



Interregional Performance of the Public Health System of a High-Inequality Country

Maria Cristina N. Gramani



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Maria Cristina N. Gramani

Inspere - Institute of Education and Research
Rua Quatá, 300 - Vila Olímpia
04546-042 São Paulo - SP - Brazil
Phone/Fax: 55-11-4504-2436 / 55-11-4504-2350
mariacng@insper.edu.br

Introduction

Brazil has the sixth-highest gross domestic product (GDP) in the world but is ranked 85th according to the Human Development Index (HDI). Although Brazil trailed Norway (the most developed country according to the HDI) by 13.5% in 2007, in 2011 this difference decreased by only 1%, indicating that there remains room for improvement in this area.

Brazil, which is a country of continental dimensions, has a current population of approximately 194 million, but this population is not uniformly distributed throughout the geographical regions of the country; for example, “*the southeast region covers only 11% of Brazil’s territory but accounts for 43% of the population and 56% of the gross domestic product.*” [1]. Because socioeconomic inequalities exist in developing countries, quality control in areas such as health and education is a complicated matter. Mackenbach et al. [2] showed that the inequalities in European health are associated with socioeconomic status and made the following conclusion: “*These inequalities might be reduced by improving educational opportunities, income distribution, health-related behavior, or access to health care.*”

Therefore, the consideration of aggregate figures for Brazil in a cross-country analysis would obfuscate the reality of each individual region. The Brazilian health system has three subsectors: 1) the public subsector; 2) the private (for-profit and non-profit) subsector, in which services are financed in various manners with public and private funds; and 3) the private health insurance subsector. Citizens can use services in all three subsectors [1]. In the Brazilian public health system, each of the 27 federal units (FUs) is responsible for its own health care through the Unified Health System (*Sistema Único de*

Saúde; SUS). According to the Brazilian government (<http://portaldasaude.saude.gov.br>), SUS “*covers procedures from simple health procedures to outpatient organ transplants, ensuring full access and universal and free coverage for the entire population.*” However, this decentralization of the health system may lead to performance variance among the FUs.

The performance of a public health system can be viewed from many perspectives. Raphael [3] considered 12 social health factors for Canadians, such as employment, individual income, income distribution, etc.. Cavelaars et al. [4] and Gupta et al. [5] argued that the level of education is a determinant of health in the country. Cavelaars et al. [4] analyzed the variation in educational levels between 11 western European countries, and Gupta et al. [5] used cross-sectional data on 50 developing and transitional countries to show that “*increased public expenditure on education and health care is associated with improvements in both access to and attainment in schools, and reduces mortality rates for infants and children.*”

Sundmacher et al. [6] examined an annual panel of approximately 20,000 16-year-olds from over 11,000 households throughout Germany and suggested that three factors contribute to variance in health: “*the capability score, cultural-behavioural variables and a lower extent, the materialist approach.*”

Few studies have performed a comparison of the health performance of FUs in a high-inequality country under different perspectives. Such comparisons reveal which FUs are efficient for each health perspective and describe the performance differences between the perspectives.

This study serves three primary purposes: (1) to examine the efficiency of the individual FUs and explore the perspectives that affect the overall performance of the public health system in a high-inequality country; (2) to explore the determinants of performance for each perspective in each geographical region of the country; and (3) to determine which elements cause some regions to be inefficient (the inefficient determinants).

The rest of the paper is organized as follows. The next section presents the two methodologies used, the balanced scorecard (BSC) to determine the health perspectives, and the data envelopment analysis technique (DEA) to evaluate the performance of each

perspective, followed by the proposed integrated BSC-DEA approach. We then present the data and show the empirical results and discussions. Finally, we offer some concluding remarks.

Methods

Balanced Scorecard (BSC)

One advantage of using the BSC methodology to categorize the aforementioned health perspectives is that it allows for the consideration of non-health factors that significantly impact health systems, such as education, income, employment and sewage treatment.

According to the Balanced Scorecard Institute, "*The Balanced Scorecard is a strategic planning and management system used to align business activities to the vision and strategy of the organization, improve internal and external communications, and monitor organizational performance against strategic goals.*" This methodology was developed by Kaplan and Norton [7] and originally analyzed four different perspectives: financial, customer, internal business processes and learning & growth. The BSC has been adopted by authors focusing on non-profit organizations. Chan [8] writes that non-profit organizations should not focus solely on implementing programs and initiatives and that it is also necessary to focus on the results of these activities.

However, Abran and Buglione [9] stated that "... *while BSC provides a vast array of individual quantitative indicators, it does not provide for consolidated performance values, either for the individual perspectives or for their consolidation.*"

In this manner, some authors seek quantitative methodologies to consolidate the performance values of each perspective in the BSC approach. DEA is one method that can be used for consolidation purposes.

Data Envelopment Analysis (DEA)

DEA provides a quantitative response for every pre-determined BSC health perspective. DEA is a non-parametric linear programming method that uses inputs to generate the outputs of decision-making units (DMU). The DMU with the highest ratio

between the outputs and the inputs is deemed the top performer. Although this construction does not constrain the efficiency of the best possible DMU, it does mean that, among the DMUs considered, it is the best one. Moreover, this methodology identifies how inefficient DMUs might reach maximum efficiency.

According to the World Health Organization [10], *“One health system differs from the other in structure, quantity and kinds of resources utilized and the outcomes attained. Nevertheless, health authorities yearn for the same objective, which are based on values like: good health for the entire population, responsiveness and fairness in financing.”* In this paper, we use the federal units as the DMUs, which differ depending on the quantity of resources (inputs) used and the products (outputs) produced (Figure 1).

FIGURE 1

Two main characteristics differentiate the DEA models.

- 1) Orientation: The input-orientation model aims to minimize the inputs while maintaining the outputs at a constant level. The output-orientation model aims to maximize the outputs given constant inputs.
- 2) Returns to scale: The model considers either constant returns to scale (CRS) or variable returns to scale (VRS). With CRS, an increase in inputs generates the same increase in outputs, whereas VRS do not require this proportionality.

Some vulnerabilities must be prevented to implement the DEA [11].

- 1) Minimizing input variables and maximizing output variables is preferable. For example, if the variable *“number of children treated”* must be considered as an input, and this variable should be maximized, we can use *“1/ number of children treated”* as the input.
- 2) The number of DMUs must be at least twice the product of the number of inputs and outputs. Because we use more than one perspective in this paper, one advantage of using the DEA technique for each perspective of the BSC methodology is the possibility of increasing the number of variables that are used [12].

Generally, the efficiency of a DMU k is measured by the rate between the outputs (Y_k) and the inputs (X_k), i.e., $\frac{uY_k}{vX_k}$, where:

- the ratio must be less than 1, and
- the weight for each variable (u and v) is positive.

The objective in this case is to determine the best weights (u and v) that optimize the ratio. If a variable weight is zero, either this input or output variable is not considered in the best solution, or this variable has a high potential to be improved.

An Integrated BSC-DEA Approach

Ramanathan and Ramanathan [13] proposed the integration of the BSC with the DEA, which can be applied to estimate the performance of health authorities (HA) in the UK. The authors used six perspectives for the BSC and different sets of inputs and outputs for the DEA model in each perspective. They found that no HA performed well in any of the six perspectives.

Identifying the input/output variables of the model is one of the most important stages of the DEA technique. In general, studies that evaluate the efficiency of health systems use variables such as the number of health professionals, cost measurement, the number of inpatients and patient life expectancy from birth [14-17]. One benefit of using the BSC-DEA integrated model is that we can be more specific; i.e., we can use more variables and directly relate them to each perspective.

Therefore, in this paper, we also propose an integration of BSC with DEA, but here, we consider all 27 Brazilian federal units and assume a dependency between the perspectives. We use the BSC-DEA approach with the four classical perspectives, which we believe cover the entire range of public health systems. These perspectives can be represented as follows:

1. *Financial perspective*: This perspective generally involves financial variables, such as return on investment, return on assets and cash flows. However, because we investigated the public health systems (i.e., non-profit organizations), other

variables, such as expenditures (i.e., spending initiatives, public health services and the average amount paid for hospitalization) as inputs and the number of available beds as outputs, were considered. For the DEA model, we considered the input-orientation model because we wish to optimize the expenditures.

2. *Customer perspective*: This perspective reflects the quality and capacity of customer care. We used the number of beds available as an input and the number of inpatients and patient life expectancy as outputs. Because customer care is the final objective, we used the output-orientation model.
3. *Internal process perspective*: This perspective reflects the socioeconomic conditions in the country. To capture this perspective, we examine health coverage plans, customer care efficiency and sewage treatment as inputs, which impact outputs such as education, average income and unemployment rates. In other words, this perspective intends that health processes (including the health system and environmental conditions such as sewage treatment) generate better performance in education, income and employment. In this perspective, we use the output-orientation model because the objective is to obtain the best socioeconomic condition (education, income and employment).
4. *Learning & growth perspective*: This perspective aims to improve people, systems and procedures. We used education, the unemployment rate and the average income as inputs to generate the number of health professionals, and we used the number of graduates in undergraduate health courses as outputs. Because learning and growth are the main objectives in this perspective, we used the output-orientation model.

FIGURE 2

Finally, we propose the integrated BSC-DEA model, as shown in Figure 2. The dotted lines in Figure 2 show the following dependencies among the perspectives:

- The outputs of the *financial perspective* are the inputs for the *customer perspective*.
- The score efficiency of the *customer perspective* is an input for the *internal process perspective*.

- The outputs of *the internal process perspective* are the inputs for *the learning & growth perspective*.

We used the VRS model for all of the perspectives because we determined that there is no proportionality between increases in inputs and increases in outputs.

Data

The data were collected from the SUS database and were publicly available for all 27 Brazilian federal units (<http://tabnet.datasus.gov.br>). All of the variables mentioned in the previous section were collected for all of the Brazilian federal units for 2008, and the descriptive statistics are shown in Table 1.

TABLE 1

Empirical Results and Discussion

Health Performance Comparison between the FUs

Figure 3 presents the public health performance of all 27 federal units in each BSC perspective. The FUs N1 to N7 belong to the northern region of the country, NE1 to NE9 belong to the northeastern region, CW1 to CW4 belong to the central-west region, SE1 to SE4 belong to the southeastern region and S1 to S3 belong to the southern region.

FIGURE 3

Figure 3 clearly shows the inequality in performance between the FUs and between the perspectives. The results show that one FU (CW1) excels in all of the perspectives, and the S and SE regions show clear superiority over the N and NE regions.

TABLE 2

Table 2 shows a moderate correlation between the efficiency of the perspectives and the GDP and PISA data for the FUs; that is, these results show that the FUs that perform better in terms of education and the economy are also superior in terms of health care.

The difference between the performances in each perspective is clear. The *customer perspective* shows the best performance overall, and the *learning & growth* and *financial perspectives* display the worst.

Figure 3 also shows that all of the federal units from the South region are 100% efficient in the *customer perspective*; i.e., this region can be considered as a benchmark for this perspective.

Efficiency Determinants

To simplify the next set of results without losing any information, the FUs were aggregated into five geographical regions: 1) North, which includes the 7 federal units in the north of the country; 2) Northeast, which includes the 9 federal units from the northeast of the country; 3) Central West, which includes the 4 federal units from the central west of the country; 4) Southeast, which includes the 4 federal units from the southeast of the country; and 5) South, which includes the 3 federal units from the south of the country.

The integrated model establishes the best contributions (or weights) for each input and output variable in every perspective; i.e., the input or output that most improves the performance of a given perspective will receive the greatest contribution (or the highest weight). The variable (input or output) with the highest contribution to a perspective can be considered the determinant of efficiency.

FIGURE 4

Figure 4 shows the contributions of each variable in each region for all four perspectives. This figure shows that the efficiency determinants are well defined in all of the perspectives, as follows:

- Financial perspective: the number of beds, which is defined by the variable *number of beds available per 1,000 inhabitants* (O1) for all regions.
- Customer perspective: again, the number of beds, which is defined by the variable *1/number of beds available per 1,000 inhabitants* (I3) for all regions.
- Internal process perspective: *Average income per capita/unemployment rate* (O5) for the South region and *population with more than 8 years of education/total population* (O4) for all other regions [4, 5].
- Learning & growth perspective: *Number of graduates with a health-related undergraduate degree/Total population* (O7) for the Southeast and Central West regions, *Total population/population with more than 8 years of education* (I7) for the North and Northeast regions and *Unemployment rate/Average income per capita* (I8) for the South region.

Inefficiency Determinants – Potential Improvements

This section describes the reasons for inefficiencies in each region from every perspective and discusses how an inefficient region can improve.

FIGURE 5

Figure 5 shows the potential improvements for the entire region to do as well as the top performers. This figure indicates how much each variable in each region must improve for all four perspectives; the vertical axes represent the percentage that the input must decrease to become the region top efficient and the percentage that the output must increase for the same purpose. For example, in the *financial perspective*, the North region must decrease 74% in I1, decrease 60% in I2 and increase 11% in O1, to make this region 100% efficient. Note that for all perspectives, the “strong” reasons for inefficiency can differ between regions. It is also noteworthy that the N and NE regions have the highest percentages of potential improvements when compared with the other three regions, which is compatible with the efficiency results that show the inferiority of the N and NE regions.

The inefficiency determinants are defined as follows.

- Financial perspective: *Spending initiatives and public health services per capita* (I1) displays the highest potential for improvement for the N and CW regions, but for the NE, S and SE regions, the variable *Average amount paid for hospitalization* (I2) merits more attention.
- Customer perspective: *1/number of beds available* (I3) is the variable with the highest potential for improvement for the N, NE and CW regions; however, for the SE region, the variable that merits more attention is *the number of inpatients per 100 inhabitants* (O2). Region S is 100% efficient in this perspective; therefore, there is no possible improvement relative to the other regions.
- Internal process perspective: The variable with the highest (absolute) potential improvement for the N and NE regions is *income average/unemployment rate* (O5). For the CW region, the variable with the most potential for improvement is *Total population/population served by the sewage treatment* (I6), and for the S and SE regions, it is *1/Health plan coverage* (I4).
- Learning & growth perspective: The variable *Number of graduates with a health-related undergraduate degree/Total population* (O7) shows the highest potential improvement for the N and S regions, and the *Number of health professionals per 1,000 inhabitants* (O6) shows the highest potential improvement for the other regions.

Finally, it is clear that the *financial* and *learning & growth perspectives* (the lowest performing perspectives) have the greatest potential for improvement.

Conclusions

The main advantage of separating the public health system performance evaluation into four perspectives is that the information that is obtained can inform the government decision-makers about which resources will truly affect the performance of each federal unit.

The relative health efficiency of all 27 Brazilian federal units was measured for each of the four BSC perspectives. The results showed significant performance differences between the federal units; 37% of the federal units were 100% efficient in at least one

perspective, but only one FU was efficient in three or more perspectives (the same FU that was efficient in all of the perspectives). An analysis of the performance of the perspectives produced divergent results and highlighted the superiority and inferiority of certain perspectives. This development shows the importance of separating the efficiency analysis into more than one perspective; otherwise, only a general ranking of the federal units will result.

The rest of the results aggregated the federal units into 5 regions (north, northeast, central west, southeast and south), and the analysis indicated that the S, SE and CW regions are more efficient for all of the perspectives than the N and NE regions.

The results clearly show that the efficiency and inefficiency determinants are well defined. The efficiency determinants reveal differences between the regions for the *internal process* and *learning & growth perspectives*, and four variables were found to drive efficiency to a significant extent: *number of beds available, population with more than 8 years of education, percentage of graduates with a health-related undergraduate degree* and *average income per capita/unemployment rate*.

Although the inefficiency determinants also showed regional differences between the variables, the absolute difference between the performance of the N and NE regions and the S, SE and CW regions is remarkable. It was determined that the N and NE regions must improve more than the other regions to achieve efficiency (as shown in the efficiency analysis).

We hope that this study emphasizes the heterogeneity of the administration of Brazil's public health system. Adopting only one perspective for an entire country that features high inequality could prove to be short-sighted.

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Table 1. The descriptive statistics for the variables from all FUs.

Variables	Mean	Standard deviation	Median	Min	Max
The spending initiatives and public health services per capita (in Reals)	530.1	132.5	524.3	324.6	829.7
The average amount paid for hospitalization in the public health care system (in Reals)	792.5	179.7	789.9	453.4	1,119.5
GDP per capita (in Reals)	13,713.9	8,344.1	11,844.0	5,372.6	45,977.6
The number of beds available per 1,000 inhabitants	2.1	0.3	2.2	1.6	2.9
The number of inpatients per 100 inhabitants	6.1	0.9	6.0	4.0	7.7
The life expectancy at birth	72.4	2.3	72.1	67.7	76.1
Health plan coverage (percentage of the population)	19.4	9.1	15.1	6.0	40.1
The population served by sewage treatment	5,006,229.6	7,713,348.6	2,139,380.0	219,843.0	38,166,149.0
The population with more than 8 years of education	2,876,834.3	4,097,769.5	1,374,032.0	169,817.0	20,499,837.0
The total population	7,022,696.8	8,422,434.6	3,453,648.0	412,783.0	41,011,635.0
The average income per capita (in Reals, per month)	533.6	204.7	459.2	291.5	1,233.1
The unemployment rate	7.1	2.3	6.2	4.0	14.9
The number of health professionals per 1,000 inhabitants	1.5	0.7	1.3	0.6	3.6
The number of graduates with a health-related undergraduate degree	3,090.5	4,704.0	1,524.0	20.0	21,107.0

Table 2. The correlation between the efficiency indexes and the PISA/GDP data.

	Financial perspective	Customer perspective	Internal processes perspective	Learning & growth perspective
PISA - 2009*	0.46	0.48	0.42	0.51
GDP - 2008	0.42	0.33	0.48	0.39

* The latest version of the Program for International Student Assessment (PISA).

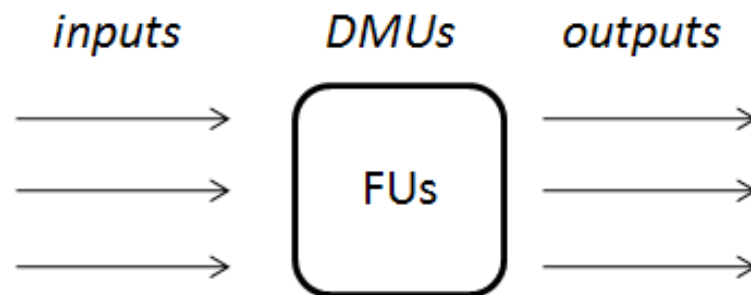


Figure 1: DEA representation.

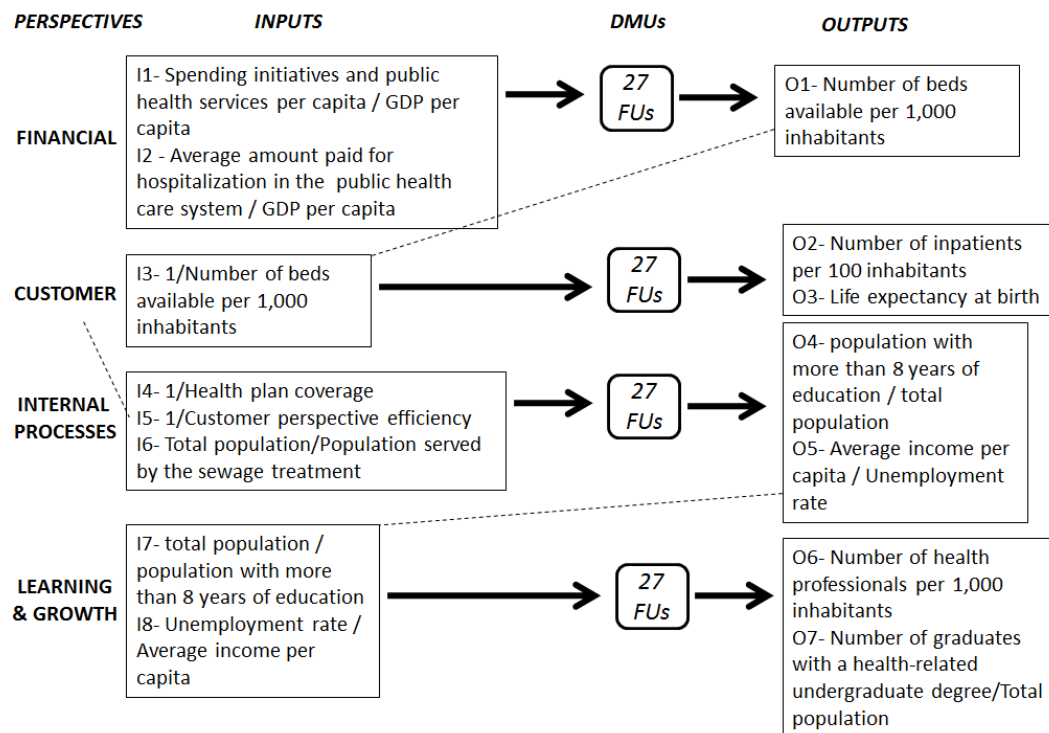


Figure 2: Integrated BSC-DEA model for the SUS.

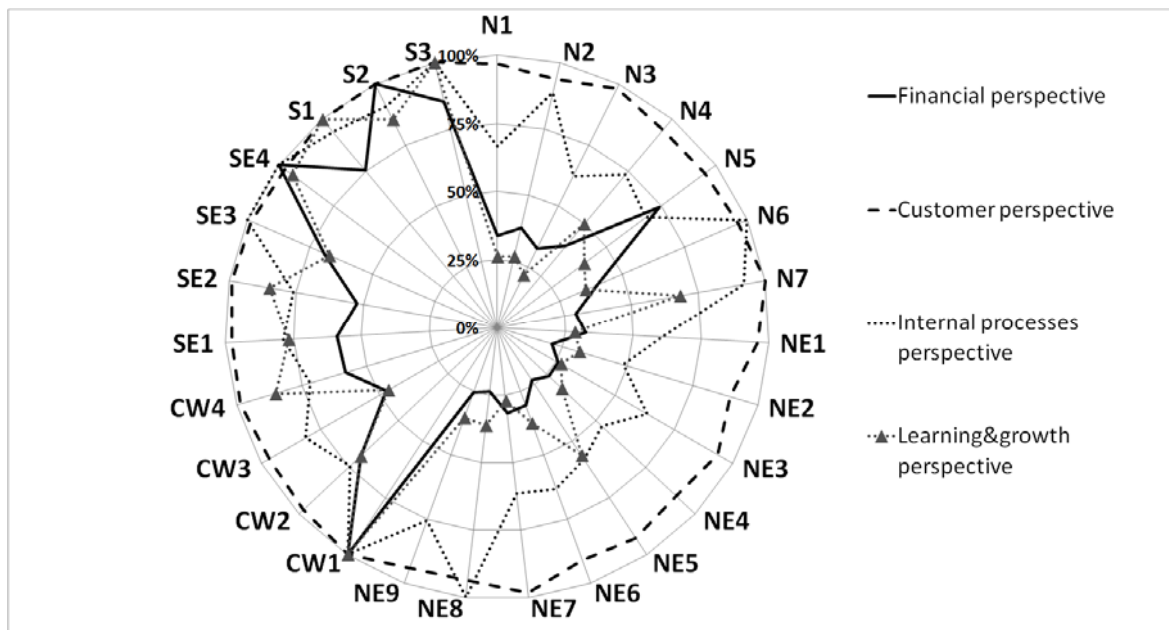


Figure 3: Public health system performance for each federal unit.

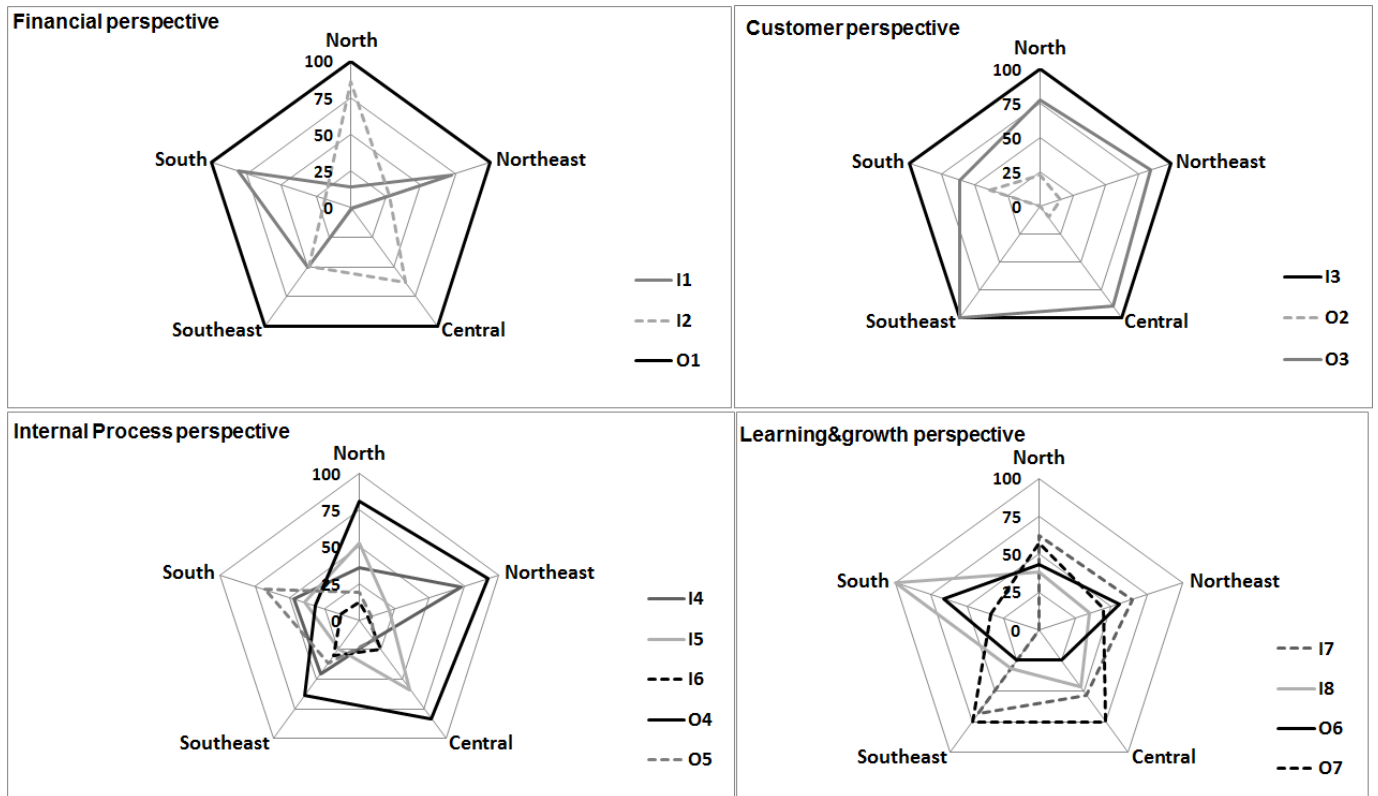


Figure 4: Input/output contributions by perspective.

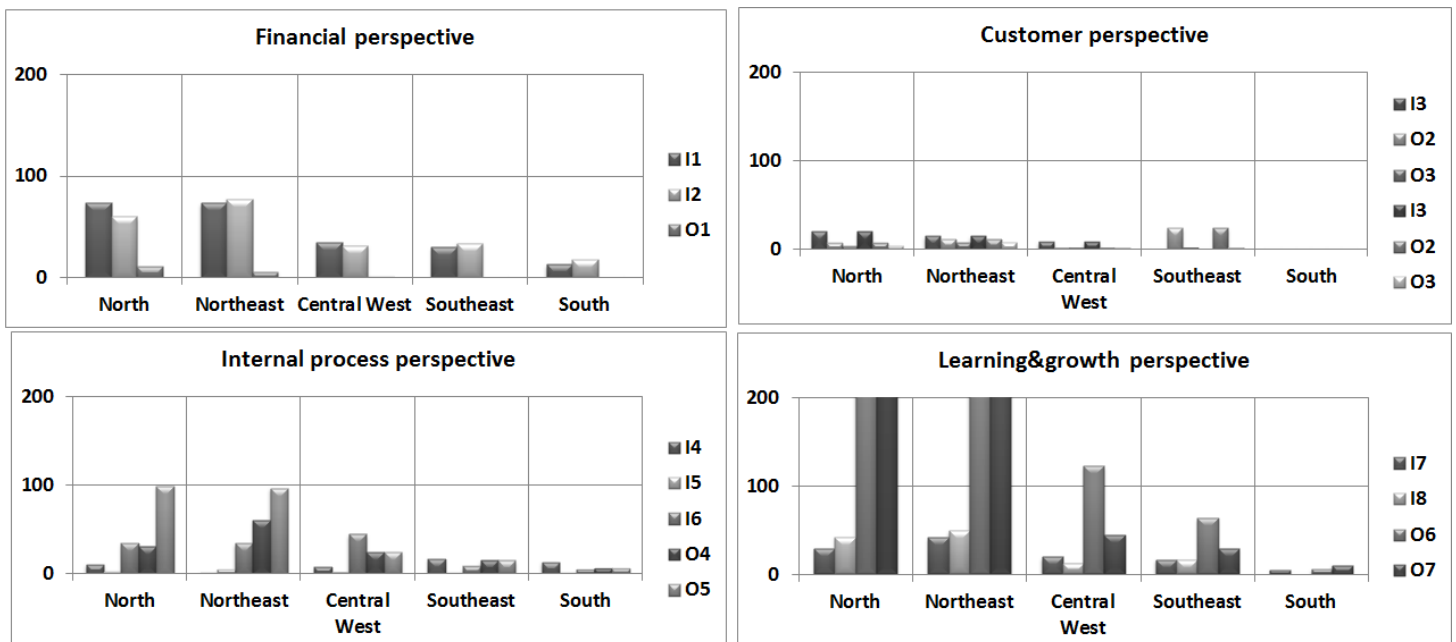


Figure 5: Potential improvements by perspective.