Miles To Go Before I Learn: The Effect of Travel Distance on the Mature Person's Choice of a Community College

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Abstract: The substantial literature on access to higher education has a narrow focus: the effect of tuition on the enrollment decisions of 18-year-olds seeking bachelors degrees. But for non-traditional (i.e. older) students who tend to prefer community college, access is more about a school's location than about its tuition and fees. Using data on over 150,000 mature workers (aged 25 to 49) in the Greater Baltimore Area, we analyze the impact of travel distance on community college enrollment decisions. We find that distance is a highly statistically significant factor in deciding whether to enroll in community college, and in which school to choose. Simulations of the model suggest that if the typical resident had to travel three additional miles from home to the nearest college, enrollment could drop by as much as 14%.

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Introduction

Quite a bit of economic literature has been devoted to analyzing student access to higher education. In nearly all of that literature, "student" means a recent high school graduate, and "higher education" means a four-year college. (See McPherson and Shapiro [1991]; Ehrenberg and Marvos [1995]; Moore, Studenmund, and Sloboko [1991]; Manksi and Wise [1983]; Kohn, Manski and Mundel [1976], among others). But these so-called traditional students comprise less than 40% of enrollees at degree-granting institutions (National Center for Educational Statistics [NCES], 2003, 2004).[1] Much less attention has been paid to older students or to students in two-year colleges.

This omission is concerning because mature people's participation in higher education is a growing phenomenon in the U.S. and abroad. Jacobs and Stoner-Eby [1998] report, for example, that the college enrollment of students over 25 increased more than 150% between 1970 and 1990. The proportion of baccalaureate candidates over age 30 nearly doubled from 1970 to 1997 (Seftor and Turner [2002]).[2] Older students, however, are more to likely to pursue an associate's degree than a baccalaureate degree. Among students aged 24-29, 49% percent attend a two-year college, compared to 39% attending a four-year college; among students over 40 the dichotomy is even more severe: 63% versus 26% (Horn, Peter and Rooney [2002]). Our study looks at the community college attendance decisions of people 25 to 49. Mature students in two-year

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[1] For example, 43% of entering freshman attend a two-year, not a four-year, college, and 38% of students at degree granting institutions are 25 or older (Center for Educational Statistics [2003, 2004]).

[2] So-called "adult education" is pervasive in industrialized countries. In Scandinavia, for example, more than 50% of workers between 25 and 49 reported having engaged in some form of adult learning in the previous year (OECD [2003]). Even very senior workers are involved: a survey by the Commonwealth Fund found that 30% of 55-59 year olds, had taken "courses or training specifically to improve … job skills or employment opportunities," since turning 50 (Peterson and Wendt [1995]).

colleges comprise 17% of enrollees at degree-granting institutions – a substantial part of the higher education community (NCES [2003]).

Like the studies of more-traditional students, we focus on mature persons' access to higher education. However, "access" means something different for mature students than for high school seniors – it is less about tuition and more about location. As the website of the American Association of Community Colleges states

> The location of community colleges near residential areas is important to many people. Women with young children, for instance, put a premium on convenience because they frequently take classes around their and their spouses' work schedules, and babysitters' availability (AACC [2007]).

Their greater time constraints help explain why 69% of mature students in higher education attend school part-time, as opposed to 33% of younger students.

This paper explores how the availability of a local community college influences a mature worker's decision to attend one. In this paper the availability of a particular community college to a particular student is defined as the travel distance from the student's home (measured by Census tract) to the school's campus (measured by the mailing address of the main campus). How does the nearness of a local school affect enrollment? We address this question using three different empirical models. A probit model examines the effect of distance to the nearest community college on the decision to enroll. A random utility model looks at the impact of distance to each local school on an enrollee's choice of institution. Finally, a nested logit model views the enrollment and school-choice decisions as separate parts of a joint decision process. We believe that we are the first to examine these issues.

The impact of travel distance on attendance is of more than theoretical interest. The community college system expanded enormously in the 1960's when the number of schools doubled, and the number of students quadrupled (Witt et al. [1994]). Given the education needs of today's population, should there be another expansion of the system? The answer depends upon the degree to which the added convenience of less travel influences the amount of additional education consumed.

We were able to study this question by the advent of a new data set that offers a unique opportunity to observe the educational choices of mature working people. Our data come from a Department of Labor policy demonstration, called Lifelong Learning, which sought to determine whether (merely) informing mature workers about local education opportunities would spark participation. (Buron, Orr, and Patrabansh [1999] found no effect of information on participation.) The demonstration took place in the six counties that comprise Greater Baltimore. Using wage records from Maryland's unemployment insurance system, DOL identified more than 150,000 people who were 25 to 49 years of age, and who had at least some minimum level earnings (see below) in 1996.

Demographic data for these individuals, including Census tract, were obtained from a commercial credit-reporting agency. From the Census tract data, we calculated the distance ("as the crow flies") between a given person's home and each of the eight Baltimore-area community colleges. Those data were then matched with education records from the Maryland Higher Education Commission to identify who had attended one of these eight schools. This provided us with a sample containing observations on 151,448 mature workers, 3,583 of whom had enrolled at one of the local community colleges during a three-year observation period. From these data we estimated the models, described above, of the enrollment and school-choice decisions.

Our results show that, as expected, travel distance is a key determinant of whether to attend a community college as well as the choice of a specific school. The model predicts that increasing travel distance to the nearest college by one standard deviation lowers a mature person's probability of attendance by as much as 10 percent. Simulations of our model suggest that were one of the more popular community colleges located 30 miles further away, nearly 10 percent of potential students would simply not attend a commonly college. These results suggest that the proliferation of local community colleges in the last few decades has been a major factor in encouraging mature people to pursue higher education.

Studies of Community College Attendance

As stated above, most of the empirical studies of higher education decisions consider only high school seniors choosing which four-year college, if any, to attend (Long, 2004; Jacob, 2002). The bulk of those studies focus on the price (tuition) effects. (A good survey appears in Heller [1997]). The literature on community college attendance is much thinner. Hilmer [1998] used student-level data from the High School and Beyond survey to investigate the own-price elasticity of community college attendance and the cross-price effect from college/university tuition. He found the own-price elasticity for university fees to be almost four times that of the own-price elasticity for community college fees.[3] A small impact of tuition is unsurprising: the average

[3] Hilmer [1998] concludes that increases in college and university fees tend to shift high-income students from four-year to two-year schools, and to shift low-income students out of school altogether.

community college charges less than half of what the typical public four-year college charges (Kane and Rouse [1999]). Two other studies, however, found that tuition *is* a factor in an enrolled student's decision to *remain* at a community college: Nora [1990], and St. John and Starkey [1994]. Again, however, the studies cited above focused on traditional students.

It is well known that completing a four-year college degree raises earnings. Is the same true for a community college degree? Although less intensively studied, two-year degrees appear to raise earnings as well. Kane and Rouse [1995] and Leigh and Gill [1997] report that an associate's degree corresponds with earnings increases of around 25 percent for men and 30 percent for women. Jacobson, LaLonde, and Sullivan [2005a, 2005b] find that an additional year of community college for displaced workers increases long-term earnings by approximately nine percent for men and 13 percent for women.

Studies of the Education of Mature Students

The comparatively few studies that exist of the education decisions of older workers have tended to be descriptive, i.e. not using multivariate analysis. Still, a number of behavioral patterns emerge repeatedly in this literature. Several studies find that average participation rates fall with age (OCED [2003], Peterson and Wendt [1995], Gower [1997], Jacobson, LaLonde and Sullivan [2005b]) and that participation rates for older workers rise dramatically with education level (Gower, [1997], Peterson and Wendt [1995]).

The relatively few multivariate statistical studies of the higher education decisions of mature workers try to measure how returning to school affects future earnings. Leigh and Gill [1997] and Light [1995], for example, compared the earnings effects of *returning* to school, after a spell in the workforce, with those of *continuing* in school after senior high. Jacobson, LaLonde, and Sullivan [2005a, 2005b] looked specifically at the return-on-investment that displaced workers can expect from returning to school at a community college. They found that older displaced workers were less likely than younger workers to enroll in community college, but enjoyed equal rates of return on their investment when they did. Only one paper, Jacobson, LaLonde, and Sullivan [2002], did a statistical analysis of the mature workers' decisions whether to enroll in a community college. This study considered only displaced workers, who, by definition, have been laid off from jobs that are disappearing. Their higher education choices are not likely to reflect those of mature students in general.

Econometric Models Used in Our Analysis

As described above, our empirical analysis addresses two questions: 1) how does distance from home to the nearest community college affect the decision whether to attend, and 2) among attendees, how does distance affect the choice of a school? These require different types of models. We address the first question with a standard binomial probit of whether a sample member enrolled in a local community college during the period from fall 1996 to fall 1998. The key independent variable is distance to the school that is nearest a person's home. This analysis uses the sample 151,448 Grater Baltimore residents for whom we know the home Census Tract. A model of this type is useful in predicting, for example, how reducing average travel distance, by building a new school perhaps, will increase system-wide enrollment.

The second question, whether distance alone matters in school choice, is useful in determining whether prospective students see community colleges as relatively homogeneous. If so, they should simply choose the most convenient school – other school characteristics should not matter. We examine this question with a random utility model (RUM) of which school was selected by each of the 3,583 sample members who enrolled in some local community college (and for whom we had location data).[4] Independent variables include a number of school characteristics, a key one of which is how far each particular school is from the home of a given sample member. Location for home is defined by census tract, whereas each school's location is determined by the mailing address of the main campus.[5]

A useful way to distinguish between the models described above is by the set of characteristics whose impact each seeks to examine. The probit considers characteristics of the chooser (prospective student) on the decision whether to go to school; the RUM considers characteristics of the choice (prospective school) on which one chooses. We undertake a third type of analysis that essentially combines these two approaches. A nested logit is used to model the joint decision whether or not to attend a local community college, and if so, which one.[6] This model is useful in predicting, for example, how system-wide enrollment is affected by removing a *particular school* from the choice set of local residents. If, for example, the most popular school were closed, would students tend to leave the system or choose a different school? Nested logit

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[4] Including the demographic aspects of the Census tract also cost us a few observations. Most of the runs reported had 3,473 observations.

[5] For examples of discrete choice models of baccalaureate or post- baccalaureate schools see Kohn, Manski, and Mundel [1976]; Manski and Wise [1983], Moore, Sudenmund, and Slobko [1991]; Oosterbeek, Groot, and Hartog [1992], Bezmen and Depken [1998], and Wetzel, O'Toole, and Peterson [1998].

[6] This approach follows Montgomery [2002] who used nested logit to examine MBA aspirants' choice of a business school. Nested logit has an advantage over other discrete choice models, such as multinomial logit, for example, in that it relies less on the assumption of the Independence of Irrelevant Alternatives.

enables such predictions. For more technical details on the nested logit model, see the Appendix.

A Caveat Regarding the Role of Distance

In our analysis, we assume that the location decision is exogenous. In particular, the assumption is made that families do not choose where to live based on the amenities provided by the local community college. If not, our observed distance effect could be confounded by being endogenous to the enrollment decision itself. To explore this potential problem we compared the demographic characteristics of community college locales (by census tract) with their respective county averages. Appendix Table 1 shows the comparisons. The table suggests that there is no consistent relationship between the education, income, and housing values of the college's location with those of the county. In some cases, the college is located in an affluent census tract within the county; in other cases the college is located in a disadvantaged census tract. Thus, the table provides anecdotal evidence that is consistent with our assumption that the household location decision is exogenous to the community college location.

Data

In 1995 the U.S. Department of Labor (DOL) contracted with Abt Associates Inc. of Cambridge, Massachusetts to conduct a demonstration that "included designing and testing a targeted public information campaign promoting lifelong learning to mature incumbent workers in the Greater Baltimore area," (Buron, Orr, and Patrabansh [1999], p. 1). The Lifelong Learning demonstration focused on individuals who a) were aged 25 to 49, b) were living in Greater Baltimore, and c) had quarterly earnings of at least $1,105 in six of the eight quarters between Q4/1993 and Q3/1995. In evaluating the demonstration, person-specific data were drawn from three major information sources:

1. The Maryland Department of Labor, Licensing, and Regulation provided wages and salaries (earned in Maryland) from the first quarter of 1990 through May 1996.

2. Experian Inc (a credit reporting agency) provided demographic data.

3. The Maryland Higher Education Commission provided enrollment records, for each public post-secondary institution in the state, from the fall term of 1990 through the fall term of 1998.

Independent Variables

About 300,000 people in Greater Baltimore met the criteria for inclusion in the Life Long Learning study sample. Because the variable of interest in our school-choice model is travel distance, we calculated the distance from each of the eight local community colleges to the Census tract of residence (in May 1996) for each individual. Unfortunately, the Experian data contained the Census tract for only half the sample, about 150,000 people. Still, that was sufficient to include more than 3,500 community college attendees. Because location is measured in May 1996, we define enrollment in a local community college as having attended in fall 1996, fall 1997, or fall 1998 (enrollment data for spring and summer were not available).

Table 1
Descriptive Statistics of Sample Members

	Estimation Sample n=151,448			
	Mean	St. Dev.	Min.	Max.
Age	38	6.7	25	49
Earnings in 94-95 ($000)	36.10	25.43	22.91	447.94
Married	0.55		0	1
Had Children at Home	0.37		0	1
Female	0.47		0	1
Attended CC F96-F98	0.024		0	1
Miles to Nearest Campus	4.39	2.77	0.21	16.71
Miles to Near. Main Camp.	5.44	3.37	0.33	20.12
% Black (in Census Tract)	17.13	26.17	0	100
% Hispanic	1.19	0.99	0	14
% College Grads	25.25	15.87	0	72
Median House Price ($000)	114.17	50.11	0	382.30
	Missing Location Data n=152,957			
	Mean	St. Dev.	Min.	Max.
Age	38	6.7	25	49
Earnings in 94-95 ($000)	31.85	25.44	2	421.00
Married	0.53		0	1
Had Children at Home	0.36		0	1
Female	0.49		0	1
Attended CC F96-F98	0.023		0	1
	CC Attendees n=3,583			
	Mean	St. Dev.	Min.	Max.
Age	36	6.8	25	49
Earnings in 94-95 ($000)	29.34	16.74	30.97	331.52
Married	0.50		0	1
Had Children at Home	0.32		0	1
Female	0.60		0	1
Miles to Nearest Campus	4.26	2.67	0.33	16.71
Miles to Near. Main Camp.	5.11	3.14	0.33	20.12
% Black (in Census Tract)	18.04	26.33	0	100
% Hispanic	1.22	1.00	0	14
% College Grads	23.50	14.73	0	72
Median House Price ($000)	109.10	44.01	0	382.30

Table 1 shows the descriptive statistics for the independent variables. The top panel of the table includes the final sample of 151,488 mature workers; the middle panel shows statistics for the 152,957 for whom the census tract could not be identified; the bottom panel shows the 3,583 community college enrollees. As the table indicates, the demographics for those missing location were similar to sample members except for earnings. People in the estimation sample earned about $36,000 compared with about $32,000 for those excluded due to missing location data. To assess whether missing these observations might bias the results, we ran a probit of Census-tract-availability as a function of the various demographic factors. Fortunately, the demographic variables proved to be only weakly correlated with the probability of non-missing Census tract. This finding suggests that Census tract availability is more or less random with respect to the independent variables that we expected to determine enrollment.[7]

As the table shows, nearly half of the sample was female, 37 percent had children in the home, and 55 percent were married. The average age was 38 among the full sample; the enrollees were slightly younger, 36.[8] Average earnings in 94-95 were $36,100 for the whole sample and $29,347 for enrollees. To avoid potential endogeneity between enrollment and earnings, we defined the latter over fiscal year 94-95, which antedated the observed enrollment period. Sample members lived relatively close to an available community college: 4.4 miles from the nearest campus, main or branch, 5.4 miles from the nearest main campus. (We see below that it is the location of the *main* campus that seems to matter most.) In no case was anyone more than more than 20 miles from a community college.

To model school choice we must first identify the so-called choice set of schools available to the chooser. This process is necessarily somewhat arbitrary. For example, is

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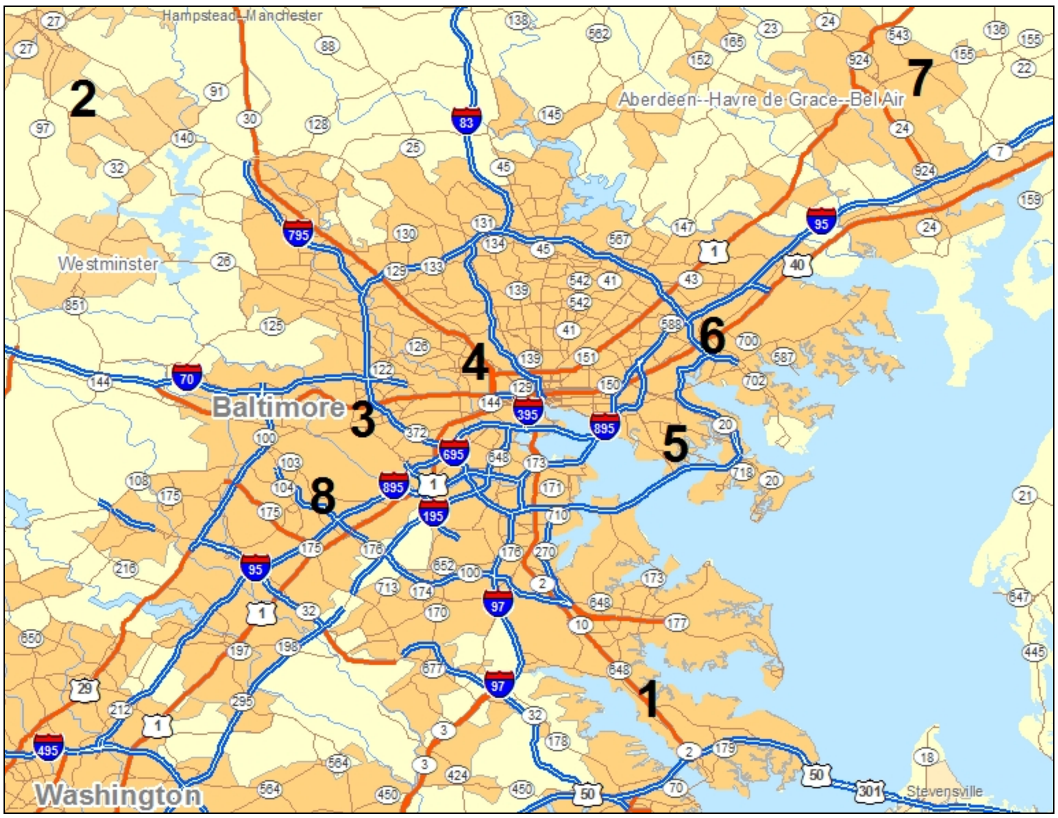
[7] Exclusively using the distance from the *residence* to each school is a potential limitation of this analysis. Surely some people go to community college classes, at night in particular, directly from their work site. Presumably, however, such people generally drive back to their homes when class concludes. In any case, we have no way of observing whether people do this.

[8] For some sample members, these demographic variables could not be observed directly and were inferred by Experian. However, Experian does not report what percentage of observations on each variable was inferred.

Kirkwood Community College in Iowa a viable choice for someone living in Greater Baltimore? In principle, yes, they can choose to go there; for practical purposes, no, it is too far away to be relevant for our model. For this study we used the convenient device

FIGURE 1



Number	Community College	Enrollment
1	Anne Arundel	12,387
2	Carroll	2,636
3	Catonsville	10,322
4	Baltimore City	6,307
5	Dundalk	3,314
6	Essex	10,490
7	Harford	5,520
8	Howard	5,050

of restricting the choice set to community colleges within the Baltimore Metropolitan Statistical Area (MSA). There are eight such schools. Their names, locations and total enrollments are identified in Figure 1. Their descriptive statistics are reported in Table 2. As a check on the validity of limiting the choice set we made alternative runs using all 20 Maryland Community Colleges.

As Table 2 shows, the eight community colleges in the Baltimore MSA vary considerably in size, from an enrollment of 2,636 students to 12,387, with an average of approximately 7,000.

Variation in tuition, as expected, was slight compared with the differences one sees among four-year institutions. The tuition cost for one year of a full-time associates-degree program ranged from $1,204 to $2,343 for local residents. Students who live in the same county as the community college pay lower tuition than other residents of Maryland, who in turn pay lower tuition than out-of-state residents. In our school-choice model, we calculate the tuition that the individual would pay at each community college (based on their 1996 location). Two of the eight colleges required some form of admissions test; half required a high school diploma or a GED. Application fees were generally small, from zero to $10.

Table 2
Characteristics of the 8 Community Colleges in Greater Baltimore

Independent Variables	Mean	Std. Dev.	Min	Max
Total enrollment (000s)	7.003	3.61	2.636	12.387
Annual full-time tuition (000s)	1.681	0.34	1.204	2.343
Application fee	6.25	5.18	0	10
Admission test requirement	0.25	0.46	0	1
HS diploma / GED required	0.5	0.53	0	1

Estimation Results

We report the results for the three types of models in the order described above. First is the probit model of whether to enroll in a community college given distance from the nearest campus. Next we report the RUM model of which school to choose, and finally the nested logit that models the enrollment and school choice decisions jointly.

A Probit Model of the Decision to Enroll in a Community College

Table 3 reports the results of a simple binomial probit model of the likelihood that a mature worker in our sample attended a local community college. Travel distance to the "nearest" campus is measured in several ways. The model needed to account for the fact that a number of the community colleges had satellite learning centers. The records from the Maryland Higher Education Commission told us which institution was attended, but not which campus. It is reasonable to expect that prospective students are more aware of a nearby main campus than a nearby satellite. Consequently we include measures distance to both, in various combinations, in the table. Model 1 uses distance to the nearest campus of any type, model 2 includes both nearest campus and nearest main campus. Model 3 (our preferred model) uses main campus only, and model 4 includes distance to the nearest main campus plus the additional distance to the next-nearest main campus.

Table 3
Marginal Effects from the Probit Model of Attending a Local Community College
By Distance Measure

	Nearest Campus		Nearest Campus And Nearest Main		Nearest Main Campus		Nearest and Next Main Campus	
	Effect	t-ratio	Effect	t-ratio	Effect	t-ratio	Effect	t-ratio
Age	-0.0009	-15.19	-0.0009	-15.29	-0.0009	-15.28	-0.0009	-15.28
Log of Earnings in 94-95	-0.0068	-7.94	-0.0068	-7.91	-0.0068	-7.92	-0.0066	-7.88
Married	-0.0006	-1.09	-0.0006	-1.14	-0.0005	-1.11	-0.0006	-1.15
Had Children at Home	-0.0020	-2.68	-0.0021	-2.83	-0.0021	-2.80	-0.0022	-2.83
Female	0.0092	12.30	0.0092	12.29	0.0092	12.30	0.0092	12.30
Distance (miles) to								
Nearest Campus	-0.0004	-4.66	0.0007	1.66				
Nearest Main Campus			-0.0011	-6.74	-0.0007	-8.10	-0.0007	-7.26
Next Main Campus (added)							0.0003	1.55
Tuition (Nearest Main)	0.0081	4.24	0.0088	4.43	0.0092	4.51	0.0076	3.99
Home Census Tract								
% Black	-0.00004	1.01	-0.00003	1.56	-0.00004	1.51	-0.00003	1.54
% Hispanic	-0.0001	-5.69	-0.0001	-6.12	-0.0001	-6.55	-0.0001	-6.46
% College Grad	0.0008	2.45	0.0012	3.68	0.0010	3.46	0.0012	3.65
Log Median House Price	-0.0013	4.14	-0.0013	5.01	-0.0013	5.42	-0.0013	4.84

All four models show that the required travel distance (from home) is a significant factor in the decision whether or not to enroll in a community college. The strongest and most significant effect comes when distance is measured to the nearest *main* campus (model 3). This finding seems to suggest that people contemplating enrollment expect to have to travel to the main campus – they may be unaware of which courses are even taught on satellite locations.

Because probit coefficients are not easily interpreted, Table 3 reports marginal effects. Given the relatively small probability of enrollment, about 0.025 for the estimation sample, the marginal effects appear to be small in absolute value. But in proportionate terms the marginal effects are non-trivial. Model 3 suggests that an additional mile of travel reduces the probability of enrollment by 0.0007, or by approximately 2.5%. To better understand the impacts of distance on enrollment, we

Table 4
Predicted Effect on Enrollment of Changes in Location of Nearest Main Campus

		Scenario 1	Scenario 2	Scenario 3
	Baseline	Campus Unavailable	One Mile Further away	One SD * Further away
Predicted Enrollment Rate	2.36%	1.91%	2.25%	2.01%
Change in Enrollment	0	-19%	-4.6%	-14.9%

simulated 3 scenarios using the probit coefficients from Model 3 above. These simulations represent events that are geographically impossible, but they are nevertheless intuitively instructive. The first (necessarily hypothetical) scenario eliminates each individual's nearest main campus, so that the second-nearest becomes the closest option. For the average person this increases the minimum required travel distance from 4.39 miles to 5.44 miles. In scenarios 2 and 3 we move the nearest main campus away by a specific distance: 1 mile and 3.37 miles, respectively, the latter figure representing one standard deviation for our sample. The results of the simulations are reported in Table 4.

As the Table shows, the probit model predicts that if everyone lost access to the nearest main campus school there would be a substantial loss in community college enrollment: 19%. Adding one mile to each person's commute to school would reduce enrollment by almost five percent. Adding one standard deviation (3.37 miles) would reduce enrollment by about 15%. These numbers suggest that the effect of geographic "availability" on community college enrollment is not only statistically significant, it is fairly large. We return to this finding below.

Other probit results

A number of other variables are significant in the probit model. Aging by 10 years reduces the likelihood of attending a community college by about 38 percent. Gender seems to matter: a woman is about 40 percent more likely to enroll than an otherwise identical man. Having children at home, on the other hand, reduces the probability of attendance by about 10%. It is reasonable to suppose that people with children, and also women, who tend to bear more responsibility for children, would find commuting to school a greater impediment to attendance than other people. To test this hypothesis we interacted the characteristics of being female and of having children with the distance variable. Neither was statistically significant in the probit model. But we return to this question below in analyzing the decision about which school to attend.

Higher earnings also reduce attendance rates: doubling earnings reduces the probability of enrollment by about 31%. This result seems quite large, even considering that opportunity cost of forgone earnings is a substantial cost of attending school. Earnings could be picking up the effect of prior education: a highly educated person should have higher earnings and less incentive to attend community college. We cannot observe prior education directly, but our census tract variables tell us whether a person lives in a community of educated people. The proportion of college graduates in the home neighborhood has a significant negative effect on enrollment. Similarly, median house price, a measure of a neighborhood's affluence, also has a negative and significant effect.[9]

As with an individual's education level, we do not observe ethnicity directly, but we know the racial composition of the home census tract. People living in Hispanic neighborhoods are significantly less likely to go to community college. Indeed, being in an all-Hispanic neighborhood, compared to a non-Hispanic one reduced the likelihood of attending community college by about 40%. The effect for black neighborhoods is also negative, but smaller and not significant.

Does Only Distance Matters? A Random Utility Model of Choosing a CC

About two thirds of the sample members who attended community college went to the school whose main campus was nearest their home. This suggests that most people may see community colleges as relatively homogeneous, so that only distance matters in selecting a school. We examine this hypothesis using a Random Utility Model (RUM) of the choice of a community college. (See the appendix for technical details of the RUM.) The sample for this model is the group of 3,473 individuals who enrolled in a local community college during the observation period and for whom we had all location data.

It is worth pausing for a moment to consider the role of demographic variables in the RUM models. As mentioned previously, variables in the RUM are characteristics of the school, not the individual, because any variable that is constant across all alternatives in the choice set drops out of the model. So, for example, the RUM can estimate the effect of a school's distance on the probability of it being the chosen school because

[9] We also estimated models that included median household income rather than housing values. The results were nearly identical to those presented in the Table.

different schools are different distances away. But the RUM cannot measure the effect of, say, gender on which school is chosen because the applicant's gender is the same, so to speak, at all prospective schools. Demographic characteristics are not irrelevant, however. RUM coefficients may differ across demographic groups. For example, we might hypothesize, as above, that due to greater family responsibilities, women and parents, when they do attend a community college, have stronger preference for the closest school. We can test this prediction by interacting travel distance with the female dummy in the traditional way. A negative coefficient on the interaction term would be consistent with the hypothesis that women respond more negatively to travel distance than do men.

Table 5 lists the results of the RUM of school choice. The first model does not include any interaction terms, whereas the second model includes interactions of demographic characteristics with distance. As a check on including only the 8 local schools in the choice set, the table also reports runs using all 20 in the state.[10] The coefficients are similar in magnitude and significance except for the high school diploma requirement, which makes a school less attractive in the 20-school model but is insignificant in the 8-school model.

The results in Table 5 suggest that prospective students do not regard all community colleges as identical except for location. The coefficient of distance is extremely significant in all of the models, but so are a number of other school characteristics. Larger schools are more attractive, as are schools with no admissions test. Perversely, students seem to *prefer* higher tuition, which we therefore assume is

[10] Why not just use all 20 schools? Using the smaller number is advantageous in the nested logit model, in which each school adds 151,448 observations (n) to the data set required for estimation.

capturing unobserved aspects of a school's educational quality and its reputation. Also, part of the tuition effect may be related to location, as community colleges typically charge higher tuition to students who do not reside in the county where the college is located.

What is the magnitude of the distance effect? Interpreting RUM coefficients is not straight forward; to address this we conduct the following simulation: what if highly-popular Anne Arundel College — attended by 23 percent of enrollees in the sample — is one standard deviation (about three miles) further away from each person? In such a scenario, "moving" Anne Arundel College one standard deviation further away from each student reduces the college's predicted enrollment share by 2.6 percentage points, from enrolling (a predicted) 17.6 percent of attendees to enrolling 15.0 percent.[11]

[11] We conducted a similar experiment for all eight schools. "Moving" a school three miles away, leaving other schools in place, reduced the likelihood of attending that school from one to seven percentage points (depending on the school).

Table 5
Random Utility Models of Choice of a Community College

	8 CC's in Greater Baltimore				All 20 Maryland CC's			
	No Interactions		Distance Interacted		No Interactions		Distance Interacted	
	Coeff.	T-stat.	Coeff.	T-stat.	Coeff.	T-stat.	Coeff.	T-stat.
Distance from home	-0.239	-53.35	-0.680	-7.49	-0.248	-56.22	-0.666	-7.51
Total enrollment (000s)	0.148	15.11	0.148	15.12	0.122	14.39	0.122	14.38
Annual full-time tuition	1.758	12.33	1.796	12.56	1.333	10.67	1.356	10.86
Application fee	-0.025	-4.54	-0.024	-4.37	-0.039	-8.31	-0.038	-8.28
Admission test requirement	-0.658	-7.65	-0.667	-7.75	-0.413	-5.71	-0.413	-5.73
High school diploma required	0.069	0.71	0.070	0.72	-0.313	-4.02	-0.324	-4.17
Female * distance			-0.034	-3.96			-0.033	-3.88
Kids at home * distance			-0.005	-0.52			-0.006	-0.65
Earnings * distance			0.045	5.17			0.043	5.03

Moving a given school one mile further away, with other schools in place, reduces that school's predicted enrollment share by about one percentage point (1% of system-wide enrollment), on average. In interpreting these results, however, note that in the RUM simulations the number of students who do not attend a community college is not allowed to change. Simulations merely re-distribute students among the eight community colleges. This is highly unrealistic -- the nested logit model estimated in the next section provides much greater flexibility.

The second RUM model in Table 5 interacts distance with female, kids, and log earnings. The results suggest that people with higher earnings – implying higher opportunity cost of time traveling – are actually *more* willing to travel to a chosen school. This result is consistent with the income effect outweighing the substitution effect. Perhaps higher-earning people are taking courses that are offered at fewer schools and therefore must travel further on average (and are better able to pay for the additional transportation costs). More likely, people with higher earnings are more oriented toward education, as evidenced by their generally having more of it. Because we cannot observe educational level, the earnings variable is probably picking up this effect.

The interactive term for female is negative and significant: women are more likely to choose a school based on proximity than are men. This result is consistent with the view that women face greater time constraints. On the other hand, surprisingly, travel distance is neither more nor less an impediment to people with kids than to people without.

The Nested Logit Model

Both the probit model and the RUM have important limitations for our analysis. The probit predicts enrollment while treating community colleges as generally homogeneous; the RUM model predicts the choice of school while holding enrollment constant. The next model, a nested logit, combines these approaches by treating the decisions whether to enroll, and which school to enroll in, as jointly determined. (Technical details are in the appendix.) Briefly stated, like the previous models, the nested logit assumes enrollment to be a function of personal characteristics, and school choice to be a function school characterless. Each represents a "nest" in the joint-decision process. But the techniques fashions a likelihood function that incorporates both models and selects coefficients by full-information maximum likelihood. The result is two sets of coefficients, one corresponding to those of the probit model, the other to those of the RUM. [12]

In the nested logit framework the enrollment and attendance models are linked by a new variable in the enrollment equation called the “inclusive valve”. The inclusive valve (see the appendix for details) is proportional to the utility valve of having available all of the alternatives in the choice set. In our case, the more attractive the set of school choices, the more likely the individual is to enroll. Changes in school characteristics—schools being further away, becoming larger, charging higher tuition—affect the inclusive valve, and (potentially) the likelihood of enrollment. This is the advantage of nested logit. Another advantage is that it allows us to simulate how a change in a particular school’s location might affect overall enrollment. For example, we use it below to predict the enrollment implications of “moving” the largest school or the most centrally located school, respectively.

The nested logit results are reported in Table 6. The top panel reports the coefficient on the school choice nest, the bottom panel the enrollment nest. Notice that no distance measure is included in the latter. As noted above, the effect of travel distance to local colleges on the attendance decision is captured through the inclusive value. It is worth noting that the coefficient of this variable is related to the correlation between the error terms of the two nests (equation 5 in the Appendix). If the error terms in the enrollment equations and school choice are uncorrelated, estimating the models jointly does not improve efficiency. The high statistical significance of the coefficient of the

[12]Because each observation adds rows to the data matrix, our estimation model used all enrollees plus a random 10% subsample of non enrollees. The likelihood function was adjusted to account for this using weights based on actual sample proportions.

Table 6
Nested Logit Model of Joint Decision to Attend a Community College and Which College to Attend
N=52798

College Choice Nest	Coeff.	t-stat	Coeff.	t-stat
Distance from Home	-0.027	-3.22	-0.066	-2.43
Distance*(Had kids)			0.0001	0.03
Distance*Female			-0.001	-0.61
Distance*Ln(Earnings)			0.004	1.86
Application Fee	0.001	0.22	0.001	0.23
Tuition	0.0002	2.99	0.0002	2.99
Enrollment (000)	0.014	2.83	0.014	2.83
HS Diploma Required	0.004	0.14	0.003	0.11
Admission test required	-0.064	-2.09	-0.063	-2.07
Enrollment Nest	Coeff.	t-stat	Coeff.	t-stat
Age	-0.040	-5.32	-0.040	-5.32
Female	0.449	4.27	0.461	4.32
Married	-0.045	-0.43	-0.044	-0.43
Children in House	-0.085	-0.77	-0.086	-0.77
Ln Earnings 94-95	-0.246	-2.42	-0.282	-2.71
Home Census Tract				
% Black	-0.001	-0.22	-0.001	-0.22
% Hispanic	-0.004	-0.81	-0.004	-0.81
% College	0.013	0.24	0.013	0.24
Ln Median House Price	0.023	0.12	0.024	0.12
Inclusive Value	7.685	3.19	7.724	3.19

inclusive value in Table 6, therefore, helps affirm the value of the nested logit approach.[13]

The school choice coefficients in Table 5 are similar to those in the RUM model. Distance from home is a statistically-significant negative impediment to choosing a given school. As with the RUM, larger schools are more attractive. Tuition still has the wrong sign – students appear to prefer schools with higher tuition. In addition to serving as a proxy for quality, part of the tuition's effect may be location: if a school is strong enough to attract students from a different county, those students generally pay higher fees.

[13] This statement assumes that the IIA assumption is satisfied.

Coefficients in the attendance nest also mimic those in the probit model both in sign and significance. Females are more likely to enroll in school. Older workers and workers with children are less likely to enroll.

Simulating the Effect of Changes in School Location

As above, for the nested logit model we simulated changes in school location. An advantage of nested logit is that we can simulate enrollment changes without assuming that all community colleges are homogeneous. This allows us to examine the impact of reducing access not just to "the nearest" community college, but to a specific institution. Table 7 presents 5 simulation scenarios. As a means of calibrating the predictions we include the two scenarios that do for all schools what the probit simulations in Table 4 did for the nearest school. Rows 1 and 2 predict the impact on system-wide enrollment of moving all schools one mile, and 3.37 miles (one standard deviation), further away, respectively. Rows 3 through 5 attempt to simulate, in effect, the removal of a given school from the Baltimore metropolitan area choice set by moving it, alternatively, 10, 20, and 30 miles away. The two schools chosen for this exercise are the largest (by enrollment), Anne Arundel Community College, and the most centrally located (by average distance from sample members' homes), Baltimore City Community College.

The nested logit simulations are generally more conservative than those of the probit simulations with respect to reducing access to schools. For example, moving all

Table 7
Predicted Change in System-Wide Enrollment from Moving CC's
Nested Logit Model

Distance Removed	All Schools	Largest School (Anne Arundel CC)	Most Centrally Located (Baltimore City CC)
1 mile	-2.76%		
1 SD (3.37 mi)	-8.9%		
10 Miles		-4.84%	-2.9%
20 Miles		-7.75%	-5.1%
30 Miles		-9.38%	-6.83%

schools 1 mile farther away reduces overall enrollment by 2.76% compared to 4.6% from the probit model for moving only the nearest school. For increasing travel distance by one standard deviation (3.37 miles),[14] the nested logit predicts about a 9% enrollment drop compared to 15% for the probit.

The Table gives an idea of the (system-wide) enrollment consequences of moving two key schools, respectively, the largest school and the most centrally located. These effects are not minor. Making people travel 10 miles further to attend Anne Arundel could cost the system almost 5% of total students. For the most central, but smaller, school, Baltimore City Community College, the effect is about 3%.

Discussion

The empirical models presented in this section tell a consistent story. Travel distance has a powerful effect on a mature worker's decision to enroll in a community college and on the choice of an institution. Even a modest increase in required travel, 2 to 3 miles, has a

[14] This is the standard deviation of the distance to the nearest school.

substantial impact on enrollment. Distance is not an extra impediment to enrollment for women and parents, as we might have suspected, but women do have a much stronger preference for nearby schools. Earnings also have a complicated effect. High earners are less likely to attend a community college, but when they do, they are willing to travel further to attend a (presumably) better institution.

If location is an important characteristic of a community college, it is not the only one that matters. Larger institutions are more attractive. The tuition effect suggests that community colleges have, to some extent, academic reputations to which prospective students respond. Finally, some potential students are daunted by the prospect of an admissions test.

Limitations

This paper focuses on the education choices faced by mature workers. Due to their employment, these workers are constrained in their education choices, and we have shown that travel distance is a major factor in these choices. This paper makes no predictions about the role of travel distance in the education choices of other individuals such as recent high school graduates or individuals who are out of the labor force (such as stay-at-home mothers). Future work should study the role of travel distance for these individuals.

Summary and Conclusions

This paper argued that the large literature on access to higher education has ignored an important segment of the post-secondary-school population: mature students at community colleges. For these people, unlike the much-studied traditional students, access should be more about location than tuition. Using data on over 150,000 mature individuals (25-49) in Greater Baltimore we establish that distance from home is a major factor in determining whether to attend community college, and if so, which one. Although hardly a surprising or counterintuitive discovery, we believe we are the first to quantify this effect. Our results suggest that if all mature persons had to travel a single additional mile from home to the nearest school, enrollment could fall by roughly 3 to 5%. Increasing the distance by one standard deviation (about 3.4 miles) would reduce enrollment by between 9 and 15%. It is clearly important that “community colleges” be located within the community if mature people are to attend.

Policy implications

The results of this study affirm that to attract non-traditional students the community college system was wise to deviate from the state university model: many scattered small schools are better than one giant one. We also believe that this study provides a tool for planners to use in deciding whether to open a new school, or close and old one, in a specified location. Note that the data set used for our analysis required no expensive survey; all information was from government administrative records or private credit agencies. With these data, a nested logit model was able to predict the enrollment consequences of “removing” two specific schools, with their particular characteristics. This method could also be used to predict the impact of adding a certain type of school in a certain place. This method might improve the precision with which the system could be expanded or contracted.

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Appendix

The Nested Logit Model

This appendix explains the nested logit model of the joint decision whether to enroll in a community college, and if so, which one. We posit that first, a person decides whether to enroll in community college; if that decision is affirmative, she then decides which of the eight local community colleges to attend.[15] These individual decisions represent the two "nests" in the model. We describe the two nests, reversing the order for purposes of exposition.

The School Choice Nest

The school-choice nest is estimated by the conditional logit technique introduced by McFadden [1973]. The model assumes that a person selects one option from among all of the options in a "choice set." The individual selects from the choice set the option that yields the highest utility. The approach is called a random utility model (RUM) because the actual utility of each choice is a random variable to the observer: we only know which option has the *most* utility, because it was chosen. To state the model formally, suppose that if individual i decides to enroll in a community college then she chooses among J alternative schools in the choice set. The utility to individual i of attending school j can be expressed as

$$U_i(\text{school j}) = \beta Z_{ij} + \varepsilon_{ij}\ ,\ \text{j=1, ... , J} \quad (1)$$

Z_{ij} is a vector of characteristics of the school j, some of which may be individual specific, such as the distance to the school from this person's home. If we observe that individual

[15] Econometrically, it is irrelevant whether the actual cognitive process proceeds in this order.

i chooses school k from the J alternatives, we infer that U_i(school k) > U_i(school j) for all $j \neq k$. The individual-specific error terms, (ε_{i1}, ε_{i2}, ... , ε_{iJ}), are assumed to be random, independently-distributed variables with an extreme value distribution. McFadden [1973] shows that under these conditions the probability that individual i chooses school j can be expressed as

$$\text{Prob(i chooses school j)} = \frac{e^{\beta Z_{ij}}}{\sum_{j=1}^{J} e^{\beta Z_{ij}}} \qquad (2)$$

Equation 2 is the well-known conditional logit formula. Intuitively, equation (2) says that the larger is the utility of school j as a proportion of total utility from all school options, the larger is the probability of selecting school j. Note that the variables in Z_{ij} are characteristics of the choices (e.g. tuition costs) and not the chooser (e.g. income or gender). Any variable that is invariant across the J schools can be factored out of both top and bottom of equation (2), thereby canceling itself out. Nevertheless, as we see below, demographic attributes of the chooser are not entirely irrelevant to the school-choice RUM.

The Enrollment Nest

The other nest in the nested logit is the decision whether to enroll in community college at all. This model employs the binary logit framework. In this case we assume that the utility of enrollment is:

$$\text{U}_\text{i}\text{(enrolling)} = \gamma X_i + \mu_i \qquad (3)$$

where X contains characteristics of the individual, and μ_i is an error term. The probability of enrolling is

$$\text{Prob(i enrolls)} = \frac{e^{\gamma X_i}}{\left(1+e^{\gamma X_i}\right)} \quad (4)$$

This is the familiar binomial logit equation.

Joint Estimation of the School Choice and Attendance Nests

To estimate the school-choice and attendance models jointly, the nested logit combines (2) and (4) in the following way. The unconditional probability that individual i will choose (enroll in) school j is:

*Prob (i enrolls in j) = Prob(i chooses j | i enrolls)*Prob(i enrolls)*

Then, using equations (2) and (4),

$$\text{Prob(i chooses j)} = \left[\frac{e^{\beta Z_{ij}}}{\sum_{j=1}^{J} e^{\beta Z_{ij}}}\right]\left[\frac{e^{(\gamma X_i + \sigma I_i)}}{1+e^{(\gamma X_i + \sigma I_i)}}\right] \quad (5)$$

Note that equation (5) is just the multiple of equations (2) and (4), except for the appearance of the parameter σ and the variable I_i. I_i is defined as

$$I_i = \sum_{j=1}^{J} e^{\lambda \beta Z_{ij}} \quad (6)$$

The variable I_i, called the inclusive value, represents the utility (to within a scale factor λ) of having available all of the schools in the choice set. It is through I_i that the distance to one or more schools affects the enrollment decision.

Notice that there is no distance variable in the enrollment nest — distance from home is a characteristic of each individual school. But, distance, of course, should also affect the enrollment decision. This impact occurs through the inclusive value: an increase in distance to any particular school lowers the utility value of the choice set of available schools, that is, it lowers I_i. Diminishing I_i then reduces the probability that individual i will enroll in any community college.

Another useful feature of the inclusive value is that it provides a means of testing whether the enrollment and school choice decisions are independent. If σ, the coefficient of I_i, equals zero, then equation (5) reduces to the multiple of equations (2) and (4), and there is no advantage to modeling the enrollment and school-choice decisions jointly.

Appendix Table 1
Comparison of Neighborhoods with Community Colleges to County Averages

	Community College							
	Anne Arundel	Carroll	Harford	Howard	Baltimore City	Catonsville	Dundalk	Essex
Percent with BA or More								
County	24.8	19.6	21.3	47.1	14.8	24.8	24.8	24.8
College	40.1	20.4	32.3	57.5	10.9	38.0	4.9	20.7
Median Household Income								
County	46,151	42,979	42,649	56,401	24,330	41,526	41,526	41,526
College	51,329	31,743	51,754	53,080	19,562	52,470	32,500	35,414
Median Home Value								
County	135,385	125,012	112,302	170,976	56,740	113,399	113,399	113,399
College	139,800	113,900	137,200	170,500	47,300	129,500	73,600	89,500