COLUMBIA BUSINESS SCHOOL – BIDDING STRATEGY OPTIMIZATION

October 2012

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I. INTRODUCTION TO THE BIDDING SYSTEM

BIDDING PROBLEM OVERVIEW

CBS bidding process is often a black box and very hard to figure out for students

A number of variables can be considered to determine a student's bidding strategy

BIDDING PROCESS OVERVIEW

- CBS students receive 12,000 points to bid for
    - At least 2 full term equivalent electives in semester 2
    - At least 5 full term equivalent electives in semesters 3 and 4

- The elective bidding is often a stressful and somewhat unpredictable process

- Students generally try to look at a number of variables to determine their bidding strategy

- Yet, many students do not get the classes they want and as a result of they are frustrated and unhappy with their classes

BOSS BIDDING PLATFORM

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Business Online Selection System (BOSS)

Home	[CourseSchedule]
Announcements	B8799-035 - Lean LaunchPad	Block Week 8/27 - 8/31
MBA Selection Guide	3.0 credit hours	9:00AM - 5:00PM
EMBA Selection Guide		
MBA Course Schedule	This course will be held in 614 Schermerhorn Hall	
EMBA Course Schedule	Area(s): Entrepreneurship, Management	
PHD Course Schedule		
Select Courses	MBA COURSE	
My Favorites	B8816-001 - Pricing & Revenue	TR - A Term
My Actions	Optimization	10:45AM - 12:15PM
My Bids & Courses	1.5 credit hours	
MBA Academic Calendar	Area(s): Decision, Risk, and Operations, Operations Management	
EMBA Academic Calendar	MBA COURSE	
PHD Academic Calendar	B8823-001 - Healthcare Industry	T - Full Term
Help	in the 21st Century	2:15PM - 5:30PM
Sign In	3.0 credit hours	
Sign Out	Area(s): Decision, Risk, and Operations, Healthcare, Operations Ma	
	MBA COURSE	

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WHY IS BIDDING IMPORTANT?

Students who get the courses that they really want are more satisfied and contribute more to their electives

$\Rightarrow$ *Satisfied students add more value to the CBS community*

SUCCESSFUL BIDDER = HAPPY STUDENT

UNSUCCESSFUL BIDDER = SAD STUDENT
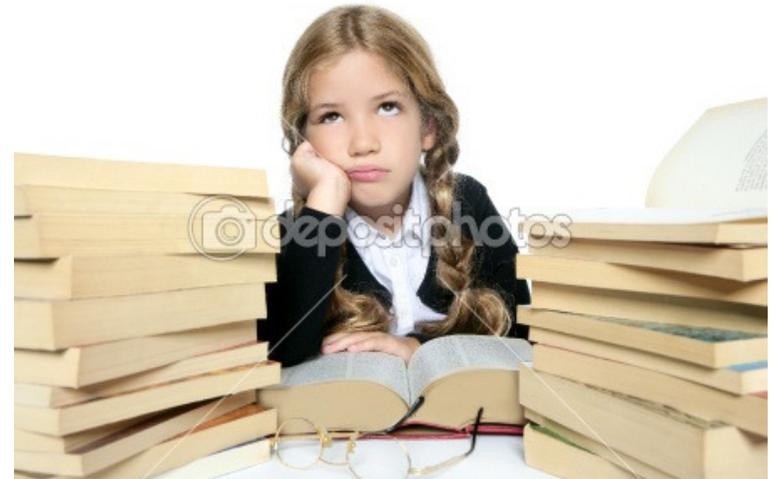
Given the impact of successful bidding on student satisfaction we want to analyze:
- How students can optimize their bidding strategy
- Which variables they should consider

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DATA GATHERING

- We downloaded 1st round bidding statistics for fall 2012 and fall 2011 from Boss

- We then downloaded professor review data from www.cbscoursereview.com

- We didn't use fall 2010 and 2009 bidding data since we suspected strong multi-collinearity effects (2010 bidding points affect 2011 bidding points etc.)

- We only included courses that were offered last year
    - If a course was not offered 2011, historical data less likely to affect bidding in 2012

- We also excluded courses for which there was no professor rating data

- We only looked at first round bidding statistics since second and third round bidding is often not reflective of actual demand for the class but rather based on unavailability of better alternatives
    - In other words, in the second and third round students often bid a lot for classes that are not their #1 choice, simply because they need 15 credits

- One should note that there are a number of qualitative variables that we cannot capture with our qualitative analysis such as group pressure/dynamics, word-of-mouth marketing etc.

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II. DESCRIPTIVE ANALYSIS OF DATA

Dependent Variable

2013 Clearing Price	Predicted clearing price

Independent Variables

| Class Capacity	Max number of seats within class section	Course Review	Ranking for Professor based on CBS Peer Course Review
Class Length	90 minute vs. 3 hour class format	2011 Professor	Same professor as last year for the same course
Class Time	9:00AM, 10:45AM, 12:15pm, 4:00pm, 5:45PM start time	2011 Clearing Price	Lowest successful bid in 2011 (clearing price)
Class Days	Monday, Tuesday, Wednesday, Thursday	Class Department	Finance, Management, Marketing or Other.

ORIGINAL VARIABLES CONSIDERED

Class Capacity	2011 Clearing Price	Flex Core	Invited Speakers
Class Length	Class Department	Number of Seats	Course Location
Class Time	Number of Credits	Final Exam	Number of Sections
Class Days	Semester	Survey Course	Course Review
Professor Review	Term A	Lecture Based	Frequency of Course Offering
2011 Professor	Term B	Case Based	Experiential Learning

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Key Observations:
- *The clearing prices are not normally distributed*
- *Most courses clear for less than 100 bid points*

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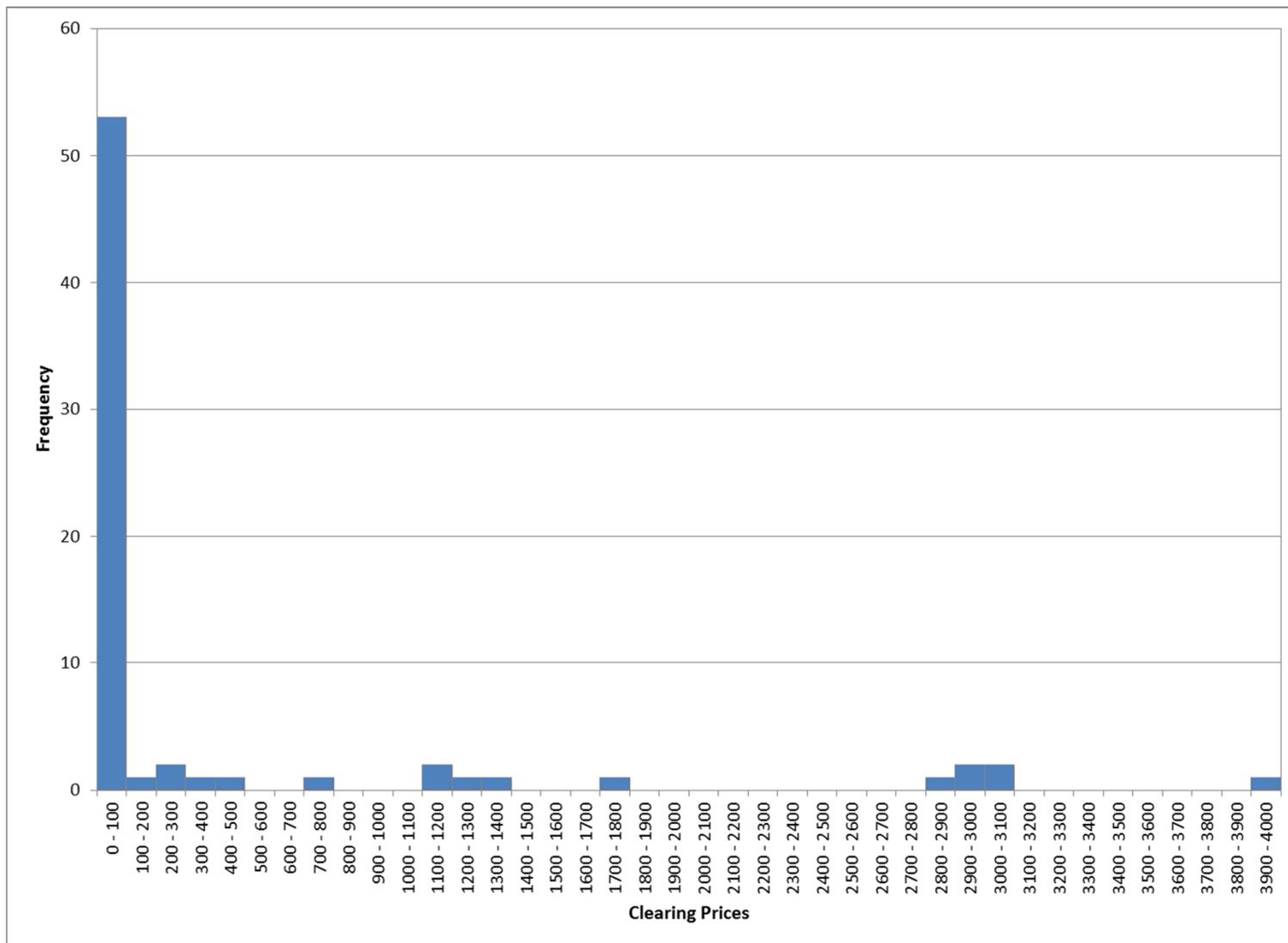
HISTOGRAM OF CLEARING PRICES (ABRIDGED) – BIN SIZE = 5

Key Observations:
- *Many courses clear for less than 5 bid points*
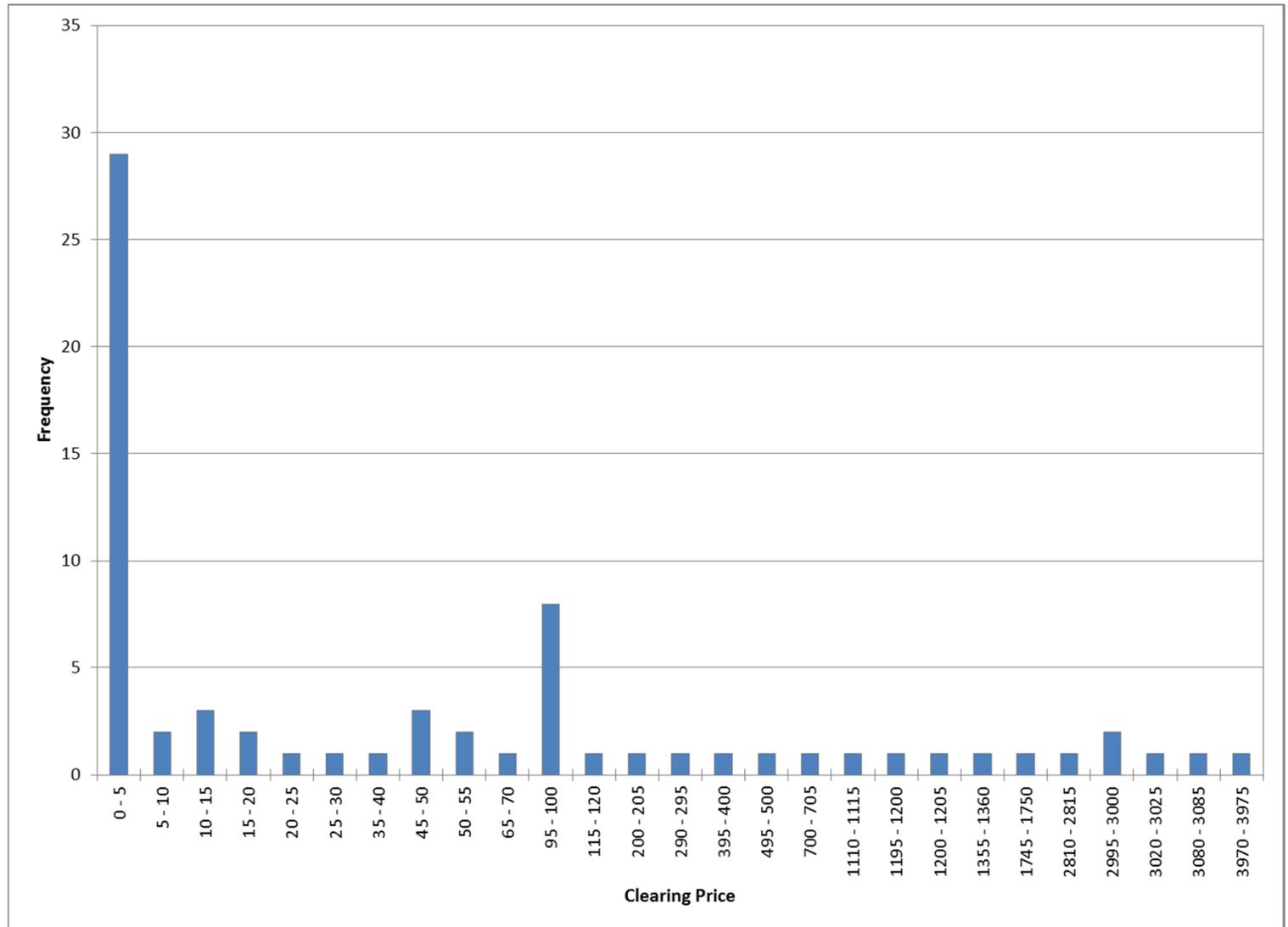
- Bins with no data have been removed for clarity

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SUBSCRIPTION LEVEL FOR ALL OFFERED CLASSES

Key Observations:
- *Most classes offered are under subscribed*
- *Popular classes attract higher bids*
- *Popularity may have more to do with class start time than professor....to be explored!*
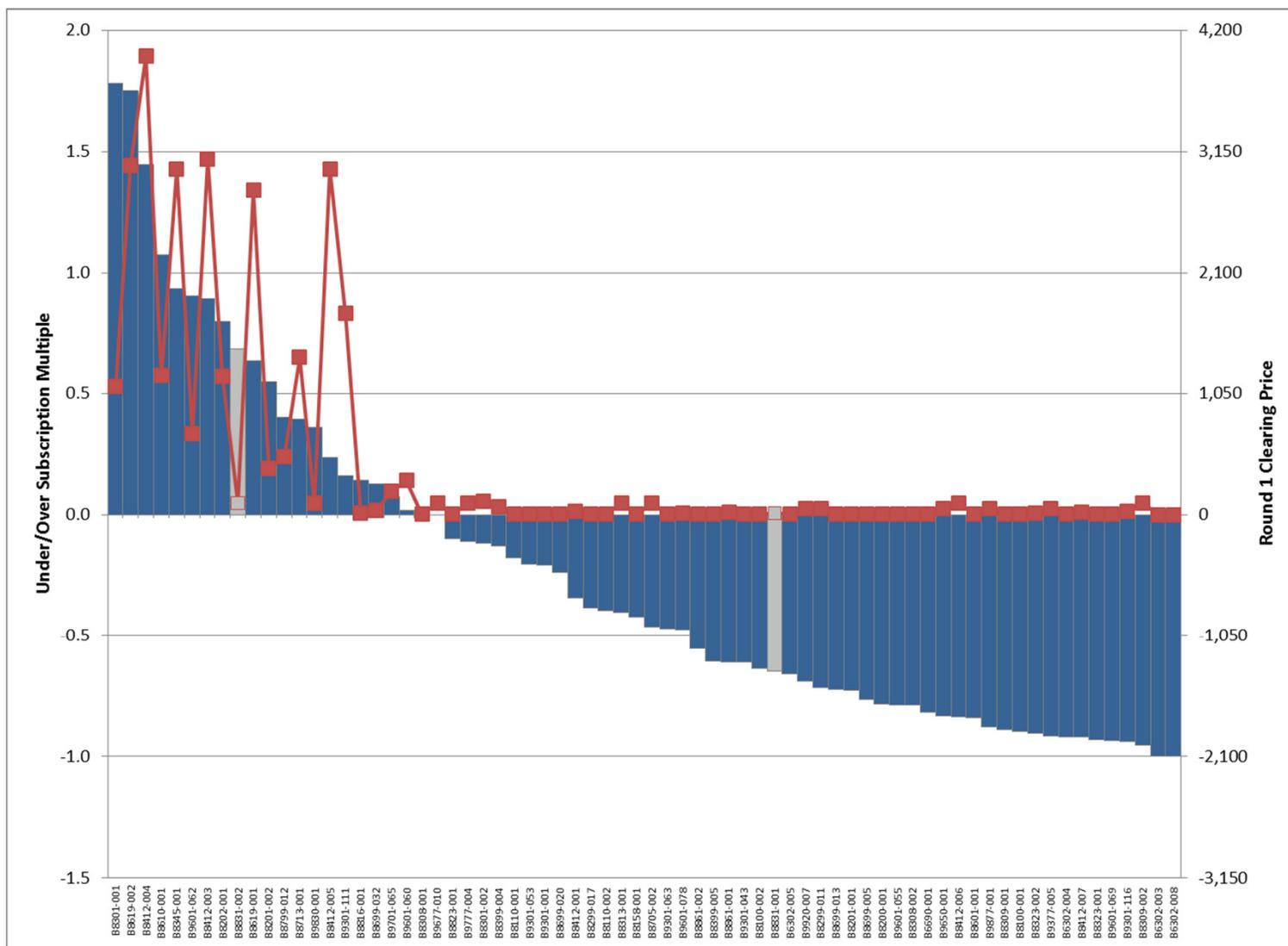
- Subscription level = Number of Bids / Number of Seats
- Over/Under Subscription Multiple = Subscription Level - 1

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SUBSCRIPTION LEVEL & CLEARING PRICES FOR THE OVER-SUBSCRIBED CLASSES

Key Observations:
- *Popularity does not necessarily translate into a high WTP*
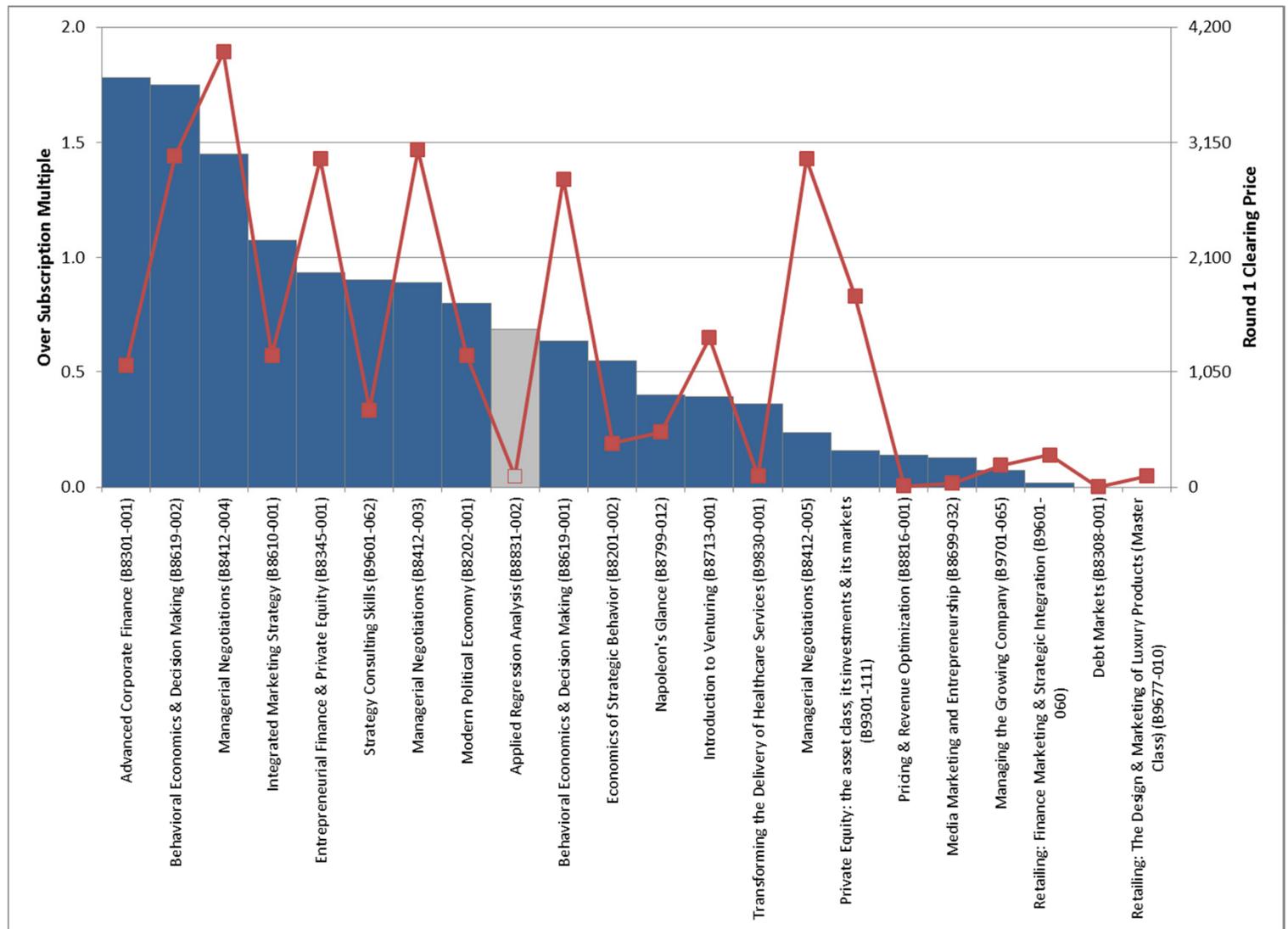
- Subscription level = Number of Bids / Number of Seats
- Over/Under Subscription Multiple = Subscription Level - 1

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SUBSCRIPTION LEVEL & CLEARING PRICES FOR THE OVER-SUBSCRIBED CLASSES

Key Observations:
- **7 of the most popular classes were from the Marketing department**
- **Only 4 classes were from the Finance department**

KEY

Finance

Marketing

Management
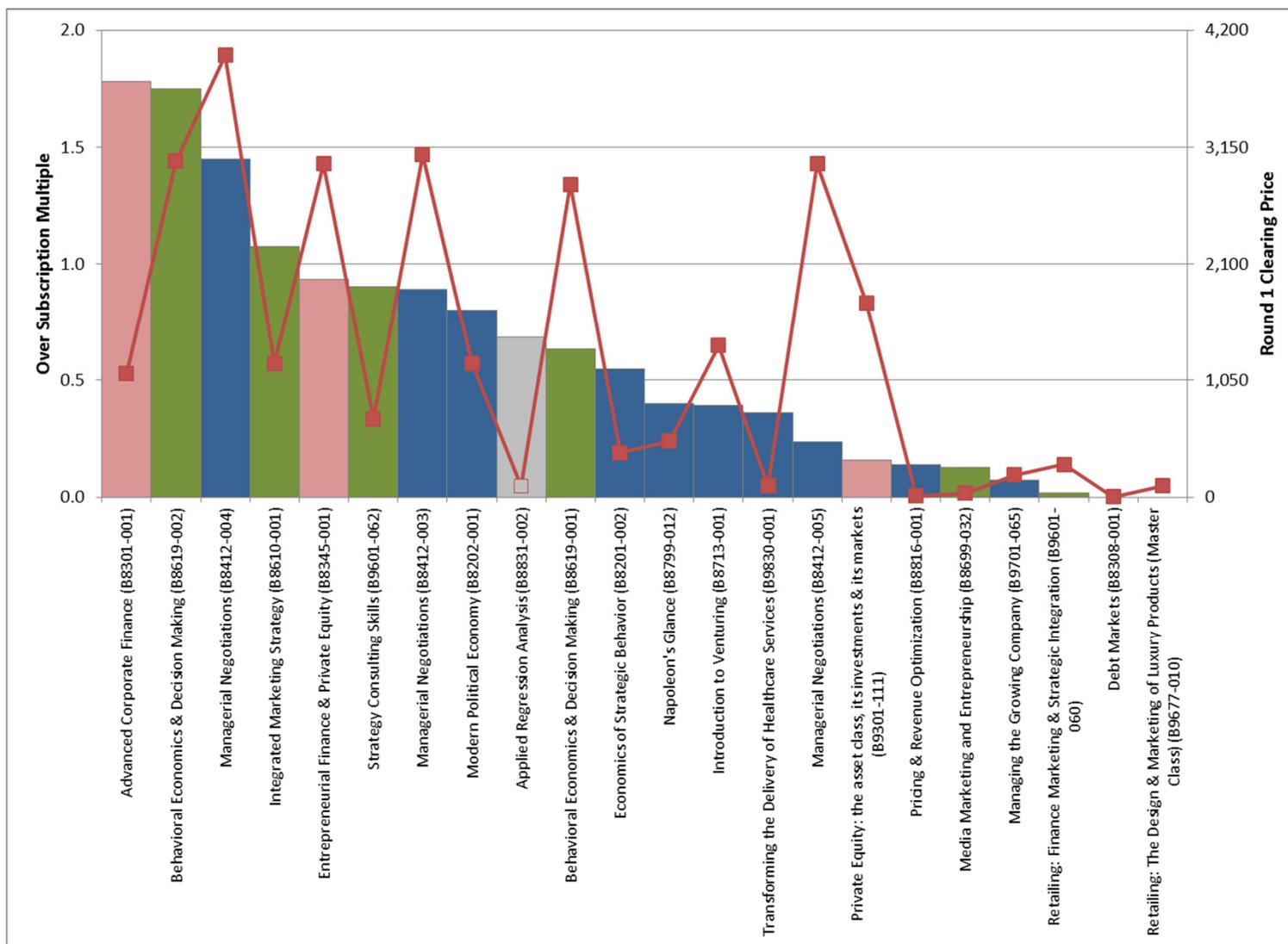
- Subscription level = Number of Bids / Number of Seats
- Over/Under Subscription Multiple = Subscription Level - 1

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SUBSCRIPTION LEVEL & NUMBER OF CLASSES OFFERED BY EACH DEPARTMENT

Key Observations:
- **The number of classes offered by a department does not reflect the student preferences**
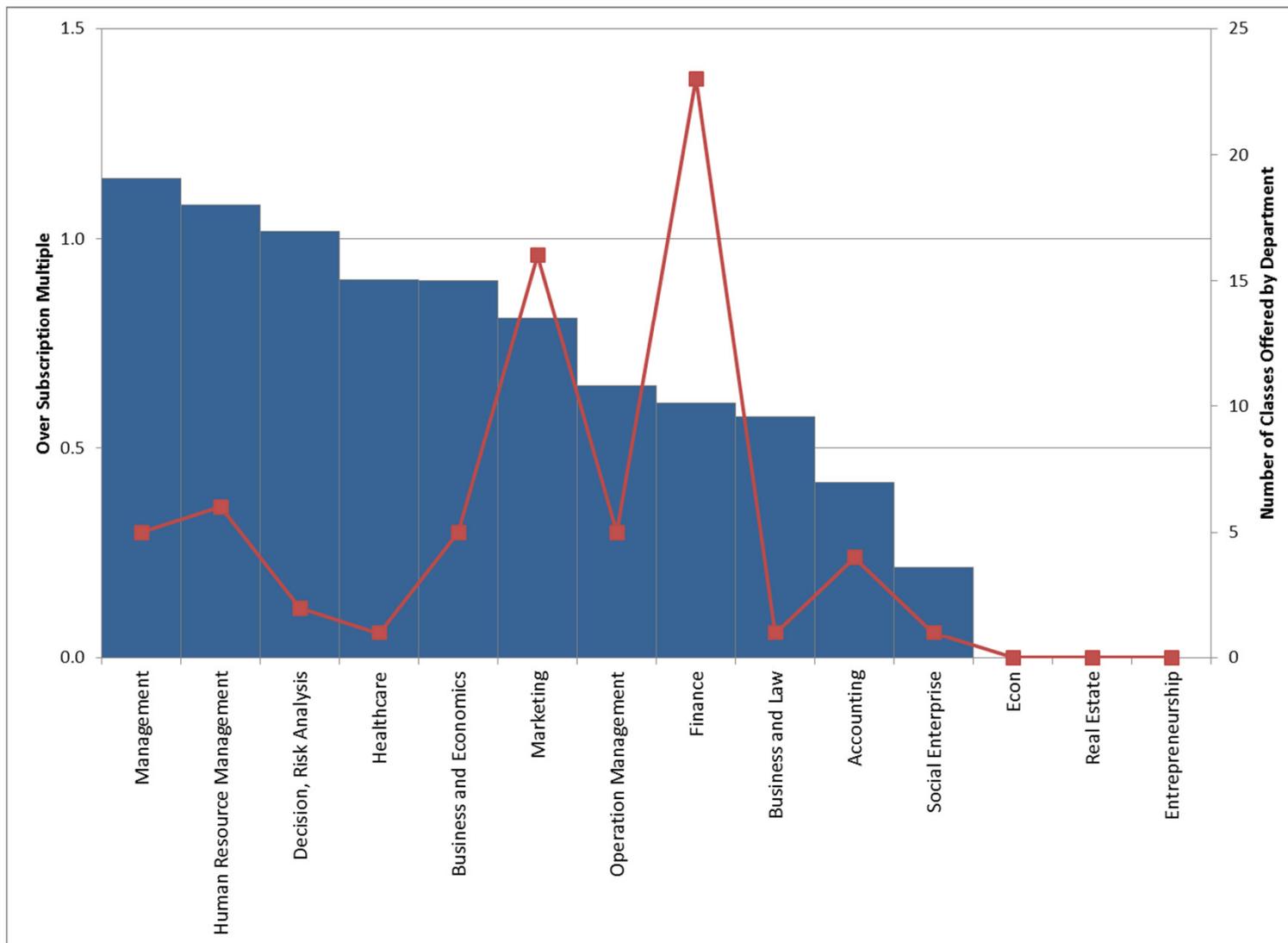
- Subscription level = Number of Bids / Number of Seats
- Over/Under Subscription Multiple = Subscription Level - 1

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Key Observations:
- *No discernible trend*
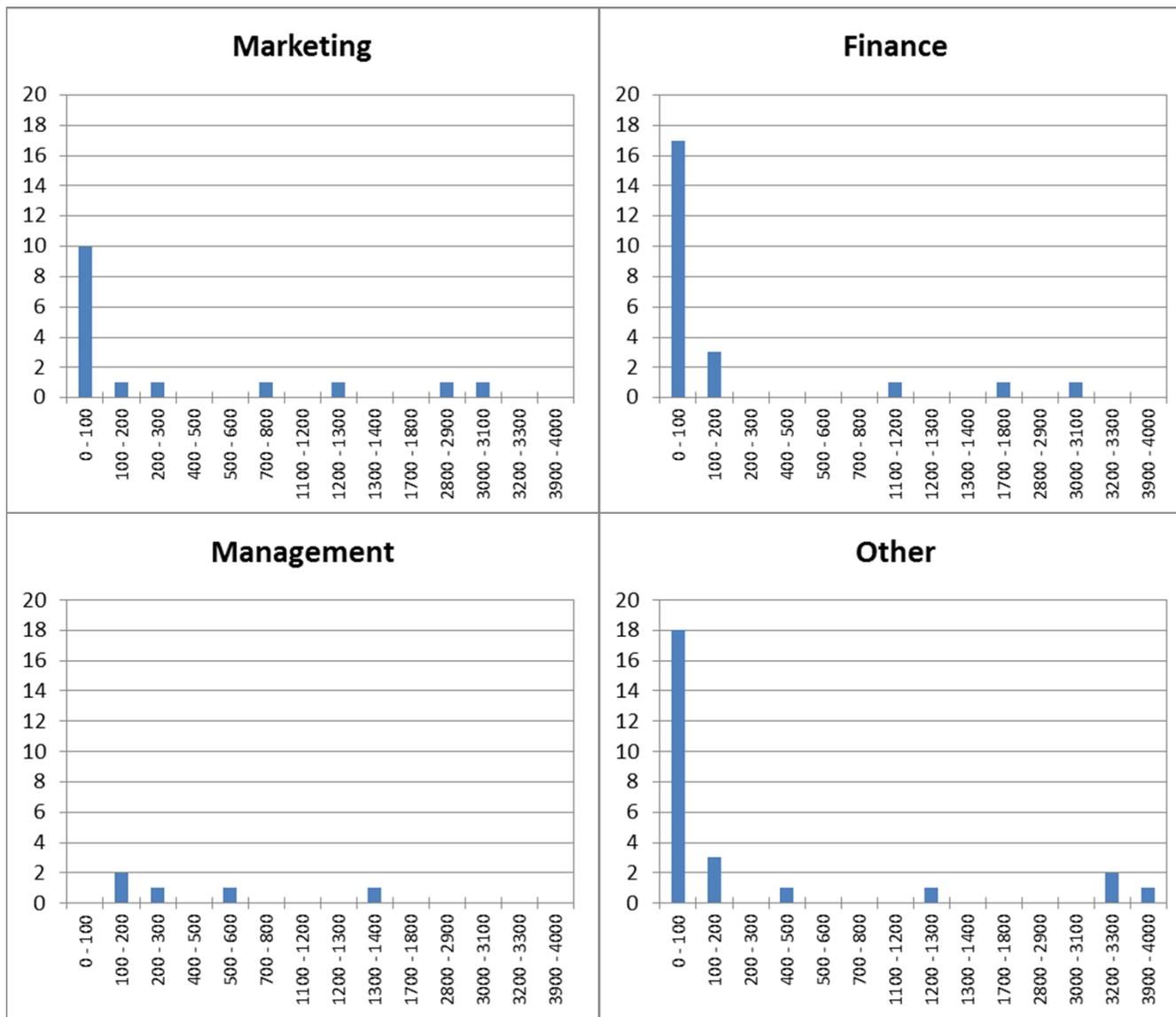
- Bins with no data, across all departments, have been removed for clarity and ease of comparison

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Key Observations:
- *The influence of the professor is reasonably low....so much for the adage to choose the class based on the professor!*
- *It would appear that the previous years Clearing Price has a greater impact on the following year*

Left chart: Professor Rating (y-axis, 0.0 to 10.0) vs Clearing Price (x-axis, 0 to 4000). Trendline: y = 0.0008x + 6.5158, R² = 0.1758

Right chart: 2011 Clearing Price (y-axis, 0 to 4,000) vs Clearing Price (x-axis, 0 to 4000). Trendline: y = 0.7337x + 125.94, R² = 0.6162
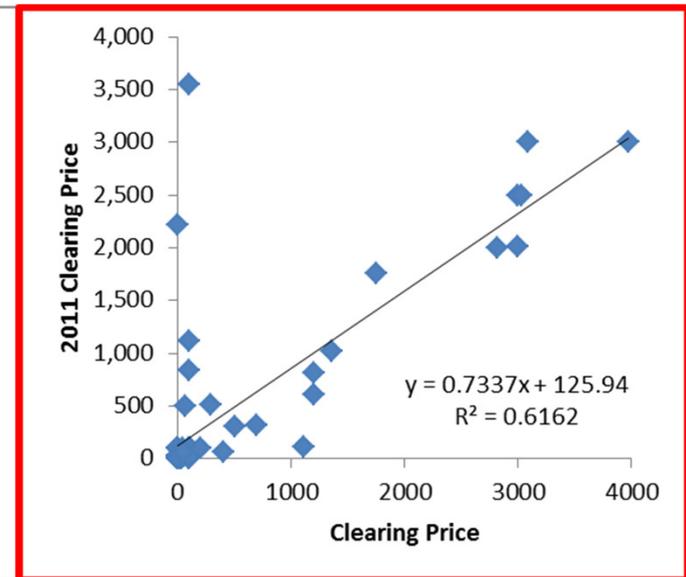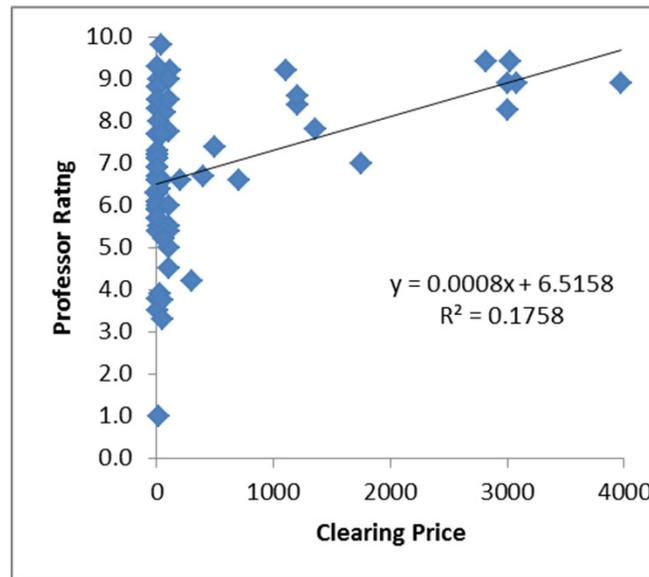
III. REGRESSION ANALYSIS

RESULTS – KEY OBSERVATIONS [FULL REGRESSION MODEL]

Key Observations:
- **Overall model's P-value is low**
- **R-square value is decent**
- **Many independent variables have high P-values – may want to eliminate**

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.8427
R Square	0.7102
Adjusted R Square	0.6227
Standard Error	565.3769
Observations	70

ANOVA

	df	SS	MS	F	P-Value
Regression	16	41515541.5424	2594721.3464	8.1174	0.0000
Residual	53	16941503.5434	319651.0103		
Total	69	58457045.0857			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-1206.7264	568.1879	-2.1238	0.0384	-2346.3669	-67.0859	-2346.3669	-67.0859
Capacity	1.9101	3.5464	0.5386	0.5924	-5.2030	9.0232	-5.2030	9.0232
90 Minute Class	-7.1038	240.3858	-0.0296	0.9765	-489.2567	475.0492	-489.2567	475.0492
9:00AM	744.4175	318.0203	2.3408	0.0230	106.5496	1382.2854	106.5496	1382.2854
10:45AM	555.3217	399.2359	1.3910	0.1700	-245.4441	1356.0874	-245.4441	1356.0874
12:30PM	623.5856	368.1216	1.6940	0.0961	-114.7729	1361.9441	-114.7729	1361.9441
2:15PM	671.8478	315.0951	2.1322	0.0376	39.8471	1303.8485	39.8471	1303.8485
4:00PM	772.2965	388.6873	1.9869	0.0521	-7.3114	1551.9045	-7.3114	1551.9045
M	55.1244	269.1959	0.2048	0.8385	-484.8141	595.0630	-484.8141	595.0630
T	48.6680	266.7094	0.1825	0.8559	-486.2834	583.6193	-486.2834	583.6193
W	488.5710	305.3466	1.6001	0.1155	-123.8767	1101.0186	-123.8767	1101.0186
Prof Rating (CBS Course Review)	78.1470	50.8272	1.5375	0.1301	-23.7995	180.0936	-23.7995	180.0936
Same Professor?	-4.8891	270.2736	-0.0181	0.9856	-546.9894	537.2111	-546.9894	537.2111
2011 Clearing Price	0.7649	0.1086	7.0460	0.0000	0.5472	0.9826	0.5472	0.9826
Finance	-108.0894	183.6032	-0.5887	0.5586	-476.3507	260.1719	-476.3507	260.1719
Management	-182.9097	307.1156	-0.5956	0.5540	-798.9056	433.0862	-798.9056	433.0862
Marketing	-120.1240	203.7529	-0.5896	0.5580	-528.8007	288.5526	-528.8007	288.5526

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RESULTS – KEY OBSERVATIONS [CORRELATION MATRIX]

	2012 Clearing Price	Open Seats	Capacity	90 Minute Class	9:00AM	10:45AM	12:30PM	2:15PM	4:00PM	M	T	W	Prof Rating	Same Professor?	2011 Clearing Price	Finance	Management	Marketing
2012 Clearing Price	1																	
Open Seats	-0.4412	1																
Capacity	-0.0474	0.3464	1															
90 Minute Class	-0.1489	0.2410	0.2222	1														
9:00AM	0.1794	-0.0188	-0.0637	0.1165	1													
10:45AM	-0.1365	-0.0282	0.0152	0.3744	-0.2432	1												
12:30PM	-0.0386	0.0612	0.0315	0.0956	-0.2432	-0.1290	1											
2:15PM	0.0199	0.0001	0.1539	-0.3097	-0.4432	-0.2352	-0.2352	1										
4:00PM	-0.0325	0.0105	-0.1075	-0.0241	-0.2073	-0.1100	-0.1100	-0.2004	1									
M	-0.1758	0.0941	-0.0276	0.4097	0.0355	-0.0389	0.2333	-0.2520	-0.0589	1								
T	0.0629	0.0085	0.0662	0.0889	0.0241	0.1996	-0.2113	0.0428	-0.0634	-0.5095	1							
W	0.3399	-0.1158	-0.0237	-0.2761	-0.0497	0.0121	0.1532	0.0588	-0.1100	-0.3111	-0.2113	1						
Prof Rating	0.4193	-0.3841	0.0060	0.1172	0.1183	0.0158	0.1908	-0.1503	-0.1693	0.0103	-0.1043	0.0261	1					
Same Professor?	0.0583	0.1154	0.1750	-0.0815	-0.0126	0.1100	-0.0504	-0.0223	-0.0885	-0.1473	0.1801	0.1100	0.0845	1				
2011 Clearing Price	0.7850	-0.4403	-0.1256	-0.2497	0.1202	-0.1757	-0.1189	0.0254	-0.0459	-0.1215	0.1331	0.2412	0.3696	0.0650	1			
Finance	-0.1067	0.1745	0.0359	0.3435	-0.0805	0.0355	0.1311	-0.0597	0.0031	0.4390	-0.1332	-0.2513	0.0839	-0.0031	-0.0668	1		
Management	0.0113	-0.2039	0.1429	-0.2132	0.0512	-0.0996	0.0747	0.0605	-0.0849	-0.1281	0.0907	0.0747	-0.0935	-0.1132	0.0315	-0.1940	1	
Marketing	0.0598	0.0236	0.0478	-0.3480	-0.0754	-0.1955	-0.0886	0.2376	-0.0451	-0.1277	-0.0867	0.2322	-0.0930	0.1667	0.1107	-0.3808	-0.1510	1

Correlation Table Observations

- Strong positive correlation between 2011 clearing price and 2012 clearing price
- Strong negative correlation between Monday and Tuesday classes
- Mild correlation between # of open seats and ultimate clearing price

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RESULTS – KEY OBSERVATIONS [BEST SUBSETS ANALYSIS]

Key Observations:

- **Best model includes following variables:**
  - **9:00AM**
  - **10:45AM**
  - **12:30PM**
  - **2:15PM**
  - **4:00PM**
  - **Wednesday**
  - **Prof Rating**
  - **2011 Clearing Price**

- **Results identical with P-value analysis of the full regression model**

Vars	R-Sq	R-Sq(adj)	Mallows Cp	S	Capacity	90 Minute Class	9:00AM	10:45AM	12:30PM	2:15PM	4:00PM	M	T	W	Prof Rating	Same Professor?	2011Clearing Price	Finance	Management	Marketing
1	61.6	61.1	4.2	574.43													X			
1	17.6	16.4	84.7	841.73											X					
2	64	62.9	1.8	560.27										X			X			
2	63.5	62.5	2.7	563.94											X		X			
3	66.3	64.7	-0.3	546.5										X	X		X			
3	65	63.4	2	556.81			X							X			X			
4	67	65	0.3	544.38			X							X	X		X			
4	66.6	64.5	1.1	548.26	X									X	X		X			
5	67.5	64.9	1.5	545.04			X			X				X	X		X			
5	67.4	64.9	1.5	545.37			X		X					X	X		X			
6	68.3	65.3	1.9	542.04			X		X	X				X	X		X			
6	67.8	64.8	2.8	546.44	X		X		X					X	X		X			
7	68.9	65.3	3	541.89	X		X		X	X				X	X		X			
7	68.8	65.3	3.1	542.44			X	X	X	X	X			X			X			
8	70.5	66.6	1.9	531.57			X	X	X	X	X			X	X		X			
8	69.3	65.3	4.2	542.55		X	X		X	X	X			X	X		X			
9	70.6	66.2	3.7	534.94	X		X	X	X	X	X			X	X		X			
9	70.6	66.2	3.8	535.45			X	X	X	X	X			X	X		X		X	
10	70.7	65.8	5.6	538.66	X		X	X	X	X	X			X	X		X		X	
10	70.7	65.7	5.6	538.96	X		X	X	X	X	X			X	X		X			X
11	70.8	65.3	7.4	542.43	X		X	X	X	X	X			X	X		X		X	X
11	70.8	65.3	7.4	542.53			X	X	X	X	X			X	X		X	X	X	X
12	71	64.9	9.1	545.46	X		X	X	X	X	X			X	X		X	X	X	X
12	70.8	64.7	9.3	546.86		X	X	X	X	X	X			X	X		X	X	X	X
13	71	64.3	11	550.22	X		X	X	X	X	X	X		X	X		X	X	X	X
13	71	64.3	11	550.26	X		X	X	X	X	X		X	X	X		X	X	X	X
14	71	63.6	13	555.01	X		X	X	X	X	X	X	X	X	X		X	X	X	X
14	71	63.6	13	555.18		X	X	X	X	X	X	X	X	X	X		X	X	X	X
15	71	63	15	560.12	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
15	71	63	15	560.12	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
16	71	62.3	17	565.38	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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RESULTS – KEY OBSERVATIONS [REDUCED (OPTIMIZED) REGRESSION MODEL]

Key Observations

- **Reduced model has better adjusted R2 value than full model (0.6665 > 0.6227)**

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.8397
R Square	0.7051
Adjusted R Square	0.6665
Standard Error	531.5743
Observations	70

ANOVA

	df	SS	MS	F	Significance F
Regression	8	41,220,200.82	5,152,525.10	18.2344	0.0000
Residual	61	17,236,844.26	282,571.22		
Total	69	58,457,045.09			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	(1,158.9047)	352.3875	(3.2887)	0.0017	(1,863.5472)	(454.2623)	(1,863.5472)	(454.2623)
9:00 AM	762.8800	267.8523	2.8481	0.0060	227.2763	1,298.4837	227.2763	1,298.4837
10:45 AM	609.6937	317.6726	1.9193	0.0596	(25.5318)	1,244.9193	(25.5318)	1,244.9193
12:30 PM	633.1834	326.7743	1.9377	0.0573	(20.2423)	1,286.6090	(20.2423)	1,286.6090
2:15 PM	671.9762	269.8878	2.4898	0.0155	132.3023	1,211.6502	132.3023	1,211.6502
4:00 PM	777.8363	325.7283	2.3880	0.0201	126.5023	1,429.1703	126.5023	1,429.1703
W	441.6316	215.8420	2.0461	0.0451	10.0288	873.2344	10.0288	873.2344
Prof Rating	79.7334	42.2515	1.8871	0.0639	(4.7538)	164.2206	(4.7538)	164.2206
2011 Clearing Price	0.7607	0.0896	8.4873	0.0000	0.5814	0.9399	0.5814	0.9399

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Key Observations
- *Residuals have slight left skew*
- *Some pattern observed in "Versus fits"*

Residual Plots for Clearing Price

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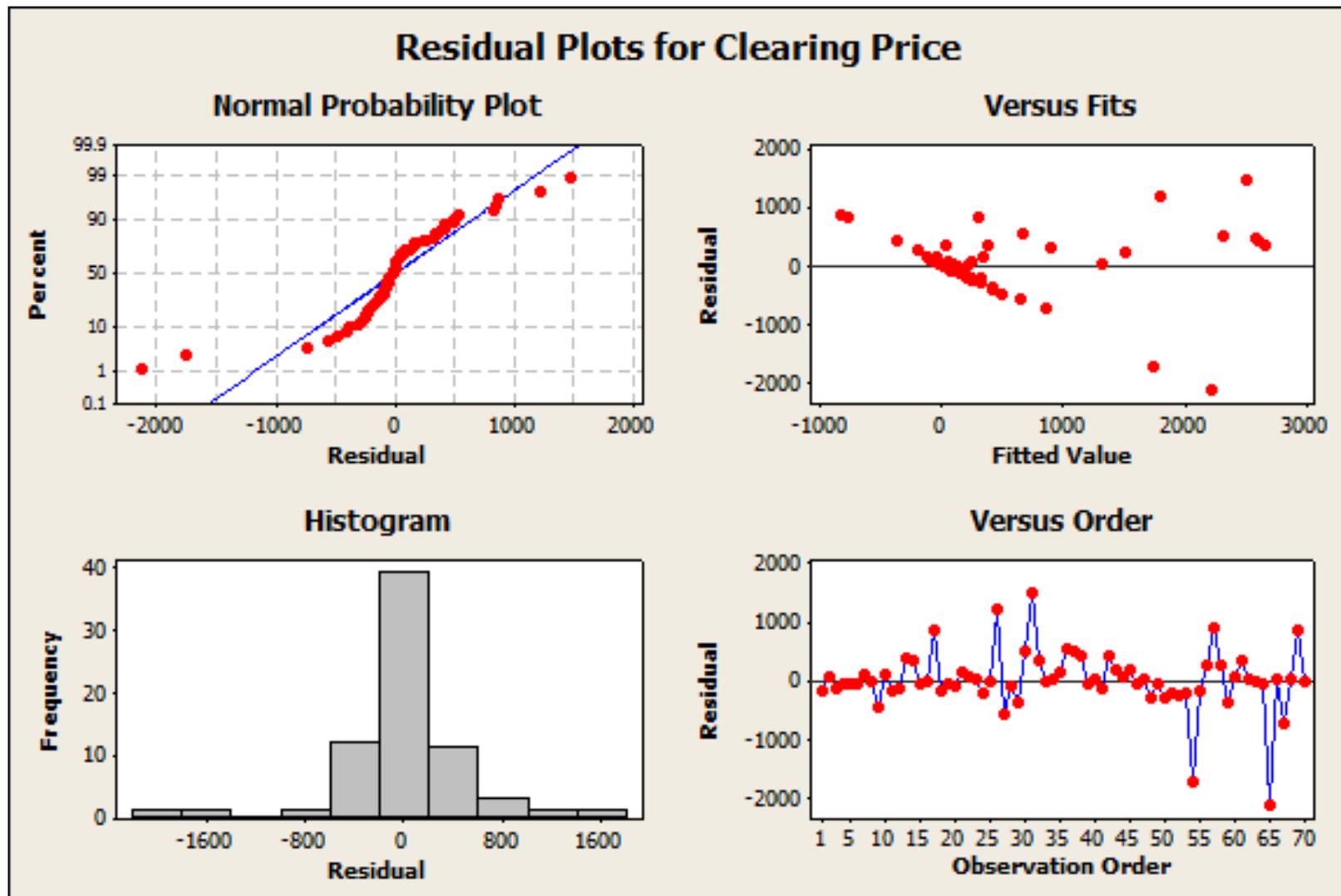
2012 Clearing Price = -1,158.9047 + 762.88 9:00AM Class + 609.6937 10:45AM Class + 633.1834 12:30PM Class + 671.9762 2:15PM Class + 777.8363 4:00PM Class + 441.6316 Wednesday + 79.7334 Professor Rating + 0.7607 2011 Clearing Price

Example:

For Professor Low's Intro to Venturing Wednesday 12:30PM Section, our model would estimate....

2012 Clearing Price = -1,158.9047 + 762.88 * (0) + 609.6937 * (0) + 633.1834 * (1) + 671.9762 * (0) + 777.8363 * (0) + 441.6316 * (1) + 79.7334 * (7.80) + 0.7607 * (1023)

2012 Clearing Price = 1316

Actual= 1360

Difference= 44

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IV. CONCLUSIONS AND RECOMMENDATIONS

ACTUAL VS. PREDICTED CLEARING PRICES

$y = 0.7051x + 122.4$

$R^2 = 0.7051$

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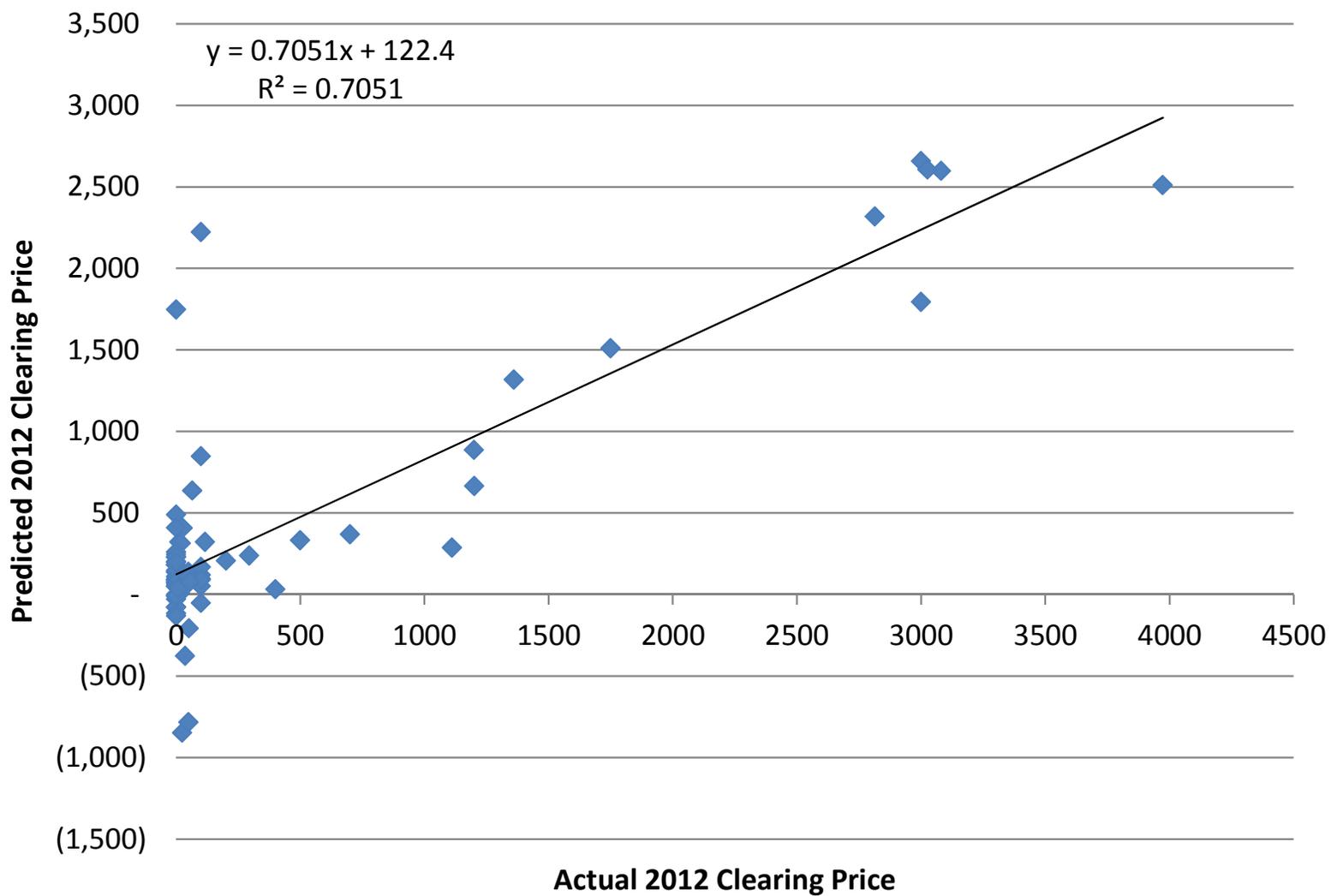
SUMMARY

- The 8 independent variables explain 70.5% of the variation in 1st round clearing price

- Our model can be helpful in assisting students with their class bidding strategy
    - However, the model doesn't take an individual student's risk aversion into account

- Weaknesses of the model include
    - Dependent variable not normally distributed
    - Patterns in residuals
    - Model doesn't measure soft/intangible factors such as group dynamics

- Next steps would be to apply this model to the spring bidding process and assess its robustness

- Additionally, one could look into performing several other analyses
    - Using more years of data / other variables
    - Cluster analysis

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- One could think of a number of ways to cluster the student bidding data

1. We could look at which individual classes could be clustered together (high bid point classes, low bid point classes, …)

2. One could analyze which departments can be clustered together

3. We could look at to which extent the students' career interest/pre-MBA experience affect their bidding behavior
   - In order to perform this analysis, we would need bidding data on an individual student level

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QUESTIONS?