Adding Value in Pre-university Selection Process: A Quartile Ranking Model

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Abstract

This paper shows how it is possible to add value by using some statistical tools in a process. In this case, it is analyzed the first stage of the value chain in the students’ learning process. The first stage is the selection of the students from senior high schools who are willing to study Industrial Engineering. The Universidad Politécnica de Aguascalientes (UPA) requires, as a selection criterion, the average obtained in the senior high school level. However, there is an empirical perception that these averages may not represent the same academic performance; i.e. the rigor in academic terms could be different from school to school though they might be reporting the same average. Therefore, it is presented an analysis of means, standard deviations and quartiles in order to assure the academic performance and to level the pre-university students’ average. This analysis was conducted by using the following factors: the average and standard deviation obtained by the last generation in an in-situ preceding course and a national assessment score of pre-university skills, both of them grouped by school. At the end, it was generated a ranking number for decision-making in the selection process.

Keywords

1. Introduction

Since the establishment of the Universidad Politécnica de Aguascalientes (UPA) in 2002, the quality in its processes has been an important matter, this is reflected in being certified on ISO 9000 since 2005. Throughout its life, the UPA has had continuous improvements in its value chain, in this case, in its main process by providing undergraduate and postgraduate educational services.

This value chain starts with the selection of the future undergraduate students in the Industrial Engineering program. Here, about the 84% of the selected students are from senior high schools in the state of Aguascalientes, there are 161 suppliers for the UPA (i.e. pre-university schools), which represents 10,367 candidates [1]. Therefore, it is important to measure the academic performance of each student, not just by his/her own means, but also, this performance should be categorized according his/her school of origin. By knowing this, the inbound process quality might be assured and then the performance along his/her career could be higher.

The problem is that there is an inherent variance from school to school in terms of the academic rigor, which is not represented in any statistical measurement. This makes difficult to establish the right criteria for the selection process in the Industrial Engineering program, thus, it is proposed a ranking method in order to know better about the school of origin of each student, and in an indirect way, balancing their grades according the academic rigor. For doing this, it was considered three variables:
1. The grade point average on seven basic subjects obtained by the last generation in an in-situ preceding course.
2. The grade point standard deviation on seven basic subjects obtained by the last generation in an in-situ preceding course.
3. The national assessment scores of pre-university skills done by the National Center for Higher Education Assessment (Centro Nacional para la Evaluación de la Educación Superior – CENEVAL).

These three variables were grouped by school, analyzed and weighted according to its quartile. After that, new averages were obtained and then a ranking was set.

The obtained ranking was used as part of a group of criteria for selecting the students in the Industrial Engineering academic program; other two criteria were a vocational test and a personal interview.

2. Performance Measurements

In order to measure the academic performance, it was considered three variables (see Figure 1).

1. Grade point average – It was computed the average of seven subjects which were taught in an in-situ preceding course. This average was grouped and linked to the school of origin. These subjects were: Algebra, English, Physics, Writing and Spelling, Research Methodology, Vocational Strengthening and Group Tutoring. All these subjects should not be new for the students since their topics were the same as those learned at high school. The results are based on 10, and this variable is represented by \( \mu_{\text{UPA}} \).

2. Grade point standard deviation - It was computed the standard deviation of the same seven subjects which were taught in an in-situ preceding course. This standard deviation was grouped and linked to the school of origin and represented as \( \sigma_{\text{UPA}} \).

3. National assessment scores - It was obtained the CENEVAL scores from an assessment of pre-university skills per school of origin. This score goes from 700 to 1300 points and it is assigned the variable \( \mu_{\text{C}} \).

Figure 1: Performance Measurements summary

3. Quartiles and Weights

The data was analyzed by using quartiles. A quartile is when an ordered set of data is divided into four equal parts. The first or lower quartile \( q_1 \), is a value that has approximately 25% of the observations below it and approximately 75% of the observations above. The second quartile \( q_2 \), has approximately 50% of the observations below its value. The second quartile is exactly equal to the median. The third or upper quartile \( q_3 \), has approximately 75% of the observations below its value [2].

For each performance measurement it was computed its quartiles first and third. By doing this, it is possible to classify by schools which ones are above the 75% (\( q_3 \)), which ones are below the 25% (\( q_1 \)) and which ones are the most common (\( q_3 – q_1 \)). This last one it is known as the interquartile range which is a measure of variability; the interquartile range is less sensitive against extreme values in the sample than the ordinary sample range is [2].

The main idea of using the quartiles is to identify which school is truly above the normal behavior in terms of performance, not just above the mean or the median, but above the 75% in its results. This same reasoning is for the
lower performance considered below the 25%. The quartiles for each variable were computed and they are represented in boxplots (see Figure 2) [3]. So that, it could be computed the interquartile range and could be defined the values for considering which schools into the sample have an outstanding performance, a normal performance and a below expectations performance (see Table 1).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Outstanding Performance ($&gt;q_3$)</th>
<th>Normal Performance ($q_3$-$q_1$)</th>
<th>Below Expectations Performance ($&lt;q_1$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade point average</td>
<td>$\mu_{UPA} &gt; 8.5$</td>
<td>$7.65 &gt; \mu_{UPA} &gt; 8.5$</td>
<td>$\mu_{UPA} &lt; 7.65$</td>
</tr>
<tr>
<td>Grade point standard deviation</td>
<td>$\sigma_{UPA} &gt; 0.87$</td>
<td>$0.44 &gt; \sigma_{UPA} &gt; 0.87$</td>
<td>$\sigma_{UPA} &lt; 0.44$</td>
</tr>
<tr>
<td>National assessment</td>
<td>$\mu_C &gt; 1019$</td>
<td>$1001 &gt; \mu_C &gt; 1019$</td>
<td>$\mu_C &lt; 1001$</td>
</tr>
</tbody>
</table>

![Boxplot and quartiles for each performance measurement](image)

Figure 2: Boxplot and quartiles for each performance measurement [4]

After defining the quartiles and for obtaining a right number in order to rank each school of origin, it was weighted the three categories: Outstanding Performance, Normal Performance and Under Expectations Performance. The values were given in a lineal way: for the schools above the third quartile a weight of 3 was assigned; in the case of the normal performance the weight was 2, and finally for the ones below the first quartile the assigned weight was 1 (see Table 2).

<table>
<thead>
<tr>
<th>Performance</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outstanding ($&gt;q_3$)</td>
<td>3</td>
</tr>
<tr>
<td>Normal ($q_3$-$q_1$)</td>
<td>2</td>
</tr>
<tr>
<td>Below Expectations ($&lt;q_1$)</td>
<td>1</td>
</tr>
</tbody>
</table>

By doing this, each school got a weight for each performance according to the quartiles, and then the three weights were averaged and called $\mu_W$ (see Table 3).

<table>
<thead>
<tr>
<th>Senior High School*</th>
<th>$\mu_{UPA}$</th>
<th>$\sigma_{UPA}$</th>
<th>$\mu_C$</th>
<th>$W_{\mu_{UPA}}$</th>
<th>$W_{\sigma_{UPA}}$</th>
<th>$W_{\mu_C}$</th>
<th>$W_W$</th>
</tr>
</thead>
<tbody>
<tr>
<td>School 1</td>
<td>7.93</td>
<td>0.7071</td>
<td>990</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1.67</td>
</tr>
<tr>
<td>School 2</td>
<td>8.40</td>
<td>1.5685</td>
<td>1145</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2.00</td>
</tr>
<tr>
<td>School 3</td>
<td>9.24</td>
<td>0.2103</td>
<td>1109</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3.00</td>
</tr>
<tr>
<td>School 4</td>
<td>9.02</td>
<td>0.9762</td>
<td>1091</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2.67</td>
</tr>
<tr>
<td>School 5</td>
<td>9.07</td>
<td>0.6135</td>
<td>1067</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3.00</td>
</tr>
<tr>
<td>School 6</td>
<td>8.15</td>
<td>2.2051</td>
<td>1040</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1.33</td>
</tr>
</tbody>
</table>

* The names of schools are confidential due to the implications of the ranking.
4. Ranking

In order to generate the ranking according to the three variables already explained, it is needed to sort the data. This is because there might be some schools which can get the same averaged weight ($\mu_W$). The sorting process is done by the following criteria:

- Averaged Weights $\mu_W$ from maximum to minimum
- Grade point average $\mu_{UPA}$ from maximum to minimum
  - Grade point Standard Deviation $\sigma_{UPA}$ from minimum to maximum
- National Assessment $\mu_C$ from maximum to minimum

The whole process is summarized in the Figure 3 by designing a ranking model.

5. Model Verification and Results

A selection process was conducted for new students from March to August 2013; in this process the model described in this paper was applied. The selected students in the Industrial Engineering program had the in-situ preceding course from September to December 2013. With the results of the last in-situ preceding course it is possible to compare the two last generations: the first one without using the model, they were the new students in 2012, and the second one, where the proposed model was applied, they were the new students in 2013.

In this direction the hypothesis is: “The selected students in 2013 had a better final academic performance than the new students in 2012 due to the selection process”. This performance is measured by the grade point average in the
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in-situ preceding course. These were divided in averages equal and greater than 8.0 and averages lower than 8.0 (see Figure 4). The grade 8 is used since is the middle point in approbatory grades in senior high schools. The Mexican Secretariat of Public Education (Secretaría de Educación Pública - SEP) considers a passing grade from 6 to 10.

![Figure 4: Grade point average divided by proportions upper and lower 8.0](image)

Figure 4 shows a difference between the generations 2012 to 2013, this can be seen by the difference in proportions, and it was proven statistically by setting a hypothesis test, see Equation 1 and 2 for the average greater or equal than 8.0.

\[
H_a : P_{2013} \geq P_{2012} \quad (1)
\]

\[
H_a : P_{2013} < P_{2012} \quad (2)
\]

For the case of the average less than 8.0, the hypothesis test is expressed in Equations 3 and 4.

\[
H_a : P_{2013} \leq P_{2012} \quad (3)
\]

\[
H_a : P_{2013} > P_{2012} \quad (4)
\]

By setting the hypotheses in this way, it can be proven that there is a shift in the average from a low performance to a higher performance. By using a significance level of 5%, both of the null hypotheses (1) and (3) were accepted (see Table 4). This proves that there is a difference between the students selected in 2012 from the ones selected in 2013, and this can be reflected in their grade point average performance.

![Table 4: Test for Two Proportions](image)

It is advised to apply this model every year since the senior high school performance might change. It is also suggested to keep a senior high school historical performance, to make a most robust ranking. After obtaining the results, the ranking was shown to the university academic board of UPA where were found several coincidences between the empirical belief of the senior high schools performance and the ranking obtained in this research.
6. Conclusions
There is a statistical difference between the 2012 and 2013 new students’ academic performance in Industrial Engineering due to the application of the quartile ranking model during the selection process as presented in this paper. The proposed model allows assuring the university suppliers quality in terms of new students, adding value to the selection process.

Through the application of the proposed model it is possible to establish an accurate variable which used in the selection process of the students in the Industrial Engineering program it is presumed to be a shift in the average from a low performance to a higher academic performance, reflected in their grade point average performance.

The improvement in the ranking model can be rated which is translated in a 12% of students who have a better performance, greater or equal to 8.0. This 12% was proven statistically to be significant; this means it was not just because a random effect but the ranking model proposed affects the selection process.

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References