5 course per academic year load or 1.81 additional full-time instructional faculty teaching a six course per academic year load. Staffing these 11 additional upper division courses would have taken 2.2 additional tenure track faculty teaching a 5 course per academic year load or 1.82 additional full-time instructional faculty teaching a six course per academic year load. The Economics Department actually taught these additional lower division courses at zero incremental cost; there were no additional faculty members of any rank teaching lower division undergraduate students in AY01 (in fact, there was one fewer tenured faculty member in AY01, as I was on Fellowship Leave that academic year).

This zero cost reflects that these additional SCH were absorbed by an increasing average enrollment in the lower division courses offered by Economics in AY01, assuming that there were sufficient empty seats to accommodate this increase. The additional upper division undergraduate courses were taught at an estimated cost of $48 per SCH. This reflects an additional full-time faculty member in economics in AY01 and additional SCH taught by full-time instructional faculty.

The final three columns provide some possible alternative staffing scenarios and the associated costs. If these 22 additional courses had been staffed entirely by additional part-time faculty, the cost would have been $26 per SCH; if these 22 additional courses had been staffed entirely by additional full-time instructors, it would have cost \$89 per SCH; if these 22 additional courses had been staffed entirely by new assistant professors, it would have cost \$129 per SCH.

Turning to the campus-wide averages at the bottom of the table, these numbers provide some context for the actual staffing changes and incremental costs in AY01. The estimated average incremental cost of the additional undergraduate SCH offered in AY01 was \$56 per SCH. This is well below the incremental cost that would have been incurred if these additional SCH would have been taught in three credit courses staffed entirely by additional full-time instructors teaching three credit courses with an average of 30 students per course, and well above the incremental cost that would have been incurred if these additional SCH were taught in courses staffed entirely by part-time faculty. In other words, the actual incremental instructional costs incurred in AY01 fell somewhere between staffing the additional undergraduate courses taught with additional part-time faculty and with additional full-time faculty. When thinking about this comparison, bear in mind that much of the additional undergraduate SCH were taught by existing faculty teaching more students. While this might be quite costly to the individual faculty members, in terms of increasing the amount of effort that went into teaching in AY01 relative to AY00, under the methodology used here this cost is not counted as part of the incremental instructional costs.

The additional graduate SCH were taught at an average cost per SCH of \$141. This is quite close to the average SCH that would have been incurred if the additional graduate SCH generated in AY01 would have been generated entirely by additional three credit graduate courses with fifteen students staffed entirely by new full-time instructors. The reason for the higher average incremental instructional cost for graduate SCH is that the additional graduate courses offered were taught by additional tenure-track faculty and offered in departments with higher average salaries at all faculty levels.

Note that for both graduate and undergraduate SCH, the estimated averages are far below the average incremental instructional costs that would have hypothetically been incurred if all additional SCH were in new courses taught by new tenure track faculty. That implies that the growth in tenure track faculty has not nearly kept up with the growth in enrollment on campus. Existing tenured and tenure track faculty have been spread more thinly over the additional students at UMBC. Although the estimated incremental instructional costs do not reflect them, there are likely a number of large and important hidden costs flowing from increasing enrollment that are being borne by existing tenured and tenure track faculty members at UMBC.

Capacity Constraints and Instructional Costs

The methodology section discussed the potential for instructional capacity to affect incremental costs. Economists call the mechanism through which these effects work “capacity constraints.” The economic theory underlying capacity constraints is discussed in detail in Appendix 1: A Primer on Economic Models of Costs in Higher Education. If capacity constraints exist in departments, then the incremental cost estimates developed in this section will understate the actual costs of increasing enrollments to departments.

In order to determine the extent to which capacity constraints might be present in departments, some indicators of the instructional capacity in departments must be developed. Economic theory does not provide any clear guidance regarding appropriate indicators of departmental capacity in this case, except that capacity is in general related to the fixed resources present in departments. In the short run - by assumption the year-to-year changes analyzed here are short run changes - tenured and tenure track faculty, specialized facilities like labs and perhaps staff can be considered fixed resources.

One indicator of capacity constraints in departments is the actual change in SCH. The greater the increase in SCH for a given number of faculty in a department in a short period of time, the more likely that the department will experience capacity constraints. Recall that the five departments with the largest increases in SCH (ECON, IFS, MLL, BIOL, and Music) accounted for 65% of the increase in SCH. In percentage terms, these increases in SCH represent between a 10% and 25% increase in SCH over the previous year. Capacity constraints may be present in these departments. However, this indicator

Table 7: Capacity Indicators

Department	Change in Total SCH	Change in Graduate SCH	Change in Upper Div. SCH	Total SCH Per Core Faculty	Graduate SCH Per Core Faculty	Upper Div. SCH Per Core Faculty
AFST	-115	-6	239	496	0	236
AMST	749	42	140	742	10	**394**
ANCS	308	3	162	**1009**	2	167
BIOL	**1239**	42	**610**	468	32	248
CENG	166	123	-68	302	72	120
CHEM	-69	**185**	410	462	27	264
CSEE	-583	**522**	476	562	88	232
DANC	168	0	-59	380	0	128
ECON	**1956**	0	**981**	**990**	21	321
EDUC	524	**764**	**504**	450	**274**	164
EHS	51	83	-12	401	75	274
ENGL	891	52	**807**	540	3	283
GEOG	678	2	-43	**966**	1	257
HIST	-324	-20	-163	566	36	255
IFS	**1777**	**901**	609	747	**131**	**470**
MATH	-89	-159	-828	860	22	152
MENG	405	-28	241	210	42	110
MLL	**1631**	-24	251	796	27	153
MUSC	**1008**	0	400	**955**	0	287
PHIL	209	-4	221	**609**	13	171
PHYS	-15	100	-176	428	25	18
POLI	515	45	41	465	15	204
POSI	-42	-72	30	176	**147**	29
PSYC	-167	83	-481	806	68	**376**
SOCY	279	40	-136	769	47	**428**
SOWK	196	0	282	483	0	**415**
THTR	545	0	-173	411	0	101
VART	-176	87	188	420	17	288

does not account for the fixed resources available to these departments.

Indicators of capacity based on ratios of students to faculty in departments would address this deficiency. The ratio of permanent instructional faculty to students provides a measure of the average contact that each faculty member in a department has with students. This would be a proxy for the intensity of direct instructional activities like grading, as well as for the intensity of indirect instructional activities like advisement.

Table 7 shows some of the capacity indicators discussed above for academic departments at UMBC. In this table, core faculty refers to tenured faculty, tenure track faculty, and full-time instructional faculty in each department. The first three columns of this table show the change in total, graduate and upper division undergraduate student credit hours generated from AY00 to AY01. The second three columns show the total, graduate and upper division undergraduate SCH to core faculty ratio in AY01 in these departments.

The numbers in bold typeface identify the departments with the five largest values in each category, except for the ratio of total student credit hours to core faculty and graduate student credit hours per core faculty, where the four and three largest values, respectively, are identified. In each case, there was a very apparent gap in the distribution of values at each of these cut-off points. As a rough indicator of potential capacity effects, I propose a "black ink test": the more values in bold for a department, the more likely are capacity effects in that department, and the more likely that the estimated incremental enrollment costs understate the actual costs incurred in the department.

The departments with the largest "black ink" counts are IFS (5), ECON (3), BIOL (2), EDUC (2) and MUSC (2). Not surprisingly, these departments are also among the largest generators of SCH on campus. Anecdotal evidence typically identifies some subset of these departments as having capacity problems. These departments may be experiencing problems adequately serving their existing students and additional enrollment increases that affect these departments might lead to problems.

These capacity indicators are simple, approximate measures of capacity and have a number of important limitations. First, they do not reflect the number of majors in the departments, and thus may not reflect the underlying advising burden. Unfortunately, the large number of undergraduates without a declared major, coupled with majors that span multiple departments and interdisciplinary studies majors makes the allocation of majors across departments a difficult process. Second, departments that teach large lecture hall sections of courses and use teaching assistants might appear to have less capacity in these indicators than they have in practice. Third, these indicators do not take into account the alternative instructional technologies discussed earlier in this section. The use of specialized facilities, technology, supervised field placements and small classes by departments will not be reflected in these indicators. Nonetheless, these indicators provide some information about the instructional capacity in departments at UMBC.

Capacity Constraints in Academic Support Units

Academic departments are not the only areas on campus that might experience capacity constraints in the face of rising enrollment. A number of academic support units on campus deal directly with students or are indirectly affected by the number of students on campus. I currently do not have enough information to identify the academic support units where costs are affected by rising enrollments. In order to learn more about the relationship between increasing enrollment and costs in administrative departments, I surveyed the administrative departments. The results of this survey are incomplete at this time.

Despite the poor response to the survey to date, the partial results indicate the potential for capacity problems in a number of administrative departments. Among the responding administrative departments, the following information emerged:

Student Judicial Affairs Program: Costs in this department rise directly with enrollment, although increases in resident students raise costs more than increases in non-resident students - approximately 10% of resident students and 1% of nonresident students appear before SJA. A recent consultant's study recommended a doubling of the current staffing, a strong indicator of capacity problems. Each disciplinary case costs $282, an indication of costs rising with enrollment.

Academic Services: This department faces among the worst capacity problems on campus. Industry standards recommend 80 students per academic advisor, but UMBC currently has 300 students per advisor. The operating budget has been unchanged for the past 9 years. Marginal costs appear to rise steeply in this department, as the estimated incremental cost of 50 to 100 additional students was in the $1,000-$2,000 range, but enrollment increases of 500 additional students would lead to over $100,000 in additional costs based on best practice guidelines.

Methodology: Estimating Incremental Benefits of Enrollment

The incremental benefits from additional enrollment can be separated into two parts: direct incremental benefits and indirect incremental benefits. Direct incremental benefits come from payments of tuition and fees by UMBC students. Indirect incremental benefits come from a variety of sources, including state government appropriations, prestige generated by higher enrollment, the effects of UMBC's Carnegie classification, which depends on PhDs granted and thus on enrollment, on external research funding, the effect of more, and higher quality, students on other outputs that are jointly produced with enrollment like departmental research and service, and other factors. Estimating indirect incremental benefits is extremely difficult, as many of these factors are difficult or impossible to quantify and equally difficult to put an estimated dollar value on.

Estimating the direct incremental benefits from additional enrollment is, on the other hand, a relatively simple process. The UMBC student data set contains a considerable amount of information about the composition of the student body and the amount of financial aid received by students. The tuition and fees paid by students of all classifications are known for each academic year. This makes it possible to calculate the amount of tuition and fees paid by each student and then subtract from this amount the "tuition discounting" - reduction in the amount of tuition and fees to be paid in the form of scholarships or grants - provided to students by UMBC. This difference is net tuition revenues generated by each student. As long as internal funds provided to students in the form of "tuition discounts" can be differentiated from external financial aid funds, the source of the money paid to UMBC from outside the institution, be it out-of-pocket expenses or Federal loans or state scholarships, does not matter for the calculation of net tuition revenues.

I estimated only direct incremental benefits in this report. Although possible, the estimation of a dollar value for indirect incremental benefits is beyond the scope of this project. Limiting the analysis to only direct incremental benefits omits one of the most important sources of funding to UMBC, state appropriations. Some may find this omission glaring, as state appropriations are often discussed in terms of "funding formulas" that, to the uninitiated, appear to be directly linked to measurable factors like enrollment. Conversations with those familiar with the state appropriation process uncovers a very different process. The state "funding formula" is more of a guideline, and a vague one at that. State government officials at a number of levels - both the executive and legislative branches of government, the Maryland Higher Education Commission (MHEC) and the University System of Maryland - provide input into the decision about UMBC's level of state funding. These political actors look at a variety of benchmarks, including UMBC's funding level relative to peer institutions across the country, as well as other factors like past funding levels and the funding levels of other public colleges and universities in Maryland, when determining UMBC's level of state funding.

The state budget situation, in terms of deficits and surpluses, also has a powerful effect on the level of funding provided to UMBC. The current fund deficit or surplus for the state budget is sensitive to general economic conditions as well as to the general priorities of the governor and legislators. The general economic conditions can also affect the decision of individuals to enroll in higher education, further complicating the relationship between enrollment and state appropriations.

Because the process is complex and political, any attempt to relate changes in funding directly to changes in enrollment would require heroic assumptions and would be of dubious value. Instead, I will simply point out that although many people on campus would like to believe that increasing enrollment have some positive impact on state appropriation to UMBC, this report contains no evidence to support this belief. There is no way to come up with a meaningful estimate of this relationship for an individual institution of higher education in Maryland at a particular point in time. Decision makers on campus should recognize that larger enrollments may or may not bring more state dollars to campus, other things being equal. Even if there were some relationship between enrollment and funding in the past, the uncertain nature of this relationship makes it problematic to forecast this relationship in the future, given the recent changes in Maryland's political landscape.

UMBC also receives funding for non-instruction related grants and contracts that depends in part on the institution's Carnegie classification. This classification, in turn, depends on enrollment related factors like the number of PhDs granted. In this way, higher enrollment leads indirectly to higher revenues. This particular indirect incremental benefit is difficult to quantify, and I did not attempt to estimate the dollar value of this incremental benefit.

UMBC also receives non-pecuniary benefits from additional enrollment. According to the literature on the economics of higher education, prestige is an important type of non-pecuniary benefit. Among public colleges and universities, prestige may flow from both larger size and higher quality of students and faculty. More prestige may also increase alumni and other donor giving and potentially state appropriation. Although it is difficult to estimate a dollar value on prestige, prestige clearly increases with size. Thus increasing enrollment may have some positive impact on prestige and, in turn, on the revenues affected by prestige.

Incremental Benefit Estimates

Estimating direct incremental benefits from increased enrollment is not a complex process. The schedule of tuition and fees charged by UMBC to students is public knowledge. These charges vary by the state of residence of the student (Maryland residents are charged less than non-residents), by the level of the student (graduate students are charged more than undergraduates), and by the status of the student (full-time students are charged more than part-time students). Beyond the tuition and fees, or "list price" of a semester of education at UMBC, some students are given a tuition "discount." This may take the form of a grant-in-aid, scholarship, assistantship, or other financial incentive. No matter what they are called, these discounts mean that UMBC charges some students less than others for a semester of education. Note that tuition discounts represent a lower price charged by UMBC, as compared to financial aid monies like federal and state loans and scholarships that reduce the amount of out-of-pocket expenses to students but do not reduce the revenues generated from outside UMBC.

So long as tuition discounts can be distinguished from outside sources of financial aid, the net tuition paid by each student at UMBC can be estimated for students in each category for which tuition varies. Once net tuition paid has been estimated for each student, the average net tuition paid by students in each category (part-time resident undergraduates, full-time non-resident master's students, etc.) can be calculated, and the total impact of enrollment changes on tuition revenues can be found by simply multiplying the average net tuition times the change in total enrollment for each category of student.

Table 8: Total Enrollment, Fall 2001

	Non-Resident		Resident	
	Full-Time	Part-Time	Full-Time	Part-Time
Bachelor's	1086	90	6458	1458
Non-Degree Undergrad.	6	23	22	185
Doctoral, No Asst.	54	68	69	152
Doctoral, Full Time Asst.			247	
Doctoral, Part Time Asst.			10	
Master's, No Asst.	124	115	227	394
Master's, Full Time Asst.	2		166	
Master's, Part Time Asst.			16	1
Non-Degree Grad, Full Time Asst.				4
Non-Degree Graduate	1	56	4	199
Total	11237			

Table 8 shows the breakdown of headcount enrollment at UMBC in Fall 2001 by the relevant categories of students. The categories on this table represent the important sources of variation in tuition paid by students. This table disaggregates enrollment by state of residence, part-time and full-time enrollment status and level of student. Each category of student shown on this table has a tuition bill calculated by a different method.

The undergraduate categories are self explanatory, but the breakdown of the graduate enrollment requires some explanation. All graduate students with assistantships - research assistants, teaching assistants or graduate assistants - are treated as Maryland residents, regardless of their actual state of residence. UMBC forgoes some tuition revenue by classifying all such students as Maryland residents. Also note that despite this policy, two master's students with full-time assistantships (Master's FTA on the table) were classified as non-resident students in the data. These probably represent mis-coded observations, based on the average net tuition revenues calculated below.

There are three classifications of doctoral students in the student financial records data. Doctoral students with part-time assistantships (Doctoral Part Time Asst. on the table), doctoral students with full-time assistantships (Doctoral Full Time Asst.) and doctoral students identified as not having an assistantship (Doctoral, no Asst.). The category with no assistantships includes doctoral students who receive some sort of tuition discounting. Graduate students with full-time assistantships in AY01 could register for up to 10 graduate-level credits without paying tuition, and were billed at the in-student rate for additional credits; those with part-time assistantships could register for 5 credit hours of graduate-level credits without paying tuition, were billed at the in-student rate for additional credits. Graduate students identified as not having an assistantship were assumed to pay the appropriate resident or non-resident graduate tuition per credit hour for all credits taken. These factors also apply to master's students. Non-degree graduate students are enrolled in post-baccalurate certificate programs at UMBC. These students pay the appropriate graduate tuition per credit hour.

Table 9 shows the key components of the calculation of the incremental direct benefits of increased enrollment from AY00 to AY01. The top panel of this table shows the change in total enrollment for each category of student. This change in total enrollment reflects the net change for each category of student, not the number of new students in each category. This change includes both decreases in headcount enrollment in each category due to graduation and drop-outs, and increases in headcount enrollment due to new student enrollment. The counts of new students are larger for each category.

From the top panel of Table 9, enrollment growth over this period was clearly concentrated in full-time students. From the top row, there were 68 more full-time non-resident degree seeking undergraduates and 225 more full-time resident degree seeking undergraduates and fewer part-time degree seeking undergraduates in both residence categories. There were also increases in full-time graduate students at both the master's and doctorate levels. Among non-degree seeking graduate students AY01 saw more part-time resident students and fewer full-time non-resident students.

The middle panel of Table 9 shows the second component of the direct benefit calculation, average net tuition revenues, for each category of student. These numbers were calculated as follows. First, total tuition revenue was calculated for each student in each category. For full-time undergraduates, this is the tuition and mandatory fees by state of residence. For first-time freshmen and transfers, the application and orientation fees are included. For graduate students, this is total credits times the appropriate tuition per credit hour and mandatory fees per credit hour; there were no fixed mandatory graduate fees in AY01. For new graduate students, this also includes the application fee.

Next, all identifiable tuition discounting, as well as other benefits provided by UMBC to students, was subtracted from the total tuition revenue for each student in each category. The details of financial aid accounting are complicated. Students at UMBC receive financial aid from a variety of off campus sources; there are also a number of different internal sources of funds made available to students. Again, the important distinction for this analysis involves identifying external funds from any source and internal funds that represent tuition discounts. I worked closely with the financial aid office to distinguish between these two types of financial aid.

This includes counting only internally funded graduate assistantships and excluding graduate assistantships funded through outside grants. For this calculation, I simply reduced the average value of graduate assistantships given to master's students by 30% and the average value of graduate assistantships given to PhD students by 48%, the fraction of total assistantship funding from outside sources for each type of student. This method of correction was used because I lacked data on the source of funding for individual graduate assistantships.

Note that, unlike tuition discounting given to undergraduates, graduate assistantships are compensation for work performed by graduate students. In exchange for graduate assistantships, the university receives services in exchange for these payments. Without these services, the university would have to hire additional employees to do this work.

Table 9: Incremental Direct Benefit Estimates, AY01

	Change in Total Enrollment				
	Non-Resident		Resident		Headcount
	Full-Time	Part-Time	Full-Time	Part-Time	Total
Bachelor's	68	-12	225	-55	226
Non-Degree Undergrad.	4	-2	8	-9	1
Doctoral	-26	-1	5	-23	-45
Doctoral w/ FT Asst.			66	-3	63
Doctoral w/ PT Asst.			4		4
Master's	-13	56	70	15	128
Master's w/ FT Asst.	0		63	1	64
Master's w/ PT Asst.			8		8
Non-Degree Grad w/ FT Asst.			-1	4	3
Non-Degree Graduate	-21	2	0	45	26

	Average Net Revenue				
	Non-Resident		Resident		Overall
	Full-Time	Part-Time	Full-Time	Part-Time	Average
Bachelor's	7434	3035	4496	1478	4111
Non-Degree Undergrad.	11290	1535	5874	769	4867
Doctoral	1329	1129	-10113	-699	-2089
Doctoral w/ FT Asst.			-7098		-7098
Doctoral w/ PT Asst.			-3528		-3528
Master's	3515	1751	1164	1159	1898
Master's w/ FT Asst.	-8792		-8483	-12766	-10014
Master's w/ PT Asst.			-5018		-5018
Non-Degree Grad w/ FT Asst.				-7254	-7254
Non-Degree Graduate	5210	1781	2800	1122	2728

	Impact on Tuition revenues				
	Non-Resident		Resident		Overall
	Full-Time	Part-Time	Full-Time	Part-Time	Total
Bachelor's	505503	-36416	1011600	-81293	1399395
Non-Degree Undergrad.	45160	-3070	46994	-6924	82160
Doctoral	-34542	-1129	-50564	16082	-70152
Doctoral w/ FT Asst.			-468481		-468481
Doctoral w/ PT Asst.			-14113		-14113
Master's	-45698	98081	81507	17388	151279
Master's w/ FT Asst.			-534419	-12766	-547184
Master's w/ PT Asst.			-40148		-40148
Non-Degree Grad w/ FT Asst.				-29015	-29015
Non-Degree Graduate	-109410	3561		50503	-55345
Total Undergraduate	1481555				
Total Graduate	-1073160				
Total Graduate, no Asst.		81127			
Total Graduate, w/ Asst.		-1069926			
Total Non-Degree Graduate		-55345			
Total	408395				

I also subtracted the dollar value of all benefits provided to graduate students with full-time or part-time assistantships and the value of the free graduate credits provided to graduate students with assistantships (valued at the resident tuition rate regardless of the actual state of residence of these graduate students because I could not determine actual resident status from the available data) from tuition revenues generated by graduate students.

Finally, I calculated the average net tuition for all new students in each of the enrollment categories. The number of new students is larger than the total change in enrollment listed on the top panel of this table, because some new students replace former students who graduated, dropped out, or transferred from UMBC. Because there is no objective way to divide new students between replacements for departing students and new enrollment, I simply averaged net tuition revenues over all new students.

The middle panel of Table 9 shows the average net tuition for each category of student. As one might expect, the average net tuition revenues on this table show quite a bit of variation. Undergraduates of all types generate positive net tuition revenues for the university, although the average is lower than the full tuition and fee payment in each case due to tuition discounting. Non-resident undergraduates generate larger net tuition revenues per student than resident students. Most categories of graduate students generate negative net tuition revenues. All of the graduate students with assistantships generate negative net tuition revenues; the value of the assistantships paid to these students exceeds, on average, the tuition and fees paid by these students. Graduate students with full-time (part-time) assistantships who take fewer than 10 (5) credits pay no tuition, so their net tuition revenues are minus the dollar value of their assistantship. Interestingly, full-time resident doctoral students identified as not having assistantships also generate negative net tuition revenues. This may be simply a coding problem; those full-time resident doctoral students identified as not having assistantships (there were 69 such new graduate students in Fall 2001) are misidentified. Alternatively, these students could be receiving tuition discounts in a form other than an assistantship with a value approximately equal to an assistantship. Master's students without assistantships and non-degree graduate students all generate positive net tuition benefits on average.

The bottom panel on Table 9 shows the total impact on tuition revenues of the changes in enrollment. These figures are simply the total change in enrollment in each category times the average net tuition revenue for each category. The negative numbers on this panel can reflect either a category of student with negative average net tuition revenues, like doctoral students with full-time assistantships, or categories of students with positive net tuition revenues that had declining enrollments over the period. Reading across the top row of the panels on this table, there were 68 additional full-time non-resident degree seeking undergraduates in Fall 2001; on average, these students generated $7,434 dollars of net tuition benefit each, or $505,503 additional dollars in tuition revenues in AY01; there were 12 fewer part-time non-resident degree seeking undergraduates; on average, non-resident part-time degree seeking undergraduates generated $3,035 dollars in net tuition revenues, but because there were 12 fewer of these students on campus in AY01, this category of student generated $35,416 fewer dollars of tuition revenues in AY01. At the bottom of the table are totals for some selected groups of students. Overall, additional undergraduate enrollment led to $1,481,555 in incremental net tuition increases in AY01, or $165 in additional tuition revenues for each additional undergraduate SCH generated. Additional graduate enrollment led to -$1,073,160 in incremental net tuition revenues, although this was primarily due to assistantships, or alternatively -$389 less in tuition revenues for each additional graduate SCH generated. Also note that non-degree graduate students were associated with negative incremental net tuition revenues because there were 21 fewer non-resident full-time students in this category in AY01.

Some care must be used when interpreting these numbers. Although I have totaled them across all categories of students, I do not believe that the goal of enrollment decisions should be to achieve a positive total incremental direct benefit in any year, especially if such a goal were achieved by reducing graduate enrollment. As I discussed above, there are a number of important indirect benefits associated with higher enrollment, and many of these are related to higher graduate enrollment. The results on this table simply demonstrate that different types of students produce different direct incremental benefits, and that increasing enrollment may not lead to increased direct incremental benefits from enrollment. Put another way, just because UMBC experiences increases in enrollment, it does not follow that UMBC will see increases in total tuition revenues. There exist distributions of enrollment increases that generate increases in tuition revenues, but the particular distribution of enrollment increases in AY01 was not among these distributions. And pursuing such distributions may not be consistent with other goals the institution would like to achieve.

Several other important caveats need to be made regarding the results on this table. First, the results are presented in terms of academic year totals but the calculations are based on fall enrollment data. If the spring semester enrollment differs from the fall semester in important ways - say in terms of average credit hours taken by part-time undergraduates and all graduate students - then these results will not accurately reflect the differences. UMBC typically admits more transfer students in the spring, but I have no evidence that the classes taken by mid-year admit transfer students differs from the classes taken by the typical fall admit transfer student. Second, the calculations for undergraduates treat Meyerhoff Scholarship money and some co-op scholarships as pure tuition discounting. UMBC subsidizes the Meyerhoff program and other special scholars programs by about $400,000 per year, but I have no detailed information about the exact relationship between individual awards and this subsidy. Thus, the actual net tuition revenues generated by undergraduates is understated to the extent that outside money is used for the Meyerhoff scholarships and these co-op programs. Third, and most importantly, some of the undergraduate funds treated as tuition discounts may go to pay for housing. I could not identify those students who lived on campus, nor the actual allocation of financial aid between tuition, fees and room and board made by individual students. This may also lead to an understatement of the actual direct incremental benefits generated by undergraduate students.

Student Quality and the Calculation of Benefits

During preliminary meetings, several faculty members mentioned that the methodology proposed for this study ignored the issue of student quality. Implicitly, the above calculation of incremental benefits treats all students as if they were of the same quality. This is clearly a drawback to the analysis, as all students are not the same quality and there is also evidence that improving the quality of the student body is a desirable goal. UMBC operates in a competitive environment for students. High quality students are, by definition, relatively scarce at any point in time, and UMBC must compete with other universities to attract high quality students. This suggests a possible trade-off between tuition discounts and student quality - high quality students can get accepted into many universities, so for UMBC to attract high quality students, it can offer those students larger tuition discounts than other competing universities. Price is clearly not the only criteria that students use when selecting a university. Other factors like the quality of the faculty, research opportunities, campus environment, and location also play factor. But at any point in time, many of these other factors are fixed, or extremely costly to adjust. In the short run - say in any given academic year - tuition discounting will be the primary adjustable factor at UMBCs disposal to attract high quality students.

Student quality is extremely difficult to quantify. Anyone who has done empirical research recognizes this fact. I will not pretend that it is a perfect, or even a very good measure of student quality, but the only possible measure of student quality I have access to are student's scores on standardized admission tests; SAT scores for undergraduates and GRE scores for graduate students. As I had already calculated the tuition discount given to each student, and have access to the GRE and SAT scores of all incoming graduate students and first-time freshmen, I used these data to estimate the trade-off between tuition discounting and test scores. Implicitly, this assumes that attracting students with higher scores on standardized admission exams will lead to a higher quality student body, and that in order to attract students with higher exam scores, UMBC must, in the short run, offer these students larger tuition discounts.

I investigated the relationship between tuition discounts and test scores using a linear regression approach (in some disciplines this would be called an analysis of variance technique). In particular, I estimated a regression model where the dependent variable is the dollar value of the tuition discount given to a student and the explanatory variable is that student's score on a standardized admissions test. The data for AY01 contained SAT scores for 1,318 new freshmen and GRE scores for 212 new graduate students. There was no statistical relationship between GRE scores and tuition discounting for the new graduate students, perhaps due to the relatively small sample size, or alternatively because the total GRE score is not a good measure of graduate student quality. There was a strong statistical relationship between the dollar value of tuition discounts given to undergraduates and the score of these students on the SAT exam. The results of this regression were

$$DISCOUNT_i = -20218 + 19.5 \times SAT_i$$

The i subscript indexes students in the sample. The t-statistics on the parameters of this regression model were quite large, suggesting that these values are statistically different from zero. The coefficient of determination indicated that variation in SAT scores accounted for about 25% of the observed variation in tuition discounts across first-time freshmen on campus in Fall 01. These results suggest the presence of a trade-off between SAT scores and tuition discounts. Based on these results, a student with a SAT score of 1035 could be attracted to UMBC without any tuition discount, and for reference the average SAT score in the sample was 1200. But in order to attract a student with a higher score on the SAT, UMBC had to offer her about $1,900 in additional tuition discounts for each additional 100 points on the SAT, other things equal. A student with a perfect 1600 on the SAT would have required just over $11,000 in tuition discounts to induce her to attend UMBC in 2001. Put another way, raising the average SAT score of the incoming class in 2001 by 50 points would have cost UMBC about $1,285,000 in additional tuition discounts.

These results provide a rough estimate of the cost of increasing student quality at the undergraduate level. To the extent that SAT scores reflect student quality, increasing the quality of undergraduate students in the short run can be achieved at a price. Of course increasing the quality of the faculty and campus facilities, and increasing research opportunities and other amenities might allow UMBC to attract higher quality students for smaller tuition discounts. But increasing these factors is costly and takes time. Also bear in mind that these results are based on the Fall 2001 entering freshmen only. Transfer students are ignored because they do not have to submit SAT scores to be admitted. Other entering classes might have a different mix of students or be drawn from a different distribution of high school graduates, and the competition faced by UMBC may differ in other years.

These results do not provide any information about the quality of incoming transfer students. Transfer students are typically admitted without SAT scores, so little information about the quality of these students, in terms of scores on widely accepted standardized tests, is available. Unfortunately, transfer students make up a large fraction of new undergraduate students at UMBC in any given semester; in fall 2000 and 2001 new freshmen made up about 12% of the student body and new transfer students made up just over 10% of the student body. If transfer students are of lower quality than new freshmen, this could reduce the overall quality of undergraduate students; a careful study of outcomes might shed some light on this issue.

Finally, a growing body of research on "peer effects" in undergraduate instruction suggests that this estimated cost of attracting high quality students may not be permanent. "Peer effects" is a buzzword for the idea that undergraduate students tend to have a higher quality educational experience as the concentration of better-able students at an institution rises; empirical evidence of this effect exists. One implication of "peer effects" is that once an institution gains the reputation of having a high quality student body, then additional students can be attracted at lower cost in terms of tuition discounting because the expected quality of the educational experience will be higher. In practice, this implies the potential for attracting higher quality students with less tuition discounting in the future. A good overview of this line of research can be found in the working paper archives of the Williams Project on the Economics of Higher Education (http://www.williams.edu/wpehe/abstracts.html). Unfortunately, little evidence about how long it takes for an institution to acquire a reputation sufficient to support this effect. At this point, I have no guess as to how long it might take for UMBC to achieve such a reputation.

Accounting for State Appropriations

As was mentioned above, the causality in the relationship between state government appropriation and enrollment is difficult to determine. UMBC's level of state funding in any given year is determined by a number of factors interacting in a complex way. The concept of a "funding formula," despite its name, is more of a rough guideline that accounts for the level of funding of UMBC's peer institutions, the funding level at "aspirational" peers, and other factors than a mathematical method of determining the level of state funding in any given year. That said, state appropriation is an important component of UMBC's revenues, accounting for between 20% and 29% of UMBC's total current fund revenues over the past 10 years. A complete discussion of incremental benefits needs to compare these benefits to incremental state appropriations in some way.

State government appropriations were $59,360,163 in FY00 and $66,473,513 in FY01. Accounting for inflation using the deflator described above, this represents an inflation adjusted change of $4,277,198 from AY00 to AY01. Expressed in terms of incremental enrollment growth, this increase in state appropriation amounts to an additional $8,948 per each additional student enrolled in Fall 2001, or alternatively an additional $365 for each additional SCH generated. It is important to bear in mind that these figures only represent an apportionment of the additional state funding received by UMBC. They are not like the direct incremental cost and revenue estimates developed in the earlier sections because those estimates reflect direct causality - the additional students led directly to those earlier incremental cost and revenue estimates - while this increase in state appropriation per additional student represents a simple apportionment and not a causal relationship.

Implications for Future Enrollment Growth

Assessing Targeted Graduate Enrollment Increases

The discussion of incremental costs and benefits associated with additional enrollment compares the average direct instructional costs with average incremental revenues for the entire campus. Costs and benefits were compared at this relatively aggregated level because incremental instructional costs were estimated by department and incremental tuition revenues were estimated by classification of student; the units of measurement make it difficult to compare these estimates at lower levels of aggregation. However, costs and benefits at this level of aggregation obscures a considerable amount of detail regarding the enrollment changes that took place on campus.

One area of interest is new graduate students who do not receive support (assistantships). The university has targeted this area for growth in recent years. For example, the three largest areas of growth in graduate SCH shown on Table 3, Information Systems, Computer Science and Electrical Engineering, and Education, are departments targeted for growth in graduate students with no support. How much did enrollment growth in these departments contribute to the university?

The incremental benefits can be seen on Table 9. The incremental direct benefits from unsupported graduate students appear on three lines of this table: Doctoral, Masters and Non-Degree Graduate students are all categories of unsupported graduate students. From the top panel of Table 9, there were fewer unsupported doctoral students, more unsupported master's students and more non-degree graduate students on campus in fall 2001. From the middle panel, each additional unsupported master's student brought in $1898 in additional tuition revenues and each additional non-degree graduate student brought in $2728 in additional tuition revenues. New unsupported master's students enrolled in, on average, 7 credits and non-degree graduate students enrolled in 9 credit hours; the incremental revenue per SCH for these students was $271 and $303 respectively.

The new unsupported master's students were primarily concentrated in the Education Department (40% of new unsupported master's students were Instructional Systems Development majors), Information Systems (25% of new unsupported master's students were IFS majors) and Computer Science (12.5% of new unsupported masters students were CSEE majors). From Table 4, the incremental cost for additional graduate SCH in these three departments were $0/SCH, $26/SCH, and $129/SCH, respectively. I have no information about the typical set of courses taken by non-degree graduate students, so I cannot estimate the incremental instructional costs associated with these students. Before accounting for capacity effects or additional administrative costs, increased unsupported graduate enrollment in these three departments led to increased new revenues in AY01.

Discussion of the Results

Based on the incremental cost and revenue estimates in this report, attracting and enrolling additional undergraduates generated positive net incremental benefits in AY01 but attracting and enrolling additional graduate students generated negative net benefits. On a per credit hour basis, each additional undergraduate SCH cost, on average, \$56 and provided an additional \$165 in tuition revenues. Adding the incremental appropriations (\$365 per SCH) to this produces an estimated net benefit of \$474 per undergraduate SCH. Each additional graduate SCH cost, on average, \$158 and reduced tuition revenues by \$651. Adding the incremental appropriations to this produced an estimated new cost of \$444 per graduate SCH. Before accounting for appropriations, the figures are +\$106 per undergraduate SCH and -\$809 per graduate SCH. I'm sure this comes as a surprise to no one reading this report, but the primary implication bears repeating: attracting additional graduate students is much more expensive than attracting additional undergraduates, even when a relatively narrow definition of costs is used.

The incremental cost estimates are consistent with the decline in average costs shown in the first section of the report. Economic theory clearly predicts that if marginal costs are less than average costs, then average costs decline. However, the marginal cost estimates are well below the average costs and average costs did not decline significantly. This can be explained by the understatement of the incremental cost estimates due to omitted instructional costs that cannot be estimated from the existing data that were mentioned throughout this report

Also, both economic theory and the evidence presented in this report suggest that additional increases in enrollment without a corresponding increase in fixed inputs to production like laboratories and other specialized facilities, classrooms and tenured and tenure track faculty will lead to even larger increases in marginal and average costs of instruction. Given the evidence of capacity problems in both academic and administrative departments, many of these units will have trouble functioning effectively if faced with additional enrollment increases. In some instances, departments may have already moved past this point. Diminished effectiveness in academic and administrative departments has the potential to quickly erode the perceived quality of education at UMBC.

It is important to bear in mind the omitted costs not reflected in the estimates presented above. The additional course sections offered because of enrollment increases were taught primarily by part-time faculty, which increased the advising burden on tenured, tenure track, and full-time instructional faculty. Staffing the additional course sections with new assistant professors would more than double the estimated incremental instructional cost estimates. The future cost to tenured and tenure track faculty of the additional graduate students will be much higher, because the incremental direct instructional costs are probably much lower than the advisement costs that will be borne by the faculty who advise the additional master's theses and Ph.D. dissertations that are generated by additional graduate students. There is evidence that both academic departments and administrative departments that serve students are experiencing capacity constraint problems. And finally, the appropriation figures probably represent the upper bound on these benefits.

Some care must be used when using the results in the report to inform present and future enrollment policy. The incremental cost and benefit calculations in this report are based on the changes from AY00 to AY01 (or FY01 to FY02). There may be factors unique to this particular time period that will differ significantly in the future. Further enrollment growth without corresponding increases in tenured and tenure track faculty, and staff in academic support units directly affected by enrollment changes, could lead to much larger future increases in incremental costs due to capacity constraints. This can also be true for the physical plant of the university, including classrooms, labs, parking, and other capital.

Also, these incremental cost and revenue estimates are based on the costs of enrollment when much of the increases are at the lower division level for undergraduates and at the new graduate student level for graduate students. As a cohort of students that is relatively larger than proceeding cohorts passes through UMBC, this cohort could lead to additional cost increases beyond those estimated here. As the large cohort of new undergraduates admitted in fall 2001 become juniors and seniors, they will utilize relatively more faculty time and effort than they did as freshmen and sophomores. Upper division undergraduate courses tend to be smaller, more specialized, and more time intensive. More writing is expected. And as these students approach graduation, there will be relatively more letters of recommendation to write, and more faculty networking done to help place these students in jobs or graduate programs.

There will also be greater costs for the new graduate students admitted in fall 2001 as they reach the point in their graduate education where they are writing master's thesis and doctoral dissertations. Supervision of graduate students at this level is significantly more time consuming than graduate course work; the placement of new PhDs in jobs or post-docs is also very time consuming for faculty.

This project also ignores the effects of retention rates. What if the retention rates for the additional students admitted in fall 2001 differ from the smaller cohorts admitted in the past? If the retention rates are higher, then the total future costs of educating these students will be greater than the total costs of educating prior cohorts.

Cost and Revenue Estimates in Context

What is the bottom line impact for the estimated incremental instructional costs and benefits developed in the previous section? These estimates need to be interpreted carefully - in the context of total direct costs and benefits related to enrollment - because changing enrollment affects more than incremental instructional costs and incremental tuition revenues on campus. Placed in the proper context, decision makers will be better able to understand the overall effects of increasing enrollment and how enrollment changes compare to other types of costs and benefits.

Beyond the incremental instructional costs and tuition revenues discussed above, additional students have a financial impact on UMBC by affecting state appropriations, academic support costs, administrative costs, and faculty-borne costs other than those from additional new faculty hired to teach additional sections that were offered as a result of additional students. What was the total financial impact of increased enrollment at UMBC? How sensitive are the incremental cost and benefit estimates to changes in key assumptions? In this section I attempt to address these issues.

Estimating the Total Financial Impact of Higher Enrollment

The incremental instructional costs and revenues estimated above provide a narrow indication of the financial impact of increased enrollment at UMBC. But attracting additional students affects more than just instructional costs on campus, and tuition and fees are only one source of revenues among many. In order to place the incremental cost and revenue estimates in context, I developed a broader measure of the costs and revenues related to enrollment at UMBC. The broader cost measure includes non-instructional costs that respond to increases in enrollment and a measure of the instructional costs associated with higher enrollment that are not attributed to additional new course sections, including academic activities like advising and writing letters of recommendation. The broader revenue measure includes state funding apportioned to a per SCH basis. Each of these expanded categories are discussed below.

Incremental State Appropriations

UMBC receives revenues from a number of sources. Over the period 1992-2001, tuition and fees accounted for about 25% of UMBC's total revenues. The other primary source of revenues is state appropriations. As I mentioned before, there is no clear causal relationship between increased enrollment and increased state appropriations. However, both enrollments and state appropriations increased from AY00 to AY01, so even in the absence of a clear causal link, comparing incremental tuition revenues per additional SCH with incremental appropriations per additional SCH provides an interesting context for the incremental revenue estimates.

In inflation adjusted terms, UMBC received $62,196,315 from the state in FY00 and $66,473,513 in FY01, a real increase of $4,277,198 when expressed in constant 2001 dollars. UMBC offered 11,713 more SCH over this period. So the incremental real state appropriation per additional SCH was $365; in terms of additional students, the figure is $8948 in incremental real state appropriations per additional student. Recall that the estimated net tuition revenues and fees per SCH was $165 for undergraduates and -$389 for graduate students. In this context, state appropriations nearly cover the cost of graduate student instruction and represents a revenue stream almost three times as large as that generated by each undergraduate SCH.

Some care must be used when directly comparing the incremental net revenue from enrollment per SCH to the average state appropriation per SCH. The state appropriation increase in any period may be attributable to factors other than current enrollment increases. The state may be making up for past periods of small increases in appropriation or for general under-funding of higher education; the university may have been unusually successful in it's lobbying efforts; or the state coffers may have been unusually full due to good economic conditions. This period was viewed as one of exceptional bounty for UMBC by many on campus, so the large size of the incremental appropriation per additional SCH should perhaps be interpreted as an upper bound on expected future increases in appropriation.

Non-instructional Costs

There are a number of non-instructional costs that may increase with the number of students on campus. These costs are related to the the wear and tear on buildings and equipment that takes place during the educational process and the costs of academic support provided to additional students. These costs, referred to here as non-instructional costs, include

- *Plant Operations and Maintenance*: This includes maintenance on buildings and roads, janitorial services, snow removal and landscaping, public safety, and utilities.
- *Departmental Administration*: Secretarial services and other administrative costs associated with the day-to-day operation of academic departments.
- *Library*: Operation of the library, including staffing and acquisitions.
- *Student Services*: Academic advising, operation of the financial aid office, billing and collecting tuition and fees, and other non-instructional services provided to students by the university.

As part of the process of setting overhead rates for external grants and contracts, Financial Services recently estimated the fraction of overhead costs that can be attributed to instruction on campus. These figures provide a rough estimate of the non-instructional costs associated with increasing enrollment. Estimates of the allocation of overhead costs to instruction and research were available for FY00. I apportioned these costs over the 233,152 SCH generated at UMBC in AY00 and converted this cost per credit hour to 2001 dollars. Table 10 shows the real total cost in 2001 dollars and the real cost per SCH for each of the categories of non-instructional costs attributable to enrollment discussed above.

Table 10: Non-instructional Costs Attributable to Enrollment, FY00

Cost Category	Real Total Cost	Real Cost Per SCH
Plant Operations and Maintenance	5,291,190	23
Departmental Administration	5,422,612	23
Library	9,103,252	39
Student Services	13,973,208	60

These figures represent estimates of the average non-instructional cost of each additional student credit hour of instruction provided in AY01. If marginal non-instructional costs - or incremental costs in the context of this report - do not rise with enrollment, then these figures can also be used as estimates of incremental non-instructional costs. They may be compared to the incremental instructional costs estimated earlier.

Recall, from Table 6 above, that the incremental instructional costs were estimated as \$56 per SCH for undergraduates and \$141 per SCH for graduate students. If totally taught by new part-time faculty members, these estimated costs would be \$38 per SCH and \$62 per SCH respectively; if taught entirely by new tenure-track faculty the incremental cost estimates were \$127 per SCH and \$254 per SCH respectively. The total of the non-instructional costs shown on Table 10 is \$182 per SCH. The estimated non-instructional costs are significant - they exceed the incremental instructional cost estimates in all cases except under the assumption that net tenure-track faculty are hired to teach additional course sections. It is also important to remember that these are *estimated* non-instructional costs, not actual costs. It may be that past enrollment, as well as the current enrollment increases examined here, were not accompanied by increases in spending on academic support units equal to this level. These estimated non-instructional costs are based on the allocation of existing overhead costs to instructional activities charged to external grants.

Other Instructional Costs

The instructional cost estimates presented above are incremental costs - costs associated with additional course sections offered because of additional students. These are not the only costs associated with educating additional students admitted to UMBC. Additional students may enroll in more courses than those additional new sections identified above; these courses are taught by existing faculty. Additional students also interact with existing faculty for advising and other academic activities. In order to account for costs not related to the additional faculty members hired and class sections offered as a result of increased enrollment, I include the average existing faculty salary expenditure per student credit hour taught at UMBC as part of the costs associated with changes in enrollment. This average cost was $163 per student credit hour taught in AY01.

Estimating the Total Impact of Additional Enrollment

What was the total financial impact of the increased enrollment at UMBC from AY00 to AY01? Table 11 summarizes the various cost and revenue estimates discussed in detail in this section, along with the incremental instructional cost and revenue estimates from above. I arrive at an estimated total financial impact, referred to as net revenue on Table 11, by adding the average state appropriation per SCH to the estimated incremental tuition revenue and subtracting the estimated incremental instructional cost, the estimated average non-instructional cost, and the average cost of existing faculty salaries per SCH.

The incremental tuition revenues and instructional costs differ by level, but the other revenue and cost estimates cannot be differentiated by level of student. On average, additional graduate students reduced tuition and fee revenues by $389 per SCH because many new graduate students are given tuition waivers and stipends; each additional undergraduate SCH raised tuition revenues by $165. The total financial impact, or net revenue, for undergraduate and graduate enrollment is shown in the final column. The estimates suggest that each additional graduate SCH had a net negative financial impact of $527 and each additional undergraduate SCH had a positive financial impact of $129.

Table 11: Revenue and Cost Per SCH

	Revenues		Costs			
Level	Incremental Tuition Revenue	Incremental State Appropriation	Incremental Instructional Cost	Average Non-Instructional Cost	Existing Faculty Salaries	Net Revenue
Graduate	-389	365	158	182	163	-527
Undergraduate	165	365	56	182	163	129

In order to calculate an overall measure of the total financial impact of increasing enrollment at UMBC, incremental net revenues for undergraduate and graduate students must be combined, based on some averaging procedure. The estimated total impact is sensitive to the averaging procedure, because the underlying incremental revenue estimates are calculated on a per student basis but the underlying incremental instructional cost estimates are calculated on a per credit hour basis. Although the revenue estimates were expressed on a per average credit hour basis above to facilitate comparison to the cost estimates, this does not help to solve the averaging problem.

Table 12 shows the estimated total net revenues for graduate and undergraduate credit hours and the total impact of enrollment on net revenues (defined as revenues minus costs) using four alternative averaging methods. The first three methods use the fraction of new students in AY01, existing students in AY01, and SCH generated in AY01 as weights. For example, in AY01 graduate students made up 17% of the student body and undergraduate students made up 83% of the student body, so the "Headcount Weight" row uses these fractions as the weights on all of the cost and revenue estimates to arrive at a total net revenue estimate. The weights for new students are 0.195/0.805 and the weights for SCH are 0.09/0.91. Note that the weighting procedure only affects the averaging of the incremental tuition revenues and the incremental instructional costs - for the other revenue and cost estimates, the total is not sensitive to the weighting procedure used, because the values are the same for graduate and undergraduate students.

Table 12: Net Revenues per SCH by Averaging Methods

Averaging Method	Net Revenue	Net Incremental Revenue
New Student Headcount Weights	-2	-22
Total Student Headcount Weights	17	-3
SCH Weights	70	50
Mixed Weights	12	-8

The "Mixed Weights" averaging method uses weights that vary across revenue and cost types. Incremental tuition revenues are averaged using weights based on new student headcounts, because the underlying revenue estimates are made on a per student basis. The incremental instructional costs are averaged using weights based on student credit hours, because the underlying cost estimates are made on a per credit hour basis. This averaging method provides the most appropriate estimated total net revenues. Based on this averaging method, the total impact of the increased enrollment from AY00 to AY01, accounting for additional state appropriations and other administrative and indirect costs, was to increase net revenues by $12 for each additional SCH. Over this period, adding students made UMBC better off financially.

In the following simulations, the "Mixed Weight' averaging method is used to calculate the estimated net revenues from changes in enrollment.

Table 12 also contains a column with estimates of the overall *incremental* impact of increasing enrollment. This *net incremental revenue* estimate reflects the overall financial effect of the incremental instructional costs and revenues from new enrollment in AY01; it includes the incremental instructional costs and tuition revenues from both undergraduates and graduate students. Like the net revenue estimates, the net incremental revenue estimates are sensitive to the averaging method used to compare the overall incremental impact of undergraduates and graduate students.

Net incremental revenues are a narrower definition of the overall impact of increasing enrollment than net revenue. Net incremental revenue includes only revenues from tuition and fees and only instructional costs while net revenue includes state appropriations in revenues and non-instructional costs from plant operation and maintenance, departmental administration, student services and the library in costs. Still, overall incremental costs exceeded overall incremental revenues for three of the four averaging methods, suggesting that the source of the overall positive impact of increasing enrollment - indicated by the positive net benefit estimate on Table 12 - is in the indirect benefits includes in this wider measure of financial impact. Put another way, the positive estimated impact of increased enrollment in AY01 depends critically on the size of the state appropriation in that year, and thus on the difficult to determine relationship between enrollment and state appropriation.

Also note that the "mixed weight" averaging method used in the following simulation exercises leads to a negative estimate of the incremental net revenue from increased enrollment.

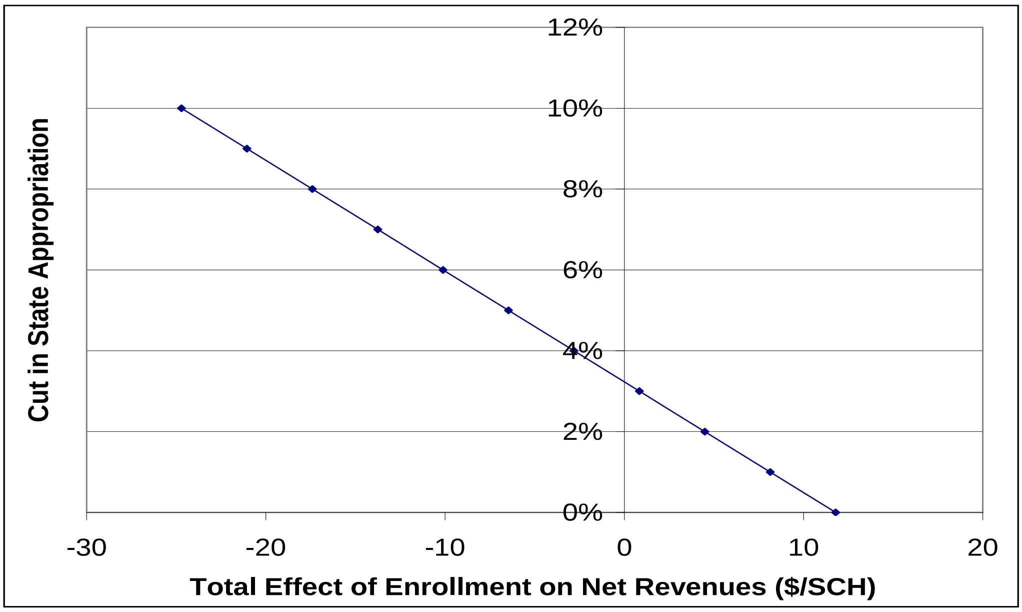

Figure 2: The Effect of State Funding Cuts on Total Net Revenues

Robustness Checks and Simulations

Based on the results above, increasing enrollment from AY00 to AY01 had a beneficial financial impact on UMBC. On average, net revenues increased by about $12 for each additional SCH offered in AY01. This net revenue estimate is based on many assumptions. In order to assess how sensitive this estimate is to changes in the underlying assumptions, as well as to make this estimate more useful to those deciding on future enrollment changes, I investigated the robustness of this net revenue estimate using simulations.

These simulations focus on the summary measure of the financial impact of enrollment, net revenue per SCH. In particular, the simulations investigate how net revenue per SCH changes in response to systematic variation in the cost and revenue factors shown on Table 11.

Changes in the Level of State Appropriation

The estimated net revenue per SCH depends critically on the assumption that state appropriation was, on average, $365 per additional SCH in AY01. This level of funding was quite large relative to historical levels of state funding at UMBC, perhaps large enough to be considered the upper bound on state funding. In the current economic environment, funding cuts, not funding increases, appear to loom large in UMBC's future. Understanding what happens to the estimated net revenue per SCH as state appropriation per SCH declines is important.

Figure 2 shows the effect of reductions in state appropriation per SCH on estimated net revenue per SCH. On this figure the size of the reduction in state appropriation, in percentage terms, is shown on the vertical axis and the estimated net revenue, in dollars per SCH is shown on the horizontal axis. The $12 per SCH estimated net revenue shown on Table 12 is at the bottom right of the graph, where the simulated cut in state appropriation per SCH is 0%. Moving to the north west along the graph shows the effects on estimated net revenue per SCH of cutting the level of state appropriation per SCH by the percentage shown on the vertical axis.

This simulation shows that the $12 per SCH estimate is quite sensitive to the assumption about the level of state funding. If state funding per SCH in AY01 would have been just approximately 3% lower, the additional enrollment in AY01 would have had no positive effect on UMBC's budget. Note that this does not imply any *causal* relationship between enrollment and state funding; it simply indicates that, holding enrollment and all other factors constant, if the level of state appropriation was a slightly lower in AY01, increasing enrollment would not have had a positive financial impact.

When the level of state appropriation declines, institutions sometimes respond by raising tuition charged to students in order to offset the funding losses. Ideally, simulations could be used to determine how much tuition would have to be raised to keep net revenues constant when the state appropriations are cut. To perform this correctly, the simulation would need to account for the decline in new enrollment due to the increase in tuition. I do not know how sensitive new student enrollment is to changes in tuition at this time, so I cannot perform this type of simulation. An alternative would be to determine how much tuition would have to be raised to offset a cut in state funding holding enrollment constant, but this appears to be an unreasonable assumption.

Increases in Enrollment

Increasing enrollment is often proposed as a method for increasing net revenues. The net revenue estimates for UMBC in AY01 suggest that the recent increases in enrollment at UMBC had a positive financial impact. How sensitive is this net revenues estimate to changes in enrollment?

An an initial step, I simulated the effects of an increase in undergraduate enrollment on estimated net revenue, holding all other factors in the analysis constant. This is equivalent to asking "if UMBC was able to attract x additional undergraduates without changing tuition, holding graduate enrollment, the level of state funding, and all non-instructional costs constant, by how much would the estimated net revenue from new undergraduate enrollment change?" This simulation involves a relatively restrictive set of assumptions, but it also provides a useful baseline for further comparison.

Figure 3 summarizes the results of this simulation. Increasing undergraduate enrollment increases the net impact of additional enrollment on UMBC's budget. Looking back to Table 11 makes it clear why this increase occurs. Undergraduate students clearly have a positive net financial impact, each additional undergraduate SCH increases revenues by, on average, \$129. Enrolling more undergraduates while holding the number of graduate students constant shifts the distribution of the student body toward those students that provide a positive financial impact, increasing the overall impact of enrollment. From Figure 3, attracting an additional 100 undergraduates would raise the net revenues from enrollment from \$12 per SCH to just under \$15 per SCH. Attracting 300 additional undergraduate students would raise the estimated net revenues from enrollment to about \$20 per SCH holding other factors constant.

Note that the additional undergraduates attracted in this simulation would have the same distribution of in-state and out-of-state students and the same distribution of scholarship and internal tuition discounting as the undergraduate student body at UMBC in AY00 and AY01. This simulation simply assumes that UMBC attracts additional new students that look exactly like the existing student body. This simulation does not reflect the effects of specific targeted enrollment growth initiatives - say an increase in out-of-state students paying full tuition - on the estimated net revenues from new enrollment.

Clearly, one drawback of this simulation is the assumption that non-instructional costs remain constant in response to the simulated increase in enrollment. The partial survey of academic support units described in the previous section suggested that effective non-instructional costs rise with enrollment in many units, as well as the fact that *past* enrollment increases have not been accompanied by increases in funding to many academic support units, making it difficult for these units to perform their functions effectively. Furthermore, the discussion of the economic theory of the firm applied to institutions of higher education in Appendix 1 predicts that increasing enrollment while holding fixed inputs to educational production like faculty, facilities, and administrative unit personnel and funding constant can lead to more than proportionate increases in the effective costs of enrollment.

Given the data currently available, I cannot estimate the effects of past enrollment increases on the overall costs of educating these students. I can examine the effects of relaxing the assumption of no change in administrative costs when additional students enroll at UMBC.

Figure 4 summarizes the results of three simulations that systematically vary the increase in non-

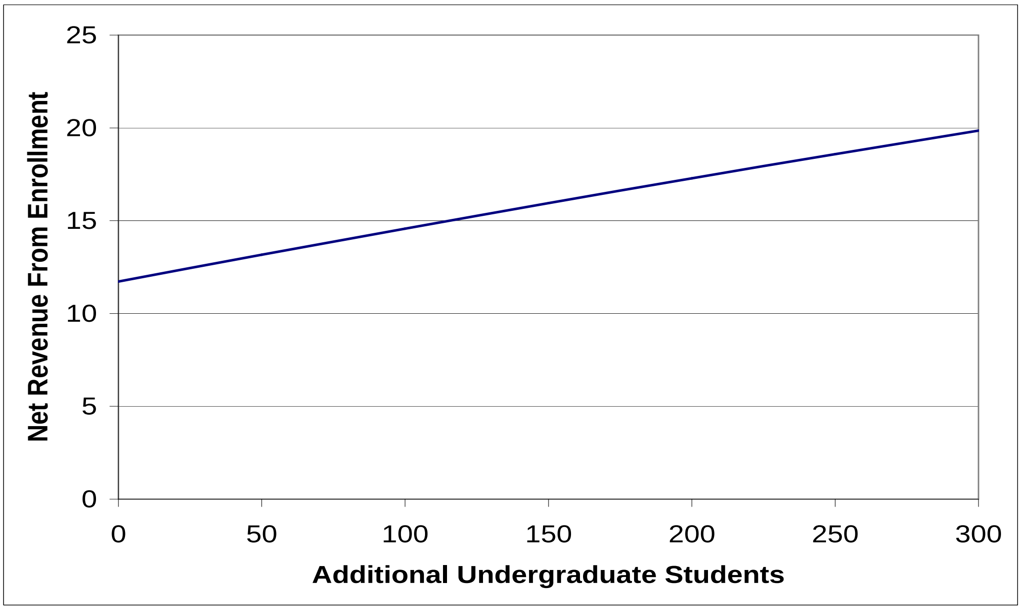

Figure 3: The Effect of Changes in Undergraduate Enrollment on Net Revenues

instructional costs (defined as plant operation and maintenance, departmental administration, library and student services) in response to increases in undergraduate enrollment. The top dashed line simply repeats the simulation shown on Figure 3, where undergraduate enrollment increases but administrative costs remain the same. Again, this simulation suggests that attracting 300 additional undergraduate students would raise the estimated net revenues from enrollment to about $20 per SCH. The middle dashed line assumes that for each 1% increase in new undergraduate enrollment, administrative costs increase by a less than proportionate amount, 0.5%. Notice how sensitive the estimated net revenues from enrollment increases are to changes in non-instructional costs. If non-instructional costs rise at a rate equal to half of the rate of increase in new enrollment, much of the estimated positive net revenue from additional enrollment disappears. The increase in net revenue per SCH under this scenario is only a little more than half as large as the increase in net revenue per SCH under the no change in non-instructional cost assumption.

The lowest solid line on Figure 4 shows the change in estimated net revenue per SCH under the assumption that the increase in administrative costs is proportionate to the increase in new undergraduate enrollment. In this simulation, a 1% increase in new undergraduate enrollment is associated with a 1% increase in administrative costs, holding other factors constant. In this simulation, there is almost no increase in the estimated net revenues from additional enrollment. The increase in net revenue per SCH is only $0.50 per SCH, 15% of the simulated increase under the no change in non-instructional cost scenario.

Although not shown on Figure 4, if the increase in administrative costs is even slightly more than proportionate - for example if administrative costs rise by 1.1% for every 1% increase in undergraduate enrollment - then the estimated net revenue associated with additional undergraduate enrollment decreases; there are no positive financial benefits associated with increases in undergraduate enrollment if administrative costs increase more than proportionately to the increase in enrollment.

This simulation also has important implications for the understanding the financial impact of past increases in enrollment at UMBC. The survey of academic support units and an examination of the budgets of academic support units at UMBC indicates that the past increases in enrollment at UMBC have not been accompanied by any significant increase in expenditure on non-instructional costs. Clearly,

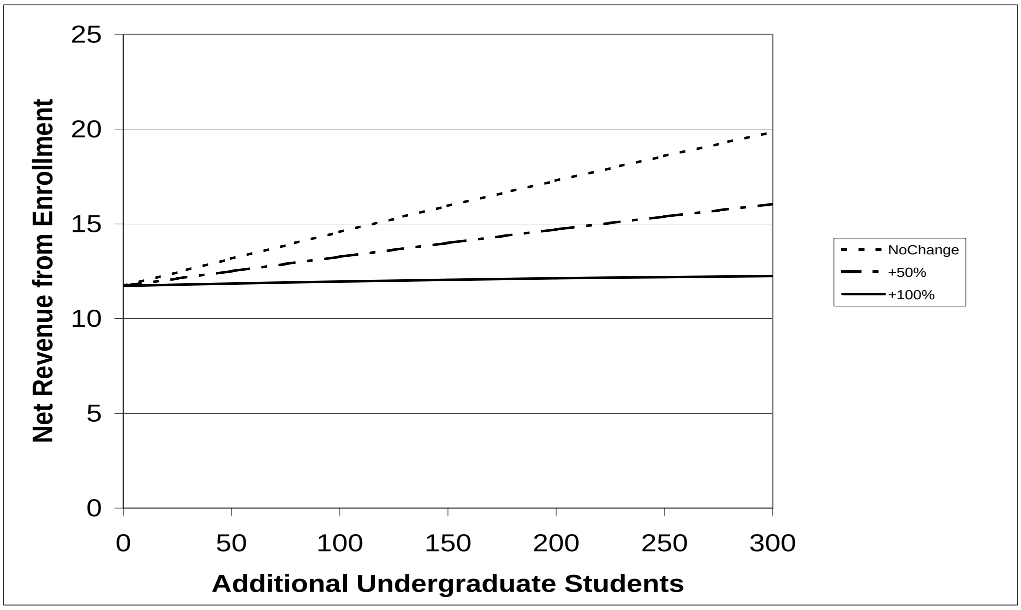

Figure 4: Net Revenues, Additional Undergraduate Enrollment, and Higher Administrative Costs

increasing enrollments place additional burdens on academic support units at UMBC. There are more students to advise, more parking tickets to write, more sick students to attend to, more bills to be distributed and collected and so on. Performing these additional productive activities with the same level of staffing and budgeting may be possible in the short run, but in the long run it is unlikely that the academic support units on campus can continue to operate effectively when they are understaffed and underfunded. The quality of the services provided will decline, or the level of services provided per student will decline, or both. Thus the short-run financial benefits associated with increased enrollments will evaporate.

The simulations above consider only the effects of increases in undergraduate enrollment on the estimated net revenue. Changes in graduate enrollment can also have an effect on the estimated net revenue from increasing enrollment. From Table 11, on average, additional graduate students reduce net revenues by over $500 per additional SCH. This negative effect comes from the tuition waivers and stipends given to many graduate students. It is also offset, in many cases, by the valuable educational and research services provided to the university by graduate students. This estimate understates the overall impact of graduate students in that the value of these services are not included in the net revenue estimate.

The overall net revenue estimate for additional graduate students also masks considerable variation in the net revenue generated by different types of graduate students. In particular, part-time, non-degree seeking graduate students and some masters students do not receive tuition remission, scholarships or stipends. Increasing enrollment in these areas may also have a positive effect on the estimated net revenue from additional enrollment.

Simulations can also be used to determine the impact of increasing enrollment of masters students and non-degree seeking part-time graduate students on estimated net revenues. Like the undergraduate enrollment simulations reported above, these simulations examine the effect of changes in graduate enrollment of masters degree students and part-time non-degree seeking graduate students on estimated net revenues holding all other factors, including the level of state funding, undergraduate enrollment, graduate enrollment of Ph.D. students, and administrative costs constant. Bear in mind that masters students are students enrolled in programs staffed by regular tenured and tenure track faculty - many with thesis requirements that make extensive demands on faculty time - while part-time non-degree seeking graduate students are often enrolled in "applied" or professional certificate programs that are taught by part-time faculty who are practitioners in the area and do not have thesis requirements. These two types of programs involve different levels of on non-instructional faculty resources. Figure 5 summarizes the results of these simulations.

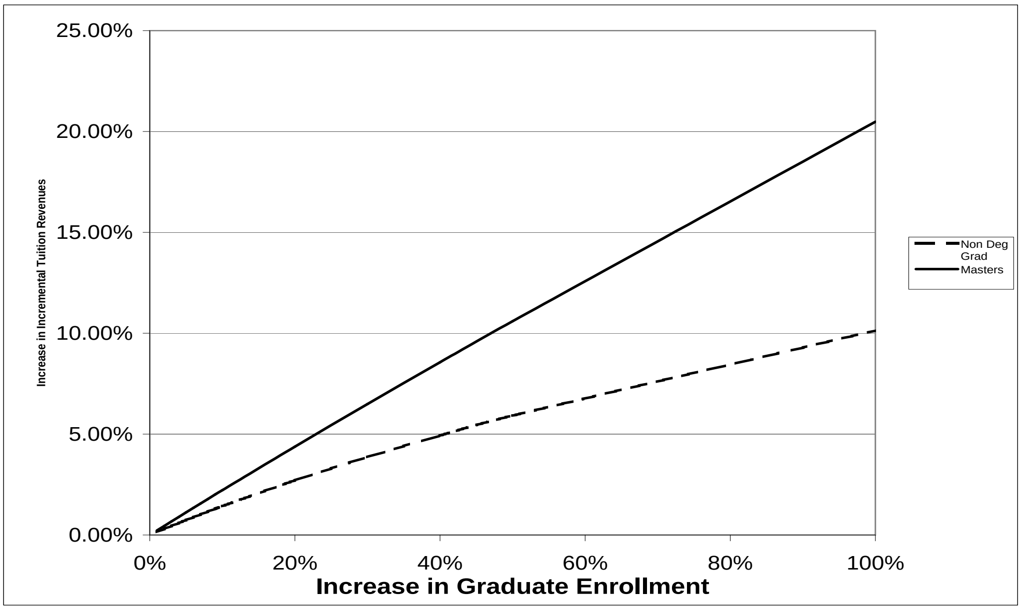

Figure 5: The Impact of Additional Graduate Enrollment on Net Revenues

The simulations summarized on Figure 5 show the increase in certain types of graduate enrollment and the change in estimated net revenues in percentage terms, rather than as the number of additional new students and the change in estimated net revenues in dollars per SCH. This is because the absolute number of part-time graduate students (198 in AY01) and and full-time masters students (405 in AY01) differs, because the impact on estimated net revenues is to make the estimated net revenue per graduate SCH less negative, and because the average number of SCH taken by each type of graduate student differs considerably. Expressing these changes in percentage terms makes a the comparison easier.

On Figure 5, the solid line shows the impact of enrolling additional new masters students on estimated net tuition revenue and the dashed line shows the impact of enrolling additional new part-time non-degree seeking graduate students. From this figure, increasing enrollment in both these areas has a positive effect on the estimated net revenue. In both cases, the effect is small, due to the relatively small number of these students at UMBC. Increasing the number of new masters students by 20% would increase the estimated net revenue by 4.3%; increasing the enrollment in new part-time non-degree seeking graduate students would increase the estimated net revenue by 2.7%, holding other factors equal. Thus new masters students lead to relatively larger increases in estimated net revenues.

However, these simulations hold non-instructional costs constant. The simulation summarized in Figure 4 indicates that these simulation results may be quite sensitive to the assumption of no additional non-instructional costs when enrollment rises. If these costs increased, the percentage increase in estimated net revenue would be lower than reported. Also, additional masters students may require relatively more faculty and academic support resources than part-time non-degree seeking graduate students. If this is the case, then the gap between the estimated effect of increases in these two types of graduate students on net revenues would be narrowed.

The simulation results on summarized in Figure 5 suggest that both traditional masters programs and "applied" graduate programs produce positive net revenues for the university. However, these programs require differing amounts of non-instructional faculty inputs, so the overall net impact - including the costs of faculty inputs to advising and thesis supervision in traditional masters programs - may differ from these net benefit estimates. In order to further explore the implications of this simulation, I performed a detailed simulation of incremental costs and revenues associated with a hypothetical "applied" masters program enrolling only part-time non-degree seeking graduate students.

In practice, "applied" post-baccalaureate programs (sometimes called certificate programs) differ widely in terms of academic requirements, students, staffing, and administration. In this simulation, I consider a stylized program that captures the important elements of these programs in a simplified way. In particular, I assume that the program is composed of a sequence of four three credit courses. A single section of each course, taught by a part-time faculty member, is offered each semester. Students in this program take one course per semester for four semesters to complete the program. Note that the average course load of part-time graduate students at UMBC is 3.5 credit hours per semester, so the observed behavior of part-time graduate students matches this assumption.

The total financial impact of these programs depends primarily on the number of students admitted to the program. In this simulation, I considered a program that admits three students per semester, for a total enrollment of 12 students once the program is fully implemented, a program that admits five students per semester (total enrollment of 20 students), a program that admits ten students per semester (total enrollment of 40 students), a program that admits 15 students per semester (total enrollment of 60 students), and a program that admits 20 students per semester (total enrollment of 80 students). Each admitted student takes one course per semester for four semesters and then is awarded a post-baccalaureate certificate; there are no drop-outs.

The simulation is based on a program that has reached a "steady-state equilibrium" in that it has been running long enough to have students enrolled in each of the four courses in the sequence and is attracting the specified number of students in each semester. The simulation shows the total net revenues per semester generated by this program based on data from 2001, expressed in 2001 dollars. The students are assumed to pay $350 per credit hour in tuition and fees.

Figure 6 summarizes the results of this simulation. The solid line, labeled *Cost1*, is the baseline simulation. This simulation shows total net revenues per semester generated by an applied program as the enrollment in the program increases. The simulation assumes that the four instructors in the program are paid the average salary of part-time instructors at UMBC, $2,797 per course, and includes the average plant operations and maintenance costs ($23 per SCH), departmental administration costs ($60 per SCH), and library costs ($39 per SCH) reported on Table 11. In this simulation, a program that admits three students per semester does not cover incremental costs in "steady state," but a program that admits five students per semester produces a small ($2,492 per semester) net positive financial impact. The financial return increases with the number of students, and a program admitting 20 students per semester generates about $45,000 in positive financial impact per semester in "steady state."

The other two lines on Figure 6 show alternative cost scenarios. The simulation for *Cost2* assumes that the part-time instructors are payed a salary equal to the 75th percentile of part-time faculty salaries on campus instead of the average salary shown on *Cost1*. Under this assumption, a program enrolling five students per semester does not cover the incremental costs, and the total net revenues per semester are reduced slightly at all enrollment levels. The simulation for *Cost3* assumes that the part-time instructors are paid the average salary of all part-time faculty and that the departmental administrative cost per SCH is zero. A program enrolling three students per semester does not produce positive net revenues under these assumptions, but the net revenues are larger than those for *Cost1* at all levels of enrollment. Under this assumption, a program that enrolls 20 students per semester produces almost $60,000 in net revenues per semester.

These results can be generalized to programs with more or fewer students in "steady state" by simply adjusting the enrollment figure. For example, a program consisting of only two courses that enrolled

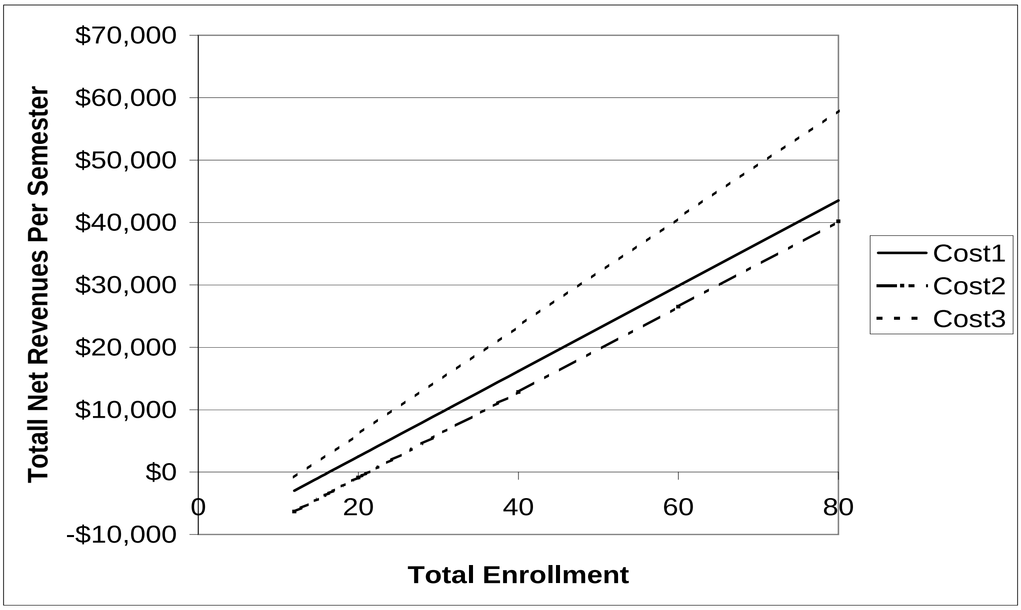

Figure 6: Simulated Net revenues for an Applied Graduate Program

twenty students per semester would have total enrollment of 40 in "steady state" (compared to a four course program enrolling 20 students per semester that would have total enrollment of 80 in "steady state.") However, the simulation results on this table cannot be generalized to programs that offer multiple sections of courses in each semester.

Appendix 1: A Primer on Economic Models of Costs in Higher Education

Economists have given considerable attention to the topic of modelling the behavior of costs in a wide variety of organizations, including public not-for-profit universities like UMBC. This appendix is a brief introduction to economic models of costs in organizations like firms or non-profit organizations for non-economists. The main point is to illustrate the twin concepts of capacity and efficiency in production, the relationship between marginal and average costs in production, and how these ideas together imply that producing more output using the same quantity of fixed inputs eventually drives up costs.

This report describes in detail the idiosyncratic, heterogeneous nature of higher education. Academic departments differ in a number of ways. Economic models attempt to characterize the behavior of individuals and organizations in a way that emphasizes the similarities in behavior. In this way, heterogeneity or highly idiosyncratic factors can be handled as special cases in these models. An economic model of production and costs at a university, or in academic departments, begins by abstracting away from idiosyncratic factors and instead identifies important factors that are common to all academic departments in a university.

A basic economic model of production and cost at a university describes a generic, bland institution. Suppose that the goal of the university being studied is to produce a single product - enrollment - defined as a student credit hour (SCH); the basic unit of output for this university is one student sitting in a classroom for a one hour class. For the moment, suppose that all students are identical in every respect; they all have equal ability and each takes the same generic schedule each semester.

The university produces student credit hours using two factors of production: instructors and classrooms. That is, the "technology" used to produce SCH requires both instructors and classrooms to produce. Natural and technological limits (the size of the blackboard, the number of seats in each classroom, the distance the instructor's voice will carry) mean that one instructor in one classroom can produce some limited number of SCH. In order to produce more SCH, the university must use more instructors. Over time, more classrooms can also be used, but within any given academic year the number of classrooms available is fixed. Each instructor is identical and each classroom is identical. The key difference is that in any academic year the number of classrooms cannot be changed while the number of instructors can be changed. Instructors are variable factors of production and classrooms are fixed factors of production. A factor of production that can be varied in the short run only at great cost is sometimes called a quasi-fixed factor; tenured and tenure track faculty probably fall into this category.

Again for simplicity, suppose that the cost to the university of employing each instructor is the same; each instructor earns the same salary - and again for simplicity think of this as some number of dollars for each one hour of instruction provided by each faculty member - because instructors are all identical (this also implies that the market for faculty members behaves in a certain way, but that detail is not important at this point.). Building and operating each classroom also costs the same, as these are also all identical.

At this point, we need to define two concepts that will be useful for describing the costs of production in this university:

- *Total Cost*: The amount paid for classrooms plus the wages paid to faculty.
- *Average Cost*: the total cost divided by the number of SCH taught.
- *Marginal Cost*: the cost of each additional SCH.

Figure 7 shows the relationship between average cost and marginal cost. On this figure, the number of SCH taught are graphed on the horizontal axis and the cost, in dollars, is measured on the vertical axis. To understand the relationship between marginal and average cost, consider the costs of the first student credit hour generated. The university has some number of classrooms, and pays some amount to

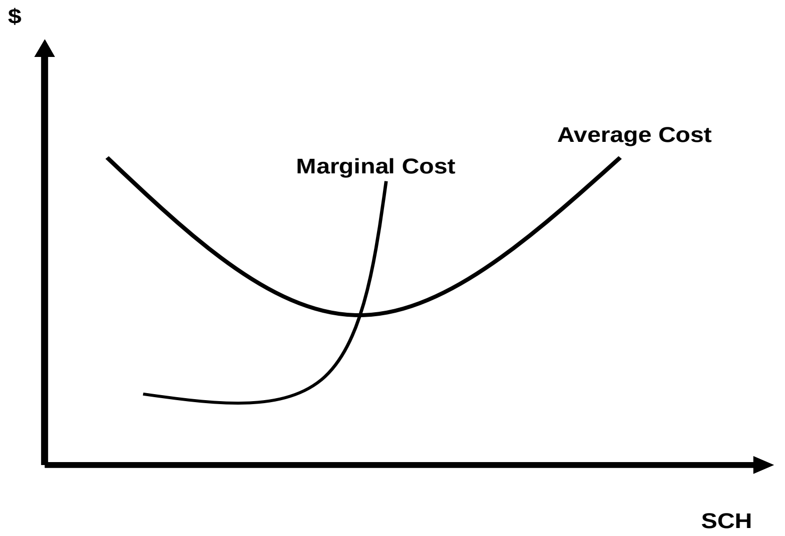

Figure 7: Average and Marginal Costs

acquire and maintain these classrooms no matter how many students are enrolled - this cost is fixed over the course of an academic year; depending on the total number of classrooms, this cost could be quite high. To produce the first unit -teach the first class of SCH - the university hires a single instructor and assigns her to a classroom to teach this class (for simplicity assume that students are enrolled one class section at a time.) Total cost is the amount paid for the classrooms plus the salary paid to the instructor. Average cost is this total cost divided by one - a large number. But the marginal cost - the incremental cost associated with this SCH, is simply the salary paid to the instructor, a small number. This can be seen at the left edge of the lines on Figure 2, where average cost is much larger than marginal cost.

As more SCH are generated, more instructors are hired (or the first instructor is hired to teach additional course sections and paid a higher salary.) The marginal cost of these additional class sections are small - just the instructor's salary - so average cost also falls as more class sections are taught. As long as marginal cost is below average cost, average cost must fall - the increment to total cost from teaching one more section is less than the average cost of teaching the previous section. But at some point, the fixed classroom space gets scarce. This limit on classroom space drives up the marginal cost of offering additional class sections.

At some point, marginal cost rises above average cost. Beyond this point, average costs begin to rise. By definition, the marginal cost curve must cut through the average cost curve at its lowest point. This point is the point of capacity - the number of SCH that can be offered at the minimum average cost per SCH. This is sometimes called the point of maximum efficiency, as cost per unit produced is lowest at this level of production.

Beyond the point of maximum efficiency, the limited number of classrooms available - the capacity effects - mean that marginal costs will continue to rise (those additional sections can only be offered at a high incremental cost) and this drives up average cost. The result is a U-shaped average cost curve and a rising marginal cost curve that passes through the lowest point on the average cost curve. This basic form emerges from the production process of a wide number of organizations and a considerable body of research supports this basic cost scenario. In some cases, the average cost curve may have a long flat section at the bottom, but at some point average costs must rise, as long as there are some fixed inputs to production. Even though many bells and whistles could be added to this model - many different types of classrooms, different types of instructors, different types of students, for any particular department or type of student, costs could be described by a U-shaped average cost curve and a rising marginal cost curve.

Once past the point of minimum average costs, the per-unit cost of production can only be lowered by increasing the amount of fixed inputs that are used to produce output. The university must acquire additional classrooms.

Note that the rising average instructional costs shown on Figure 1 can be interpreted as evidence that UMBC has been producing past the minimum point on its average cost curve since 1997. Figure 1 shows average instructional costs - the average cost of producing teaching outputs - at UMBC over five years. During this period, SCH and average costs were both rising. Figure 1 can be interpreted as tracing out the section of the average cost curve on Figure 2 that is to the right of the point where the marginal cost curve cuts the average cost curve: the rising part of the average cost curve on Figure 2. This would also imply that UMBC has been operating past its point of capacity and in order to lower average costs more fixed inputs to production (tenured and tenure track faculty, classrooms and other physical facilities) need to be acquired.

In profit-driven firms, the profit motive ensures that more inputs will be acquired to lower unit costs - as this will increase profits earned by the firm in the long run. But in a not-for-profit setting like a university, there may be a tendency to increase output beyond the point of efficiency, as decision makers at universities do not have strong incentives to keeps costs low. Moreover, many of the costs associated with producing past the point of minimum average cost may not be directly observed or felt by decision makers.

In this model, some types of heterogeneity in academic departments can be explained using a different average and marginal cost curve for each department; imagine drawing a different diagram resembling Figure 2 for each department on campus. If departments differ in that each has a different type and quantity of fixed factors of production, then each will have a separate average and marginal cost curve at any point in time. Depending on the position of these cost curves, and the number of units of output produced by each department relative to the availability of these fixed factors of production, different departments will have different points of capacity. Increases in production by departments will have a different effect on departmental costs, again depending on the location of the cost curves and the relationship between production and fixed departmental resources.

Clearly, joint production and costs complicated the analysis considerably. These factors lead to interdependencies in costs and production. They also underscore the importance of other academic outputs and some of the other costs omitted in this analysis. For example, tenured and tenure track faculty members are typically thought to produce three types of outputs: research, teaching and service. This analysis focuses only on the production of teaching outputs. Faculty face a constraint on the amount of time available to produce these three outputs, so increasing teaching outputs might lead to a decrease in the other two primary faculty outputs; this will occur if teaching and the other two faculty outputs are substitutes in production (doing more of one means doing less of another.) But some teaching outputs - graduate teaching in particular - might instead be a complement in production to research. In this case, increasing teaching output might lead to more research output.

Despite these complications, capacity effects - the prediction that increasing the amount of output while holding the quantity of some inputs to production fixed will eventually drive up both marginal and average production costs - still holds in most cases. In an environment of rapidly rising enrollment over a short period of time, such capacity effects may be present, and the marginal and average costs associated with this capacity effect can rise rapidly.

A (Brief) Literature Review

Economists have devoted a considerable amount of attention to costs and revenues in higher education. Some readers may be interested in this broad literature. A concise summary of the various techniques the have been developed to estimate marginal instructional costs, and a discussion of the economic theories that underlie these techniques, can be found in *Marginal Costing Techniques for Higher Education*, Richard Allen and Paul Brinkman, (Boulder Colorado: National Center for Higher Education Management Systems, 1983).

In a closely related paper, Hoenack, et. al. ("the Marginal Costs of Instruction," *Research in Higher Education*, vol. 24, no. 4, pp. 335-417) estimate marginal instructional costs for a large public research university (the University of Minnesota). This lengthy paper contains a detailed theoretical discussion of joint costs in higher education as well as the theoretical underpinnings for differential pricing of tuition by academic discipline. The marginal instructional costs reported in this paper are $28/SCH for undergraduate education and $466/SCH for graduate education, in 2001 dollars. The lower estimate for undergraduate instruction reported in this paper is probably due to the heavy use of graduate students to teach undergraduate classes at Minnesota. The higher estimate for graduate instruction is probably due to the presence of professional schools at Minnesota and the relatively greater prestige of that institution.

A related, but broader study by Duc-Le To (*Estimating the Cost of a Bachelors Degree: An institutional Cost Analysis*) Washington D.C.: Office of Educational Research and Improvement, U.S. Department of Education, focuses on estimating total costs of an undergraduate education across many colleges and universities; the study estimates costs for the entire enrollment period of undergraduates and accounts for factors like drop-outs. No direct estimated of instructional costs per SCH are presented, but the ratio of graduate instructional costs to undergraduate instructional costs at research universities, 3.5:1, is similar to the ratio reported here (2.8:1, from Table 6.)

Recent surveys of costs and revenues in higher education include the collected volumes edited by Clotfelter, et. al. (*Economic Challenges in Higher Education*, Chicago, IL: University of Chicago Press, 1991), and McPherson, et. al. (*Paying the Piper: Productivity, Incentives and Financing in U.S. Higher Education*, Ann Arbor, MI: The University of Michigan Press, 1993). These volumes contain a number of articles addressing many topics related to this study. A more recent examination of costs in higher education was done by Ehrenberg (*Tuition Rising: Why College Costs So Much*, Cambridge, MA: Harvard University Press, 2000), although this book focuses primarily on selective private universities.

Appendix 2: Details on Cost Estimates

Average Faculty Salaries By Department and Rank

In order to calculate incremental instructional costs, and the hypothetical incremental instructional costs shown on Table 6, I needed an estimate of the average salaries of faculty members at UMBC by department and rank. I used the UMBC Faculty data files to get these average figures.

Table 13: Average Faculty Salary by Department and Rank, AY01

	Rank				
Department	Professor	Associate Professor	Assistant Professor	Full-Time Instructor	Part-time
AFAM	87153	68479	58161	–	1691
AMST	78756	84420	49042	47112	3750
ANCS	–	69609	72503	–	1939
BIOL	102132	59986	50450	37992	4491
CENG	122990	82997	57673	40545	4108
CHEM	98894	58247	48527	33224	1771
CSEE	125361	73407	67085	51890	2760
DANC	–	69720	28051	41692	1121
ECON	83534	57433	58108	47949	2323
EDUC	110170	70186	55524	45401	2298
EHS	–	80589	46800	50088	2387
ENGL	73303	64726	47515	37048	3632
GEOG	89690	71017	53749	46151	3209
GEST	95704	73085	60497	53779	–
HIST	81593	55269	46369	–	2419
IFSM	118995	95863	79653	50652	4137
MATH	96949	66415	58236	34576	2262
MENG	101003	63867	63311	42640	5152
MLL	75020	56076	47709	24385	3649
MUSC	90994	54080	44208	37151	1652
PHIL	99178	64415	39778	45640	7194
PHYS	105516	67176	56753	40281	–
POLI	85730	74804	51765	–	1827
POSI	112876	68053	59743	–	1333
PSYC	82627	62330	51600	40387	1233
SOCY	93695	62679	47964	–	1732
SOWK	–	70984	55076	59792	1372
THTR	85788	63807	46080	39006	2467
VART	127476	69204	51563	40560	3609

Table 13 contains the average salary figures used in the incremental cost estimation procedure. The average salaries for tenured, tenure track, and full-time instructors is a simple average of the salaries of each faculty member at each of these ranks in each department. Note that these salaries include both 12 month and 9.5 month employees; I did not adjust the salaries of faculty on 12 month contracts to a 9.5 month basis. Full-time instructors are defined as those faculty members who are identified as working in instructional positions and employed 100% of the time and are not in a tenure-track position in the Faculty data files. The average salary for part-time faculty is a weighted average that reflects the percent of full-time employment worked by each faculty member. The average salary of a part-time faculty member reflects a full-time equivalency of each part-time faculty member's salary.

Appendix 3: Data Sources and Limitations

I used four primary data sources for this research project. Each of these data sources contains data for differing time periods and each is organized around different individuals and groups on campus. Each has different strengths and weaknesses, and no single source was sufficiently rich to allow for the generation of estimates of the incremental costs and benefits of enrollment from one single source. I drew from all four sources in preparing this report in order to take advantage of the strengths and avoid the weaknesses inherent in each data source. The four data sources are: a UMBC student data set, containing records on major, level, status, current credits, and financial aid information for all UMBC students enrolled in Fall 2000 and Fall 2001; a UMBC faculty data set containing rank, salary and department information for all faculty employed at UMBC in Academic Year 2000 and 2001; a department budget data set containing salary and other budget item data for all academic departments and other Management Responsibility Areas (MRAs) on campus for Fiscal Year 2001 and 2002; and the UMBC faculty workload data set containing information on staffing, student credit hours generated, and other measures of faculty output for each UMBC department in Academic Year 2000 and 2001.

The UMBC student data set is a rich source of information about students enrolled at UMBC in the fall semester of each year. The records in this data set allow each UMBC student to be distinguished by level (freshman through senior and first year and continuing graduate student), major, enrollment status (full-time/part-time), time on campus (new or continuing student) and the number of credit hours taken in the fall semester. Transfer students can be differentiated from new first-time freshmen, and SAT and GRE scores are available for all new first-time freshmen and graduate students. Maryland resident and non-resident status can also be identified. Details on the financial aid package offered each student, including the source of all funds, is also available.

Despite this richness, these data have a number of important limitations. First, the data are for the fall semester only - there are no corresponding Spring semester data available. Students who drop out during the fall semester or over Christmas break, and new students who enroll in the spring semester are not part of the data. Students in these data are identified by major and the number of credit hours enrolled in, but these credit hours cannot be assigned to individual departments. This is further complicated by the fact that several large departments at UMBC have no majors, and others teach large number of students who are not departmental majors. Thus these data are difficult to combine with the other departmental-level data.

The financial aid data are also limited in that the amount given to each student, and the source of these funds, is known but what these funds were spent on is not. This is problematic for students living on campus, as some of the funds may go to pay for room and board, and thus may not represent incremental revenue received by UMBC.

The faculty workload data are drawn both from the Faculty Annual Reports submitted by individual faculty and departments each spring and from data generated by the student information system. For the purposes of this report, the portion of the workload data collected from the student information system were one of the most important data sources used. This data set contains information on the number of student credit hours generated at the lower division undergraduate, upper division undergraduate and graduate level by department. It also contains detailed information about the instructors who taught these students and the number of faculty teaching in each department. The Office of Institution Research (OIR) collects and compiles these data, which are also passed on to USM and MHEC. Because these regulatory agencies used these data, they are audited by OIR for inconsistencies.

A large amount of budget data are available for UMBC academic and administrative departments. These data are available for broad spending categories like Salary and Wages Communication, Travel, Contract Services, and Supplies and Materials. These data provide a picture of the distribution of expenses within departments as well as a basis of comparison across departments. As I mentioned earlier, broad measures of average instructional costs are often based on budgetary data. Note that the budget data I used were the amount of funds allocated to departments and not the amount that was actually spent. In some instances departments were allocated additional funds to cover unexpected expenses. Unspent funds are often placed into departmental revolving accounts and spent in later fiscal years.

Appendix 4: Narrative Description of Departmental Instructional Techniques

Africana Studies (AFST) - does not make extensive use of any of the factors.
American Studies (AMST) - makes extensive use of individualized instruction (independent research projects) and small seminar-style courses in undergraduate instruction. The curriculum is not suited to large lecture hall courses because of the emphasis on critical reading and writing skills and the interdisciplinary nature of the curriculum.
Ancient Studies (ANCS) - offers many upper level language courses that are taught in a small group setting.
Biology (BIOL) - makes extensive use of specialized facilities and technology in both undergraduate and graduate education; uses alternative instructional techniques in undergraduate education. The department has 8 instructional labs for undergraduate education, and two labs for graduate education. In addition, both undergraduate and graduate education takes place in faculty research labs. The technology used is specialized and expensive (DNA sequencers, laser cell sorters, etc.) but are also used in research. Typically has between 50-75 undergraduate students involved in independent research at any point in time, although some of this may not be for credit.
Chemical and Biochemical Engineering (CENG) - makes extensive use of specialized facilities in both graduate and undergraduate education. Graduate education also takes place in faculty research labs. In the freshman year, all undergraduates must complete a hands-on fabrication project.
Chemistry (CHEM) - makes extensive use of specialized facilities in both graduate and undergraduate education. In addition, both undergraduate and graduate education takes place in faculty research labs. Typically about 65 undergraduate students involved in independent research in any semester.
Computer Science and Electrical Engineering (CSEE) - uses a single computer lab for undergraduate education. Much of the graduate education takes place in research labs.
Dance (DANC) - makes extensive use of specialized facilities - studio and performance space - as well as individualized and small group instruction in undergraduate education; has a capstone course involving the creation of original choreography. Requires musical accompanists for some courses.
Economics/Administrative Sciences (ECON) - does not make extensive use of any of the factors.
Education (EDUC) - uses computer labs and supervised field work in both undergraduate and graduate education. The department is subject to significant influence from external mandates on instruction and use of technology.
Emergency Health Services (EHS) - uses a clinical lab that is similar to labs in the sciences for undergraduate paramedic students. Many undergraduate classes are limited to 15 students. 50% to 60% of the SCH in the undergraduate curriculum involve clinical or field experience that requires faculty supervision.
English (ENGL) - every major is required to take a capstone "Senior Seminar" course that is limited to 15 students per section, but this is a single course.
Geography (GEOG) - makes use of both technology and alternative instructional techniques in undergraduate education. Roughly 30% of the SCH generated involves use of a computerized cartography lab and a geographic information systems (GIS) lab. The curriculum includes several field classes, internships, and independent research projects that involve mapmaking. The respondent compared the major to music in the use of small group and individualized instruction in the major.
History (HIST) - does not make extensive use of any of the factors.
Information Systems (IFS) - makes extensive use of technology, in the form of computer labs, in both graduate and undergraduate education.
Math and Statistics (MATH) - makes little use of these factors in undergraduate education, although their lower level students make heavy use of the Learning Resources Center. Graduate instruction involves heavy use of technology including specialized labs and computing clusters.
Mechanical Engineering (MENG) - makes use of specialized facilities and technology in both graduate and undergraduate education. The department uses six specialized labs for both graduate and undergraduate

courses. Some of these labs also serve as faculty research labs. There are also a significant number of required graduate and undergraduate courses that make use of software and high-end computer workstations. The department maintains a dedicated computer lab for student use.

Modern Language and Linguistics (MLL) - makes use of technology in the International Media Center in undergraduate instruction. Upper level undergraduate courses are also taught in small seminar-type sections.

Music (MUSC) - makes use of both specialized facilities and alternative instructional techniques undergraduate education. The department uses three specialized facilities: a recital/rehearsal hall for large ensembles, a piano lab, and three digitally-equipped recording studios. The piano lab and recording studio also make use of technology. The department uses private instructional techniques as a required part of the undergraduate major. These include required individual lesions taken by every major every semester and small performance ensembles.

Philosophy (PHIL) - uses small courses and extensive one-on-one instruction in both undergraduate and graduate education.

Physics (PHYS) - makes extensive use of specialized facilities and technology in both graduate and undergraduate education. The department has four labs for undergraduate education each with different facilities and purposes; also uses a clean room and observatory. Principles-level courses use separate lab facilities and have large enrollments. Maintains computer labs for undergraduate majors that use specialized software.

Political Science (POLI) - does not make extensive use of any of the factors.

Policy Sciences (POSI) - does not make extensive use of any of the factors.

Psychology (PSYC) - does not make extensive use of any of the factors.

Sociology (SOCY) - does not make extensive use of any of the factors.

Social Work (SOWK) - requires a full year of field placement in local social service agencies as part of both the graduate and undergraduate degree program. This field experience requires significant faculty oversight.

Theatre (THTR) - uses studio space and sound/lighting rooms for 2/3 of undergraduate instruction. Small groups and individualized instruction used extensively.

Visual Arts (VART) - makes extensive use of technology in undergraduate and graduate instruction. The department maintains a large number of specialized computer facilities containing high-end desktop computers that make use of specialized software.