OMIS 4000 R

SSB PROPOSAL FOR FAIR COURSE ALLOCATION

BY: BEN GAHTAN (214150528), SHAHZEB AFROZE (214677462), ADI TZADOK (214809222), SOOIN LEE (216845489)

DATE: MARCH 28TH, 2019
PROFESSOR: ADAM DIAMANT

Executive Summary

SSB is seeking to shift the way that students will be assigned to courses, and ensure that their new system is both fair and effective. To both (1) provide students with equal opportunity for students to enroll in courses at favorable times, and (2) ensure an effective allocation of courses, we propose that SSB adopts a method whereby students can choose a single preferred section time per course. Given that students have complex needs that cannot be generalized (i.e., the student stating a preferred section in the morning on Tuesday vs. stating that all mornings are preferred), sections are a necessary component of understanding student preferences. The proposed model will aim to meet everyone's preferences equally; in the case where many students want to enter a particular section and the course becomes full, it will be randomly chosen who will be enrolled. Most interestingly, when simulating student preferences (i.e., assuming each student is equally likely to prefer any section in a class), we discover that this method produces a high degree of student satisfaction. In fact, students can expect to receive 5/6 of their preferred sections. However, it is important to note that one limitation with this approach is that it does not build as strong a sense of community as a cohort system because they will not be surrounded by the same individuals for the entire term.

Introduction

Problem Description

The client, SSB, is seeking to determine a quantitative modelling approach that addresses how first-year students will choose their courses. The problem is two-fold: (1) the administration wants to know how they could build fair cohort schedules given the courses that are offered and their respective meeting times; and (2) given a set of cohorts, the administration needs to determine how students will choose cohorts fairly. In this report, we have chosen to focus on solving the latter of these two problems. However, for reasons outlined later in the report, we will propose an approach to allocate students fairly to schedules rather than cohorts. The motivation behind the shift in the way that students will be assigned to courses is the issue of 'fairness'. It is important that the administration provides students with equal opportunity for students to enroll in courses at favorable times.

Objective of the Study

The objective of this study is to maximize fairness between students in choosing their courses while ensuring student preferences are met. This study uses a Python model to allocate students to course sections in the most fair and effective manner. The term "fair" in this context is defined as <u>"the maximum degree that each student's individual preferences for course meeting times can be met, without any partiality over other students".</u> It is also noted that to successfully solve this problem, the group must ensure (1) students cannot be scheduled to classes that run concurrently, (2) students cannot be assigned to sections that are full (and preferably, ensure each section is mostly full), (3) iBBA and BBA students must be able to fit a language credit and general nonbusiness elective respectively, and (4) BBA students must also be able to fit one section of ECON1000 and ECON1010.

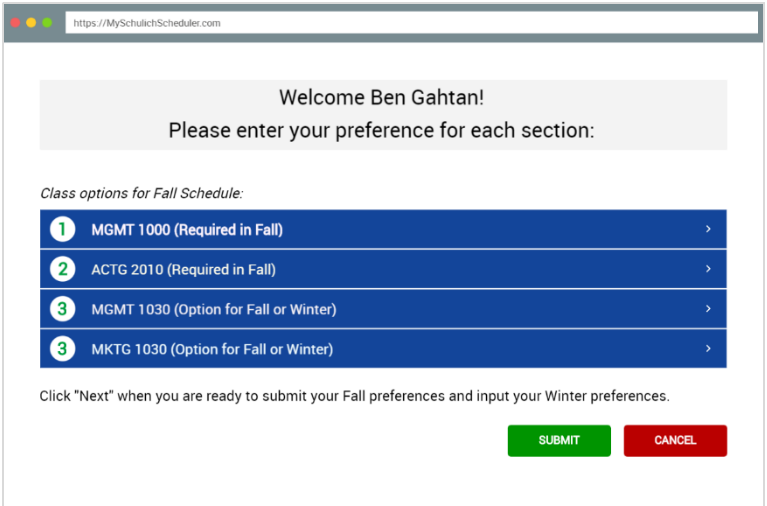
Exploratory Research

To gain deeper insight about the ways in which other schools and faculties have structured course enrollment for students, we interviewed individuals from Osgoode Hall Law School. Students in this program have explained that they are required to rank courses in order of priority to signify importance. Once all forms are submitted, students are randomly assigned to courses with higher chances of getting their priority course. Most students were very satisfied with their course allocation system. Interestingly, a typical Osgoode course only has 4 different meeting times, so it is a quick process to rank each section per class. However, for BBA/iBBA first-year courses, the average number of potential meeting times is 8 per course. As such, adopting the exact scheduling structure that Osgoode uses would potentially create an inconvenience for Schulich students. So, the approach we used to assign students to schedules is inspired by the section-ranking model used at Osgoode, with some modification.

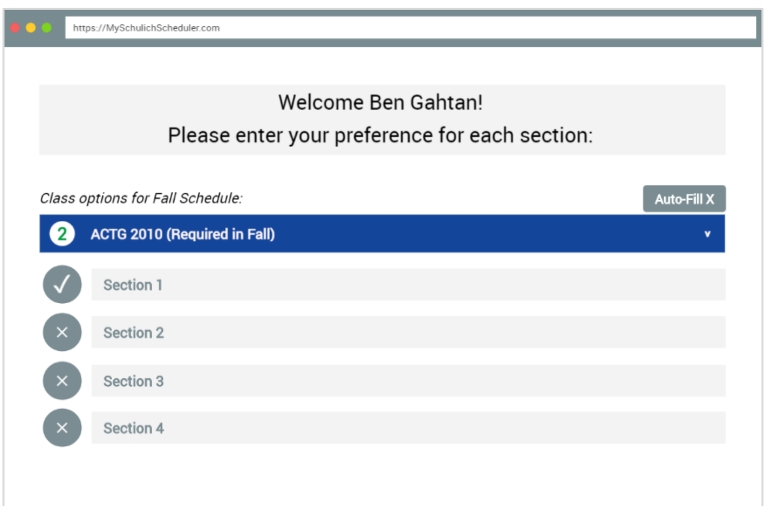
Following this, secondary research was used to validate our findings from these one-on-one interviews. The Hanover Research study shows how student preferences impact course enrolment. The study suggests that a single students' preferences vary widely across multiple days; students might prefer morning classes on Monday, afternoon classes on Wednesday, and evening classes on Thursday. This would often be the case for part-time students who may have a wide range of shift times. Therefore, given the complexity of student needs, it is evident why students would opt to choose particular sections instead of generalizing that they "prefer morning classes". Furthermore, even in a cohort approach where students can state section preferences, it is unlikely that enough students would have the exact same preferences to group them into a cohort.

Summary of Approach and Findings

In this report, our group proposes a method that involves i/BBA students inputting a simple "✓" to indicate their preferred section. The rationale for this is that it provides more flexibility to meet student needs than a cohort model. Additionally, compared to Osgoode's approach, it is much simpler for students to enter their preferences; they do not need to determine how much more they want it compared to another section. The webpage (visualized below) to submit section preferences is open to everyone up until a deadline. By simulating student preferences (i.e., students are equally likely to enter their "✓" for any meeting time per course), we learn that this method is highly effective. In fact, students can expect to receive 5/6 of their section selections.



On the webpage, the numbers of 1,2,3 and 3 represent that students need to choose their section preferences for three Schulich courses in their Fall semester. The first two are mandatory for Fall but they have an option of MGMT 1030 or MKTG 1030 as their third.



In this example, the student has chosen Section 1 as the preferred section for ACTG 2010. Note that the model does not support choosing multiple section preferences, in order to simplify the student experience. Once the user enters the "✓" for their desired section, they can use the "auto-fill X" feature to automatically set all the other sections to "X".

Roadmap of Report

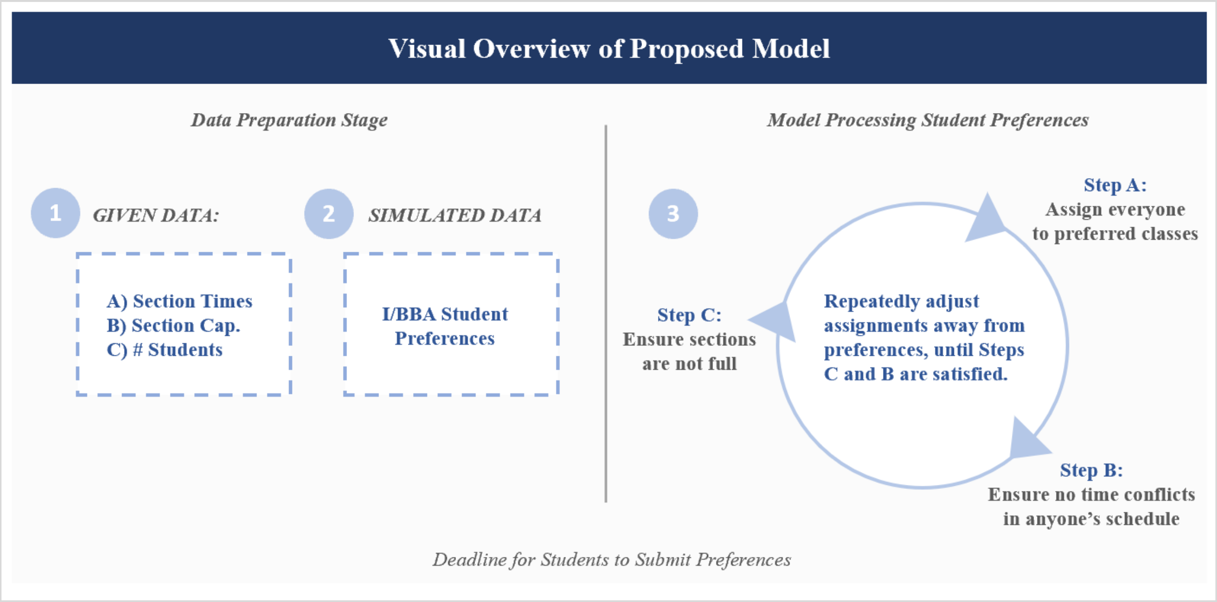
In the next sections of the report, we will describe: (1) the model in greater detail along with the SSB data and analysis to facilitate it; (2) key results from the approach and managerial implications; and finally, conclude with (3) actionable recommendations for SSB with implementation steps.

Data Collection and Analysis

This section will explain the data that was collected, and the methods used to analyze it. We will also explain what steps were taken, why certain modeling decisions were made, and the different components that comprise the model (See Appendix for complete mathematical formulation). Finally, we will conclude with a qualitative and quantitative rationale for adopting our proposed approach.

Explanation of Approach, Data Collection, and Data Analysis

The following diagram is a visual representation of the model approach and the data used in implementing it:



Note that this model has two stages: Stage 1 is the data preparation stage which are all the steps that must happen before the model can be ran. Stage 2 represents the stage that the model processes student preferences and creates the optimal schedule; this stage can only happen once all students have submitted preferences. The following 3 Steps (which are also illustrated in the above diagram) describe this process in greater detail.

Starting from Step 1, all the information provided by Schulich and York University's Course Catalogue is inputted. The model only requires section times, section capacities, and the number of students to be manually entered. After that, the model will automatically generate every possible time conflict which will be used in Step 3 to determine if a student is in two places at once (See Appendix).

At Step 2, the model simulates information about section preferences (although, in practice students will submit their actual section preferences). Importantly, allowing each student to input whether they do or do not want a particular section offers a precise informational data. For example, if a student is interested in enrolling in a morning section they do not need to specify that they "prefer morning classes", because it would mislead the fact that they only want to join one particular class that is held in the morning.

Finally, at Step 3, all the preferences are weighed, and the model assigns everyone to their preferred section. However, if there is a time conflict (i.e., the model schedules someone to be in two places at once) or a section is full, then a student will not get their preference. The model will continuously try to satisfy everyone but also ensure that the previously-mentioned hard constraints are met.

Explanation of Assumptions

The assumptions made in developing this approach included:

- *Number of Courses per Semester –* It is assumed that students can take 6 courses in one semester and 4 in the other. According to the Undergraduate Academic Handbook, students can opt for this allocation of courses throughout the year.
- *Lectures are not Linked to Labs –* In our proposed approach, the group did not specify that a student in a particular section must take a corresponding lab/tutorial. The reason is because it makes the approach more flexible to ensure that the student's schedule best reflects his/her needs.
- *Schulich will not Choose York Classes* – It is assumed that York Courses are not included in an assigned schedule. Likewise, it is also assumed that there are enough language courses for iBBAs and electives for BBAs that will fit into any schedule assigned.

Quantitative Rationale for Approach

The most compelling piece of quantitative evidence for adopting this is that for every student, the system will, on average, meet 5/6 preferences for BBAs or 7/8 preferences for iBBAs. This was determined by running a simulation (assuming students are equally likely to choose any particular section in a class as their preference). In the end, we believe that student preferences vary quite a lot, as we learned in the previously-mentioned secondary research. As a result, this seems like a fair assumption to be made.

The following illustrates the total deviation (1 deviation for each preference not met) from running a simulation using the proposed approach, in 10 trials. These total deviation values are included below. By taking each number below and dividing by 500, the resulting number is the amount of preferences that each student can expect to <u>not</u> receive (e.g., 240/500 ~= 0.5). Across all the trials, the average preferences each student can expect to <u>not receive is 0.5</u>. In other words, conservatively speaking, each student can expect to receive 5/6 of their section preferences.

240	234	246	236	226	250	240	282	246	248

Recommendations

Recommendations and Implementation Steps

The recommendation is for SSB to <u>adopt the method of scheduling students to course selections based on a preference system that is developed through Python</u>. The reason is because the above analysis reveals that, conservatively, the system will only fail to meet one of a student's section preferences. In other words, <u>if a student submits 6 section preferences they will likely receive 5 of them</u>. This ultimately results in an incredibly high degree of satisfaction for students while ensuring that the sections are divided fairly between students.

Overall Strengths and Limitations of Approach

There are several strengths with using this approach:

- *Fairness* – Enrolment does not open for everyone at different times and is not on a first-come first-serve basis. The model will aim to offer each student their first choice, however, if many students want a particular section (and it becomes full) then the program will randomly select which of them will get that section.
- *Effectiveness* – the proposed approach is more effective than a cohort model. To illustrate this point, imagine that Student A and Student B are in different cohorts that each have a mix of mid-day, morning, and evening courses. Student A prefers morning meeting times and Student B prefers evening meeting times. These cohorts would be fair but not effective because Student A would have preferred to take all of Student B's morning sections and vice versa.
- *Visibility* – the proposed approach will provide visibility to SSB about the section times and professors that students most prefer (instead of just the ones they end up getting). For example, if many students choose sections that have a particular professor, then Schulich can infer the professor must be popular.

Some limitations to our approach include:

- *Sense of Community* – Assigning students to sections will not build as strong of a sense of community in comparison to students assigned to cohorts because they will not be surrounded by the same group of individuals for the entire term. However, this limitation could be mitigated by grouping all the students with the same section combinations into a cohort.
- *Degree of Students' Manual Effort* – The system requires students to specify the section they want per course. This manual effort is partially reduced with the automated "auto-fill" tool described earlier in the report. However, there is still an inherent risk that students will forget to input their preferences, which would prevent them from choosing their desired meeting times.

Future Outlook

- *Application of Proposal to Other Schulich Programs* – While the proposed course allocation approach was designed for Schulich (i)BBA students, it could effortlessly be adapted for any of Schulich's Master's programs. This could be done simply by tweaking parameters such as the number of students, the classes that a student must take, and their meeting times.

Appendices

Complete Mathematical Formulation of Approach

Supporting Data:

Note that: the following table was generated analytically using Python. The Python generator created a row in the below table if a student was enrolled in 2+ sections from <u>different</u> courses that would conflict (e.g., one is from 8:30am – 11:30am and another is 9:00am – 9:30am). It was unnecessary for the program to include a row if there were two sections from the same course at the same time, because that is handled by another constraint. That constraint requires each student is only assigned to one section from each course.

BBA Time Overlap	
Fall	
Start Time	
Tuesday 8:30am	MKTG1030 1, MGMT1030 3
Tuesday 11:30am	ACTG2010 6, ACTG2010 9, MGMT1030 2
Wednesday 2:30pm	ACTG2010 2, MKTG1030 5, MGMT1030 1
Thursday 11:30am	ACTG2010 4, MKTG1030 3, MGMT1030 4
Friday 11:30am	ACTG2010 8, MKTG1030 4
Winter	
Start Time	
Monday 8:30am	MKTG1030 5, ACTG2011 4
Monday 11:30am	MGMT1030 6, MGMT1050 1, ACTG2011 1
Tuesday 8:30am	MGMT1030 8, MGMT1050 4, ACTG2011 2
Tuesday 2:30pm	MGMT1030 9, ACTG2011 6
Wednesday 8:30am	MKTG1030 7, ACTG2011 5
Wednesday 11:30am	MGMT1050 2, MGMT1050 7, ACTG2011 3
Wednesday 2:30pm	MKTG1030 8, ACTG2011 9
Thursday 8:30am (incl. mgmt. tut starting later)	MGMT1030 10, MGMT1050 6
Friday 11:30am	MKTG1030 4, MGMT1030 7, MGMT1050 5, ACTG2011 7

iBBA Time Overlap	
Fall	
Start Time	
Tuesday 2:30pm	ACTG2010 3, INTL1200 1
Wednesday 8:30am	MKTG1030 2, INTL1400 1
Wednesday 2:30pm	ACTG2010 2, MKTG1030 5
Thursday 11:30am	ACTG2010 4, MKTG1030 3
Thursday 2:30pm	ACTG2010 7, INTL1200 2
Friday 11:30am	ACTG2010 8, MKTG1030 4
Winter	
Start Time	
Monday 8:30am	MKTG1030 5, ACTG2011 4
Monday 11:30am	MGMT1050 1, ACTG2011 1
Tuesday 8:30am	MGMT1050 4, ACTG2011 2
Tuesday 2:30pm	ACTG2011 6, INTL1210 1
Wednesday 8:30am	MKTG1030 7, ACTG2011 5, INTL1400 2
Wednesday 11:30am	MGMT1050 2, MGMT1050 7, ACTG2011 3
Wednesday 2:30pm	MKTG1030 8, ACTG2011 9
Thursday 2:30pm	MKTG1030 10, INTL1210 2
Friday 11:30am	MKTG1030 4, MGMT1050 5, ACTG2011 7

Formulation:

Note that: (1) a **bolded** value represent a placeholder for a Python variable used to incorporate the desired logic; and (2) a preference for section x in any class is 0 if the student did not ”✓” it. And it is 1 if they did.

<u>Define Decision Variables</u>

$BBA\_MGMT1000_{i,x}$ = {1 if BBA student i is in section x of MGMT1000}
$Dev\_BBA\_MGMT1000_{i,x}^{+/-}$ = {+/- deviation of BBA student i meeting preference for section x}
$BBA\_ACTG2010_{i,x}$ = {1 if BBA student i is in section x of ACTG2010}

$Dev\_BBA\_ACTG2010_{i,x}^{+/-}$ = {+/- deviation of BBA student i meeting preference for section x}
$BBA\_MKTG1030_{i,x}$ = {1 if BBA student i is in section x of MKTG1030}
$Dev\_BBA\_MKTG1030_{i,x}^{+/-}$ = {+/- deviation of BBA student i meeting preference for section x}
$BBA\_MGMT1030_{i,x}$ = {1 if BBA student i is in section x of MGMT1030}
$Dev\_BBA\_MGMT1030_{i,x}^{+/-}$ = {+/- deviation of BBA student i meeting preference for section x}
$BBA\_MGMT1050_{i,x}$ = {1 if BBA student i is in section x of MGMT1050}
$Dev\_BBA\_MGMT1050_{i,x}^{+/-}$ = {+/- deviation of BBA student i meeting preference for section x}
$BBA\_ACTG2011_{i,x}$ = {1 if BBA student i is in section x of ACTG2011}
$Dev\_BBA\_ACTG2011_{i,x}^{+/-}$ = {+/- deviation of BBA student i meeting preference for section x}

$iBBA\_MGMT1000_{i,x}$ = {1 if iBBA student i is in section x of MGMT1000}
$Dev\_iBBA\_MGMT1000_{i,x}^{+/-}$ = {+/- deviation of iBBA student i meeting preference for section x}
$iBBA\_ACTG2010_{,x}$ = {1 if iBBA student i is in section x of ACTG2010}
$Dev\_iBBA\_ACTG2010_{i,x}^{+/-}$ = {+/- deviation of iBBA student i meeting preference for section x}
$iBBA\_MKTG1030_{i,x}$ = {1 if iBBA student i is in section x of MKTG1030}
$Dev\_iBBA\_MKTG1030_{i,x}^{+/-}$ = {+/- deviation of iBBA student i meeting preference for section x}
$iBBA\_MGMT1050_{i,x}$ = {1 if iBBA student i is in section x of MGMT1050}
$Dev\_iBBA\_MGMT1050_{i,x}^{+/-}$ = {+/- deviation of iBBA student i meeting preference for section x}
$BBA\_ACTG2011_{i,x}$ = {1 if iBBA student i is in section x of ACTG2011}
$Dev\_iBBA\_ACTG2011_{i,x}^{+/-}$ = {+/- deviation of iBBA student i meeting preference for section x}
$iBBA\_INTL1200_{i,x}$ = {1 if iBBA student i is in section x of INTL1200}
$Dev\_iBBA\_INTL1200_{i,x}^{+/-}$ = {+/- deviation of iBBA student i meeting preference for section x}
$iBBA\_INTL1400_{i,x}$ = {1 if iBBA student i is in section x of INTL1400}
$Dev\_iBBA\_INTL1400_{i,x}^{+/-}$ = {+/- deviation of iBBA student i meeting preference for section x}
$iBBA\_INTL1410_{i,x}$ = {1 if iBBA student i is in section x of INTL1410}
$Dev\_iBBA\_INTL1410_{i,x}^{+/-}$ = {+/- deviation of iBBA student i meeting preference for section x}

<u>Build the Objective</u>

Min Z = Minimize Deviation in Section Preferences = (Sum of $Dev\_BBA\_MGMT1000_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_BBA\_ACTG2010_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_BBA\_MKTG1030_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_BBA\_MGMT1030_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_BBA\_MGMT1050_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_BBA\_ACTG2011_{,x}^{+/-}$ over all x,i) + (Sum of $Dev\_iBBA\_MGMT1000_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_iBBA\_ACTG2010_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_iBBA\_MKTG1030_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_iBBA\_MGMT1050_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_iBBA\_ACTG2011_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_iBBA\_INTL1200_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_iBBA\_INTL1400_{i,x}^{+/-}$ over all x,i) + (Sum of $Dev\_iBBA\_INTL1410_{i,x}^{+/-}$ over all x,i)

<u>Create Constraints</u>

Ensure each student is assigned to exactly one section of each class

(Sum of $BBA\_MGMT1000_{i,x}$ over all BBA students i, MGMT1000 sections x) = 1
(Sum of $BBA\_ACTG2010_{i,x}$ over all BBA students i, ACTG2010 sections x) = 1
(Sum of $BBA\_MKTG1030_{i,x}$ over all BBA students i, MKTG1030 sections x) = 1
(Sum of $BBA\_MGMT1030_{i,x}$ over all BBA students i, MGMT1030 sections x) = 1
(Sum of $BBA\_ACTG2011_{i,x}$ over all BBA students i, ACTG2011 sections x) = 1

(Sum of $BBA\_MGMT1050_{i,x}$ over all BBA students i, MGMT1050 sections x) = 1
(Sum of $iBBA\_MGMT1000_{i,x}$ over all iBBA students i, MGMT1000 sections x) = 1
(Sum of $iBBA\_ACTG2010_{i,x}$ over all iBBA students i, ACTG2010 sections x) = 1
(Sum of $iBBA\_MKTG1030_{i,x}$ over all iBBA students i, MKTG1030 sections x) = 1
(Sum of $iBBA\_ACTG2011_{i,x}$ over all iBBA students i, ACTG2011 sections x) = 1
(Sum of $iBBA\_MGMT1050_{i,x}$ over all iBBA students i, MGMT1050 sections x) = 1
(Sum of $iBBA\_INTL1200_{i,x}$ over all iBBA students i, INTL1200 sections x) = 1
(Sum of $iBBA\_INTL1400_{i,x}$ over all iBBA students i, INTL1400 sections x) = 1
(Sum of $iBBA\_INTL1410_{i,x}$ over all iBBA students i, INTL1410 sections x) = 1

Each section is within capacity
(Sum of $BBA\_MGMT1000_{i,x}$ over all BBA students i, sections x) + (Sum of $iBBA\_MGMT1000_{i,x}$ over all iBBA students i, sections x) – **Capacity** <= 0
(Sum of $BBA\_ACTG2010_{i,x}$ over all BBA students i, sections x) + (Sum of $iBBA\_ACTG2010_{i,x}$ over all iBBA students i, sections x) – **Capacity** <= 0
(Sum of $BBA\_MKTG1030_{i,x}$ over all BBA students i, sections x) + (Sum of $iBBA\_MKTG1030_{i,x}$ over all iBBA students i, sections x) – **Capacity** <= 0
(Sum of $BBA\_MGMT1030_{i,x}$ over all BBA students i, sections x) – **Capacity** <= 0
(Sum of $BBA\_ACTG2011_{i,x}$ over all BBA students i, sections x) + (Sum of $iBBA\_ACTG2011_{i,x}$ over all iBBA students i, sections x) – **Capacity** <= 0
(Sum of $BBA\_MGMT1050_{i,x}$ over all BBA students i, sections x) + (Sum of $iBBA\_MGMT1050_{i,x}$ over all iBBA students i, sections x) – **Capacity** <= 0
(Sum of $iBBA\_INTL1200_{i,x}$ over all iBBA students i, sections x) – **Capacity** <= 0
(Sum of $iBBA\_INTL1400_{i,x}$ over all iBBA students i, sections x) – **Capacity** <= 0
(Sum of $iBBA\_INTL1410_{i,x}$ over all iBBA students i, sections x) – **Capacity** <= 0

All decision variables are limited to binary values
$BBA\_MGMT1000_{i,x}$, $Dev\_BBA\_MGMT1000_{i,x}^{+/-}$, $BBA\_ACTG2010_{i,x}$, $Dev\_BBA\_ACTG2010_{i,x}^{+/-}$, $BBA\_MKTG1030_{i,x}$, $Dev\_BBA\_MKTG1030_{i,x}^{+/}$, $BBA\_MGMT1030_{i,x}$, $Dev\_BBA\_MGMT1030_{i,x}^{+/-}$, $BBA\_MGMT1050_{i,x}$, $Dev\_BBA\_MGMT1050_{i,x}^{+/-}$, $BBA\_ACTG2011_{i,x}$, $Dev\_BBA\_ACTG2011_{i,x}^{+/-}$ are binary

$iBBA\_MGMT1000_{i,x}$, $Dev\_iBBA\_MGMT1000_{i,x}^{+/-}$, $iBBA\_ACTG2010_{i,x}$, $Dev\_iBBA\_ACTG2010_{i,x}^{+/-}$, $iBBA\_MKTG1030_{i,x}$, $Dev\_iBBA\_MKTG1030_{i,x}^{+/}$, $iBBA\_MGMT1050_{i,x}$, $Dev\_iBBA\_MGMT1050_{i,x}^{+/-}$, $BBA\_ACTG2011_{i,x}$, $Dev\_iBBA\_ACTG2011_{i,x}^{+/-}$, $iBBA\_INTL1200_{i,x}$, $Dev\_iBBA\_INTL1200_{i,x}^{+/-}$, $iBBA\_INTL1400_{i,x}$, $Dev\_iBBA\_INTL1400_{i,x}^{+/-}$, $iBBA\_INTL1410_{i,x}$, $Dev\_iBBA\_INTL1410_{i,x}^{+/-}$ are binary

Ensure no time conflicts
(Sum of $BBA\_MKTG1030_{i,5}$ over all BBA students i) + (Sum of $BBA\_MGMT1030_{i,3}$ over all BBA students i) <= 1
…. Repeat for each BBA time constraint as per appendix section above

(Sum of $iBBA\_ACTG2010_{i,3}$ over all iBBA students i) + (Sum of $iBBA\_INTL1200_{i,1}$ over all iBBA students i) <= 1
…. Repeat for each iBBA time constraint as per appendix section above

Define the deviation variables

$BBA\_MGMT1000_{i,x}$ + $Dev\_BBA\_MGMT1000_{i,x}^{-}$ - $Dev\_BBA\_MGMT1000_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$BBA\_ACTG2010_{i,x}$ + $Dev\_BBA\_ACTG2010_{i,x}^{-}$ - $Dev\_BBA\_ACTG2010_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$BBA\_MKTG1030_{i,x}$ + $Dev\_BBA\_MKTG1030_{i,x}^{-}$ - $Dev\_BBA\_MKTG1030_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$BBA\_MGMT1030_{i,x}$ + $Dev\_BBA\_MGMT1030_{i,x}^{-}$ - $Dev\_BBA\_MGMT1030_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$BBA\_MGMT1050_{i,x}$ + $Dev\_BBA\_MGMT1050_{i,x}^{-}$ - $Dev\_BBA\_MGMT1050_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$BBA\_ACTG2011_{i,x}$ + $Dev\_BBA\_ACTG2011_{i,x}^{-}$ - $Dev\_BBA\_ACTG2011_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$iBBA\_MGMT1000_{i,x}$ + $Dev\_iBBA\_MGMT1000_{i,x}^{-}$ - $Dev\_iBBA\_MGMT1000_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$iBBA\_ACTG2010_{i,x}$ + $Dev\_iBBA\_ACTG2010_{i,x}^{-}$ - $Dev\_iBBA\_ACTG2010_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$iBBA\_MKTG1030_{i,x}$ + $Dev\_iBBA\_MKTG1030_{i,x}^{-}$ - $Dev\_iBBA\_MKTG1030_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$iBBA\_MGMT1050_{i,x}$ + $Dev\_iBBA\_MGMT1050_{i,x}^{-}$ - $Dev\_iBBA\_MGMT1050_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$iBBA\_ACTG2011_{i,x}$ + $Dev\_iBBA\_ACTG2011_{i,x}^{-}$ - $Dev\_iBBA\_ACTG2011_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$iBBA\_INTL1200_{i,x}$ + $Dev\_iBBA\_INTL1200_{i,x}^{-}$ - $Dev\_iBBA\_INTL1200_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$iBBA\_INTL1400_{i,x}$ + $Dev\_iBBA\_INTL1400_{i,x}^{-}$ - $Dev\_iBBA\_INTL1400_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x

$iBBA\_INTL1410_{i,x}$ + $Dev\_iBBA\_INTL1410_{i,x}^{-}$ - $Dev\_iBBA\_INTL1410_{i,x}^{+}$ = **Student i's preference for section x**

For each section i, for each section x