12-3-2013

The Undergrad's Dilemma: *n*-Person Games and Information Asymmetry in Undergraduate Course Selection

Michael A. Verlezza

The Undergrad’s Dilemma:

n-Person Games and Information Asymmetry in Undergraduate Course Selection

Michael A. Verlezza

Submitted in Partial Completion of the

Requirements for Commonwealth Honors in Economics

Bridgewater State University

December 3, 2013

Dr. Michael Jones, Thesis Director
Dr. Daniel M. Lomba Jr., Committee Member
Dr. Quoc Tran, Committee Member

The Undergrad's Dilemma:

n-Person Games and Information Asymmetry in Undergraduate Course Selection

Michael A. Verlezza
3 December, 2013

Abstract:

In 2012, the White House released its College Scorecards for institutions of higher education. In their overview, the White House states that Bridgewater State University in Bridgewater, MA, has a six-year graduation rate of just 51.7 percent. By approaching the question of low graduation rates as a consequence of economic inefficiency, my research led me to treat undergraduate course selection as a Nash *n*-person game. From there, my investigation led to an analysis of information asymmetry as I attempted to identify the various internal and external information sources driving course selection. Specific attention was given to Bridgewater State's internal system, Infobear, which was held alongside the external professor evaluation site RateMyProfessors.com. The data was analyzed using Ordinary Least Squares regression models. Ultimately, I propose a solution to help maximize utility, which I refer to as Involuntary Equilibrium, which holds the potential to create a novel relationship between the institution and the student while maximizing aggregate societal utility.

Acknowledgements:
This paper was prepared under the guidance of Dr. Michael Jones, Bridgewater State University Economics Department. His assistance and guidance has proven invaluable. Moreover, this paper would have been impossible without the ongoing assistance of Honors Program Administrator Amy Couto and Program Director Dr. Teresa King. I have also benefitted tremendously from the insights of my wife, Alice, who has consistently helped me evaluate, defend, refine, and reinforce my ideas.

I. Competitive Forces: A Keynesian Approach to Course Selection

In his landmark work *The General Theory of Employment, Interest, and Money,* John Maynard Keynes introduces a concept familiar to many but entirely understood by few. Supply and demand curves are plotted along two axes, typically labeled "price" along the vertical axis and "quantity" along the horizontal one. While the graph in *The General Theory* is used to describe interest rate effects of changes to the money supply, it is useful to use the graph to explain an array of economic phenomenon (1936).

The Supply of Education

In an economic sense, this paper treats the "supply of education" as the quantity of classes offered in a particular subject, but a more specific approach – treating every individual seat in each separate course – is a viable alternative, particularly when investigating the issue of course selection from an individual perspective. At the larger institutional level, it is more sensible to take the class-by-class approach. Over the course of this paper, various scenarios will call for a course-level approach, a seat-based approach, or a combination of the two.

It is important to establish a few assumptions. Firstly, it is important to establish that individuals are intrinsically selfish (250 years of economic thinking speaks to the power of rational self-interest). It is also important to acknowledge that seats in a class are effectively private goods – they are both rivalrous and excludable. Rivalrous goods are those goods that their consumption by one person precludes the consumption of the same good by another. Excludability is the notion that people cannot access a specific good without incurring some cost. The finite nature of seats or classes offered ensures the logical underpinnings of these assumptions.

Stemming from these assumptions are a few key observations. First, students will follow a selfish path through their degree programs, seeking to optimize their own well-being through course selection and continued enrollment. Second, the finite number of seats and classes creates competition (for a preferred professor, a particular course, and a specific time for an offering). Third, this competition creates winners and losers in the higher education system.

The answer, however, is not an increase in supply – neither in the form of additional seats or additional course selections. Braess' Paradox tells us that merely adding additional capacity will reduce overall performance across the system. This will have systemic implications as the additional choice creates added confusion, a scenario only avoidable if the system was in Nash Equilibrium to begin with. Braess tells us that students perceiving an easier path will flock to the new alternatives, while others vacillate between offerings. It has been shown that this dithering creates a less optimal selection strategy, which remains until Nash Equilibrium is reestablished. In the interim, this allocation of resources (here taking the form of seats in a course) is less than ideal. Students (as has been shown to be the case in various studies involving motorists) continually re-rank their options, falling back reliably on rational self-interest (Braess, 2005). Conversely and perhaps counter-intuitively, limited selection may lead to fewer idle classroom resources.

<u>The Demand for Education</u>

The escalating price tag of higher education over the last half decade has created an environment conducive to an investigation of buyer behavior. One study in particular, has demonstrated the inelasticity of higher education. Consequently, students will continue to purchase higher education without regard to increasing costs (Rivera, 2012).

Historically, the understanding was that cultural and familial mores were a powerful motivator driving the demand for higher education. While there is indeed a social component, more recent analyses suggest that the biggest driver of continued pursuit (or return to) higher education comes from a student's peer group. In their 1965 analysis, McDill and Coleman evaluated the various factors that drove college enrollment. To their surprise, while familial influences (educational attainment of previous generations, parental income, etc.) were a factor, they were not nearly as influential as initially assumed. In their model, the variable with the most explanatory power was social standing – peer pressure in common parlance. For McDill and Coleman, high school students entering college are doing so simply in an effort to "keep up with the Joneses."

There is also the widespread expectation that higher levels of educational attainment drive higher income potential later in life. David Card's comprehensive work on the subject brings the relationship between years of education and income into clear focus. His 1999 paper demonstrates that the relationship is essentially logarithmic in nature. On balance, more schooling does in fact lead to higher mean wages. By looking at earners between the ages of 40 and 45, Carr is able to account for people with decades in the workforce, avoiding any biases that might arise from institutional prestige or underpaid entry-level work.

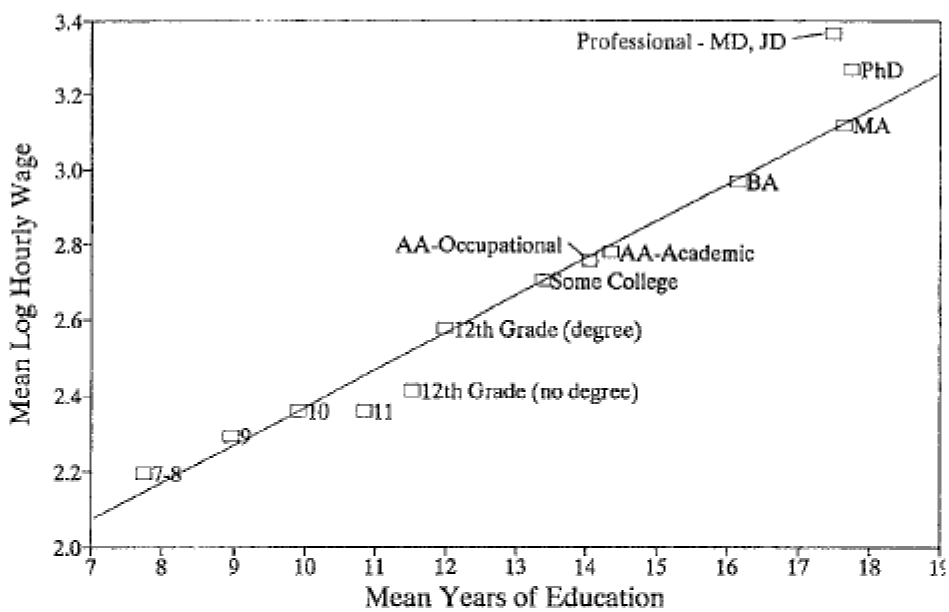

Figure 1 - Relationship between mean log hourly wages and completed education (Card, 1999).

When held against data from the Bureau of Labor Statistics (2013), Card's research lays plain the relationship between educational attainment and income potential, and those with a college education will fare far better than their less-well educated peers.

Other Economic Considerations

In May of 1991, the entire Ivy League, along with the Massachusetts Institute of Technology, faced a complaint from the Justice Department regarding the manner in which they set tuition prices. All but one school named in the action (MIT) settled the complaint. In response, the Justice Department was forced to issue a decree specifically "preventing…schools from jointly fixing tuition or financial aid awards or and from exchanging financial aid information on admitted applicants" (Morrison, 1992). Knowing that this was a common practice going back to at least the 1980s, it is impossible to discuss the economics of higher education without at least a cursory treatment of cartel pricing.

Cartel pricing stems from the notion that a group of ostensible competitors would agree, formally or informally, to set market prices for their product. In the case of the Ivy League and MIT, this took the form of tuition and financial aid packages, ensuring the cartel could ensure abnormal financial gains for themselves while extracting value from students. Collusion was simple in the Ivy League due the small number of firms involved, but in the present regulatory environment and in a nation that boasts hundreds of colleges and universities, cartel pricing of higher education on a larger scale would verge on the impossible.

It may go without saying, though, that institutions of higher education have the monopoly on higher education. That said, schools are not perfect substitutes for one another, creating an environment of oligopoly. While the Cournot-Nash model of oligopoly is the simplest, it is perhaps not the most appropriate, given the dominant nature of prestige institutions in various parts of the country. With a Dominant Firm model, there is a single firm (or handful of firms) that control the market, be it through product differentiation, branding, or other aspects. As a result, the entire market follows the pricing model of the dominant firm. In the Boston area, it would be hard to argue that the dominant firm is Harvard. In this instance, reality closely follows economic theory. According to data from the Provosts of both Harvard and Bridgewater State University, Harvard tuition (in nominal dollars) has gone from $13,085 in 1990 to $33,656 in 2010, while Bridgewater State tuition has gone from $1,788 $6,603 over the same time period. By increasing their prices so dramatically over the previous two decades, other universities in the area have been forced to keep pace. This demonstrates the dominant firm oligopolistic model and explains rising prices across the board.

In this introductory and admittedly high-level analysis, it would seem that students and their peer groups are not the only entities trying to "keep up with the Joneses." Interestingly, higher education seems to follow similar paradigms on both the demand and supply sides.

II. Strategic Course Selection – A Game Nobody Really Wins?

Having established the underlying economic forces at the core of higher education, it is possible to begin an investigation as to how students end up in various courses. Anecdotally, it has been suggested by students themselves that rarely is a semester comprised of an ideal combination of courses, times, and professors. This is attributable to a variety of forces, and this section will approach the problem from a trio of more advanced economic concepts, from which I derive an additional explanatory economic construct. It is important to introduce three more advanced mechanics in order to arrive at the fourth. With these additional mechanics in place, we can move on to a real-world example of how to an econometric analysis of undergraduate enrollment.

n-Person Games

In his seminal work, *Non-Cooperative Games,* John Forbes Nash improved on existing zero-sum game theory originally introduced by John von Neumann. By treating individuals as competitors rather than parties in collusion, Nash assumed "that each participant acts independently, without collaboration or communication" (1950). For the purposes of this analysis, we can treat individual students as competitors in a zero-sum, non-cooperative *n*-person game. Nash's work dictates that there is an ideal outcome whereby in a finite system such as a college registration environment, there is an equilibrium point at which every member of the community enjoys the best possible outcome (within the constraints of said system). The underlying mathematics that Nash uses to establish that equilibrium point is beyond the scope of this paper. Nonetheless, it is important to start with the assumption that there exists an ideal scenario whereby everyone in the system, in a manner of speaking, "wins."

In practice, however, Nash's model is insufficient. Consider a binary state whereby two competing parties employ strategies *i* and *j* in an effort to build the ideal schedule. Nash's model would suggest that an equilibrium point exists at the intersection of the two strategies, whereby both parties (students) would get everything they want. While Nash Equilibrium would suggest academic harmony, it is rarely practical in the typical course registration setting. Frequently, students get a mixed bag consisting of some combination of ideal courses and other, less useful options. Thus, Nash's model requires two substantial modifications: the presence of strategic dominance and intransivity.

In the case of strategic dominance, assume students Alice and Bob are employing strategies *i* and *j* in order to build their ideal schedule. In the case of course registration, strategy can be defined as the courses needed to maintain full time enrollment, progress within a major, complete prerequisites, etc. The problem arises from the competitive nature of course registration and the rivalrous, excludable nature of the good being sought. Nash's original mathematical model incorporates the competitive and non-collaborative nature of these processes, but overlooks the notion that there exists a strategy *i* which will always yield a superior result. Moreover, while our example has a binary state of two students employing only two distinct strategies, in reality there are as many different strategies as there are students. In the context of course registration, strategic advantage will most typically arise from two factors – priority registration and academic standing.

The consequence of prioritized registration leads to a second requisite modification to Nash's original insights. Intransivity, in economic terms, refers to an individual acting in a manner inconsistent with their self-interest. In our game of course registration, we can think of this as Alice or Bob self-assigning (effectively relegating) themselves to inferior strategy *j*. In practice, we see this frequently among the population of underclassmen, who are forced to enroll in courses that are not necessarily their first choice, either for one or for an array of reasons. As this paper will go on to demonstrate at the end of this section, it is possible to employ set theory to express the effects of strategic dominance and intransivity within the context of *n*-person games. Later still, we will see a modified model with the potential to incorporate not only individual preferences and the natural "pecking order" of undergraduate registration, but also the virtually infinite combinations of possible schedules within a variety of parameters.

Information Asymmetry

Treating course registration as a competitive *n*-person game as we are, any discussion would be incomplete without the incorporation of information asymmetry. The notion was originally introduced by the economist Joseph Stiglitz in his 1992 paper, in which Stiglitz suggests that information is a critical component of any economic system. Specifically, his paper dealt with the implications of imbalanced information between buyers and sellers in credit markets, but the economic tools he introduced can easily be scaled down and applied to microeconomic decision-making.

In virtually any exchange, there is an unbalanced relationship between knowledge held by the seller and the knowledge held by the buyer. In the case of higher education, the under-informed buyer is clearly the student, while the school (or more specifically, faculty and staff) maintain a more solid understanding of institutional policies and academic requirements. In our *n*-person game where there existed strategies *i* and *j*, the problem arises when neither of our students (Alice and Bob) truly understand all the variables that may affect their decisions, and thus cannot adequately account for them strategically.

To remedy the gap, students seek sources of external information. This can be problematic for a variety of reasons, because as Stiglitz tells us, not only are the cost of accumulating additional information is increasingly expensive, but delivers marginal benefit at a decreasing rate. The dynamic is further complicated by the realities of navigating the world of higher education for undergraduates – reliable information is only occasionally gleaned. The possibility of a student developing a given strategy which will actually engender maximum utility when that strategy is predicated on inaccurate or incomplete information creates problems for our *n*-person game. Fundamental concepts in information economics tell us that information may be easy to create but is virtually impossible to verify. The consequence for students is strategy rife with error – a scenario that leads to intransivity.

As a way to demonstrate the dangers of external information sources, the econometric component of this paper will examine the relationship between enrollment and one specific external source of information, the infamous ratings website RateMyProfessors.com. While additional detail follows below, it is worthy of note here that in our *n*-person game, the relationship between enrollment in a specific course having *m*-tuple parameters is statistically significant, suggesting that students may, in reality, be predicating their course selection strategies on less than trustworthy sources.

Pareto Optimality

The Italian economist Vilfredo Pareto originally applied his understanding of resource allocation to income distribution. Like Nash's strides in game theory and Stiglitz's introduction of information asymmetry, Pareto Optimality (frequently referred to interchangeably as Pareto Efficiency) can be couched in terms of higher education. In fact, it is perhaps the easiest of the three to see at work at a university, as Pareto Efficiency deals specifically with microeconomic outcomes – in short, Pareto Efficiency exists when no one party can be made better off without making another party worse of (Barr, 2012).

Optimization under Pareto Efficiency is predicated on a pre-existing allocation of goods. Typically this is done randomly or treated as a given for the purposes of economic modeling. In higher education, this would be equivalent to enrolling every student in a full roster of randomly assigned classes. From there, Pareto Improvement takes place as members of the undergraduate community exchange seats in various classes to more closely align their realized schedule with their established strategy. While such a mechanic is impractical, it does demonstrate the viability of Pareto's optimal distribution of resources, and ultimately, how it aligns with Nash's notions of equilibrium.

The difference between equilibrium states for Pareto and Nash, however, is that Pareto's scheme is predicated on a good-faith exchange of resources amongst participants in the system. While it's true that a form of equilibrium state emerges, that state would be dominated by students with a handful of desirable classes (and likely one or two courses they would rather not take, or have no use for). From the perspective of the student, this outcome is anything but efficient, even though it aligns with Pareto's understanding of optimal outcomes. Because of the finite number of seats and finite number of classes, it becomes impossible for any one student to improve their lot without doing so at the expense of another student. To complicate matters, the risk of aggregate disutility and inefficiency grows exponentially with every additional member of the academic community.

While institutions do not assign courses with various parameters randomly, the implications of a system predicated entirely on Nash or Pareto is clear, particularly in light of the costs associated with information gathering on the demand side. Consequently, the traditional institutional model of offering several hundred different courses having various attributes then leaving students to sort out the mess is a broken paradigm. It is a relic. It is an artifact of a system predicated on an irrational expectation of students and an inherently flawed method of distributing information.

Let S denote the range of all student strategies.
Let s denote an individual strategy such that:
$s \in S$.
Let U denote the range of all possible utility outcomes.
Let u denote an individual utility outcome such that
$u \in U$.
Let *i* and *j* be individual students having course selection strategies s_i and s_j.

$$\forall S, (s_i \neq s_j) \rightarrow (u_i \neq u_j)$$

$$\therefore (u_i + u_j + \ldots + u_n) < U_{max}$$

for *n* number of students.

Equation 1 - Mathematical Model of Existing Course Selection Strategy

III. Involuntary Equilibrium

By synthesizing an analysis of strategy and outcomes in *n*-person games, the effects of and student reliance upon asymmetric information, along with the concept of Pareto Optimality, it is clear that a group of competitors (read as: students) cannot be reasonably expected to arrive at an equilibrium state where every party engaged is maximizing their economic well-being. When we factor in the costs of higher education and the societal ramifications of this waste, a need arises for a new economic concept. From this need, I have developed the concept of Involuntary Equilibrium.

From a macroeconomic perspective, the effects (and practicality) of a planned economy is well understood (Mandel, 1986). What is lacking is a treatment of how such a macroeconomic construct could be applied to higher education in a way that not only maximizes individual well-being but also the aggregate social benefit of a more educated population. It is clear from the preceding analysis that the traditional free-for-all approach allocating a critical rivalrous and excludable good is insufficient.

Ultimately we can identify that the state (in this case, the state takes the form of a university or other institution) must step in and regulate who takes what when, working on behalf of the students and broader society to establish what, from the student's perspective, can be referred to as Involuntary Equilibrium.

Consider the foregoing economic concepts. Nash suggests that if left to their own devices, an equilibrium state will emerge amongst students whereby every competitor will get some of what they want, yet by definition something somehow something less. The problem with Nash's model is analogous to the issues that arise with Pareto's: that what is systematically efficient is a far cry from what is ideal for the individual, and by extension, society. The implications of Stiglitz's insights create a multiplicative effect for the deficiencies left behind by Nash and Pareto. On average, students looking to ameliorate their standing within the *n*-person game cannot. This is the very definition of the zero-sum game.

Revisiting again the *n*-person game, we identify that the institution already establishes the framework by which students select courses and the mechanic by which they enroll in them.

Thus, the institution controls the parameters which would define Nash's equations. This in turn removes the gamesmanship that arises from various attempts by students to derive a given strategy. Were an institution to offer a sufficient *m*-tuple combination of possible schedules and take the decision-making process out of students' hands, the institution has the potential to maximize the efficient use of academic resources. In so doing, the institution ensures that each individual student has the ideal combination of courses having *m*-tuple attributes.

In conclusion, if we treat the academic institution as a firm, we see that by maximizing the individual benefits of their customers the firm itself holds wasted resources to a minimum. Second, since we are speaking in terms of higher education, and the benefits of a more educated population (workforce) have been exhaustively analyzed and demonstrated (Judy and D'Amico, 2006), the institution maximizes the broader benefit to society. From these two realizations stems an important observation – Involuntary Equilibrium allows a public institution to fulfill their societal mandate by creating the most educated and capable population possible.

Let S denote the range of all student strategies.
Let s denote an individual strategy,
Let B denote a global (or institutional) strategy such that:
$\mathbf{s \in S \in B.}$
Let U denote the range of all possible utility outcomes.
Let u denote an individual utility outcome such that
$\mathbf{u \in U.}$
Let *i* and *j* be individual students having course selection strategies s_i and s_j.
$$\exists B, (\forall S, (s_i = s_j) \rightarrow (u_i = u_j) \rightarrow \sum_i^n (u) = U_{max}$$
$$\therefore (u_i + u_j + \ldots + u_n) = U_{max}$$
for *n* number of students.

Equation 2- Mathematical Model of Course Selection Strategy Under Involuntary Equilibrium

IV. Econometric Analysis

<u>Introduction</u>

As economics is the science of allocating limited resources to address unlimited wants, this paper has, thus far, been a treatment for fitting a virtually infinite number of possible student schedules into a finite quantity of class seats. The econometric component of this paper will inform our understanding of the relationship between various administrative inputs (which take the form of course attributes) as well as external information. In so doing, quantitative analysis will yield policy insights and demonstrate the viability of a registration system predicated on Involuntary Equilibrium which still has the potential to reflect consumer preferences.

Hypotheses

The quantitative component of this study focuses on various aspects of undergraduate course selection, specifically how assorted course attributes affect enrollment in a given course. If the aim is to allocate classroom resources in the most efficient way possible, such an analysis will provide insights in light of asymmetric information, but also point to the different drivers that contribute to undergraduate course selection. Various null hypotheses are stated expressed below:

> H1: Students do not rely on external information sources prior to enrolling in courses. As a result, the coefficients for NOOFRANKINGS, RMPOVRALL, and RMPEASY will be zero.
>
> H2: Web or web hybrid courses are not in higher demand than traditional lecture settings. Consequently, the coefficient for DHYBRIDWEB will be zero.
>
> H3: Junior- and Senior-level are not in higher demand. Thus, the coefficient for DUPPER will be zero.
>
> H4: Economics courses required for business majors are not in higher demand. As a result, the coefficient for DCROSSLIST will be zero.
>
> H5: Economics courses that satisfy a Core Curriculum requirement are not in higher demand. Therefore, the coefficient for DCORE will be zero.
>
> H6: Economics courses required for the Economics major are not in higher demand. As a result, the coefficient for DMAJOR will be zero.

While not a hypothesis test in the traditional sense, attention should also be given to the mean of PROPENROLLED. A mean below 1 indicates unfilled seats.

Data and Methods

Data has been gathered from Bridgewater State University’s own course registration and reporting tool, Infobear. Using this system, it is possible to obtain registration and course data going back several years. Initially, the aim of this study was to derive two distinct data sets – one containing all semester registration data from September 2007 to May of 2013 and a sample data set containing all the offerings from the Economics department for the same time period (Infobear, 2007-13).

Since the focus of the study is undergraduate course selection, any graduate Economics courses were purged from the dataset. One-off courses, such as independent studies or internships, were also removed, as neither is a “college course” in the traditional sense. Ultimately, this left the dataset with 465 observations.

A variable was created to represent enrollment in a specific class (labeled in the regression output as PROPENROLLED). It is a simple function whose output is derived by dividing the number of students actively enrolled in a section of a given class by the maximum number of seats in said class. When stated as a proportion, this allows the model to capture the effects of over- or under-subscribed sections, and provides for professorial and departmental discretion in the case of over-enrollment.

A series of dummy variables were created from the categorical data. The first, denoted DHYBRIDWEB, is used to identify if a class is a traditional lecture setting (indicated by a 0), or an online or hybrid offering (indicated by a 1). The second dummy variable is DUPPER, which captures a course's upper- or lower-division attribute. Those courses having a numerical designation less than 300 (for example, ECON 210), are assigned a value of 0. Those courses with a designation greater than or equal to 300 (for example, ECON 420), are given a dummy value of 1. The third dummy variable is denoted as DCORE (such as ECON 199), where a 1 indicates that a given course meets a Bridgewater State Core Curriculum requirement. The final dummy variable is DCROSSLIST, which indicates if an Economics course is a requirement for students in other majors (such as ECON 315 – Money and Banking, required by all Finance majors, for example). Here, 1 denotes a cross-listed class.

Bridgewater State enrollment data is included in the data. Using information from the BSU Factbook, it is possible to determine the number of undergraduates enrolled in business majors and more specifically, the quantity of declared Economics majors. This was done to provide an important control. As one would expect, a non-Economics major has no use for an upper-division Economics class, with the exception of certain business students who are required to take ECON 315. The number of students enrolled at BSU as Economics and business majors in a specific semester may be the dominant determinant of demand for economics courses.

Data from an external information source completed the dataset. By investigating the relationship between enrollment data and external information source completed the datasets, we are able to identify the effect, if any, of students seeking additional information sources about their prospective courses. Data was culled from the external site RateMyProfessors.com, which allows students to evaluate their professors in several ways. All evaluations are conducted on an integer interval from 0 to 5, with 5 being the best and 0 being the worst possible score. Three data points were collected for every course section: the professor's easiness score, the professor's overall score, and as a control, the number of ratings a professor has received. In certain cases, professors had not been evaluated by their students, in which case a value of 0 was assigned for all three variables. In accordance with existing research (Tipoe, 2013), overall score is calculated as an average of a professors "helpfulness" rating and an evaluation of their instructional clarity. Thus, RMPOVRALL captures both aspects of professorial style.

A final note: ultimately professor names were removed entirely from the dataset, leaving entirely quantitative data and eliminating the possibility for any personal bias in the results.

Table 1 - Summary Statistics for Independent and Dependent Variables
For all, *n* = 463

Variable	Definition	Mean	Std Error	Minimum	Maximum
NOOFRANKINGS	Number of rankings. A count of RateMyProfessors.com ratings for a given professor.	36.3823	26.9679	0	92
RMPOVRALL	RateMyProfessors.com Overall rating for a given section's professor.	3.4116	0.7547	0	4.1
RMPEASY	RateMyProfessors.com Easiness rating for a given section's professor.	3.2181	0.9034	0	4.8
RMPOVRALL* RMPEASY	Interaction term calculated by multiplying the two previous variables.	11.4961	4.5460	0	19.68
PROPENROLLED	Active Enrollment / Seats Available in a course, representing the occupied proportion of total capacity.	0.8068	0.2946	0	1.44
DHYBRIDWEB	Dummy variable - 1 indicates a web-based or hybrid web/lecture course.	0.2981	0.4579	0	1
DUPPER	Dummy variable - 1 indicates an upper-division class.	0.1620	0.3688	0	1
DCORE	Dummy variable - 1 indicates the course meets at least one Core Curriculum requirement.	0.8034	0.3978	0	1
DCROSSLIST	Dummy variable - 1 indicates an Economics class required by non-Economics degree programs.	0.7970	0.4027	0	1
DMAJOR	Dummy variable – 1 indicates an Economics class that is a requirement for the Economics major.	0.8056	0.3612	0	1
BUSENROLLED	Number of students with declared majors in the College of Business for a given year.	1562.75	57.7479	1475	1639
ECONENROLLED	Number of declared Economics majors for a given year.	58.3585	11.7676	43	72

The data was analyzed using Ordinary Least Squares regression in Stata. Evaluating time series data with OLS is not typically undertaken without substantial adjustments (Wooldridge, 2012). However, the manner in which the dataset has been constructed ensures that the regressions that follow utilize cross-sectional data. This paper is not investigating departmental enrollment numbers over time, but rather the various factors that drive enrollment in a given course section. While it is true that the dataset culls information from several semesters, OLS remains a viable analytical tool because of the nature of this study.

As we are dealing with cross-sectional data, it is important to test for multicollinearity before analyzing the model. While some multicollinearity does exist in the models, cross-sectional data devoid of any collinearity is exceptionally rare. Despite a scattering of fairly high collinear relationships, we are nevertheless satisfied that this condition of Gauss-Markov is met. Additionally, robust standard errors were utilized in every model to account for heteroskedasticity. Robust standard errors were chosen because initially a Breusch-Pagan test suggested marginal heteroskedasticity. The output for each OLS regression is in the following table.

Table 2 - OLS Estimates of Independent Variables on Course Enrollment

Dependent Variable: PROPENROLLED					
Variable	**Model 1:**	**Model 2:**	**Model 3:**	**Model 4:**	**Model 5:**
NOOFRANKINGS	-0.0002	-0.0002	-0.0002	-0.0004	-0.0001
	(0.0006)	(0.0006)	(0.0006)	(0.0005)	(0.0006)
RMPOVRALL	0.0180	-0.0014	0.0050	0.0023	0.0085
	(0.0259)	(0.0337)	(0.0257)	(0.0261)	(0.0298)
RMPEASY	0.0620***	0.0221	0.0656***	0.0765***	0.0764***
	(0.0216)	(0.0408)	(0.0219)	(0.0212)	(0.0233)
RMPEASY*RMPOVRALL	-	0.0112	-	-	-
	-	(0.0102)	-	-	-
DHYBRIDWEB	0.0531*	0.0467	0.0670**	-	-
	(0.0312)	(0.0317)	(0.0306)	-	-
DUPPER	-0.2854**	-0.2849**	-0.2861**	0.0494	-
	(0.1144)	(0.1134)	(0.1133)	(0.0441)	-
DCORE	0.1719**	0.1718**	0.1775**	0.3123***	-
	(0.0841)	(0.0833)	(0.0841)	(0.0509)	-
DCROSSLIST	0.1287*	0.1326**	0.1250*	-	-
	(0.0676)	(0.0672)	(0.0677)	-	-
DMAJOR	-0.2836***	-0.2880***	-0.2887***	-	-
	(0.0744)	(0.0736)	(0.0727)	-	-
BUSENROLLED	0.0001	0.0001	-	-	0.0001
	(0.0004)	(0.0004)	-	-	(0.0004)
ECONENROLLED	0.0026	0.0026	-	-	0.0028
	(0.0018)	(0.0018)	-	-	(0.0020)
Constant	0.3078	0.3909	0.6019***	0.3101***	0.1957
	(0.5302)	(0.5296)	(0.0981)	(0.0574)	(0.5619)
N	463	463	463	463	463
R-Squared	0.2350	0.2370	0.2226	0.1938	0.0766
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000

Robust Standard Errors are shown in parenthesis
*** Indicates significance at the 0.1 level**
**** Indicates significance at the 0.05 level**
***** Indicates significance at the 0.01 level**

Interpretation of Results

Using Model 1, we reject H1, because of the statistical significance and non-zero coefficient for RMPEASY. As it turns out, a one point increase in a professor's perceived easiness results in a six percent increase in enrollment in their class. This relationship clearly suggests that students are not only seeking outside information, but that they appear to be acting based on that information, further suggesting external information's role in the formulation of course selection strategy.

Note too that when we introduce an interaction variable in Model 2, we see that all four dummy variables remain statistically significant. While DHYBRIDWEB is only marginally significant, this model has substantial implications for H2, H3, and H4. We reject H2, which suggests that there is increased demand for web and web-hybrid courses.

The null is rejected for H3. This is because DUPPER is statistically significantly different from zero in every model in which it is included. The coefficient for DUPPER is negative, indicating an upper-level class lowers the likelihood of filling the seats in the class.

The null is rejected for H4. DCROSSLIST is highly significant, and the positive coefficients suggest that students from the College of Business are demanding the Economics courses required for their majors. This is an unsurprising result.

The null is also rejected for H5. The positive coefficients for DCORE indicate that Economics courses which satisfy a component of the Bridgewater State Core Curriculum are in higher demand. The null is also rejected for H6 because of the non-zero coefficients for DMAJOR.

When taken as a whole, the various models suggest that if left to the information freely and readily available from the institution, students will develop strategies predicated on this information.

The array of nulls is rejected, and along with the persistent statistical significance of the dummy variables, we see how institutional information is closely tied to course enrollment. While correlation is not causation, the models seem to suggest that data from internal information sources is extremely important in undergraduate course selection, which only further stresses the importance of the institution’s role in student strategy formulation and enrollment decisions.

Additional Commentary on Regression Results

Students in the business school are required to take a set of introductory Economics classes, specifically micro- and macroeconomics, as well as statistics. One would expect the number of business students to drive enrollment in these offerings. This draws our attention to Model 1, where a counter-intuitive relationship exists. Here, DCROSSLIST is statistically significant, but the size of the College of Business is not. One would expect that as the College has grown, so too would demand in these cross-listed classes, but neither ECONENROLLED nor BUSENROLLED were statistically significant in any model in which they were included. Model 1 suggests that external information sources are more responsible for the variability of course enrollment numbers. A dataset with semester-by-semester enrollment values for majors rather than yearly would likely improve the relationship and result in statistical significance.

Models 1, 2 and 3 also call attention to the desirability of web and hybrid courses. Two distinct models show that DHYBRIDWEB having positive coefficients and statistical significance. This has clear policy implications: students are demanding web and web hybrid courses higher rates than traditional lecture settings.

Another important relationship exists between a course’s core attribute and enrollment numbers. Recall the definition of DCORE: a value 1 indicates that a course meets a Core

Curriculum requirement. From the regression results we see that students are demanding Economics courses that satisfy Core Curriculum requirements. Interestingly, these are the same classes many business majors are required to take – the two introductory micro- and macroeconomics classes as well as statistics. Unfortunately, these data do not incorporate total University enrollment, leading to the possibility that the larger pool of potential students is demanding these classes. This omission may also account for the relatively low R-Squared values seen across the various models.

An analysis of DCORE leads naturally to an investigation into the effects of the DUPPER, the upper- or lower-division dummy variable. DUPPER was statistically significant in three separate models. One might expect ECONENROLLED to adopt some of this relationship in Model 5, but interestingly ECONENROLLED was not found to be statistically significant, even with fewer regressors in play. The population of students demanding junior- and senior-level Economics classes is far smaller than the population that would demand freshman- and sophomore-level courses, so the results for DUPPER are somewhat intuitive. The relationship between DUPPER and PROPENROLLED also underscores the rational dynamics at work behind course selection and strategy development.

Note that DMAJOR is also statistically significant, but it is negative. Since DMAJOR represents whether a class satisfies an Economics major requirement, one would expect its effect on PROPENROLLED to be positive. Based on this result, it is possible that the models are failing to control for some other independent variable. A potential remedy is outlined under Next Steps.

The statistically significant variable that presents the most problematic case against the status quo is RMPEASY. In Model 1, it is not only statistically significant, but has a relatively sizable coefficient when held against the institutionally-provided dummy variables. A professor's perceived easiness accounted for six percent of the variability in class enrollment. A recent investigation from the University of California at Berkeley suggests that online ratings by students and internal institutional evaluations of faculty are fairly consistent with one another (Tipoe, 2013), and that the informal evaluations are rarely retaliatory or grade-related. Tipoe's work speaks to the logical validity of predicating course selection strategy on external information sources.

The implication for this study is the realization that students are not only using a synthesis of internal and external information, but that they assign varying degrees of credibility to different pieces of information, even if that information comes from the same source (hence the significance of RMPEASY but not RMPOVRALL). This underscores a central problem in information economics: information is easily created but difficult to verify and act reliably upon. Consider that this paper only investigates two data points from one external source. When the individual considers an array of external information sources of varying quality, it is ultimately next to impossible for the student to derive an optimal strategy or ideal enrollment outcome.

Conclusions and Next Steps

The models above have a few noteworthy limitations, further encouraging the pursuit of future research into the area of undergraduate course selection, particularly as an analogue for microeconomic strategy formulation and the maximization of societal utility.

Most notably, the low R-Squared suggests there are additional forces at work when students select undergraduate classes. Two notable omissions in this model include the total undergraduate enrollment numbers as well as course location. While the former may contribute considerably to the variation in enrollment, the time at which a course is offered is a critical component in terms of consumer choice. While it's true that each has the potential to significantly increase the explanatory power of the model, additional regressors carry with them the risk of misrepresenting the significance of existing variables. Future projects should investigate the effects of competing demands for students' time, notably standing professional, familial, or personal obligations.

Another noteworthy omission within the model is its inability to account for the comments section of RateMyProfessors.com. This is qualitative data, and would be impossible to accurately quantify without making outrageous and likely inconsistent assumptions. The problem with this omission is that students evaluating professors on RateMyProfessors.com are able to provide comments, which despite the quantitative scale ranging from zero to five, may dramatically impact a user's interpretation of the professor's desirability. Consider the case where a professor is given an overall rating of 5 and an easiness rating of 2. The comments section of the website may include details about assignments, lecture style, the frequency of tests, or worse, *ad hominem* attacks. As a consequence, the quantitative component of this study may not fully capture the effect that the ratings have on professorial desirability (Baldwin and Blatner, 2003).

A final problematic result is the negative coefficients for DMAJOR. One proposed solution would incorporate a new variable that quantifies how many sections of a given course are offered each semester, rather than list every offering individually. To be executed appropriately, future research should consider all the various permutations that the five dummy variables can take on, and determine how many sections with those attributes are offered. When organizing and evaluating the data in this method, one would expect the coefficient to become positive while DMAJOR remains highly statistically significant.

It has been shown, however, that students rely on external information sources when deciding on courses, which has ramifications for institutional academic advising processes. Clearly, there is an information gap between buyers and sellers of education, and it is incumbent upon the university to ameliorate this imbalance.

Other conclusions arise from the statistical significance of the various dummy variables. Because students are obligated to attend courses that satisfy certain Core Curriculum requirements, it is again incumbent upon the school to ensure such offerings exist in satisfactory quantities. The data also indicates that the Economics program (and overall enrollment in the College of Business) is growing. To that end, it is critical that the school looks to align the supply of courses (and seats within said courses) with growing demand. Furthermore, the absence of class location data within the Infobear registration system creates confusion, barring students from incorporating location preference into their course selection strategy.

If future research is able to account for this missing information, or somehow quantify the comments section of RateMyProfessors.com, one might find a significantly higher R-Squared in future iterations of this model.

V. Involuntary Equilibrium and Proposed Policy Action

The regression analysis confirms what the field of Economics has demonstrated repeatedly over the years: that a variety of consumer tastes and preferences factor into course selection. The low R-Squared of the regression model indicates that there are still more preferences that have not been captured in this particular study. Nonetheless, enough data exists to demonstrate the economic imperatives from which the notion of Involuntary Equilibrium is derived.

It has also been shown through the investigations in previous sections that the state of Nash Equilibrium leaves every participant in the *n*-person game with a mixed bag of courses. This mixed bag yields a certain amount of utility, but in an amount significantly less than the maximum potential utility. Another significant observation is that individual utility derived from such a system will never equal the utility derived by another student, thus the system is not only inherently unfair, it is grossly inefficient.

The regression analysis also demonstrated that students do in fact rely on external information sources when selecting classes. While the econometric model does not (and in fact cannot) capture all influences of external information on consumer choice, it can (and does) inform development of an institutional structure inspired by models of a planned economy.

Finally, the econometric model, by its very nature, illustrates there are a finite number of options available to students in a given semester. For economic purposes, we can treat the various combinations of courses as a Pareto Frontier. This too should inform the development of any administrative or institutional model whereby the Pareto Frontier is shifted outward, reflecting increased utility across the system.

Systemic Modifications in the Short Run

As touched upon in Section IV, one glaring deficiency in the existing Bridgewater State University system is a course registration system, Infobear, which does not provide class location information to students prior to course selection. This is an artifact of an administrative system that does not assign classrooms to courses until registration has been completed. While the impetus behind this policy decision may be noble (having to do with disabled access to certain facilities, for example), it serves as a barrier that prevents the typical student from making a more fully informed choice. The consequence of this missing information is a significant source of disutility not only for students, but also for the surrounding community as throngs of students move from building to building during passing time. Bridgewater State's traffic issues are well documented (Carboneau, 2013), but from an economic standpoint, an ill-informed student cannot possibly develop a schedule that maximizes utility.

Another problematic policy is that of prioritized registration, as it represents a classical example of The Matthew Effect (Gladwell, 2011). In the current system, those students who have completed more courses are allowed to register before those who have made less progress. Additionally, certain Honors students and student athletes are given priority registration. There is a considerable amount of anecdotal evidence suggesting that underclassmen are unable to make satisfactory academic progress because pre-requisite, core, or lower-division classes are full or otherwise unavailable by the time it is their turn to register.

Mathematically, progress towards graduation can be treated as a Hamiltonian Path Problem (Bellman, 1962), an analysis of which makes for a compelling follow-up to this particular thesis. Still, an institution's continued commitment to prioritized registration complicates the issue of what the school considers "adequate academic progress," and ultimately drives down both four- and six-year graduation rates.

Systemic Modifications in the Long Run

This analysis has worked to demonstrate that Bridgewater State University treats course offering and student registration from the supply side. Macroeconomic policy analysis has demonstrated that this is not necessarily the best approach to optimizing utility in such complex systems as undergraduate course registration (Krugman, 1995).

Effectively, what the University does is provide a supply of courses, provide advising resources of questionable consistency and reliability, and expect student demand for said courses to accommodate what is being provided. From its inception, this paper has worked to illustrate that the system is far more complicated, and that additional steps can be taken to maximize overall utility within the system.

By starting with concrete data regarding student's academic objectives (gathered from the students themselves), an institution can adjust supply to better align it with demand. Theoretically, a system designed in such a way can ensure that every consumer gets exactly what they want. This is the simplicity of a planned economic environment, and the implications of such a system are as profound as they are elegant. By considering consumer preferences in aggregate, an institution can ensure that realized consumer utility equals (or very nearly equals) potential utility. In macroeconomic terms such a structure would be analogous to a central government taking policy action to ensure that Real GDP equals Potential GDP. This is not a foreign ideal in American culture – it is a cornerstone of fiscal and monetary policy in the United States.

Conclusion and Author's Notes

Critics will certainly suggest that this paper's dismal view of college students as intrinsically dim-witted or otherwise incapable. To the contrary – I acknowledge that college students represent the upper quartile of academic attainment in the United States. As a population, however, undergraduates are not tremendously skilled at decision-making, optimization, or evaluation of external information.

Detractors will certainly note that Involuntary Equilibrium requires an administrative framework verging on the impractical. Furthermore, as one administrator pointed out, "doesn't this take all the fun out of college?" While an institution providing planned, rigid, degree programs would certainly require more manpower, more robust planning tools, and various methods to analyze consumer demand on an ongoing basis, the economic potential for systematic improvement is impossible to overlook. The purpose of this paper was to analyze weaknesses within the system and derive policy recommendations from that analysis. To that end, this analysis simply does not support the existing "free-for-all" environment.

This is the crux of the Undergrad’s Dilemma. Does a student continue to own the process of course enrollment and risk a less than ideal slate of courses every semester, or do they allow the institution to step in and assign them to certain classes? When coupled with an analysis of game theory and information economics, the data does not suggest the existing system of self-enrollment is the ideal method for delivering consistently optimized outcomes.

That said, the evidence speaks for itself. According to the White House’s Higher Education Scorecard, Bridgewater State has a six year graduate rate presently hovering just over 50 percent (WhiteHouse.gov, 2013). How can we justify the status quo when nearly one out of every two students cannot or does not finish a degree within six years? While students face a variety of competing demands for their time (family, work, and social pressures, etc.), this study has demonstrated the course selection and registration system – the gateway to degree completion – is rife with inefficiency and a source of massive disutility.

Author and *Chronicle of Higher Education* editor Jeff Selingo rightly points out that since World War II, education has held the promise of being the great American equalizer, eliminating social strata while engendering individual and societal well-being (2013). The community and the Commonwealth are entitled to a higher education system that is more carefully designed and administered, with the specific aim of ensuring student success.

References

Barr, N. (2012). *Economics of the Welfare State* (5th ed.). Oxford, United Kingdom: Oxford University Press.

Bellman, R. (1962, January). Dynamic Programming Treatment of the Travelling Salesman Problem. *Journal of the Association of Computing Machinery, 9*(1), 61-63. Retrieved October 31, 2013

Baldwin, T., & Blatner, N. (2003). Guarding Against Potential Bias in Student Evaluations. *College Teaching*, *51*(1), 27-32. Retrieved October 31, 2013

Braess, D. (2005, November). On a Paradox of Traffic Planning. *Transportation Science*, *39*(4), 446-450. Retrieved October 31, 2013

Bureau of Labor Statistics. (2013, May 22). Earnings and Employment Rates by Educational Attainment. In *Employment Projections*. Retrieved October 31, 2013

Carboneau, A. (2013, April 15). Bridgewater State wants to close road to traffic. *Brockton Enterprise*. Retrieved October 31, 2013

Card, D. (1999). The Causal Effect of Education on Earnings. In *Department of Economics, University of California at Berkeley*. Retrieved October 31, 2013

CollegeCalc.org. (2013, November). Costs to Attend Bridgewater State University. In *Bridgewater State University*. Retrieved October 31, 2013

Gladwell, M. (2008). *Outliers: The Story of Success*. New York, NY: Little, Brown and Company.

Harvard University. (2010, November). Tuition at Harvard Schools: FY1990 – FY2010. In *The Office of the Provost*. Retrieved October 31, 2013

Judy, R. W., & D'Amico, C. (2006, February 16). Work Force 2020: Work and Workers in the 21st Century. In *Hudson Institute*. Retrieved October 31, 2013

Keynes, J. M. (1936). *The General Theory of Employment, Interest and Money*. N.p.: Palgrave Macmillan.

Krugman, P. (1994). *Peddling Prosperity*. New York, NY: W. W. Norton and Company.

Mandel, E. (1986, September). In Defense of Socialist Planning. *New Left Review*, *1*(159), 5-37. Retrieved October 31, 2013

McDill, E. L., & Coleman, J. (1963, December). Family and Peer Influences in College Plans of High School Students. *Sociology of Education*, *28*(6), 905-918.

Morrison, R. (1992). Price Fixing among Elite Colleges and Universities. *University of Chicago Law Review*, *59*, 807.

Rivera, C. (2012, March 14). Santa Monica College to offer two-tier course pricing. *Los Angeles Times*. Retrieved October 31, 2013

Selingo, J. J. (2013). *College Unbound: The Future of Higher Education and What It Means for Students*. New York, NY: Houghton Mifflin Harcourt.

Tipoe, E. L. (2013, May 6). Course Enrollment Decisions: The Substitutability of Online Ratings Websites for Official Professor Evaluations. In *Department of Economics, University of California at Berkeley*. Retrieved October 31, 201

Wooldridge, J. M. (2013). *Introductory Economics: A Modern Approach* (5th ed.). Mason, OH: South-Western Cengage.