Engineering Education as a development factor in Brazil

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Abstract
Engineering Education correlates to GDP according to the OCDE. The objective of this paper is to correlate also social (e.g.: HDI), economical (e.g.: Revenue per Capita) and educational indicators. The cities with high quality engineering institutions present an average improvement of all indexes when compared to state references.

Keywords: Engineering Education; Economic Development.

INTRODUCTION

According to Lins *et al.* (2014), there is a direct correlation observed by the OCDE in terms of Human Resources in Science and Technology (HRST) and GDP. However, GDP does not reveal social growth, or even social development. It does not show, necessarily, a better environment for the people and what positive effects can take place. GDP does not reflect in equality of income, or even better life standards. For this, it would be necessary to analyze other indexes such as Human Development Index (HDI), Revenue per Capita, and GINI.

There is a constant worry about Sustainable Development (SD) and the consequences if we do not take action. Many authors such as Stephen *et al*., (2008), Quandt (1998), de Oliveira (2011), and da Costa (2010) show the importance of sustainable regional development. Zilahy and Huisingh (2009) mention the important role that academia can take, with practical implementations suggested by Lansu *et al.* (2013) and the development of expertise as discussed by Litzinger *et al.* (2011). The results of focusing in HEIs as a strategy for development can generate significant increases in wages and regional dependency (Sgobbi and Cainarca, 2015; de Oliveira, 2011).

Taking into consideration the quantity and quality of HEIs and their global effect it could be possible to establish policies to drive sustainable development. This is an important factor especially in the case of a continental country with big disparities between its macro-regions as Brazil. However, we first must understand if the presence of high performance HEIs does benefit the regions, not only in a pure economical factor, such as GDP, but also helps to increase social factors.

The objective of this paper is to establish other correlations between the presence of active HRST - that come from good quality High Education Institutions (HEIs) - and the above indexes of HDI, GDP per Capita and GINI, to have a better understating of the effect it can have in regional communities, such as cities and macro-regions. We will take into consideration only the Engineering Education for a first analysis as Engineers represent both Science and Technology in the HRST described by the OCDE.

Engineering Education Performance

Brazil has a performance exam of high education named ENADE (National Exam of Student Performance). The result from ENADE evaluates graduation students on a grade from 1 to 5, with 5 being the highest score. There is also a SC concept that is given to HEIs that do not have at least two graduates taking the exam in that term, which is common on new approved universities. Good performance evaluation is considered on grades 4 and 5. The exam is annual however, due to the number of different careers and HEIs each one is evaluated every three years.

ENADE takes into consideration both specific and general performance. The general graduation curriculum represents 25% of the total grade and the specific represents 75%. After calculating the average grade and standard deviation for each particular HEIs, the method than calculates the average and standard deviation of all HEIs in that specific area that took the test to standardize the grade in all Brazil. (INEP, 2011)

Table 1: Number of HEIs per region by ENADE score in 2011

Region	1	2	3	4	5	SC	Total
Central-West	6	13	17	12	3	8	59
Northeast	11	41	50	34	4	21	161
North	5	19	19	4	0	25	72
Southeast	36	197	176	84	43	82	618
South	7	44	96	59	15	38	259

Source: (INEP, 2011).

If we take into consideration the distribution of HEIs of engineering and their evaluation, as shown in Table 1, we can conclude that the disparity between regions is significant.

The ENADE results can be questionable, as some universities still do not take the test and the spread of testing for every three years can present variations. ENADE also do not take into consideration curriculum design and, as shown by the calculation criteria, it takes into consideration the average standardized score for the highest grade rather than an absolute one.

GDP and HEIs Scenario

Brazil is the seventh biggest economy in the world; however due to the continental dimensions of the country (8,515,767 km²) there is a great challenge to equally develop all the regions. Global Brazil´s GDP has had an increase of a 5.27% on average in the last 20 years. In this period the annual increase has not been consistent, presenting a rate that varies a great deal, as can be seen in

Figure 1. This shows that Brazil´s GDP growth results are inconsistent with big fluctuations when compared to the average growth. (Banco Central do Brasil, 2015).

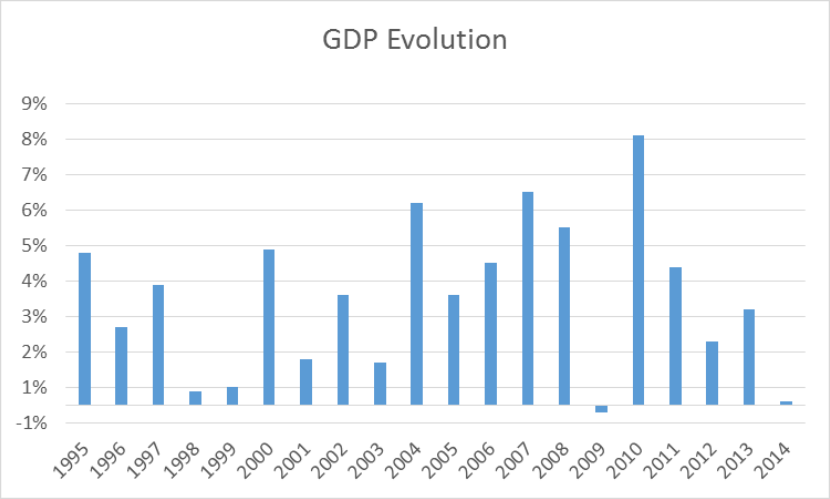

Figure 1 - Brazil´s GDP Percentage Growth from 1995-2014 (IBGE, 2014)

There is a direct correlation between regional GDP percentage participation of the regions and number of high performance HEIs. This relationship can be found in figure 2 below:

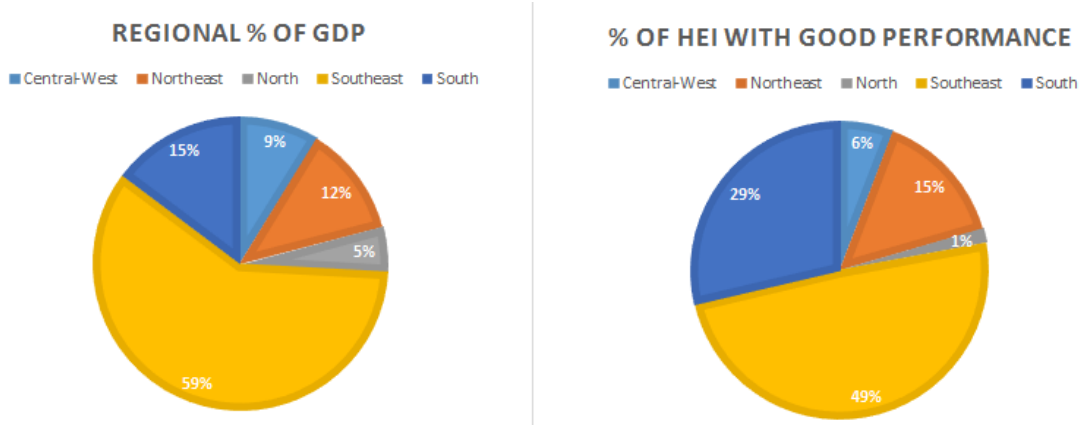

Figure 2 – Regional GDP and Regional High Performance HEIs

METHODOLOGY

To understand the impact of high performance HRST, this study will consider only cities in which there is presence of high performance of Engineering HEIs from the 2011 ENADE results. The method choose all cities that have Engineering HEIs with continuous ENDADE grades 4 and 5 in any of the eight different Engineering degrees that ENADE evaluates. Any HEI without a CPC concept was excluded from this study.

The CPC index is calculate on the following year of each ENADE results. It is an index that takes into consideration not only ENADE scores – that evaluate students – but also scores from

the University itself such as facilities and infrastructure, pedagogical and teaching techniques applied, faculty (titles and publications), etc.

After selecting the cities, we will take into consideration all Engineering HEIs in that area. With the criteria described above 236 HEIs fitted the criteria. These HEIs are established in 95 distinct cities across the territory, divided as show in table 2 below:

Table 2: Number of cities and HEIs after selection

Region	Number of Cities	HEIs with 4 and 5	Total HEIs
Central-West	7	15	39
Northeast	18	36	124
North	3	4	36
Southeast	38	116	371
South	29	65	171
Total	95	236	741

Source: (INEP, 2011; PNUD, 2013) .

After the selection of the cities, the study made two comparisons. The first comparison was between the city´s data and the country´s index value. After that, the study will also make a comparison between the city´s index value and the value of state it is located in to verify the regional factor. We used a simple percentage formula to assess what is the proportional gain or loss of that particular city as described in the example formula (1) below about Brazil´s HDI:

$$\%HDI_{City} = \frac{HDI_{City} - HDI_{Brazil}}{HDI_{Brazil}} \quad (1)$$

To achieve the regional percentage the same comparison displayed on formula (1) was recalculated but, instead of utilizing the Brazil´s index, each comparison was made with the respective state index. After all the individual percentage of variation for the cities with well-evaluated schools were obtained, the simple average of the results were calculated for the Brazil index, as displayed in formula (2).

$$HDI_{BrazilAvarage} = \frac{\sum_{n=1}^{95} \%HDI_{City}}{95} \quad (2)$$

For the state values, each state had its own average calculated as described by formula (3). These values take into consideration that each different region can present variations and a regional comparison can show a better understanding of the impact of HEIs. To achieve the Marco-Regional values the values were again averaged as described in formulas (4)

$$HDI_{StateAvarage} = \frac{\sum_{n=1}^{N} \%HDI_{City}}{N} \quad (3)$$

$$HDI_{MacroRegionAvarage} = \frac{\sum_{n=1}^{N} HDI_{StateAvarage}}{N} \quad (4)$$

RESULTS

The selection of 95 cities represent 1.7% of all of Brazil´s 5.565 cities in 2011. In addition, out of the 26 different states plus the Federal District, four states did not have any Engineering HEI with the necessary criteria. The states are Acre (AC), Pará, (PA), Rondônia (RO) and Tocantins (TO). All of the mentioned states are part of the North macro region of the country. In all other states at least one city had a HEI that fitted the necessary criteria.

The Federal District is composed of the city of Brasilia only. The city fitted the necessary criteria. The Federal District is part of the Central-West region and the absolute country comparison and state numbers (even if 0.0%) were took into consideration.

Human Development Index (HDI) Results

The information about global HDI values is presented in table 3. It shows the number of cities in which a percentage gain took place and the number in which a percentage loss took place. The average absolute gain of HDI was 0,039. The average final value of all cities achieved a gain percentage of +5.37%.

Table 3: Brazil HDI Results

Region	Number of Cities with HDI gain	Number of Cities with HDI loss	% of Cities with HDI Gain
Central-West	7	0	100.00
Northeast	8	10	44.44
North	3	0	100.00
Southeast	32	6	84.21
South	29	0	100.00

Source: (INEP, 2011; PNUD, 2013) .

When looking at the macro regional information, HDI values is presented in table 4. It shows the number of cities in which a percentage gain took place and the number in which a percentage loss took place. The percentage of cities with a higher HDI index displays a positive factor. The analysis did not take into account the percentage value, but simply if the result showed a positive or negative gain.

Table 4: Macro Regional HDI Results

Region	Number of Cities with HDI gain	Number of Cities with HDI loss	% of Cities with HDI Gain
Central-West	7	0	100.00
Northeast	16	2	88.89
North	3	0	100.00
Southeast	27	11	71.05
South	25	4	86.20

Source: (INEP, 2011; PNUD, 2013) .

The macro regional gain of HDI is presented in Figure 3. It shows that in every region of the macro-region of the country the presence of well-evaluated HEIs had a positive effect. In the North region, were there are only three HEIs the result is the biggest, that can be explained by both sample size and the positive development associated with the HEIs.

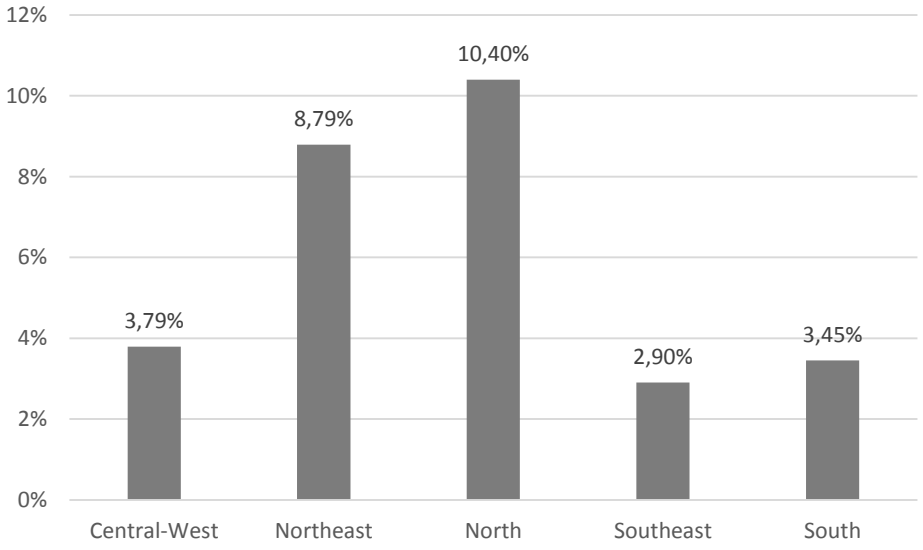

Figure 3 – Macro Region HDI Results

Revenue per Capita Results

The information about global Revenue per Capita results are presented in table 5. It shows the number of cities in which a percentage gain took place and the number in which a percentage loss took place. The average absolute gain of Revenue per Capita was R$ 203.18. The average final value of all cities achieved a gain percentage of +25.59%.

When looking at the macro regional information, Revenue per Capita results are presented in table 6. It shows the number of cities in which a percentage gain took place and the number in which a percentage loss took place. This analysis did not take into account the percentage value, but simply if the result showed a positive or negative gain.

Table 5: Brazil Revenue per Capita Results

Region	Number of Cities with Revenue gain	Number of Cities with Revenue loss	% of Cities with Revenue Gain
Central-West	5	2	71.43
Northeast	7	11	38.88
North	1	2	33.33
Southeast	29	9	76.31
South	28	1	96.55

Source: (INEP, 2011; PNUD, 2013) .

Table 6: Macro Regional Revenue per Capita Results

Region	Number of Cities with Revenue gain	Number of Cities with Revenue loss	% of Cities with Revenue Gain
Central-West	5	2	71.43
Northeast	13	5	72.22
North	3	0	100.00
Southeast	25	13	65.79
South	19	10	65.52

Source: (INEP, 2011; PNUD, 2013) .

The macro regional gain of Revenue per Capita is presented in Figure 4 above. It also shows that the cities with well-evaluated HEIs had a significant increase in Revenue per capita when compared to the complete number of cities in their macro-region. This represents a better environment for not only the Engineer graduates but for the entire city society.

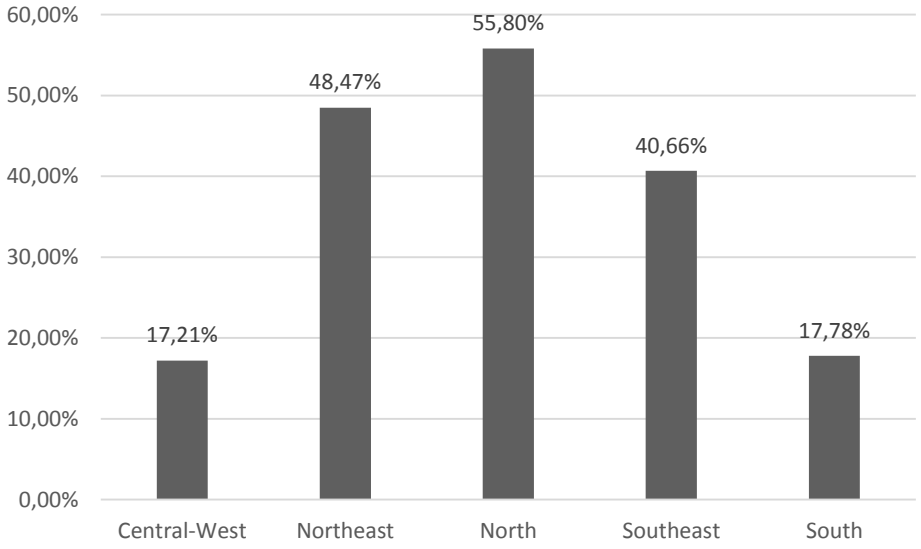

Figure 4 – Macro Region Revenue per Capita Results

GINI Results

In the case of the GINI index, the negative signal in both absolute and percentage results shows a better equality in distribution of income. This is because the index has a value of "0" for a perfect equal distribution of income and a value of "1" for total unequal distribution. Is this case a value closer to zero in the cities and macro regions would be desired and since the formulas were not altered, a gain in equality of distribution will yield a negative signal.

The information about global GINI results are presented in table 7. It shows the number of cities in which a percentage gain took place and the number in which a percentage loss took place. The average absolute gain of GINI was -0.067. The average final value of all cities achieved a gain percentage of -11.14%.

Table 7: Brazil GINI Results

Region	Number of Cities with GINI gain	Number of Cities with GINI loss	% of Cities with GINI Gain
Central-West	6	1	85.71
Northeast	8	10	44.44
North	1	2	33.33
Southeast	36	2	94.73
South	29	0	100;00

Source: (INEP, 2011; PNUD, 2013) .

When looking at the macro regional information, Revenue per Capita results are presented in table 8. It shows the number of cities in which a percentage gain took place and the number in which a percentage loss took place.

Table 8: Macro Regional GINI Results

Region	Number of Cities with GINI gain	Number of Cities with GINI loss	% of Cities with GINI Gain
Central-West	6	1	85.71
Northeast	13	5	72.22
North	3	0	100.00
Southeast	30	8	78.95
South	21	8	72.41

Source: (INEP, 2011; PNUD, 2013) .

The macro regional gain of GINI is presented in Figure 5. It shows that the cities with well-evaluated HEIs had a significant increase in GINI when compared to the complete number of cities in their macro-region. This represents a better distribution of revenue between the citizens in those cities.

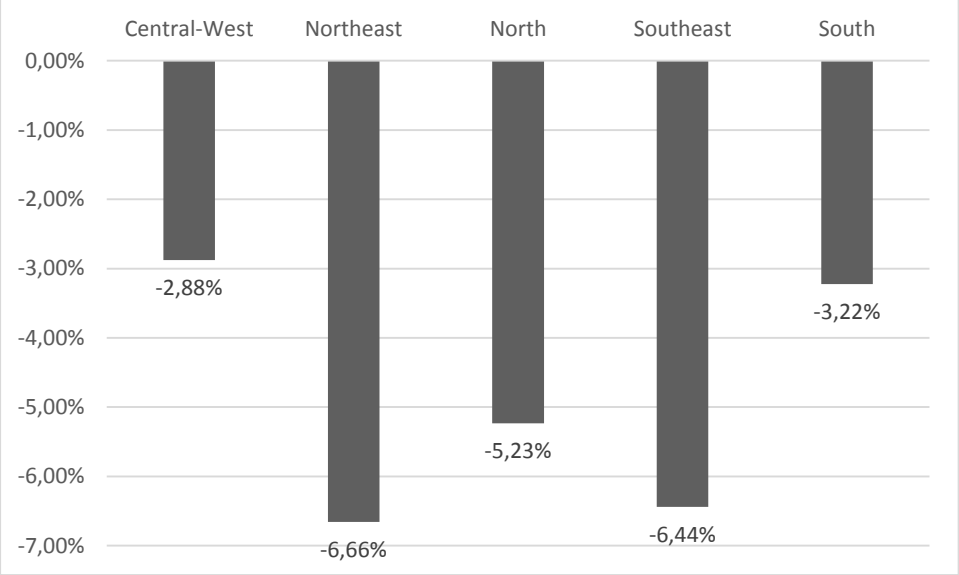

Figure 5 – Macro Region GINI Results

CONCLUSION

From the analyzed data, it is possible to conclude that the presence of well-evaluated Engineering Education HEIs will bring a significant benefit to the region.

All state and macro regional indexes showed a positive return. When we look at the combined effect of HDI, Revenue per capita and GINI we can understand that the cities with well-evaluated HEIs will not only have a better GDP, but also better standings of living. HDI results are particular important to measure that.

Another conclusion is that, due to the increase in both Revenue and GINI, the idea that only the graduates would ensure a better salary is discarded. The situation points to a better salary and better distribution, which is coherent with the hypothesis of general improvement. This improvement will not only affect the Engineers, but the entire society.

Another conclusion reached is that to achieve better standards, the current percentage of 1.7% of total cities with well-evaluated cities must improve. The quantity of cities is small and the result of HEIs in such cities, as presented in both global and macro regional results, are optimistic and can lead to a better country to live in. Policies to implement this scenario need to be studied by local actors, both in the private and public sector, to achieve a viable solution.

Even though most HEIs and GDP is produced in the Southeast region, the results of this region were not the highest in the comparison. It graded fifth in HDI, third in Revenue per capita and second in GINI. This shows that the presence on high GDP is not the only factor to increase those indexes, and show a possible path to take to better develop other regions. The case of the North, even with only three cities is interesting, as it is the macro region with the least GDP and HEIs and was able to achieve the best increase in HDI and Revenue per capita and the third best increase in GINI.

It was unclear, during the study, if the success in implementing well-evaluated HEIs is a result of a previous favorable development condition, in which the city would need to be previously prepared to receive it, or if the implementation of a well evaluated HEI can yield positive outcome regardless of a previous investment. This research needs to be conducted to understand if investing

in HEIs directly is a viable alternative of investment or if it is necessary to consider previous infrastructure needs.

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