Tools and methods for decision support

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ABSTRACT
The Instituto Tecnologico de Ensenada (Ensenada Technological Institute), as provider of higher education, must face at least two perspectives for the community: on one hand, graduates from the high school are looking careers as tagged as interested for them; but on the other hand, in the future they should have a hiring panorama (labor force requested in the region). The present work provides an analysis perspective from a probabilistic point of view using Markov matrices, to study whether there is a possible future congruence point which would indicate which is (are) the career(s) that university should bet as "safe". Namely, according with the historical data of new student's vs graduates and considering that every semester involves costs offer a career that has a major probability that students do not continuous with their studies; knowing this, will allow at school to redirect their resources to another career that has this possibility; i.e., continuity in their student's and hiring probability. Additionally, this methodology may help to other universities in the region to make decisions that will influence in the future of the entity.

Keywords: Markov matrix, decision analysis, dropout rate.

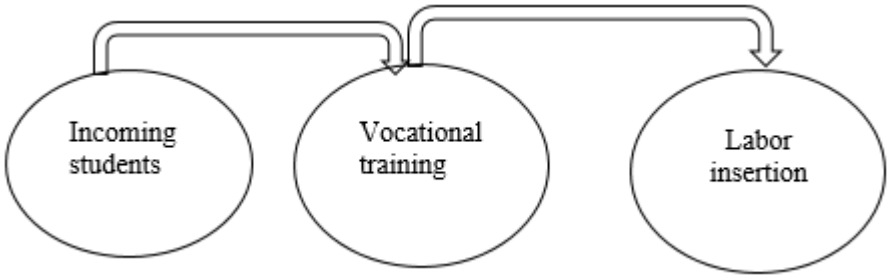
1 INTRODUCTION

By Presidential decree, the Technological Institute of Mexico (TNM Spanish abbreviation) created on July 23, 2014, has as one of its goals, to develop and promote applied research to maintain study plans and programs. Likewise, that of offering the broadest educational coverage, which in other words, is equivalent to saying that TNM must offer graduates from high school the greatest number of careers as

possible.

These objectives can be represented roughly as a chain as shown in Figure 1. It is attention paid to the raw material (initial circle) of the institution, will be those students who are interested in some career that the university has to offer; after that, receive vocational training and educational studies conducted (central circle) to finally, be able to be hired by any company or dependence (final circle).

Figure 1. Representation of the cycle of the university students.



In quantifiable terms, the rate of labor absorption is equal to the ratio between the numbers of students admitted in a certain period vs those who, being graduates, become part of the labor sector. This index should be as close to one as possible (DGPP).

This measurement allows us to know, in real terms, the degree of relevance that a career presents (study plans, studies of offer and educational demand) with respect to the needs and expectations of the community (Grijalva). In numerical terms, this value indicates the following:

- The number of students accepted (i.e., applicants that requested to be accepted in the university) must be as close to the number of professionals that the labor sector requires.
- This number must be an amount moderate, where theoretically, if the amount accepted is determined to a certain value, this indicates rather that the number of graduates will be lower and, therefore, should have a greater chance of recruitment.

Consider the institution as a company, the latter point measured in economic terms, few graduates indicates that less is achieved in relation to the number of entrants, more investment is wasted (González, S).

Therefore, must regard the appropriate deduction of accepted applicants as one factor priority from several aspects:

- Achieve a high job absorption rate (in terms of closeness to one).
- To manage economic, service and human resources in a more responsible manner.

Regardless of the selection criteria that each institution has, the general objective will be to determine, based on a quantitative analysis, that of having an institutional target value for the school dropout rate.

Once determined the target value of the dropout rate, will consider the specific objective of determining those careers that meet or not with this amount.

If any career exceeds the specified value, they will be indicated as those in which the Institution must increase (reinforce) its acceptance criteria; meanwhile those that do not exceed it, indicates that the university can "bet" on them as growth points for the region.

2 METHODOLOGY

2.1 OBTAINING THE DATA

Table 1 shows the numbers of selected applicants from years 2013 to 2016, as well as the number of those who continued the next cycle (did not drop out from the first to the second semester).

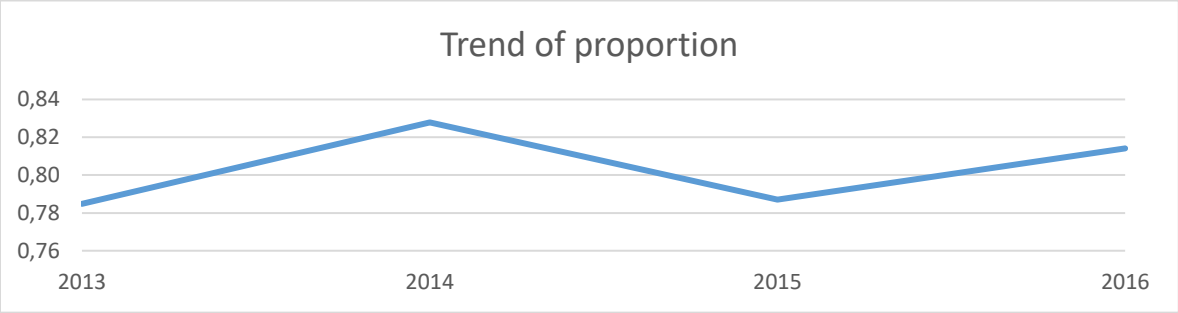
Here, we have not considered those students whom entered by equivalence or by transfer or career changes, which in statistics represent the states of nature and for the moment, are not relevant for the study (Ruíz, C).

Table 1. Number of students approved to join at university as well as those who continued to the semester immediately afterwards.

	Year			
	2013	2014	2015	2016
Selected applicants	553	639	587	635
Students who continue in the immediate cycle they entered	434	529	462	517

Based on this information, figure 2 shows the trend of the proportion of high school students continuing in the following semester.

Figure 2. - Non- dropout trend from students that passed from first to second semester during the years 2013 to 2016.



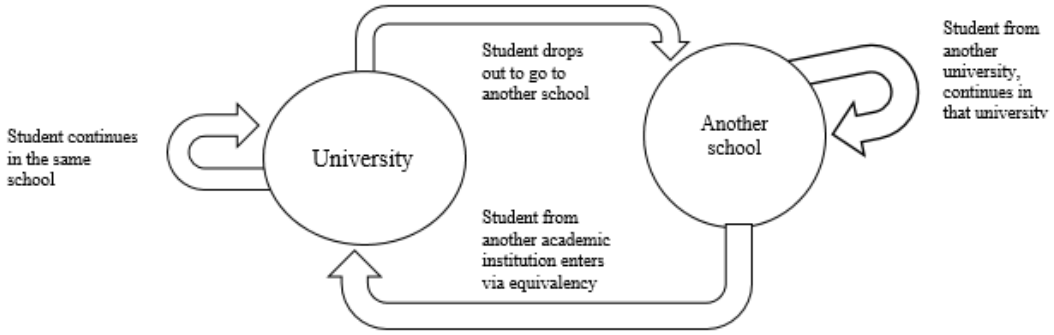
Also, the trend shows that points are in an interval near to the mean (0.80); therefore, in general terms, the probability that a student once has been accepted and did not drop out in the immediate subsequent cycle, has a percent value of 80%.

2.2 MARKOV CHAIN POINT OF VIEW

Another graphic perspective of visualizing this information is the following: suppose for a recently accepted student of university, that there are only two possible scenarios: to continue in the institution (even when changing careers) or drop out to go to another school.

These states are reciprocal for any other educational institution as shown in figure 3.

Figure 3. - Basic cycle of a student, continue in the same institution or join to another one.



At any time, any students of the institute is part of these states:

- Those who entered through the admission exam and continue (at least) in the immediate cycle.
- Those who entered via equivalency.

Table 2 is the representation of figure 3; the rows are the two schools (the subject to study and the set of all other universities, represented as “another”); meanwhile columns are the transitions between them.

That means that the first row represents the colleges student’s from the university subject of study, and second row represent “as general” any other; meanwhile, columns are the loops: the first column is when students continues in the same university, and second column when goes from one school to another (called entry via equivalency).

Although dropping out of one educational institution does not guarantee that the student will enter another one, for our purpose it should be as is.

Table 2. – According to figure 3, this is the matrix of possible scenarios for a student.

Probability that:	Continue in the same school in the immediate cycle from which entered	Continue in another educational institution
Students from the university		
Students from another school		

2.3 ANALYSIS DATA

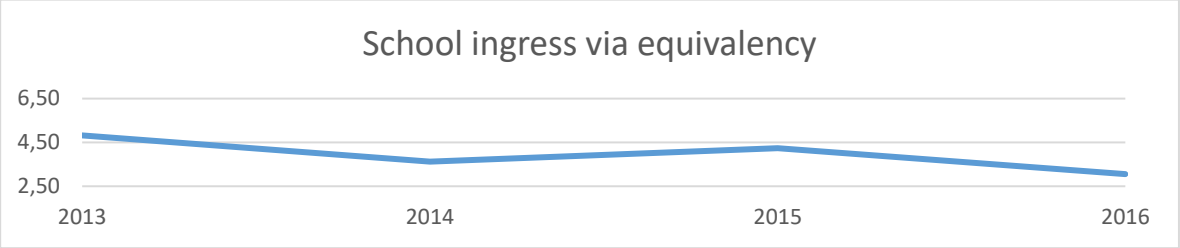
The first numerical data for cell located in row one - column one of table 2, has already been obtained and corresponds to 0.80. Taking the procedure used previously as a reference, table 3 shows those who entered via equivalence vs. the total population of the first semester.

Table 3. - Income data via equivalency during the years 2013 to 2016.

	2013	2014	2015.	2016
Total students enrolled 1st semester	581	663	613	655
Income entry students via equivalence	28	24	26	20
Proportion (%)	4.82	3.62	4.24	3.05

These data lead to figure 4, which indicates that, on average, 3.93 % of students who defected from another educational institution of higher education, did access the institution to complete their studies. Without loss of relevance, we will assume to be in the immediate subsequent cycle.

Figure 4. - Enrollment trend via equivalency to the technological institute.



Thus, completing table 2 according with those values, gives as a result table 4:

Table 4. - Values of continuity in the same school via either equivalence (2nd row) or non-desertion (1st row).

Probability that:	Continue in the same school in the immediate cycle from which entered	Continue in another educational institution
Students from the university	0.80	
Students from another school	0.039	

This matrix will have a Markov solution (Ortega, J) as long as the dropout rate is not greater than 20% (in the case of students that continue in the same university), and that 96 % of students from other higher education institutions continue with their studies in their own campus.

Although the last data does not depend on the institution, and there is not any chance of knowing with certainty the real value, it can be established as a goal of the university that the dropout of students from the first to the second semester, should not be greater than 20%.

Table 5 (the term DE means Distance Learning Education) presents the dropout rates by career that the school has presented during the years 2013 to 2016; when compared graphically using statistical

software, gives as result figure 5.

Table 5. - Dropout rates by career from 2013 until 2016.

	Year			
University career	2013	2014	2015	2016
Electromechanical Engineering	0.30	0.12	0.23	0.19
Electronics Engineering	0.35	0.67	0.33	0.22
Business management Engineering	0.14	0.20	0.21	0.14
Business Management (DE) Engineering	0.06	0.21	0.11	0.16
Industrial Engineering	0.22	0.22	0.17	0.12
Industrial (DE) Engineering	0.13	0.11	0.20	0.17
Mechatronic Engineering	0.28	0.17	0.21	0.28
System Computer Engineering	0.20	0.28	0.39	0.18
Administration	0.21	0.17	0.25	0.37

Figure 5. - Comparison obtained of each average of the dropout rates per career.

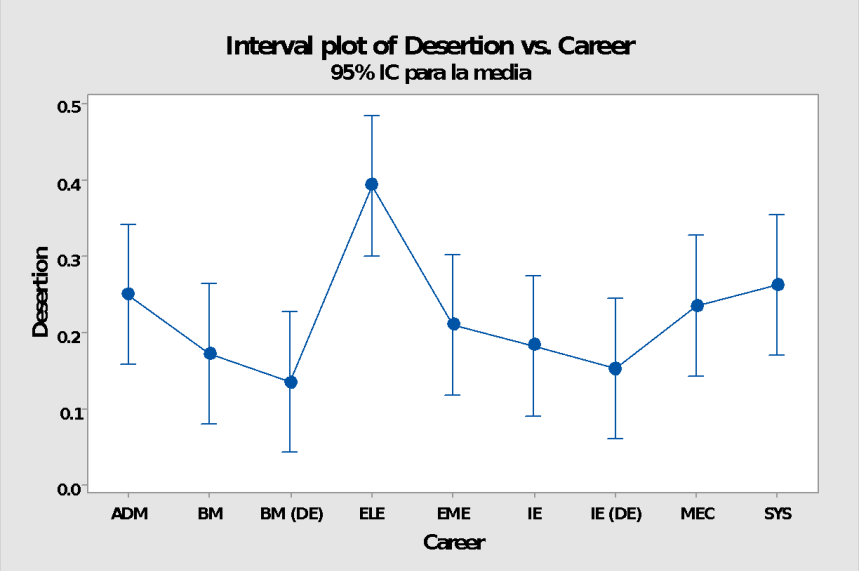


Figure 5 seems to suggest that the institution should consider whether to offer the Electronic Engineering degree. Assuming that the career could not be considered (remove it from the analysis), and performing a Tukey's test to comparing the differences between the career's means to determine if there are equal or not, table 6 is the result of this study and indicates that averages can be considered equal; that is, without significant difference between them (Ximénez C).

2.3.1 Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Table 6. - Result of the comparison between the means of the dropout rate by career using Tukey's test.

CAREER	N	Mean	Grouping
SYS	4	0.2625	A
ADM	4	0.2500	A
MEC	4	0.2350	A
EME	4	0.2100	A
IE	4	0.1825	A
BM	4	0.1725	A
IE(DE)	4	0.1525	A
BM (DE)	4	0.1350	A

Means that do not share a letter are significantly different.

2.4 MARKOV ANALYSIS

The fact that the dropout rate is the one required for the Markov chain to have a solution (under the theoretical assumption that they drop out to enter another educational institution) does not mean anything because it has not yet been detailed what information it yields.

Basically, the Markov's matrix (when the sum of the amounts of each row is equal to one) explains the probability that an event taking future reference only to the immediately preceding event occurs (Ortega, J); in other words, for a population that enters to the school in any particular period, what is expected to happen after n-periods? Could it have a stable value?

Considerer again table 2 but with the assumptions made before, to obtain table 7 as follow

Table 7. - Markov matrix. Note that the sum of each row equals one.

Probability that:	Continue in the same school in the immediate cycle from which entered	Continue in another educational institution
Students from the university	0.80	0.2
Students from another school	0.04	0.96

Where, although the value of 0.96 cannot be obtained in real terms and corresponds to the probability that a student from another educational institution will continue in the same school in the immediate cycle after which entry, it will be assumed as is to explain what means to a further analysis or projection.

Suppose that for any given period, 600 students enter the school, while another institution of higher education enrolls 3,500 students.

Using the QM software (https://bit.ly/3yXhsdd) in the Markov analysis module and entering the previous values as shown in figure 6

Figure 6. - Data entered in QM to perform an analysis with the population proposed.

	Initial	State 1	State 2
State 1	600	.8	.2
State 2	3500	.04	.96

The solution obtained (figure 7) indicates that approximately 683 students would continue in the institute (already considering transfers) meanwhile 3416 students would be in the other higher education school.

Figure 7. - The Markov analysis foresees an upward trend in the school enrollment.

Ending number (given initial)	683.2882	3416.441

Therefore, maintaining a dropout level below 20% can be considered profitable and even a priority.

3 CONCLUSION

In the above example, the initial values are deliberate selected: 600 was chosen as the average of selected applicants (as according to table 1 the real value is 603.5); meanwhile 3500 was taken as same but now from a specific competing institution; then, what could happen if the university may maintain at least at 20% the dropout proportion?.

The Markov analysis indicates that the population tends to grow unlike the competing institution.

If the income is "tighter" in the sense of accepting fewer applicants (which eventually represents most potential terminal efficiency) and considering the results of Table 6, then:

- The Institution should consider not bidding for the Electronic Engineering career.
- It is recommended to be stricter in accepting students from:
  - Computer systems engineer.
  - Administration.
  - Engineering in mechatronics.
- Consider expanding the curricula in distance learning education, due they are the ones with the lowest dropout rate.
- Prioritize careers in Industrial Engineering as well as in Business Management, whether in infrastructure, internship material, visits, postgraduate studies, etc.
- Establish a strict system in the careers indicated before, that allow knowing in depth: Why the student’s plans to drop out? Is there something wrong with the way they thought the career was? Is something happening with the teaching staff? (For example bad preparation for the class or insufficient material or insufficient teaching methods). Is there a lack of infrastructure?

Although the value provided as probable (row two – column two from table 7) is not plausible to measure, it can be taken as a reference to have an idea of where to focus the future of institution careers, thus trying to ensure that their resources (human, material, etc.) have an efficient use, and thus:

- Improve the academic conditions of students in the careers of Systems, Administration and Mechatronics (fewer students could mean better attention).

- Reduction of staff by fees. By not offering subjects, it will not be necessary to hire personnel; and it gives the necessary time to prepare the basic teaching staff for the subjects that require it where it is necessary to contract fees.
- Students with better possibilities to positions in the labor force.

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