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COST STRUCTURE AND ECONOMIES OF SCALE IN CHILEAN TRADITIONAL UNIVERSITIES: COMPARATIVE STUDY BETWEEN STATE AND PRIVATE UNIVERSITIES OF CRUCH

Keywords: Private and State Universities, Economies of Scale, Costs, Cost Function, Cost Structure.

Classification: I21, I22, D24, C33, E23

Abstract

In Chile, over the years, higher education has experienced a series of changes, with the creation of new universities and the subsequent increasing number of enrolled students, among other transformations. At present, there is little information about the efficiency with which the state resources are managed regarding this issue. This investigation identifies the main variables affecting the cost of Chilean traditional private and state universities, entities that constitute the Chilean Traditional University Council or CRUCH. Furthermore, this paper presents an evaluation of economies of scale in these universities, becoming evident that average remunerations and full-time equivalents are relevant in these entities' production, this last input is relevant because represent the available human resource to develop all the products. The results of this research will provide tools that will make it possible to plan the expansion of these institutions in all their production lines and to make decision regarding the placement of resources by the State. Finally, the study has allowed us to conclude that CRUCH private universities are not more cost efficient than public universities in all their production lines, thereby destroying the premise that the public sector is managed less efficiently than the private sector.

Resumen

La educación superior en Chile ha experimentado una serie de cambios que han impulsado la creación de nuevas universidades y la expansión de la matrícula entre otras transformaciones. Actualmente, se cuenta con poca información respecto de la eficiencia con la que se administran los recursos del estado en este ámbito. Esta investigación, ha permitido identificar las principales variables que afectan el costo de las Universidades privadas y estatales del CRUCH. Asimismo, se han evaluado las economías de escala de estas universidades, mostrando que las remuneraciones promedio y las jornadas completas equivalentes, estas últimas relevantes en la producción de estas instituciones, por cuanto representan el recurso humano disponible para el desarrollo de todos sus productos. Los resultados de esta investigación,

entregarán herramientas que posibilitará planificar la expansión de estas instituciones en todas sus líneas de producción y tomar decisiones en cuanto a la colocación de recursos por parte del Estado. Finalmente, el estudio ha permitido concluir que las Universidades privadas del CRUCH no son más costo eficiente que las Universidades públicas en todas sus líneas de producción destruyendo con ello la premisa que el sector público se gestiona con menos eficiencia que el sector privado.

INTRODUCTION

Since the 1980's, university systems in Latin America have experienced a series of reforms. The main focuses of these institutions have not been the production of knowledge and the role of the State as their benefactor but the meeting of the ever-increasing demand for higher education and the need for incorporating efficiency and effectiveness, thus protecting the State's investment and transitioning into the marketing fields, leting the university degree programs be ruled by the market and trusting the production of knowledge to globalization. Attesting to this, the reforms in Argentina, Brazil, Mexico, Bolivia and Chile have been based on the transition from a public university context to a business context with universities seeking self-financing and ruled by the market, where the production of scientific publications has been entrusted to the most important world knowledge centers. As a result of these processes, a set of transformations has been noted, such as the expansion of higher education enrollment, the enacting of laws regarding higher education, diversification of institutions, diversification of funding, presence of private investment, evaluation and accountability reports, accreditation and certification of programs, shortening of degree programs, prevalence of information technologies in connection with virtual learning, among other transformations (Mollis, 2003).

Chile had to cope with reforms started in 1980 with the enactment of Law 3.541. The social pressures regarding university admission and the deregulation of technical education entities that offered short non-university degree programs, allowed the entry of private entities to the university system and widened the student coverage with lower cost for the State (González, 2003). The implemented changes promoted self-financing, university autonomy, the dissolution of Chilean national universities such as the Universidad de Chile and the Universidad Técnica del Estado in order to convert them into regional universities. This tried to respond to the needs regarding higher education in Chile (SIES, 2014).

Driven by those changes, a sustained increase in the enrollment has been noted. In 2009, a number of 938,338 undergraduate students enrolled in 180 institutions with total annual allocated budget of 670 million dollars, approximately. More recent information shows that

1,144,605 undergraduate students enrolled in 2014 (SIES, 2014). Additionally, between 2007 and 2017, the total enrollment number had experienced an increase of 57%.

Moreover, the Chilean Traditional Public University Council (CRUCH), formed by 18 state universities and 9 private universities, has proved to be a relevant actor regarding higher education in Chile. Through revising the undergraduate enrollment, it was found that these institutions represent the 48% of the university enrollment in the country. The figures indicate that, at a national level, 318,966 undergraduate students enrolled in 2017 (SIES, 2017). The same year, the CRUCH universities enrolled 86,080 first-year students, this meaning a 47% of the total enrollment in university system. Similarly relevant is the post-graduate training programmes. In 2007, these universities were responsible for the 68% of the post-graduate activities and in 2017 enrolled a 47% of the total national number of master and doctorate students (SIES, 2017).

In recent years, it has been demonstrated that Chile has one of the most expensive undergraduate tuition fee among the OECD countries, according to "Education at a Glance 2017". In the public sphere, Chile presents the second most expensive tuition fee with US$7,654 per year, surpassed only by public colleges in the United States of America. On the other hand, in the private sphere, the fee is the fourth most expensive, with US$7,156 per year, surpassed by the United States, England and Japan.

The present investigation is oriented to the generation of both tools and a methodology that enable us to evaluate the current situation of CRUCH universities. Accordingly, the determination of a cost function and the evaluation the economies of scale will allow us to know about the efficiency with which these institutions are performing their activities and, in addition, it will be possible to predict what is going to happen with the expansion in all of their lines and, finally, to determine which university group belonging to the CRUCH, either private or state, have better indicators.

This study required the revision of the budgets executed between 2011 and 2016 of sixteen state or public universities and nine private institutions, all belonging to the Chilean Traditional University Council (CRUCH). Additionally, it has been possible to make a comparative study regarding the cost structure between private and state universities belonging to the CRUCH. Finally, a FFCQ (flexible fixed cost quadratic) cost function has been made, similar to the function developed in other studies (Cohn, Rhine, & Santos, 1989) (Hashimoto & Cohn, 1997), (Koshal & Koshal, 1998), by using a data panel model with acceptable levels of confidence, being possible to evaluate the economies of scale for the products of the mentioned universities.

Evolution of the Studied Universities

In Chile, the Higher Education Institutions (HEI) are results of the experience accumulated by the country regarding vocational training (SIES, 2012). Changes started in September 1980, with the Decree-law 3.541, that establishes that "the President of the Republic may restructure the universities in the country". The DFL (Decree with the Force of Law) ordered the establishment of a new legal regime in order to regulate the organic structure of the existing institutions. The DFL also established a one year period for the adoption of the proposed changes.

In 1980, there were 8 universities and just two of them belonged to the Chilean State, the Universidad de Chile and the Universidad Técnica del Estado Ex Escuela de Artes y Oficios (EAO), the latter founded in 1849 and current Universidad de Santiago de Chile, both of them had a national presence; and on the other hand, there were 6 private institutions. In 1981 the DFL No.1, DFL No.5 and DFL No.24 were enacted. These decrees were intended to promote the creation of new universities, vocational colleges and technical training centers. The new regulations included the establishment of regional universities out of the regional branches formerly belonging to the Universidad de Chile and the Universidad Técnica del Estado, plus other regional universities in Atacama, La Serena, Valparaíso, among others. In addition, other institutions were established such as the Instituto Profesional de Iquique, nowadays Universidad Arturo Prat, the Academia Superior de Ciencias Pedagógicas, current Universidad Metropolitana de Ciencias de la Educación, the Academia Superior de Ciencias Pedagógicas de Valparaíso, institution that in 1985 became the Universidad de Playa Ancha de Ciencias de la Educación, the Instituto Profesional de Osorno, current Universidad de Los Lagos, the Instituto Profesional de Santiago that in 1993 became the Universidad Tecnológica Metropolitana, the Instituto Profesional de Valdivia that became the Universidad Austral and the Instituto Profesional de Chillán that finally merged into the Universidad del Bío Bío.

Thus, once these decrees were enacted, the higher education sphere changed definitely. The group of state universities and those universities denominated as "traditional" was formed by 25 institutions: 16 state universities and 9 private universities form the CRUCH, organism created in 1954 and confirmed as a public entity in the DFL No.2 of 1985, whose main function is to coordinate the national university labor, among other functions in relation with scientific research and quality. The same decree establishes the creation of the General Secretariat of this institution, office that would manage the administration of the service and would have an internal regulation, duly approved by the Council.

In 1990, the LOCE, Constitutional Education Law, was enacted. This Law establishes that "universities, vocational colleges and the technical training centers of the State may only be created by law. Those universities not having that quality shall be created accordingly to the established procedures, and they shall be always nonprofit private entities, in order to have

official recognition." Additionally, by enabling the creation of private universities, different from the so called "traditional universities", the Higher Education Council (HEC) is established, entity that will ensure compliance with the existing regulations and will certificate the Chilean institutions, being the keystone in relation with the system regulation and quality (González, 2003).

Regarding the same sphere of evolution of the CRUCH universities, in 2015 and as part of the educational reform, the Chilean State enacted the Law 20.842 and created the regional universities of Aysén and O'Higgins, which started operating in 2017 and were incorporated to the CRUCH. **Table No. 1**, shows the situation of the CRUCH universities in 2017.

Data

In order to elaborate the database for this investigation, a collection of budgetary balances belonging to the CRUCH universities between 2011 and 2016 was analyzed. In this regard, it is necessary to highlight that the budgetary information belonging to the CRUCH universities is regulated by Decree No. 180 of 1980, which establishes the budgetary items that must be considered in the annual execution report. These reports are published by each institution on their web sites, notified to the Comptroller General of the Republic and also published in the yearbooks of the CRUCH. With regard to the private CRUCH universities, they have all standardized their respective execution reports, accordingly to the mentioned decree, and even though all of them consider the same budgetary items, it can be noticed the lack of disaggregation of some of them, like expenditures on personnel.

Moreover, regarding the enrolled undergraduate and post-graduate students, this study considered the CRUCH yearbooks, the Chilean Information Service on Higher Education (SIES) and the reports of each one of the mentioned universities.

Finally, in order to collect information about the publication of higher education institutions, this study consulted the National Commission for Scientific and Technological Research (CONICYT), an autonomous institution and a public entity, whose main function is to provide government advisory services in relation with scientific research and technological development in the country.

Cost Structure of CRUCH Universities

Once the study of the cost budgetary items was completed, it was possible to determine the amount of each one of them for both universities groups. **Table No. 2** shows possible alterna-

tives for determining the cost of the CRUCH universities. It is possible to ascertain that the most important budgetary items that may contribute to the cost estimate are: remunerations, purchase of goods and services, real investment corresponding to infrastructure and depreciation, the latter in relation with debt servicing and other expenses.

It is important to note the items excluded from this estimate, the transfers item, which corresponds to subsidies, are the expenses aimed to finance student benefits such as: work grants, meal grants, tuition grants, contributions to television corporations and funds for extension and research activities. This has been incorporated to the execution of the budgetary expenditure, but they do not constitute an expense made by the university, since most of the expenses are reimbursed by the State or by private entities.

Moreover, also the financial investment has been excluded, since this item includes loans to the students for the latter to finance the tuition fee in connection with the system of university credit, other loans such as: maintenance, purchase of books and materials, and instruments put into the equity market, which are going to be recovered in subsequent budgetary years.

In conclusion, the total cost of the universities expressed in Equation No.1 will be: the total expense declared in a budgetary period, excluding the transfer or subsidies, the financial investment and the cash balance, which is the remaining cash after discounting outstanding liabilities, which will be used in the next budgetary period.

1. EQUATION NO.1 COST ESTIMATE OF CRUCH UNIVERSITIES

Total Cost = Total Executed Spending –Transfers – Financial Investment – Cash Balance

In addition to the foregoing, **Table No. 2** shows that the most important expense in both institution group is the remunerations item, which represents an average, between the studied years, of 65% of the total cost of the state universities and 52% for private institutions, followed by the consumption of goods and services item, with an average of 17% and 24% of the cost, respectively. From the same information, it is possible to deduce that the expressed items represent at least a 94% of the cost of the CRUCH universities.

Table No. 3 shows the evolution of the cost for both university groups, in the table one can notice that the total cost within the studied period has increased in both university groups, the most important increase corresponding to the state universities with a 28% of the cost. In the same way, the same summary table shows that the average cost for each private university

was higher every year within this period, reaching in 2016 an average cost of MM$67,567 for public universities and MM$108,953 for private institutions, both amounts expressed in Chilean pesos in 2016.

Similarly, it is possible to determine that in all of the studied years, the cost per enrolled undergraduate and post-graduate student was higher for private universities, being noticeable that the maximum average cost per enrolled student for the state universities was MM$5.675, amount that is lower than the maximum for private universities that reaches an amount of MM$6.703 with both values expressed in Chilean pesos in 2016.

The Production of CRUCH Universities

The determination of the production level for each university group is particularly relevant for the present study. In order to do so, it is convenient to establish the main products and the value of these, which will allow us to investigate the outputs that may affect the cost of the universities, and along whit this, it will be possible to compare the CRUCH state and private universities in connection with their productions.

Table No. 4 shows a sustained increase in the enrollment for both universities group, the higher value corresponding to state universities; it also confirms that the state universities graduated more students within the studied period. Finally, publications in global terms show figures with higher values for the CRUCH private institutions.

Notwithstanding the global figures regarding the production of both university groups, it is possible to establish certain performance indicators based on the available resources. In this sense, the CRUCH universities have an academic indicator called JCE[1], or full-time equivalents. This indicator is based on the working hours of full-time academics and the working hours of part-time teachers, establishing that a working day corresponds to 44 hours, a clear indicator of the human resource available for teaching and research, on the other hand, the study count on the supporting staff associated with these products. The information found has allowed the construction of a series of indicators for evaluating the performance of the studied universities and also for comparing the different products.

Table No. 5 shows some indicators that allow us to compare the performance of both university groups at study. This table shows that the amount of publications per ten full-time

1. JCE=(working hours of full-time academics + working hours of part-time teachers)/44

equivalents is higher in the CRUCH private institutions. Also, it is possible to confirm that state universities attend more enrolled students per ten JCE, the same situation occurs with the graduated students since the indicator of graduated students per ten JCE is slightly higher for state or public universities. Finally, it is worth mentioning that public universities maintain higher indicators in connection with supporting staff when compared to private universities.

MODEL

Initially, studies about cost and economies of scale have consider educational institutions as one-dimensional organizations, this means, with a single product, situation that does not represent the reality of these organizations since universities have multiple products such as research, postgraduate degrees, undergraduate programs, links with the environment, among others. Nevertheless, at the beginning, single-output models were proposed, for example: number of registered or enrolled students (Maynard, 1971) or graduate students in order to determine how the average cost decreases with the expansion of the enrollment (Bottomley & Dunworth, 1972). Othe studies of the same period tried to evaluate the cost of higher education (Bowen, 1980), to establish a dependence between size and efficiency by obtaining a relation between enrollment and the cost of colleges and universities (McLaughlin, Montgomery, Smith, Mahan, & Broomall, 1980), to promote comparisons between tuition costs and to identify the possible effects in case of changes in the university enrollment happen (Brinkman, 1981) and finally, to establish the economies of scale and the optimization of the unit cost regarding the size of these organizations (Brinkman & Leslie, 1986).

Once the complexity of higher education institutions and their multiple products originated was known, then it was necessary to make progress on studies that reflected the current reality of higher education institutions. For this reason, important steps have been taken in establishing a total cost model by using as explicative variables the undergraduate students, graduate students and the total number of enrolled students Cohn et al. (1989), the latter achieved the determination of a total cost function, the FFCQ (flexible fixed cost quadratic) by considering multiple products, denominated as outputs. In this opportunity, a cost function was modeled for a group of public and private universities in the United States, determining the existence economies of scale in public universities for their products, research and graduated alumni, along with establishing the existence of ray scale economies in both subgroups. The latter conclusion was made on the basis of an indicator which is based on the proportional production of multiple products, denominated as ray economies of scale, an indicator developed from the theory of contestable markets (Baumol, Panzar, & Willig, 1982). In the same way, a study of 147 public and private universities in the United States determined the cost function by means of a logarithmic function, considering as the output variable elements such as gra-

duate students, undergraduate students, and the results of research and also by considering, in the cost structure, variables such as: academics' remuneration, services to students and maintenance, among others; this allowed to demonstrate the existence economies of scale for the average of institutions (De Groot, McMahon, & Wolkwein, 1989). Both studies meant a sound progress in the modeling of universities.

The efforts made to improve the multivariate models of higher education continued the search for other explicative variables of total cost. Thus, the FFCQ was also used to establish a relationship between the quality of higher education and the total average cost in a study which demonstrated that the quality of a group formed by institutions granting a doctorate degree, is important when explaining the average total cost, proving the existence of economies of scale based on the number of full-time enrolled students FTE (Full-Time Equivalent) (Koshal & Koshal, 1995). Another study demonstrated the existence economies of scale for the research product, by using a multiple product function which considered factors such as research results, graduate, undergraduate, among others (Dundar & Lewis, 1995). In addition to the above mentioned results, another cost function was modeled, based on the FFCQ for 94 Japanese universities, which demonstrated the existence of ray economies of scale for a specific range of outputs (Hashimoto & Cohn, 1997), achieving results that were similar to those obtained by Cohn in 1989.

It is worth mentioning a certain study, performed in the same period, which considered a total number of 329 US universities, 158 private and 171 public. This study demonstrated that it is possible to model the cost function by using the FFCQ, considering the already mentioned classic variables, such as graduates, undergraduates and a way to measure the research activity. Moreover, the same study incorporates a variable that measures the quality and a dummy variable in order to measure either if the doctorate degree offer increases the cost of the studied institutions (Koshal & Koshal, 1998) The mentioned authors demonstrate that the reduction in the class size affects the total cost in both types of institutions. Quality also proved to be a variable that affects the total cost in private universities. The quotient between the marginal cost of the graduate variable and the undergraduate variable demonstrated to be lower to the one obtained by Hashimoto and Cohn in 1997. Moreover, the same study showed the existence of ray economies of scale for complete universities with results similar to those obtained by other studies Cohn et al. (1989) (Dundar & Lewis, 1995) (Hashimoto & Cohn, 1997). However, the demonstration of economies of scale for specific products was inconclusive.

Other studies have calculated the cost function by disaggregating the outputs according to the type of institution, thus proving the existence economies of scale for the research product in every type of institution (Thomas, 2004). In the search for non-traditional economies of scale, there is a certain study which, along with including outputs such as graduates, undergraduates

and research, it considers extension services, thus demonstrating the existence economies of scale for this latter output (Laband & Lentz, 2005). Moreover, the pursuit of modeling and comparing university costs has been oriented not only to the incorporation of new inputs and output but also to the attempt to model costs and evaluate economies of scale with other kinds of functions, different from the FFCQ. This is the case of a study that compares public and private universities in Spain, study that achieves the modeling of a cost function by means of a logarithmic function, using graduate and enrolled students, which demonstrates the existence of decreasing costs as the production increases, highlighting that such reduction was more important in the private institutions than in the public institutions, along with making a cost comparison which questions the premise that the private sector is managed more efficiently than the public sector (Moreno & Navarro, 2010).

In the search for incorporating inputs in the cost function, there are several studies that include production factors such as: cost of academic and non-academic personnel, besides capital. This is the case of a study of the Australian universities, which incorporates these inputs and determines the existence of ray economies of scale, along with economies of scale for some specific products like undergraduates (Worthington & Higgs, 2011). In a similar way, a study of 155 German universities uses a logarithmic function and a stochastic frontier analysis method in order to demonstrate the existence of economies of scale for these institutions, suggesting that these are far from over in German higher education (Olivares & Wetzel, 2011).

More recent studies, have demonstrated that the application of the FFCQ model is still valid and has been used for estimating the economies of scale in English higher education, thus demonstrating that the greatest scale economies are in postgraduates and research (Johnes & Johnes, 2016). Finally, by using the same concept of multiple products, it has been possible to establish a connection between scale and scope economies and the reputation of universities, the latter measured by the ARWU and QS indicator. A certain studies that the most important higher education institutions worldwide, demonstrated that universities with better scale and scope economies are ranked in a higher level, with this connection being more important in public universities. This is because more efficient universities have a higher capacity for encouraging research, among other factors (Zhang & Worthington, 2017).

The present investigation has allowed the modeling of a cost function by using multiple inputs and outputs, based on the theory and the works of Baumol et al. (1982), Cohn et al. (1989), (Koshal & Koshal, 1998), (Dundar & Lewis, 1995) and (Hashimoto & Cohn, 1997). It is assumed that the total cost is expressed by Equation No.2.

2. EQUATION NO. 2 COST FUNCTION OF CRUCH UNIVERSITIES

$$CT = \beta_0 + \sum_{i=1}^{5} \beta_i Q_i + \sum_{i=1}^{5} \sum_{j=1}^{5} \beta_{ij} Q_i Q_j + \mu TIPO + \mathcal{E}$$

Q_1 : Output, Product, Number of Enrolled Undergraduate and Postgraduate Students per Year **(AL.MAT)**.

Q_2 : Output, Product, Number of Graduated Undergraduate and Postgraduate Students per Year **(AL.TIT)**.

Q_3 : Output, Product, Number of Publications per Year **(PUB)**

Q_4 : Input, Average Remunerations per Year **(REM)**

Q_5 : Input, Full-time Equivalents Used per Year **(JCE)**

TYPE : Dummy Variables TYPE=0 CRUCH private, TYPE=1 CRUCH state

$\mathcal{E}$: Error

The input variables considered in the study are: average remunerations (REM) and full-time equivalents (JCE), on the other hand, the outputs considered for the estimate are: undergraduate and postgraduate enrolled students (AL.MAT), graduated undergraduate and postgraduate students (AL.TIT) and SCIELO and WOS publications (PUB).

It should also be taken into consideration that the variable combinations $Q_i Q_j$ are shown in Table No.7, in which AL.MAT.AL.TIT corresponds to the multiplication of the number of enrolled and graduated students, AL.MAT.PUB corresponds to the multiplication of enrolled students and publications, among other combinations. When estimating the cost function as a multivariate function, it will be possible to establish the total cost by considering the multiple outputs, in this case Q_1, Q_2, Q_3 enrolled students, graduated students and publications respectively, along with the inputs Q_4 average remunerations and Q_5 full-time equivalents.

In this case, the value E_1 will be the one obtained for the product Q_1, where $E_1 > 1$ indicates existence of economies of scale and $E_1 < 1$ diseconomies of scale, values obtained by calculating, initially, the incremental cost for the product Q_1 like:

$$AIC_1 = \frac{CT(Q_1, Q_2, Q_3, Q_4, Q_5) - CT(0, Q_2, Q_3, Q_4, Q_5)}{Q_1}$$

and then, to obtain the marginal cost like $\mathrm{CM}_1 = \frac{\partial \mathrm{CT}}{\partial \mathrm{Q}_1}$ and finally to obtain the value economies of scale E_1 of the product Q_1.

$$E_1 = \frac{AIC_1}{CM_1}$$

Similarly, the values of E_2, E_3 can be obtained for the products graduated and publications, respectively. Moreover, the existence of ray economies of scale is demonstrated if $E_r>1$ where E_r is obtained with the following expression:

$$\boldsymbol{E_r} = \frac{CT(Q_1, Q_2, Q_3, Q_4, Q_5)}{Q_1 MC_1 + Q_2 MC_2 + Q_3 MC_3}$$

Data Panel Model

In recent times, the works on economics provide numerous estimates by using the ordinary least squares or OLS method. Notwithstanding its limitations, like the fact that it does not measure individual effects or the production of inconsistent and unbiased estimators regarding the analysis different periods of time (Castellacci, 2008). In order to improve these estimates, during the last years, the data panel technique has been used frequently. This makes possible to measure the fixed effects of the individuals that may cause variables to behave non-randomly (Labra & Torrecillas, 2014). There are two kind of data panel, static and dynamic; static can be applied by means of a series of statistical packages in order to explain a certain phenomenon depending on a series of explicative variables and thus determining either if the data sets have individual or variable effects; it is also possible in some cases to apply dynamic panels since the latter allow the incorporation of an endogenous structure to the model, by integrating past effects with the use of instrumental variables. Classic authors of dynamic panels, like Arellano and Bond (1991), Arellano and Bover (1995), and Blunder and Bond (1998), achieved the identification of instruments which are suitable for this kind of analysis, by using the delays of the dependent variable (Y) as a regressor (Yit-n).

In order to estimate the cost function, a classic static data panel model was applied, using a series of explicative variables, products called outputs and average remunerations and supplies called inputs.

For that purpose, the following model is proposed:

$$\boldsymbol{y_{it}} = \boldsymbol{\alpha_{it}} + \boldsymbol{x'_{it}\beta} + \boldsymbol{u_{it}} \quad con \quad u_{it} \sim N(0, \sigma_u^2)$$

x'_{it} is the vector that contains the predetermined k variables, β is a vector of k parameters, i represents the individuals i = 1,…, N, t represents time t = 1,.., N and α_{it} collects the heterogeneity caused by the efects of the individuals and/or time caused by unobservable variables.

Based on the expressed value of, the following types of models are considered:

If $\alpha_{it} = \alpha$, it is called a pooled model α_{it} is constant for every individual and for all periods.

It is called a fixed effect model if the independent term is different for each individual $\alpha_{it} = \alpha_i$ or for each period $\alpha_{it} = \alpha_t$ or both.

If α_{it} is a random variable it is called a variable or random effect model.

Once the cost function is established by equation No.2, it is necessary to estimate the values of β_{ij} β_i and μ, for this reason this study has been used study software, and the data panel structure has been considered. The panel model is shown in **Table No. 6** and it considers 25 universities and the observations between years 2011 and 2016. In the column titled "Univ", one can notice an identification tag for each institution, in the column "year" the different time periods and in the column "TYPE" the kind of state or private institution. Moreover, the model considers all of the variables and their combinations presented in **Table No. 7**.

Once the model has been proposed, it is necessary to determine which model is more suitable to the available data, in this sense, it must be determined if the suitable model is the fixed effect model, the pooled model or the random effect model. In this regard, the following hypothesis are proposed:

OLS versus Individual Fixed Effects

In order to select the best model, a series of hypothesis tests are necessary to be performed, which will allow to measure either if there are fixed effects, random effects or to determine if the pooled model is the most suitable for the available data.

If we suppose the following pooled OLS model, in which

$$\boldsymbol{y_{it}} = \boldsymbol{\alpha} + \boldsymbol{x'_{it}\beta} + \boldsymbol{u_{it}} \;\; con \;\; u_{it} \sim N(0, \sigma_u^2) \;\; i=1,\ldots.,N \text{ and } t=1,\ldots..,T$$

And we establish an alternative fixed effect model based on the individuals

$$\boldsymbol{y_{it}} = \boldsymbol{\alpha} + \boldsymbol{x'_{it}\beta} + \boldsymbol{v_i} + \boldsymbol{u_{it}}$$

so, we propose the hypothesis:

$$Hipótesis \quad \begin{cases} H0 : v_i = 0, \quad i = 1, \ldots, N \\ \qquad\qquad \text{ó} \\ H1 : \ni \;\; v_i \neq 0 \quad i = 1, \ldots, N \end{cases}$$

Accordingly to the proposed hypothesis, the statistic F will allow to determine either if the individual effects are significant, this with the purpose of establishing if the pooled OLS model or the individual fixed effect model are significant or not (Kunst, 2009) where SSE is the sum of the error squares and F with (N-1,(T-1)N-k) degrees of freedom.

$$F = \frac{(SSE_{h0} - SSE_{h1})/(N-1)}{SSE_{h1}/(T-1)(N-K)}$$

On the other hand, it is possible to demonstrate, with a statistical test, the presence of individual effects and/or temporary effects. For this purpose the following model should be considered:

$$\boldsymbol{y_{it}} = \boldsymbol{\alpha} + \boldsymbol{x'_{it}\beta} + \boldsymbol{v_i} + \boldsymbol{\lambda_t} + \boldsymbol{u_{it}}$$

The model suggests to test the existence of individual effects expressed by $\boldsymbol{v_i}$ or the temporary effects expressed by $\boldsymbol{\lambda_t}$, in this sense, the null hypothesis on the pooled model **Ho** is given by

$\boldsymbol{\sigma_v^2 = \sigma_\lambda^2 = 0}$. It has been demonstrated that the best test for this hypothesis is the multiplier test of Lagrange de Breusch and Pagan (Breusch & Pagan, 1980) where the hypothesis and the LM statistician is proposed as follows:

Individual Effects

$$\text{Hipótesis} \quad \begin{cases} H0: \sigma_v^2 = 0 \\ \text{ó} \\ H1: \ \sigma_v^2 > 0 \end{cases}$$

$$LM1 = \frac{nt}{2(t-1)}\left[\frac{\sum_{i=1}^{n}(\sum_{1}^{t} e_{it})^2}{\sum_{1}^{n}\sum_{1}^{t} e_{it}^2} - 1\right]^2 \sim X^2(1)$$

Where $\boldsymbol{e_{it}}$ are the remains of the pooled model, *n* represents the number of individuals and t represents the years considered for each individual.

Temporary Effects

$$\text{Hipótesis} \quad \begin{cases} H0: \sigma_\lambda^2 = 0 \\ \text{ó} \\ H1: \ \sigma_\lambda^2 > 0 \end{cases}$$

$$LM2 = \frac{nt}{2(N-1)}\left[\frac{\sum_{i=1}^{t}(\sum_{1}^{n} e_{it})^2}{\sum_{1}^{t}\sum_{1}^{n} e_{it}^2} - 1\right]^2 \sim X^2(1)$$

Temporary and Individual Effects

$$\text{Hipótesis} \quad \begin{cases} H0: \sigma_\lambda^2 = \sigma_v^2 = 0 \\ \text{ó} \\ H1: \ \sigma_\lambda^2 > 0 \ o \ \sigma_v^2 > 0 \end{cases}$$

$$LM = LM1 + LM2 \sim X^2(2)$$

Fixed Effects versus Random Effects

Finally, a hypothesis test must be realized in order to discriminate between the fixed effect model and the random effect model. For this purpose the following model is considered:

$$\boldsymbol{y_{it} = \alpha + \varepsilon_i + x'_{it}\beta + u_{it}} \quad con \quad u_{it} \sim N(0, \sigma_u^2) \ y \ \varepsilon_i \sim N(0, \sigma_\varepsilon^2)$$

Where ε_i is not a value fixed for each individual and with variation in time, and for this reason a random variable is considered. The random model is more efficient but less consistent than the fixed effect model, this meaning that the former model is more precise but also more biased. A way to determine either if these differences are statistically significant is by using the contrast method of Hausman (Hausman, 1978) this is based on the direct comparison between the fixed effect estimator and the random effect estimator under the null hypothesis that the random effect model is consistent and efficient. If we assume that $\boldsymbol{\beta}_{\mathbf{EF}}$ is the estimator vector of the fixed effect model and $\boldsymbol{\beta}_{\mathbf{EA}}$ is the estimator vector of the random effect model, with $\boldsymbol{V}_{\mathbf{EA}}$ and $\boldsymbol{V}_{\mathbf{EF}}$ as the covariance matrixes of the random and fixed effect model respectively, with **n** as the number of variables including the constant, the estimator is calculated as follows:

$$H = (\beta_{EF} - \beta_{EA})'(V_{EF} - V_{EA})^{-1}(\beta_{EF} - \beta_{EA})\; H \sim X^2(n)$$

RESULTS OF THE PROPOSED MODEL

By applying the panel theory, several cost functions with the FFCQ format were obtained, for the three scenarios: considering all universities, taking into account only the state or public universities and finally, considering only the private universities. After that, one or more of these functions must be selected to evaluate the economies of scale in state or public universities and in private universities.

In order to make an analysis, the cost functions (1), (2), (3) and (4) will be considered. **Table No. 8** shows the coefficients of the selected functions, the model have random effect and similar r-adjusted, in all cases higher than 96% and with different combinations of variables.

Model (1), has been obtained from data of all CRUCH universities. This shows that the p-values of the coefficients are not higher than 16%, that the products enrolled and graduated are not complementary and the same situation occurs with enrolled and publications. On the other hand, it is possible to determine that the full-time equivalents and the average remunerations are relevant in the elaboration of the cost function, since the combinations of these variables have coefficients with significant p-values. The function confirms that the cost structure of both university groups are similar, since this function does not contain any variable that allows to differentiate the cost between both groups, this means that at the same production level both groups will have similar cost. Finally, once the tests of Breush and Pagan and Hausman were made, the results were p-value=2.2e-16 and p-value=0.058 respectively. This leads us, on one hand, to reject the hypothesis that the pooled model is better that the fixed effect model and, on the other hand, we accept the hypothesis that the random effect model is better than the fixed effect model.

Alternatively, model (2) shows another combination of variables with less significant p-values, this is the case of AL.MAT^2 and AL.TIT^2 where the p-values of the coefficients are higher than 18%. Additionally, it can be confirmed that average remunerations and full-time equivalents are relevant when elaborating the cost function. Besides, it also demonstrates that model (2) is a random effect model and with data from all the CRUCH universities.

Regarding the cost function for public universities, model (3) shows that average remunerations and full-time equivalents are present in some combinations of the cost function. This model has been elaborated by using only data from public or state universities and two of the p-values present significance levels higher that 46%. Additionally, one can confirm this is a random effect model and, in a production level that is equal to zero, the cost of public universities is MM$18,700 (eighteen billion seven hundred million Chilean pesos) approximately.

Finally, regarding private universities, function (4) is a random effect model with a small number of variables. In this model, it is possible to notice the presence of the inputs already established and combinations of these with average remunerations and full-time equivalents. In addition, even though the r-adjusted is 96%, the function presents several less significant p-values.

Once the analysis of the obtained functions, one can determine that model (1) have a greater number of significant p-values, confirming that the cost function is a FFCQ similar to those obtained in previous investigations Cohn et al. (1989), (Koshal & Koshal, 1998).

Tables No. 9 and **No. 10** show the economies of scale for both university groups, considering increases which are equal to all products, with an average remuneration which is constant in both groups, where the JCE have been calculated by means of a random effect model based on products and average remunerations with an r-adjusted of 80%.

$$JCE = \beta_0 + \beta_1 AL.MAT + \beta_2 \text{PUB} + \beta_3 AL.MAT.AL.TIT + \beta_4 AL.MAT.PUB + \beta_5 AL.TIT.PUB + \beta_6 REM$$

$\beta_0 = 2{,}2185e+02^{***}, \beta_1 = 1{,}0946e-02\ *, \beta_2 = 9{,}9589e-01\ ***\ \beta_3 = 4{,}3830e-06\ ***$
$\beta_4 = -6{,}0501e-06\ , \beta_5 = -7{,}3121e-05\ *, \beta_6 = -2{,}9525e-03\ \cdot$

*Significances: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·'*

Data Analysis

In Chile, the group of universities that form the CRUCH is a relevant actor in the professional education, since they represent 48% of the national undergraduate enrollment, approximately. Moreover, in 2017, the same group of universities enrolled 47% of first-year students and 47% of postgraduate students, both figures regarding the total national university enrollment.

Additionally, it is noticeable that state universities enroll and grant more degrees to students of undergraduate and postgraduate programs per every ten full-time equivalents than private universities. In another context, private universities publish a greater amount of papers in SCIELO and WOS per every ten full-time equivalents.

Regarding the staff supporting teaching, research and administrative activities, there are similar indicators, since private universities have an indicator of 15 professional and administrative people per every 100 JCE during the study term, while state universities present an indicator of 16 people for supporting administrative and teaching activities.

The cost estimation has been realized by using the value declared by universities, extracting subsidies, financial investment and available cash balance. This cost is explained by items such as remunerations, infrastructure spending, cost of goods and services and debt servicing, which explain 94%, on average, of the cost of these institution.

The items that affect the cost are: remunerations, procurement of goods and services, infrastructure spending and debt servicing. In addition, data indicate that, in state universities, the most important expense is remunerations item, followed by procurement of goods and services, infrastructure spending and debt servicing. A similar situation occurs in private universities, except that these institutions spend a greater amount of resources on procurement of goods and services that state universities and a smaller amount on remuneration payments. The information indicates that private universities spent an average 51.95% on remunerations and 24.84% on procurement of goods and services. Instead, state universities spent an average 64.99% and 16.46%, respectively, all percentages calculated with regard to total cost.

The developed theory, considering universities as multiproduct organizations Cohn et al. (1989) has been successfully applied to the CRUCH universities and with that, it has been possible to elaborate a cost function by considering enrolled undergraduate and postgraduate students, graduated students from undergraduate and postgraduate programs, research results, average remunerations and full-time equivalents, the latter is a way to measure the academic activity for developing the products at issue. The obtained function is a FFCQ, similar to the one developed by other authors' investigations, (Dundar & Lewis, 1995) (Filippini & Lepori, 2005) (Rajindar K & Manjulika, 1999) among others in this paper.

The available data from 25 universities have been used for estimating a cost function. For this purpose, the elaboration of a data panel has been necessary and a number of pooled, fixed effect and random effect models have been analyzed. In order to choose the best cost function, the multiplier test of Lagrange Breush and Pagan (1980) and Hausman (1978) have been performed, and the resulting option is a random effect model with significant p-values and an r-adjusted of 96%.

The economies of scale have been calculated by taking as a basis the average production in 2016. Data indicate that having more that 50% of average production, both groups are in diseconomies for enrolled students. In addition, both groups have economies of scale in the production of publications and graduated students.

Also, data indicate that diseconomies for enrolled students slightly decrease, as the production over the average for all products increase. On the contrary, economies of scale for publications and graduated students decrease along with the mentioned increases. These results are observable regardless of the kind of institution, either public or private.

From 50% over the average production in 2016, economies of scale for enrolled students are more depleted in public universities. In addition, state universities have greater economies for graduated students and smaller economies of scale for the production of publications.

CONCLUSIONS

Firstly, it is important to mention that this investigation analyzed the budgetary balances of the CRUCH universities between 2011 and 2016. These balances do not constitute a detailed explanation of the operation, since these reports are ruled by the Decree 180 and does not constitute an operational budget per product. For this reason, a thorough review and read of 150 budgetary balances have been performed in order to estimate the cost of these organizations.

Once the data had been analyzed, it was possible to demonstrate that, from the collected information, both university groups have similar cost structures. The items which explain 94% of the cost are: remunerations, procurement of goods and services, infrastructure spending and debt servicing. The difference is that private universities spend less in remunerations and more in procurement of goods and services. This demonstrates that this kind of institutions outsource more services than state universities. This is related with two relevant factors: first, state universities must comply with Law 19.886 on Supply Contracts and Provision of Services, fact that undoubtedly affects the outsourcing of services; and second, private universities can maintain a higher staff rotation, since they are not forced to comply with Law 18.834, which

establishes procedures and requirements about staff turnover. These two factors do not allow state organizations, on the one hand, to manage staff requirements in a suitable and flexible way and, on the other hand, it is not possible to access goods and services as quickly as the operation demands. This explains the greater staff and the smaller expenditure on procuring goods and services. The foregoing allows to conclude that both university groups have the same cost structure, but they differentiate from each other in the amount of each budgetary items, this is explained in **Table No. 2**.

Another important element resulting from this study, has to do with some performance measures. In this case a series of JCE-based indicators was developed. Information in **Table No. 5** allows us to conclude that state universities enrolled and graduated more undergraduate and postgraduate students per JCE and maintained a lower level of publication per JCE. Additionally, from the analyzed information it is possible to conclude that private universities spend more per undergraduate and postgraduate student; from both data sets one can conclude that private universities spend more per student but there is no significant difference regarding performance that makes possible to conclude that private entities are more cost efficient in all of their production lines.

With regard to whether the expansion of enrollment would cause higher costs, a cost function has been developed in order to evaluate the economies of scale in different scenarios. This function is a FFCQ similar to the function obtained by authors revised in this investigation Cohn et al. (1989) (Rajindar K & Manjulika, 1999) (Filippini & Lepori, 2005) with an additional result, which has been estimated by applying a panel method and adding a variable never used before, like the JCE. Results have demonstrated that 50% over the average production, there are diseconomies of scale for enrolled students in both groups in this study. In addition to this, it is possible to confirm the presence of economies of scale for publications and graduated students. Likewise, it is possible to conclude that economies of scale are more depleted in state universities for enrolled students. Regarding publications, state institutions have smaller economies of scale and greater economies of scale in graduated students.

In the same way, data indicate that an increase in the production causes a slight increase in the economies for enrolled students, but the same situation depletes the economies for publications and graduated students. In addition, it is noticeable that ray scale economies are depleted up to 550% over the average production in 2016. For this reason, an expansion in the activity needs the establishment of a product mix which guarantees economies of scale for all of the three studied products, with the consequent global economies.

When comparing this investigation with previous studies, the present study obtained results similar to those obtained by one of the pioneers of the theory on state institutions Cohn et al.

(1989), where is possible to determine diseconomies for the product enrolled students and the existence economies of scale for publications and graduated students.

Finally, the above results make possible to conclude two relevant questions which are relevant for analysis. The CRUCH public universities and private universities present the same behaviors, regarding their cost structures and that both tend to economies of scale, as their production is increased regarding enrolled students, graduated students and publications. In addition this behavior is similar to those private universities studied by Koshal in 1998, in connection with tendencies of the average production.

The final conclusion is that state universities show no difference from private universities, both group from CRUCH, regarding cost structure, this study demonstrates that there are no special contributions from the State, situation that is very relevant. Since state universities are owned by the Chilean State, on the one hand they must play a social role and, on the other hand, they present indicators which are very similar to CRUCH private universities, with the difficulty of having to comply with a series of accountability reports, thus confirming that state universities are finally ruled by the market, having to compete with similar private institutions.

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Tables

1. Table No. 1 CRUCH Universities

Acronym	University	Foundation	Ownership	Observations
UCHILE	Universidad de Chile	1842	State	
UC	Universidad Católica de Chile	1888	Private	
UDEC	Universidad de Concepción	1919	Private	
PUCV	Pontificia Universidad Católica de Valparaíso	1928	Private	
USM	Universidad Técnica Federico Santa María	1931	Private	
UACH	Universidad Austral de Chile	1954	Private	
UCN	Universidad Católica del Norte	1956	Private	
UTA	Universidad de Tarapacá	1981	State	
UA	Universidad de Antofagasta	1981	State	
UDA	Universidad de Atacama	1981	State	
ULS	Universidad de Serena	1981	State	
UV	Universidad de Valparaíso	1981	State	
USACH	Universidad de Santiago de Chile	1981	State	Former EAO 1849 and Former UTE 1947
UTALCA	Universidad de Talca	1981	State	
UFRO	Universidad de la Frontera	1981	State	
UMAGALLANES	Universidad de Magallanes	1981	State	

UNAP	Universidad Arturo Prat	1984	State	
UPLA	Universidad de Playa Ancha	1985	State	
UMCE	Universidad Metropolitana de Ciencias de la Educación	1985	State	
UBB	Universidad del BíoBío	1988	State	
UCM	Universidad Católica del Maule	1991	Private	
UCSC	Universidad Católica de la Santísima Concepción	1991	Private	
UCT	Universidad Católica de Temuco	1991	Private	
UTEM	Universidad Tecnológica Metropolitana	1993	State	
ULAGOS	Universidad de los Lagos	1993	State	
UAYSEN	Universidad de Aysén	2015	State	
UOH	Universidad de O'Higgins	2015	State	
Source Mineduc 2017: Compiled by Author				

2. Table No. 2 Budget Expenditure Items of CRUCH Institutions

Summary Table CRUCH Universities Items Regarding Yearly Expenditures								
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**Importance**	**Average**
Public of State Universities Average Numbers per Year								
Remunerations vs. Total Cost	66.01%	64.85%	63.08%	63.68%	65.94%	66.41%	1st	64.99%
Infrastructure Spending vs. Total Cost	5.17%	6.52%	8.98%	8.06%	6.16%	6.08%	5th, 4th or 3rd	6.83%
Cost of Goods and Services vs. Total Cost	15.65%	16.68%	16.40%	16.51%	17.27%	16.25%	2nd	16.46%
Debt Servicing vs. Total Cost	7.37%	6.71%	7.00%	6.36%	5.57%	5.97%	4th or 5th	6.50%
Explanatory Percentage of Cost	94.20%	94.76%	95.46%	94.61%	94.94%	94.70%		94.78%
Private Universities Average Numbers per Year								
Remunerations vs. Total Cost	51.18%	51.35%	49.73%	49.64%	54.69%	55.14%	1st	51.95%
Infrastructure Spending vs. Total Cost	11.48%	9.47%	8.85%	7.24%	8.44%	9.01%	4th or 5th	9.08%
Cost of Goods and Services vs. Total Cost	23.70%	24.35%	24.96%	25.16%	25.92%	24.96%	2nd	24.84%
Debt Servicing vs. Total Cost	7.45%	8.99%	11.12%	14.08%	6.52%	3.67%	3rd or 5th	8.64%
Explanatory Percentage of Cost	93.81%	94.15%	94.66%	96.12%	95.57%	92.78%		94.51%
Compiled by Author. Source: Executed Budgets of the Chilean Traditional University Council								

3. Table No.3 Costs of CRUCH State and Private Universities

Summary Table of the Costs of CRUCH Universities						
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Costs in Million Chilean Pesos 2016						
Average Cost of State Universities	52,577	55,896	58,645	63,775	63,547	67,567
Average Cost of Private Universities	88,464	95,103	103,188	104,863	103,423	108,953
Average Cost of CRUCH	65,496	70,011	74,680	78,566	77,902	82,466
Total Cost of State Universities	841,225	894,334	938,317	1,020,392	1,016,748	1,081,072
Total Cost of Private Universities	796,177	855,931	928,692	943,765	930,810	980,574
Cost of Enrolled under and post Graduate Students Private Universities	6.028	6.251	6.674	6.703	6.484	6.509
Cost of Enrolled under and post Graduated Students State Universities	5.090	5.264	5.090	5.573	5.446	5.675
Compiled by Author. Source: Mineduc, Chilean Traditional University Council						

4. Table No.4 Production Levels of CRUCH Universities

Summary Table of CRUCH Universities Products						
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Products in Total Annual Figures per University Group						
Students Enrolled in State Universities	165,260	169,906	184,355	183,106	186,686	190,507
Students Enrolled in Private Universities	132,076	136,919	139,145	140,798	143,564	150,660

Students Graduated from State Universities	24,392	23,903	25,138	25,857	27,082	27,664
Students Graduated from Private Universities	15,369	14,484	19,273	19,799	19,692	20,842
Publications of State Universities (WOS and SCIELO)	2,775	3,212	3,147	3,924	4,371	4,853
Publications of Private Universities (WOS and SCIELO)	3,031	3,675	3,514	4,059	4,515	4,876
Compiled by Author. Source: Mineduc, Conicyt and Chilean Traditional University Council						

5. Table No. 5 Performance Indicators of CRUCH Universities

	Public or State		Private		2011-2016
Indicator	**Average**	**Std**	**Average**	**Std**	**Period Observations**
Total Executed Spending vs. Number of Enrolled Students	6392.72	290.37	7296.71	384.74	Average Indicator per Higher Year in the Private Universities, in Millions of CLP 2016
SCIELO and WOS Publications per every ten JCE academics	3.19	0.49	4.73	1.33	Average Indicator per Higher Year in the Private Universities
Graduated Students per every ten JCE Academics	15.80	0.76	14.66	0.69	Average Indicator per Higher Year in the Public Universities
Enrolled Students per every ten JCE	228.80	20.96	211.36	9.98	Average Indicator per Higher Year in the Public Universities
Administrative Staff per every ten JCE	15.80	0.76	14.66	0.69	Average Indicator per Higher Year in the Public Universities
Compiled by Author. Source: Chilean Traditional University Council					

Table No. 6 Panel Model for CRUCH Universities

Univ	year	TYPE	CT	REM	AL. MAT	AL.TIT	PUB	REM2	REM. AL. MAT	REM. AL. TIT	REM. PUB	AL. MAT2
1	1	1	25,934,844	17,601	9,410	1,141	34	309,808,605	165,628,993	20,083,175	598,447	88,548,100
1	2	1	33,056,721	19,672	9,704	995	30	387,004,586	190,901,282	19,574,070	590,173	94,167,616
1	3	1	34,139,397	15,740	10,315	1,076	42	247,732,175	162,353,046	16,935,713	661,059	106,399,225
1	4	1	35,661,538	24,719	9,219	1,267	41	611,011,987	227,881,296	31,318,538	1,013,465	84,989,961
1	5	1	42,005,920	26,504	8,984	1,335	22	702,449,346	238,109,789	35,382,521	583,083	80,712,256
1	6	1	36,261,195	24,799	8,881	1,129	248	614,977,275	220,237,569	27,997,772	6,150,086	78,872,161
2	1	1	36,833,222	13,726	9,341	3,324	8	188,404,954	128,215,205	45,625,451	109,809	87,254,281
2	2	1	35,705,029	14,231	12,311	2,148	13	202,526,572	175,200,095	30,568,581	185,005	151,560,721
2	3	1	35,342,432	18,136	15,322	1,943	15	328,897,076	277,872,434	35,237,315	272,033	234,763,684
2	4	1	34,816,399	18,288	15,216	1,944	14	334,459,156	278,273,624	35,552,308	256,035	231,526,656
2	5	1	39,308,941	16,488	13,783	2,991	8	271,853,693	227,253,915	49,315,567	131,904	189,971,089
2	6	1	48,828,757	17,326	14,060	1,765	52	300,201,009	243,607,915	30,580,937	900,968	197,683,600
3	1	1	22,329,922	22,240	6,877	781	12	494,612,518	152,943,694	17,369,351	266,879	47,293,129
3	2	1	26,626,563	25,903	6,770	967	16	670,946,604	175,360,853	25,047,850	414,442	45,832,900

7. Table No. 7 Inputs and Outputs Used to Calculate the Cost Function

List of Variables Used to Calculate the Cost Function					
		Public or State Universities		Private Universities	
	Variable	Average	St. Dev	Average	St. Dev
Total Cost	CT	55,635,580	87,218,266	92,692,206	104,642,429
Full-time Equivalents	JCE	525	457	808	533
Average Remunerations	REM	21,709	6,056	20,740	10,352
Under and Post Graduate Enrolled Students	AL.MAT	11,248	8,240	15,614	7,347
Under and Post Graduate Graduated Students	AL.TIT	1,605	1,223	2,027	1,085
Publications	PUB	87	248	153	310
Square of Full-time Equivalents	JCE2	482,663	1,071,413	931,778	1,308,487
Full-time Equivalents x Average Remunerations	JCE.REM	11,693,108	10,841,032	21,497,831	29,121,873
Full-time Equivalents x Enrolled Students	JCE.AL.MAT	9,466,852	18,933,809	16,005,545	18,064,877
Full-time Equivalents x Graduated Students	JCE.AL.TIT	1,338,070	2,574,459	2,109,679	2,566,749
Full-time Equivalents x Publications	JCE.PUB	109,954	542,316	213,085	637,310
Square of Average Remunerations	REM2	507,571,468	338,111,298	535,322,290	658,636,613
Average Remunerations x Enrolled Students	REM.AL.MAT	250,574,491	200,698,745	374,453,467	385,327,547

Average Remunerations x Graduated Students	REM.AL.TIT	35,671,375	29,428,117	49,782,943	56,571,406
Average Remunerations x Publications	REM.PUB	2,155,330	6,166,057	4,861,328	14,445,859
Square of Enrolled Students	AL.MAT2	193,704,259	338,426,726	296,778,228	267,375,431
Enrolled Students x Graduated Students	AL.MAT.AL.TIT	27,513,996	46,423,480	38,839,942	37,147,938
Enrolled Students x Publications	AL.MAT.PUB	2,033,376	9,325,647	3,493,592	9,335,028
Square of Graduated Students	AL.TIT2	4,054,196	6,639,783	5,263,840	5,416,782
Graduated Students x Publications	AL.TIT.PUB	284,148	1,269,788	476,864	1,381,522
Square of Publications	PUB2	68,213	520,353	117,818	548,368

8.TABLE NO.8 COST FUNCTIONS OF CHILEAN UNIVERSITIES

Dependent variable:				
	CT			
	All (1)	All (2)	Public (3)	Privates (4)
AL.MAT2	0.0809	0.0641	0.2123*	0.0392
	(0.0563)	(0.0484)	(0.1254)	(0.0361)
AL.TIT2	-2.4217*	-1.5041	1.9147	6.9609***
	(1.3709)	(1.4805)	(1.6406)	(1.7131)
PUB2	-63.0132***	-63.3583***	-72.3601***	-13.6694
	(15.4845)	(14.8243)	(11.5735)	(20.5083)
AL.TIT.PUB		31.9739***		
		(6.5544)		
AL.MAT.AL.TIT	1.0352**	1.0940*	-1.7805	
	(0.4679)	(0.6379)	(1.1016)	
AL.MAT.PUB	4.5662***		8.5547***	
	(1.1192)		(1.4606)	
JCE.AL.TIT		-29.1406***	29.1709*	
		(6.3416)	(16.3882)	
REM2	0.0157***	0.0196***		
	(0.0052)	(0.0047)		
REM.PUB			0.5524	2.4102*
			(0.7589)	(1.3377)
JCE.REM	3.5851***	3.8293***	0.6386	3.3506***
	(0.5754)	(0.5736)	(0.5931)	(0.6255)
REM.AL.TIT	-0.4978**	-0.5175**		-1.1599***
	(0.2078)	(0.2429)		(0.3042)
AL.TIT	8,941.3900**	14,455.7700***		
	(3,602.5650)	(4,412.3940)		
REM			169.1757	
			(250.0182)	
JCE.AL.MAT	-3.6754***		-4.4127*	
	(1.0428)		(2.3452)	
REM.AL.MAT	-0.1099***	-0.1418***		-0.0514
	(0.0406)	(0.0423)		(0.0614)
JCE.PUB	60.0511**	64.8618***		
	(24.3553)	(19.8387)		
Constant	7,459,250.0000**	3,533,668.0000	12,224,553.0000***	2,624,419.0000***
	(3,408,409.0000)	(3,819,214.0000)	(4,101,730.0000)	(7,206,105.0000)
Observations	150	150	96	54
R2	0.9777	0.9803	0.9917	0.9669
Adjusted R2	0.9757	0.9786	0.9907	0.9619
F Statistic	5,999.3250***	6,809.6600***	10,183.0300***	1,344.6070***
Note				*p<0.1; **p<0.05; ***p<0.01

9. Table No. 9 Economies of Scale in State Universities

Enrolled					Graduated			Publications			
Target Value		Enrolled	Mc. Enr.	Enr. Ec.	Graduated	Mc.Grad	Grad. Ec.	Publications	Mc. Pub	Pub. Ec.	Ray Ec.
50%	Above Average	17,860	1,742	0.1706	2,594	2,497	3.5158	455	76,137	1.3765	1.1751
100%	Above Average	23,813	3,305	0.4171	3,458	4,472	2.8725	607	100,348	1.3809	0.8271
150%	Above Average	29,767	4,813	0.4996	4,323	6,448	2.6234	758	125,461	1.3808	0.6881
200%	Above Average	35,720	6,265	0.5388	5,187	8,424	2.4912	910	151,475	1.3785	0.6149
250%	Above Average	41,673	7,662	0.5600	6,052	10,400	2.4092	1,062	178,391	1.3750	0.5699
300%	Above Average	47,627	9,005	0.5721	6,916	12,375	2.3534	1,213	206,209	1.3707	0.5391
350%	Above Average	53,580	10,291	0.5788	7,781	14,351	2.3129	1,365	234,929	1.3661	0.5163
400%	Above Average	59,533	11,523	0.5820	8,645	16,327	2.2823	1,517	264,551	1.3612	0.4986
450%	Above Average	65,487	12,700	0.5828	9,510	18,303	2.2582	1,668	295,075	1.3562	0.4841
500%	Above Average	71,440	13,821	0.5818	10,374	20,279	2.2389	1,820	326,500	1.3512	0.4718
550%	Above Average	77,393	14,887	0.5794	11,239	22,254	2.2230	1,972	358,827	1.3462	0.4610

Compiled by Author, the average production in 2016 was considered for this table.

10. Table No. 10 Economies of Scale in Private Universities

Enrolled					Graduated			Publications			
Target Value		Enrolled	Mc.Enr.	Enr. Ec.	Graduated	Mc.Grad.	Grad. Ec.	Publications	Mc.Pub.	Pub. Ec.	Ray Ec.
50%	Above Average	25,110	3,748	0.4580	3,474	4,901	2.7165	813	89,112	1.5747	0.8727
100%	Above Average	33,480	6,059	0.5530	4,632	7,957	2.4096	1,084	117,343	1.5819	0.6937
150%	Above Average	41,850	8,328	0.5935	5,789	11,014	2.2730	1,354	146,273	1.5835	0.6123
200%	Above Average	50,220	10,554	0.6151	6,947	14,070	2.1957	1,625	175,903	1.5822	0.5664
250%	Above Average	58,590	12,737	0.6279	8,105	17,127	2.1461	1,896	206,233	1.5794	0.5369
300%	Above Average	66,960	14,878	0.6359	9,263	20,183	2.1114	2,167	237,262	1.5756	0.5163
350%	Above Average	75,330	16,975	0.6410	10,421	23,240	2.0859	2,438	268,991	1.5711	0.5009
400%	Above Average	83,700	19,030	0.6442	11,579	26,296	2.0663	2,709	301,419	1.5663	0.4890
450%	Above Average	92,070	21,042	0.6460	12,737	29,353	2.0508	2,980	334,548	1.5612	0.4793
500%	Above Average	100,440	23,011	0.6469	13,895	32,409	2.0382	3,251	368,375	1.5560	0.4711
550%	Above Average	108,810	24,938	0.6470	15,053	35,466	2.0278	3,522	402,903	1.5508	0.4642

Compiled by Author, the average production in 2016 was considered for this table.

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