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College Auction System**

**By**

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## **Bidding for Classes: Course Allocation Under the Colorado College Auction System**

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**Abstract:** Colorado College uses an economic system to allocate scarce course seats: annually during a sealed-bid auction, each student receives nontransferrable, nonbankable currency with which to bid on courses. We estimate an instrumental variables probit model to determine whether particular student populations are a) implicitly wealthier, having the ability to afford more expensive electives, or b) more risk-averse, choosing to avoid ambiguity by bidding more strongly and/or remaining in a class rather than selecting another after pre-registration. Beyond the anticipated department-specific and instructor-specific effects attributable to popular majors or charismatic instructors, we find strong evidence that students bid more strongly for courses that have perceived scarcity of seats, courses that offer a higher expected grade, courses taught by an instructor similar to themselves, or courses with special attributes like limited enrolment or field trip components. We also find evidence of some populations being more willing to “shop around” for new class experiences after the pre-registration period.

Like many educational institutions, Colorado College, a small liberal arts college, strongly affirms the practice of individualized classroom attention by placing strict limits on the number of seats in every course. Budish and Cantillon (2012) have noted that these limits on class-size engender a multi-unit assignment problem: as students attempt to complete their major in a timely and cost-effective manner, finding the perfect course schedule becomes necessary. Lehrer (2008) reports that students experience significant difficulty securing a spot in necessary classes at many schools, so were often forced to enroll in classes they did not really want to attend. Lehrer noted that students commented that the course distribution systems could increase the duration a student was enrolled in college because they hadn't been able to register for one or two necessary classes.

Given this problem, some schools are attempting different methods to allow students to select and rank their course choices. Institutions such as Harvard Business School and the Massachusetts Institute of Technology employ a lottery system, while the University of Pennsylvania's Wharton Business School uses a completely free market auction (Bartlett, 2008; Guernsey, 1999). Colorado College is one of the few schools that use an auction system to allocate course seats; however, unlike the course market at Wharton, it does not allow students to sell their course seats for bidding credit.

We study the course auction system at Colorado College in an effort to examine the characteristics of both students and course experience that make it relatively "more valuable" in terms of student bids. The paper is organized as follows: Section 1 explains the institutional environment and the auction system, Section 2 describes the data, Section 3 explores the instrumental variable probit regression results, and Section 4 concludes with implications.

## **1. Institutional structure and auction system**

In April of every year, students at Colorado College (CC) are each allotted eighty points as the consumer budget for all courses he/she wishes to enroll in during the following academic year. Given CC's unique "block plan system", students are only permitted to bid on one class per block (where a "block" is a one-month period, arranged into four sequential blocks per semester). In addition to these eight blocks that are the core of the academic structure, students may enroll in adjunct courses which meet concurrently with traditional full courses over two blocks, four blocks, or eight blocks. Students may also enroll in half-block classes, which occur in their own dedicated timeslot during January between blocks 4 and 5.

Students wishing to enroll in a course enter their point-bids online during a two-week pre-registration period. Any bid from zero to eighty points is permissible but the eighty-point budget is a binding constraint. Once a student submits final bids or the pre-registration period ends, points cannot be regained.

There is a slight wrinkle here: incoming first-year students are not on campus the preceding April in order to bid for their courses. Therefore, the registrar reserves a fraction of seats in relevant courses (i.e., courses accessible with minimal prerequisites) for them. First-year students are assigned their first two-month course before arriving on campus. After their first two months on campus, first-year students have a separate second-round bidding auction for the reserved seats (where they receive 60 points to bid on six courses). At the end of that auction, all unallocated, but reserved, seats are released to the merged waitlist of first-year and upper-year students.

Each course has an enrollment limit: most have a limit of 25, but courses with multiple instructors may permit up to 50, and several courses each block have limited enrollment of 10-15 students. Therefore, at the end of pre-registration, the registrar admits students in order of decreasing bids until the class cap is reached. Students who bid below the minimum bid are placed onto a waitlist that is sequential by student bid amount, thereby allowing the list to remain in ordered preference by bid amount. Points are not returned to unsuccessful bidders. While students are permitted to bid on adjunct courses and half block, bidding is usually unnecessary to enroll in those courses.

This initial allocation is followed by a shopping period (or “add-drop” phase) where students may change their course selection up until the third day of that course’s block (and as late as April for block 8 classes). After pre-registration but before the first day of a course, students may enroll in any course with an open seat while remaining on the pre-registration waitlist for a different course. If a student drops a course, the registrar automatically updates enrollments from the waitlist in order of bid. Students may remain on a waitlist until the first day of the course, but after the first day of the block, the instructor has the final decision on enrollment.

Several factors during a student’s time at CC may increase his/her bidding advantage or disadvantage. For instance, a student who travels abroad for one semester is still given 80 points for the entire year, though the student will only bid on four courses instead of eight. A similar circumstance may occur during students’ capstone or thesis blocks, because some departments (but not all) guarantee enrollment into these courses, eliminating the need to bid for those experiences. While these advantages are well known, this paper determines whether certain student populations or course experiences are associated with higher or lower course bids.

## **2. Data**

We use data from several different Colorado College sources including the Registrar’s Office. This new merged dataset contains information on 79,750 auction bids covering the 2006-09 academic years. Data include information on the bidding students (every bid made during pre-registration, standing as first/sophomore/junior/senior, whether course counted toward student’s

major or met an all-college requirement, grade point average (GPA), financial aid eligibility, whether they completed the course associated with each bid, number of blocks the student intends to be on campus during the year, the number of courses a student successfully bid into the preceding year); instructor (name, gender, ethnicity, rank, average grade given across previous courses); and course (number of seats, number of students relegated to the waitlist, block during which course was taught, course level 100/200/300/400, average grade given in the previous iteration of this course, whether course was cross-listed with another department, whether course was co-taught and details of co-instructor). While we recognize that students' previous experiences with an instructor likely influence their bids, we were unable to incorporate this information into our analysis. From individual grade data, we calculated not only student GPA at the time of each pre-registration bid cycle, but the GPA for each course from the previous year, and each professor's average grade given.

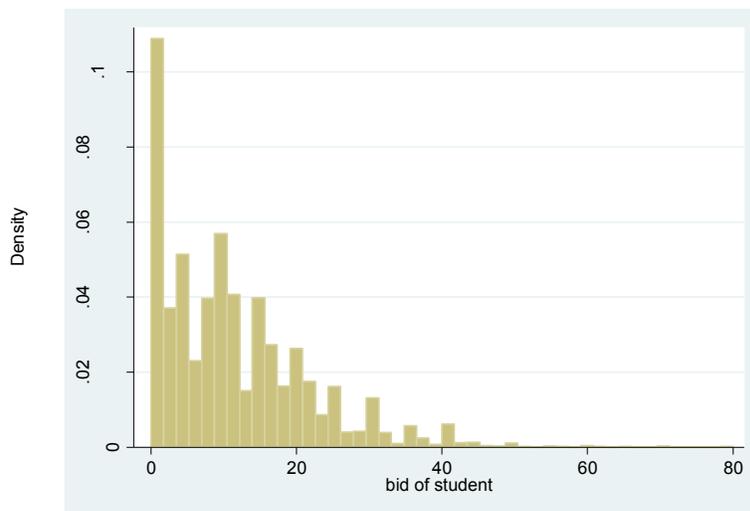
There are five all-college requirements that must be met to graduate: a two-block course known as the "West in Time" credit (knowledge of the broader world through critical inquiry), a lab class in the Natural Science division, an investigative credit of the natural world in the Natural Science division, three "Diversity" credits which ask students to study a diverse culture or viewpoint, and a two-block foreign language credit. However, given that students can test out of the language requirement, we only study the effects of the first four requirements on bidding strategy.

Interestingly, of the students who complete a course, on average less than forty percent initially bid on the course (the vast majority of those securing a seat initially, but three percent arriving from the waitlist); the majority "shopped" their way into courses. A full forty-four percent of students who initially bid on a course never completed that course, presumably finding other more attractive opportunities elsewhere. As economists, we find this behavior fascinating. While the auction system may help students to secure their critical courses, there is obviously an important role for shopping, so information must be revealed after pre-registration but before the start of each course. Clearly, this trend varies by student, by class, by instructor and by time of year. For example, there were 33 students over the three years who gained access to all 8 blocks, but chose not to complete any of those courses. Bids are fairly uniform across blocks of the academic year, but there is the greatest volatility (shopping) during block 8, the last block of the traditional academic year.

During preregistration, roughly 87.3% of all bids were high enough to guarantee a seat in the course, leaving only 12.7% to be placed onto the waitlist for a course. The average waitlist is 3.6 students, but given that most courses have a waitlist of zero, this distribution is highly skewed with a rightward tail. Among courses with a waitlist, the average number of waitlisted students is 12.44, ranging to an astounding 100 students on the waitlist for one particular course.

The average bid value during preregistration is 11.57 points. That value makes sense given that students are effectively given 10 points per class but obtain some courses for free (by departmental guarantee or by studying abroad). It also slightly outbids the annually lagged average actual point bid of 11.34 points, a reasonable outcome given the fact that annually lagged bids for every course are published in advance of pre-registration. The mean effective bid value of 5.94 reiterates that there are a large portion of students who do not bid during preregistration. The effective bid accounts for students who did not bid for a class during preregistration, but who were interested in completing the course. These individuals who did not bid during preregistration were assigned an effective bid value of zero, as they did not bid any points to garner a seat in the course. This explains why the number of effective bids (79,750) exceeds the number of actual point bids (40,946). We observed 657 cases over the three year period in which students bid above 40 points; and a startling 18 cases where students bid all 80 points on one course. Figure 1 displays the bid distribution across all courses, but the description is similar if decomposed by college division (Humanities, Natural Science, Social Science, and Interdisciplinary).

**Figure 1: Bids on All Classes**



Since only upper-level students are on campus to bid on courses in April, it is not surprising that nearly half (45.1%) of all course bids in that venue are on 200-level courses. Once we include the second-round bidding of first-year students, 31.1% of all course bids are on 100-level courses while only 23.6% are taught at the 300- level.

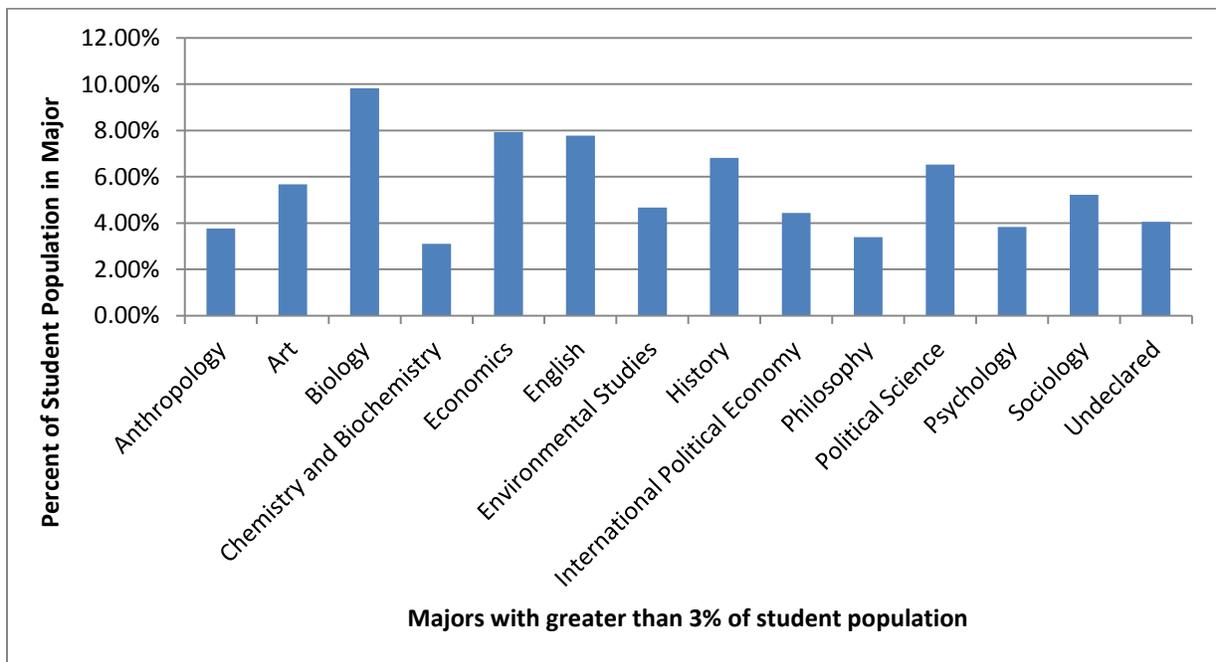
We suspect that students may bid strongly for a particular course due to a higher anticipated grade outcome as well. We calculate the course GPA as well as the course GPA from the previous year, and find an all-college average that is stable at 3.30 over the sample period.

In terms of student characteristics, men make up 45% of the student sample in a strongly Caucasian population (81.1%). Students who self-identify as Hispanic (7.0%), Asian or Pacific Islander (6.3%), African American (2.3%) and American Indian (1.0%) make up the largest minority ethnicities. International students comprise 8.7% of the student body, and half identify the American “West” as home, with the remainder split fairly evenly between “Northeast”, “Midwest” and “South”.

Roughly 49% of students received financial aid during their education at CC, but we were unable to code data on the financial amounts involved. We include an indicator variable for the presence of financial aid in the student’s history, recognizing that it does not adequately reflect the potential difference between light- and deep-need aid.

Colorado College has 43 academic majors and the option to remain undeclared for underclassmen. The distribution of declared majors in our sample, double-counting the four percent of students who declare two majors, is shown below.

**Figure 2: Most Popular Majors at Colorado College**



There were 426 instructors who taught at least one course during the observation period, a huge number for an institution with roughly 160 permanent faculty members. The reason is partly due to visitors who replace sabbatical leaves, but partly due to the curricular structure which permits block-long visitors as curricular enhancements (e.g. the former CEO of a company may visit to teach a topics course for a month).

Within all permanent CC faculty, 27% identify as female while 41% identify as male, leaving a perplexingly large share of our faculty who preferred to not identify with either gender. Instructors range from a youthful 24 years old to a seasoned 90 years old, averaging 54.17 years of age with a standard deviation of 11.9 years. The majority of permanent instructors are tenure track with only 15% ranked as non-tenure track. Twenty-four percent of all instructors are assistant professors, another 19% are associate professors, with the bulk of all instructors (40.3%) ranked as full professors. Ethnicities parallel the student body very closely: 81% identify as White/Non-Hispanic, 7.7% as Hispanic, 6.3% as Asian or Pacific Islander, 2% as African American, and 2% chose not to identify with any of the listed ethnicities.

We anticipate that instructor characteristics may matter for several reasons: charisma, personal resonance or complementarity of learning style between student and faculty, or higher anticipated average grades. While charisma is difficult to quantify (and so is left for an instructor-specific effect), we measure personal resonance by comparing the gender and ethnicity of student and faculty, and measure the average grade given in all courses offered previously by the instructor.

### 3. Estimation Results

We model the course allocation system in two steps: (1) what factors influence a student's bid amount, and (2) what factors influence a student to complete the course? We hypothesize four categories of variables that influence these two semi-separable outcomes: student characteristics, course characteristics, instructor characteristics and timing. We ran our two stages separately in order to ensure that extraneous regressors were not used as instrumented variables during the second stage probit. The actual point bid of student  $i$  for course  $j$  at time  $t$  is modeled as:

$$Bid_{ijt} = f(w_{it}, x_{jt}, y_{jt}, z_t) + e_{ijt} \quad (1)$$

where  $w$  is a vector of student characteristics for all  $i$  students,  $x$  is a vector of course characteristics for all  $j$  courses,  $y$  is a vector of instructor characteristics for all  $j$  courses,  $z$  is a vector of time-based characteristics, and  $e$  is an unmeasurable component of preferences leading to a bid outcome. Based upon those bids, we model the probability that student  $i$  completes course  $j$  at time  $t$  as:

$$\text{Prob}_i(\text{Completing course}_{jt}) = g(\widehat{Bid}_{ijt}, w_{it}, x_{jt}, y_{jt}, z_t) + u_{ijt} \quad (2)$$

where the  $u$  is an unmeasurable component of preference or ability leading to a course completion outcome. In equation 2, note that the bid amount is hypothesized as a factor in determining whether the student is more or less likely to complete the course. To operationalize equations 1 and 2 for estimation, we assume a reduced-form linear approximation, and use the predicted bid values from the first stage as an instrument for the bidding behavior of the student

in the second stage of the model. In other words, we want to find the distinct impact of the bid value on a student's decision to complete the course, above and beyond the role that other characteristics of the class experience might exercise both directly and indirectly via the bid value. Hence we estimate:

$$Bid_{ijt} = \alpha + \sum_{k_w} \beta_{k_w} w_{it} + \sum_{k_x} \gamma_{k_x} x_{jt} + \sum_{k_y} \delta_{k_y} y_{jt} + \sum_{k_z} \theta_{k_z} z_t + e_{ijt} \quad (3)$$

$$Prob_i(\text{Completing course}_{jt}) = \alpha' + \sum_{k_w} \beta'_{k_w} w_{it} + \sum_{k_x} \gamma'_{k_x} x_{jt} + \sum_{k_y} \delta'_{k_y} y_{jt} + \sum_{k_z} \theta'_{k_z} z_t + \rho e_{ijt} + u_{ijt} \quad (4)$$

where  $k_w$ ,  $k_x$ ,  $k_y$ , and  $k_z$  are the number of variables in the student, course, instructor and time categories respectively, and the accented coefficient pairs (e.g.  $\alpha$  and  $\alpha'$ ) have nothing in common quantitatively but are similarly named for their parallel roles in the two equations.

Student characteristics ( $w$ ) include gender, ethnicity, year, major, home-region, GPA, and financial aid status. Course-specific characteristics ( $x$ ) include anticipated course GPA (proxied using the ex post GPA from the current course, which correlates very closely with previous iterations where they are available), number of seats in the course, number of vacancies after bidding has occurred, number of students on the waitlist, the number of points required to earn a seat the previous year, the level of the course, and indicators of whether the course fulfills a divisional requirement or college-wide requirement. Instructor variables ( $y$ ) include gender, ethnicity, and professional rank. Timing variables ( $z$ ) include the year the course is offered as well as the block during the year when the course is offered.

### a) Student bid values

Results of the first-stage regression to explain bid values are shown in Table 1. We estimated coefficient values corresponding to indicator variables for each student major and for the department offering each course, and while they are significant and interesting, they have been omitted here for reasons of space (and to avoid the unavoidable emotional conflagration that such values would provoke at the institution kind enough to share the data). They are available on request. Suffice it to note that students who declared certain majors were able to spend an average of more than fifty percent more points per class than students who declared other majors. Some departments averaged fifteen points more per class bid (130 percent of the College's average bid overall) than other departments averaged.

We were delighted to confirm that student characteristics beyond their major (such as gender, ethnicity, GPA, and home region) did not have any significant effect on bid values. However

surprisingly, students appear to bid progressively more as they age: compared to fourth-year students, first-year students bid 2.67 points less per class, sophomores bid 1.67 points less per class, and juniors bid 0.96 points less per class. This effect could be attributable to at least three reasons: a perceived shortage in highly desirable classes combined with guaranteed access to upper-level classes (a supply-side effect), risk-aversion concerning the adverse outcome of spending additional semesters before graduation to obtain required courses (a demand-side effect), and the fact that seniors are wealthier than first years and sophomores. Seniors have the ability to allocate their 80 points on fewer courses because capstone projects and thesis blocks often do not require a bid.

Students who were more successful at bidding into their courses the previous year appeared wealthier and able to place larger bid amounts on their courses the following year. This might suggest that students who found a winning strategy (risk-averse overbidding) stayed with it, or it might suggest that students who were more successful have now secured seats in prerequisites and can gain access to upper division courses which require fewer points.

Bids appear much more sensitive to course, instructor, and time characteristics than to student characteristics. On average student bids are higher where the student and instructor have similar gender and ethnic identities (a result found in Cheryan et al, 2009; Carrel, Page, and West, 2009; Rask and Bailey, 2002; Rask and Tiefenthaler, 2004; and attributed to a greater probability of an inclusive learning environment). The effects are small but significant: on average one half-point higher for an instructor with the same ethnic identity and one quarter-point higher for an instructor of the same gender.

Students also appear to care deeply about their anticipated grades, and bid strongly for higher outcomes. For a one-scale-point increase in an instructor's average GPA, students will on average bid 2.85 points higher for the course. In a robustness test using instructor-specific effects, this coefficient was reduced to statistical insignificance suggesting that either charismatic

**Table 1: First Stage—Explaining Student Bid Amounts**

<b>Variable</b>	<b>Coefficient (T-Statistic)</b>	<b>Variable</b>	<b>Coefficient (T-Statistic)</b>
First-year student	-2.672 (-8.74)***	Instructor is a full professor	0.2 (1.02)
Sophomore	-1.668 (-6.24)***	Instructor identifies as African American	0.733 (1.58)*
Junior	-0.96 (-3.6)***	Instructor identifies as American Indian	9.973 (4.58)***
Student identifies as female	-0.185 (-1.59)	Instructor identifies as Asian or Pacific Islander	1.026 (3.86)***
Number of blocks student intended to be on campus	-0.919 (-16.88)***	Instructor identifies as Hispanic	-1.133 (-4.27)***
Number of courses student successfully bid into last year	0.149 (5.63)***	Instructor chose not to identify ethnicity	3.362 (6.73)***
Student is a double major	0.249 (0.55)	Instructor identifies as "other"	-2.228 (-4.36)
Student is on financial aid	-0.071 (-0.61)	Course is a 100 level	5.929 (23.7)***
Student GPA	0.02 (0.19)	Course is a 200 level	5.031 (22.01)***
Student's home region in West	-0.039 (-0.17)	Course is a 300 level	3.398 (15.68)***
Student's home region is Midwest	0.011 (0.04)	Course is a two block course	6.342 (14.8)***
Student's home region is Northeast	-0.272 (-1.08)	Course is in the Natural Science division	-0.061 (-0.18)
Student's home region is South	-0.297 (-1.16)	Course is in the Humanities division	-1.577 (-6.65)***
Student identifies as African American	0.119 (0.33)	Course is in the Social Sciences division	-0.363 (-1.88)*
Student identifies as American Indian	0.453 (0.68)	College Requirement 1	3.104 (5.99)***
Student identifies as Asian or Pacific Islander	0.239 (0.91)	College Requirement 2	3.404 (10.51)***
Student identifies as Hispanic	0.346 (1.33)	College Requirement 3	0.727 (2.55)***
Student chose not to identify	-0.176 (-0.15)	College Requirement 4	1.546 (8.39)***
Student identifies as "other"	-0.227 (-0.59)	Year	-0.171 (-2.56)***
Class GPA	0.479 (2.42)**	Block 1	1.683 (8.79)***
Number of Seats in the class	-0.197 (-15.49)***	Block 2	1.362 (6.68)***
Student and instructor have similar ethnic identities	0.51 (2.42)**	Block 3	1.085 (5.43)***
Student and instructor have similar gender identities	0.267 (2.47)***	Block 4	0.832 (4.28)***
Instructor is female	-0.573 (-4.33)***	Block 5	0.727 (3.49)***
Instructor's average GPA	2.852 (10.46)***	Block 6	-0.689 (-3.66)***
Instructor is an assistant professor	-0.149 (-0.74)	Block 8	-0.142 (-0.73)
Instructor is an associate professor	0.488 (2.31)**	Constant	3.197 (2.82)**
N =	30731	R-Squared	.2027

\*Indicates the coefficients are significant at the 10% confidence level; \*\*indicates the coefficients are significant at the 5% confidence level; \*\*\*indicates coefficients are significant at the 1% level.

and talented instructors are on average high graders, or that students actually care about the instructor quality rather than anticipated grades. While the results are currently empirically indistinguishable, we prefer to believe the latter.

Lower level courses require higher bid amounts, presumably because they have a larger population eligible to enroll, and the four all-college requirements indicate that on average a class that fulfills an all-college requirement can increase a student's bid amount by as much as 3.4 points.

Finally, timing clearly matters. We found it very surprising that students bid more for courses earlier in the year, with block one enjoying a 1.68 point premium over block seven courses, *ceteris paribus*. This result might reflect a strong myopia or discounting of the importance of future events (also evidenced by the more active shopping during the last months of the academic year) or it might reflect the uncertainty about enrolment preferences and pressures given the sequential nature of prerequisites to be surmounted before the spring courses.

#### **b) Probability of course completion**

Leveraging this information, the second stage probit analysis models the factors that might influence a student's decision to complete the course. Table 2 shows the estimated coefficients and computed marginal effect of each variable on course completion.

Surprisingly, the bid amount had no statistically significant effect on a student's probability of completing the course. This would appear to contradict some theories in popular behavioral economics (Ariely, 2008) and may indicate that students (correctly) consider the bid a sunk cost by the start of the class.

Several student-specific characteristics appear to correlate with course completion rates. Women are 1.4% less likely to complete a course on which they bid than are their male counterparts. This effect may be ameliorated or exacerbated by the gender of the instructor, since a similarly-gendered instructor increases course completion rates by a modest 0.3%.

Perhaps more important for any institution attempting to boost student diversity, ethnic minorities have lower probabilities of completing the course compared to their Caucasian peers; African American students are 1.2 % less likely, Hispanics 1.2% less likely, Asian and Pacific Islanders are 1.3% less likely, and students identified as "other" are 2.5% less likely to complete the course. This could be a positive result, indicating that students who identify with an ethnic minority feel more comfortable switching to a more comfortable learning environment, a possibility which is neither confirmed nor rejected by the ethnicity of the instructor.

When taking courses after declaring one's major, completion rates increased an average of roughly 3%. There are a few possible reasons for this result as well. Perhaps students with a declared major feel more secure in the classes he/she has chosen to bid upon. Perhaps students in a major have access to better information, from personal experience or from other students, with which to pick their courses initially. Perhaps students feel less willing to shop away from courses for fear of delaying their graduation.

**Table 2: Second Stage--- Probability of Course Completion and Marginal Effects on Probability of Course Completion**

Variable	Probit MLEs (Z-Statistic)	dy/dx	Variable	Probit MLEs (Z-Statistic)	dy/dx
Bid	-0.002 (-0.510)	0.000	Instructor's average GPA	0.109 (2.6)***	0.011
First Year Student	0.042 (0.940)	0.004	Instructor is an assistant professor	0.033 (1.07)	0.003
Sophomore	0.081 (2.220)**	0.008	Instructor is an associate professor	0.081 (2.56)***	0.008
Junior	0.039 (1.10)	0.004	Instructor is a full professor	0.092 (3.13)***	0.009
Student identifies as female	-0.145 (-7.53)***	-0.014	Instructor identifies as African American	-0.241 (-3.63)***	-0.028
Number of blocks student intended to be on campus	-0.001 (-0.13)	0.000	Instructor identifies as Asian or Pacific Islander	-0.026 (-0.59)	-0.003
Number of courses student successfully bid into last year	-0.007 (-1.760)*	-0.001	Instructor identifies as Hispanic	0.016 (0.38)	0.002
Student is a double major	-0.364 (-4.50)***	-0.047	Instructor chose not to identify ethnicity	-0.165 (-2.03)**	-0.018
Student is on financial aid	0.074 (3.940)***	0.007	Instructor identifies as "other"	0.03 (0.32)	0.003
Student GPA	0.065 (3.82)***	0.006	Course is a 100 level	-0.716 (-16.17)***	-0.095
Student's home region in West	0.043 (1.110)	0.004	Course is a 200 level	-0.616 (-15.67)***	-0.065
Student's home region is Midwest	-0.015 (-0.330)	-0.001	Course is a 300 level	-0.341 (-9.1)***	-0.038
Student's home region is Northeast	-0.054 (-1.280)	-0.005	Course is a two block course	-0.11 (-1.97)**	-0.012
Student's home region is South	0.004 (0.100)	0.000	Course is in the Natural Science division	0.316 (8.21)***	0.027
Student identifies as African American	-0.115 (-1.780)*	-0.012	Course is in the Humanities division	0.251 (8.98)***	0.022
Student identifies as American Indian	-0.173 (-1.60)	-0.019	Course is in the Social Sciences division	0.219 (8.01)***	0.02
Student identifies as Asian or Pacific Islander	-0.126 (-2.820)***	-0.013	College Requirement 1	0.3 (4.58)***	0.023
Student identifies as Hispanic	-0.115 (-2.630)***	-0.012	College Requirement 2	0.033 (0.73)	0.003
Student chose not to identify	-0.198 (-1.12)	-0.023	College Requirement 3	0.078 (1.61)	0.007
Student identifies as "other"	-0.214 (-3.110)***	-0.025	College Requirement 4	-0.319 (-12.09)***	-0.037
Class GPA	0.138 (4.12)***	0.013	Year	-0.012 (-1.06)	-0.001
Student bid into the course	-6.485 (-76.25)***	-0.689	Block 1	0.538 (15.78)***	0.038
Student bid onto the Waitlist	-7.211 (-73.28)***	-0.993	Block 2	0.312 (8.94)***	0.025
Seats in the class	0.003 (1.31)	0.000 (1.31)	Block 3	0.265 (7.88)***	0.022
Vacancies in the class after pre-registration	-0.016 (-9.57)***	-0.002	Block 4	0.057 (1.67)*	0.005
Number of students on the waitlist	-0.004 (-4.09)***	0.000	Block 5	0.118 (3.52)***	0.011
Student and instructor have similar ethnic identities	-0.038 (-1.04)	-0.004	Block 6	-0.045 (-1.34)	-0.005
Student and instructor have similar gender identities	0.031 (1.71)*	0.003	Block 8	-0.251 (-7.33)***	-0.028
Instructor is female	0.023 (1.15)	0.002	Constant	5.660 (29.720)***	
N =	30729		Pseudo R-Squared	0.26	

\*Indicates the Z-scores are significant at the 10% confidence level; \*\*indicates the Z-scores are significant at the 5% confidence level; \*\*\*indicates z-scores are significant at the 1% confidence level.

In contrast, the all-college requirements, which required many points to gain access, range from College Requirement 1, which increases the probability of completion by 2.3% to College Requirement 4 which decreases the probability of completion by 3.7%. This result may be attributable to the number of courses which satisfy each requirement (and therefore reflect simply a question of relative scarcity) or there could be something else afoot. Further, College Requirement 1 (the “West in Time” credit) is a two-block course and therefore harder to “replace” likely making students more reticent to drop the course.

Additionally, we find that instructor rank, while exerting no influence on bid amount, does influence a student’s probability of completing the course. A tenured professor, either associate or full, increases the probability of course completion compared to a non-tenure track instructor by roughly 1%.

Finally, timing (surprisingly) matters again. Courses offered during the first three blocks of the year are more likely to be completed than are courses offered later in the year. This occurs due to the add-drop or shopping phase that is longer for block 8 than it is for block 1, but it poses interesting challenges for the registrar, instructor and students, as course enrollments are differentially volatile throughout the year.

As a final note on Table 2, the large negative effects of bidding into the course (-0.689) and bidding onto the waitlist (-0.99) should not engender a great deal of emphasis. Rather, these large effects are caused by the biased sample. Since we only have data for students who either bid on the course or completed the course, the effect of bidding into the class/on the waitlist is overstated. We do not have any data for students who attempted to take the course without bidding and failed to complete the course. When we considered only students who bid upon the course and their rates of completion, we find that bidding into the course, relative to bidding onto the waitlist, increases the probability of completing the course by 28.4%.

Robustness tests that replace department effects with instructor-specific effects show very similar results. Again, we will not report the instructor-specific effects here out of respect for the instructors at the institution, but students clearly bid for the instructor as much as for the course itself. Several instructors exhibited premiums of more than twenty points over their peers, *ceteris paribus*, while the lowest ten percent of instructors decreased a student’s average bid between five and eleven points. Rather disturbingly, over and above instructor-specific effects, instructor ethnicity matters--- bids average 4.77 points lower for courses taught by African American instructors while averaging 5.17 points higher for courses taught by Hispanic instructors.

#### 4. Conclusion

The auction system that Colorado College uses to allocate class seats results in about forty percent of those who bid seeing those classes through to completion. The resulting seemingly volatile registration system involving waitlists and add-drop periods that last for months is worth modeling in two stages, in order to explain the student, class, instructor and time-based characteristics that lead to higher bidding and to higher probability of course completion. As a result, the analysis offers some insights that are less visible within other course assignment systems, where students do not “pay for courses one at a time”.

Most interesting to us were the large and statistically significant differences in bid values associated with particular academic majors or departments, differences that easily account for fifty percent or more of bid value variation, even controlling for all other factors. Instructor-specific effects were nearly as impressive, suggesting that students bid strongly for particular teaching experiences over and above other attributes of the course.

While personal attributes associated with the bidding student were not correlated with bid values, they had some surprising explanatory power in the second stage of analysis, namely course completion. We found evidence that students may bid more for courses in which they anticipate a higher grade, where they expect a more receptive learning environment (as measured by congruence between student and faculty gender and ethnicity), and where they have been successful auction winners in the past. In terms of course completion, women and ethnic minorities were less likely to complete the courses for which they initially bid, but all students were more likely to complete courses within their major, courses taught by a more senior faculty member, or courses taught earlier in the year.

At an institutional level, we conclude that there are inequities between majors that could be addressed at this institution. While shopping is clearly an accepted manner of obtaining a class seat, students in some majors are obviously left with fewer points with which to secure advance seats, and presumably seats in more desirable and high-bid courses.

Further, in terms of efficiency the institution could manipulate course offerings over the year to ensure that seat shortages (and surpluses) are reduced. Given that students are much more likely to complete courses offered first semester than late second semester, departments could offer a larger number of required courses during first semester and more electives and high-bid, popular courses in the second semester. The institution might even consider two separate auctions, one for each semester, to reduce class composition volatility and enable better logistic planning.

For institutions without an auction system, we would encourage careful and thoughtful review of any data that might reflect on differential demand and supply forces, and differential course

completion rates. In academia, where the supply of courses is frequently tied inexorably to tenured faculty lines which can only be changed in volume at a generational rather than annual rate, it is particularly important to watch for signs of shortage or surplus. Open bidding is one way to illuminate those market forces, for the purposes of better serving our students and our long-term efficiency as providers of education.

## References

- Ariely, Dan (2008). *Predictably Irrational: The Hidden Forces that Shape Our Decisions*. New York, NY. Harper-Collins Publishers.
- Bartlett, Thomas (2008). "Class Warfare: When Getting in is the Hardest Part." *The Chronicle of Higher Education*. February 15.
- Bettinger, Eric P., and Bridget Terry Long (2005). "Do faculty serve as role models? The impact of instructor gender on female students." *American Economic Review*: 152-157.
- Brams, Steven J., and Alan D. Taylor (1996). *Fair Division: From Cake-cutting to Dispute Resolution*. New York: Cambridge University Press.
- Brams, Steven J., and Alan D. Taylor (1999). *The Win-Win Solution: Guaranteeing Fair Shares to Everybody*. New York: W.W. Norton and Co.
- Budish, Eric, and Estelle Cantillon (2012). "The Multi-Unit Assignment Problem: Theory and Evidence from Course Allocation at Harvard." *American Economic Review*. 102(5): 2237-2271.
- Carrel, Scott, Marianne Page, and James West (2009). "Sex and Science: How Professor Gender Perpetuates the Gender Gap." *UC Davis Economics Department Working Paper*. Retrieved from <http://www.econ.ucdavis.edu/faculty/scarrell/gender.pdf>
- Cheryan, Sapna, Victoria Plaut, Paul Davies, and Claude Steele (2009). "Ambient Belonging: How Stereotypical Cues Impact Gender Participation in Computer Science." *Journal of Personality and Social Psychology*, 79, 1045-1060.
- Colorado College (2013). "Guidelines for Points." Retrieved from: <http://www.coloradocollege.edu/offices/registrar/pre-registration/guidelines-for-points.dot>
- Guernsey, Lisa (1999). "Business School Puts Courses in Hands of an On-Line Market." *New York Times*. September 9, 1999.
- Kominers, Scott, Mike Ruberry, and Jonathan Ullman (2010). "Course Allocation via Proxy Auctions." WINE'10 Proceedings of the 6th international conference on Internet and network economics, pages 551-558.
- Lehrer, Jim (2008). "College Students Squeezed by Rising costs, Less Aid: Straining the System." *NewsHour*, PBS, December 9, 2008.
- Nelson, Kirby (2009). *The Economics of Auctions: An Examination of the Colorado College Bidding System of Course Selection*. Colorado College Department of Economics & Business undergraduate thesis.

Neumark, David, and Rosella Gardecki (1996). *Women helping women? Role-model and mentoring effects on female Ph. D. student in economics*. No. w5733. National Bureau of Economic Research.

Pathak, Parag and Jay Sethuraman (2010). "Lotteries in Student Assignment: an Equivalence Result". *NBER Working Paper* 16140.

Rask, Kevin N., and Elizabeth M. Bailey (2002). "Are Faculty Role Models? Evidence From Major Choice in an Undergraduate Institution." *The Journal of Economic Education* 33.2: pp 99-124.

Rask, Kevin N., and Jill Tiefenthaler (2004). "Too Few Women or Too Many Men? The Gender Imbalance in Undergraduate Economics," working paper. Retrieved from [www.cswep.org/papers/RaskTiefenthaler2004.pdf](http://www.cswep.org/papers/RaskTiefenthaler2004.pdf)

Sönmez, Tayfun & M. Utku Ünver (2010). "Course Bidding At Business Schools," *International Economic Review*, 51(1): 99-123.

Sullivan, Harold (2011). *Course Allocation on the Block Plan: the Relationship Between Professor and Points Bid*. Colorado College Department of Economics & Business undergraduate thesis. Retrieved from <http://dacc.coalliance.org/fedora/repository/coccc:3425>