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Quantifying the benefits of digitalizing and centralizing student applications and assignment to schools

Division of Education

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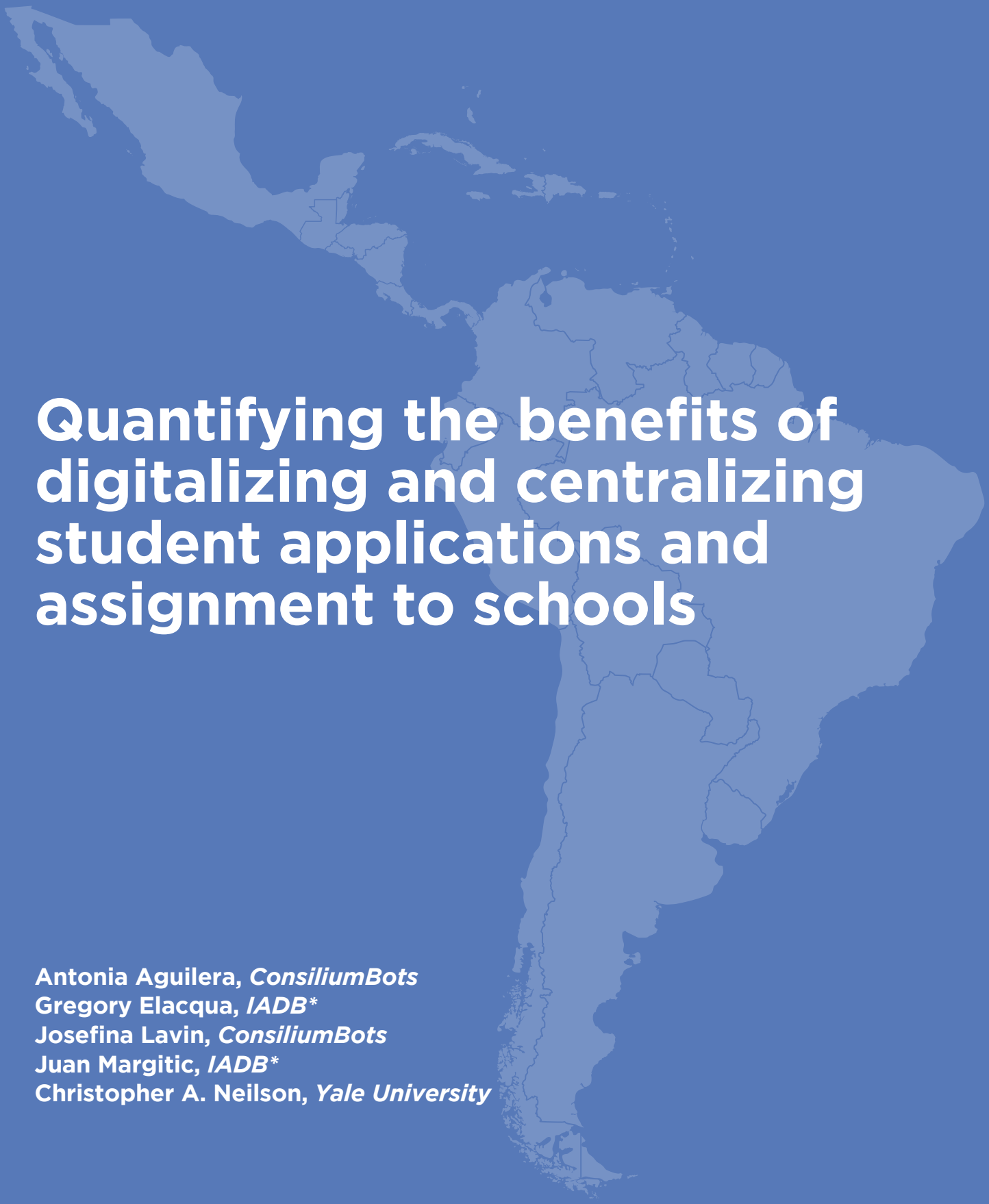

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December 13, 2022

Abstract

Traditional (decentralized) student assignment systems are characterized by their inefficiency, lack of transparency, and inequity of distribution. In response, ever more places have begun to implement digital centralized assignment systems. Although the literature has endorsed these systems' assignment efficiency, this document is the first to analyze their cost-efficiency and discuss traditionally overlooked benefits: monitoring, transparency, and planning tools in the market. Using administrative data from Chile, the analysis estimates that the implementation of digital centralization could generate a net impact of USD 13 million, considering the direct implementation costs, the savings generated during the transition, and the resulting efficiency gains. Our results confirm that this policy is not only efficient but also cost-efficient.

*Inter-American Development Bank (IADB)

Keywords: centralized assignment, digital enrollment, cost-effectiveness

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1. Introduction

One of the most critical processes in education, both for families and governments, is the allocation of students to schools. Traditionally, this has been carried out in a decentralized manner, resulting in numerous problems of inefficiency, inequity, and dissatisfaction. Such experiences have been documented in different parts of Latin America: hours of waiting in long lines to secure a slot,[1] the high costs of searching for vacancies, mistrust, suspicions of corruption in schools due to a lack of transparency, and a wide margin of discretion in assigning vacancies. There have even been reports of the use of bribes or kickbacks to obtain a slot at a school.

The majority of student assignment systems are not centralized. However, an increasing number of school systems around the world have begun to implement digital centralized choice and assignment systems to address many of the problems described. This note seeks to contribute to the evidence in support of such systems by analyzing the costs and savings associated with their implementation. Based on this, the note concludes that the adoption of centralized student assignment systems as a public policy is not only effective and efficient but also cost-efficient.

Put simply, a digital centralized choice and assignment system[2] consists in the implementation of an online platform that, by bringing together all the information about available vacancies in a single place, makes it easier for families to register for the subsequent assignment of vacancies. These are allocated using a computational algorithm[3] that takes students' applications and assigns them to vacancies according to each system's particular criteria. Some of Latin America's main cities already have systems of this type in operation, with examples including Santiago (Chile), Bogotá (Colombia), and Buenos Aires (Argentina), while others, such as Manta (Ecuador), Tacna (Peru), Pernambuco and Recife (Brazil), and Palmira (Colombia) are implementing pilot systems.

The main arguments in favor of adopting a centralized allocation system have to do with their greater efficiency and transparency compared to traditional decentralized systems. Centralized allocation through an online platform, using deferred acceptance algorithms, can drastically reduce the costs incurred both by families when searching for schools and by administrators when managing the admission process. It can also improve the match between students and educational institutions. This has the potential to increase the system's efficiency and families' satisfaction with the procedure.

[1] This situation has been reported in countries that include Peru (Año escolar: padres acampan desde hace 3 días por matrícula, 2018), Panama (La odisea para obtener cupo en escuelas públicas, 2015), and Chile (Muñoz, 2017).

[2] A complete overview of the use of student choice and assignment systems can be found on the Centralized Students Choice and Assignment Systems website (ccas-project.org).

[3] Which has a random element and can incorporate different priorities.

The available evidence indicates that the adoption of centralized systems and the information interventions that can be carried out have numerous positive effects on the efficiency of the process, including the assignment of students to their preferred schools, a lower risk of not being assigned a vacancy, an improvement in student performance, a higher rate of graduation from secondary education, greater transparency, and a reduction in discrimination against students (Abdulkadiroğlu et al., 2017; Arteaga et al., 2021; Carrasco et al., 2019).

However, little information is available about the feasibility of implementing a policy of this type or its scalability. It is important to bear in mind that, when analyzing the implementation of any public policy, it is necessary to assess its cost-effectiveness and the potential impacts on stakeholders. Only in this way is it possible to evaluate its sustainability over time and as the target population increases. Ignoring these considerations can have dire consequences.[4]

This technical note focuses on the savings that can be achieved by moving from a traditional decentralized system to a centralized one. In addition, it examines the policy's sustainability over time and its scalability for different student enrollment sizes. For this purpose, it uses administrative data, opinion surveys, and geo-referenced information about schools and applicants. In assigning costs, the so-called *ingredients method* was used to identify each of the components involved and give them a value. Finally, the note discusses short, medium, and long-term benefits that must be taken into account when conducting a comprehensive cost analysis.

A brief study of the context is presented in the next section, followed by an outline of the conceptual framework and, finally, the estimates and sustainability and scalability analysis.

[4] One clear case of this lack of analysis was the class size reduction policy implemented in California in 1996, which proved very costly and eventually led to increases in districts' spending and, in order to finance it, budget cuts on other state programs (Bohrnstedt Stecher, 2002). Moreover, it had negative consequences for the academic performance of students in low-income school districts due to an exodus of high-quality teachers to higher-income districts as demand for teachers increased (Jepsen Rivkin, 2002).

2. Student assignment systems: centralized vs. decentralized

The assignment systems found in Latin America can be classified according to their administrative level, degree of centralization, entry level, and degree of digitalization. A more detailed description of all these categories and examples from different parts of the continent can be found in Appendix B.

For the purposes of this note, two types of systems are defined:

- **Traditional or decentralized assignment system:** Under systems of this type, each school has its own admission criteria and provides information about the process and the available vacancies through its own means and at its own timetable. Applicants must attend in person to apply for a vacancy and, if there are more applicants than available slots, the tiebreaker criteria are also defined by each school. Decentralization means that a large number of processes take place in parallel and their regulation and monitoring become very complex for the authorities, making it difficult to ensure the effectiveness and transparency of the assignment.

- **Digital centralized system:** In this case, applicants access an online platform where they can learn about all the available vacancies. The tiebreaker criteria are established by the corresponding authority before the start of each process and are communicated clearly and transparently to the families and institutions. The corresponding body (which may be a central government, a local government, or another public administrator) carries out the final assignment using an algorithm[5] and may or may not consider applicants' preferences. Finally, the families and schools are informed of the results. For the purposes of this note, it is assumed that the digital centralized assignment system is national in scope and includes all educational levels.

This analysis distinguishes between three main stakeholders: 1) the administrator of the process (typically the state through the central or local government); 2) the schools; and 3) the families. Table 1 shows the situations faced by each of these stakeholders in each type of system. Based on this description, the costs and savings involved are quantified.[6]

[5] In general, an algorithm known as the deferred acceptance algorithm is used.

[6] Since public schools are part of the state, all the expenditure they incur is understood to be state spending. This classification is merely a simplification to facilitate identification of the costs and savings and attempt to assign the expenditure to the stakeholder who makes it and is present in a particular situation.

3. Implementation costs and savings

Estimates of this policy's costs use information from Chile[7] in order to examine the situation before and after its implementation as well as the associated costs and savings. Chile began its transition to a centralized assignment system (SAE)[8] in 2016, starting in the Magallanes Region before extending it sequentially region by region until covering the rest of the country in 2019.

Table 1 Assignment systems by situations faced by stakeholders

	TRADITIONAL SYSTEM	CENTRALIZED SYSTEM
STATE	• Monitoring: This must take place at the level of each school, making it costly. • Support for families: Given the greater dispersion of applications, it is difficult to provide support for families during the process.	• Creation of the algorithm and establishment of the assignment criteria. • Construction of the technological infrastructure: As a minimum, a website is required to post vacancies and allow families to submit applications. • Communication of the terms of the policy: Vacancies and the dates of the process, as well as the criteria for assignment and to break ties, are published at the centralized level. • Coordination and annual maintenance of the process. • Support for families during the process, provided remotely or through support desks. • Centralized monitoring.
SCHOOLS	• Publication of vacancies: Each school publishes its vacancies and sets the dates of the process according to its own means and norms. • Implementation of the process: In-person reception of parents/guardians, definition of admission criteria, review of applicants' information, assignment of places, and communication of the results. • Enrollment process: Also carried out in person. • Provision of information about the admission process: Each school is responsible for mass communication of its admission policies in order to inform families. • Expenditure: All this process implies spending on supplies and support personnel for each establishment.	• Publication of vacancies: Each establishment informs the centralized body about the slots available. • Enrollment: Once the results of the process have been announced (by the government or administrator), the school is responsible for the enrollment process. In some cases, this may take place online.
FAMILIES	• Search for vacancies: The information comes from multiple sources and is published at different dates. High barriers of access. • Application: Parents/guardians have to go in person – during working hours – to each school to which they wish to apply. This activity tends to take several hours and involve transportation costs. • Assignment: The criteria depend on each school and are not always clear, leading to mistrust and a lack of transparency.	• Search for vacancies: All the information is centralized. A connection to internet and a device to access it reduce barriers of access. • Application: This takes place online and can, therefore, be carried out outside working hours. Opportunity costs are drastically reduced and transport costs are eliminated. • Assignment: Students are assigned according to criteria and priorities that are known to the families.

The following estimates were calculated using administrative data from the SAE 2021 admission process (which includes geographical information about both students and schools), the survey of families' satisfaction conducted after the SAE 2021 process, data from the Education Ministry on the costs associated with the process, and information about the cost of living in Chile.

[7] Chile is one of Latin America's wealthiest countries and the estimates in this study, therefore, fall within the upper range of costs and savings. However, after a thorough review of the situation in a number of other countries, we believe that the implementation, administration, and monitoring costs are representative and informative for the implementation of policies in other countries in the region.

[8] *Sistema de Admisión Escolar* (School Admission System) or SAE.

As mentioned above, this cost analysis used the ingredients method. This strategy is commonly employed in studies of this type and seeks to identify the key components in the functioning of each process and assign them a value so that comparisons between the costs of each system are comprehensive and ensure their complete operation.

3.1 Costs

All expenditures arising directly from the implementation and maintenance of a centralized choice and assignment system are considered costs. The assumptions and calculation formulas used in the estimation can be found in the appendix. All values are expressed in US dollars (USD). When available, the source of the figure is indicated in a footnote.

It should be noted that a universe of 463,209 applicants was considered (Appendix C) and that parents carry out the search for schools and registration during working hours, implying an opportunity cost greater than zero. This cost could be eliminated if the search and application process took place online outside working hours.

Table 2 Costs of implementing a centralized assignment system

	COSTS Description	Total (USD mill.)	By applicant (USD)
ADMINISTRATOR	• Algorithm team and construction of the technological infrastructure	$0.186	$0.40
	• Information and communications campaigns	$0.248	$0.54
	• Annual administration of the process	$0.050	$0.11
	• Annual maintenance of the process	$0.007	$0.0151
	• Support for families during the process, provided remotely or through support desks	$0.060	$0.13
	• Centralized monitoring	$0.009	$0.0196
SCHOOLS	• Publication of vacancies and related information using the digital platform	$0.0727	$0.16
FAMILIES	• Creation of profile, provision of applicants' information, search for vacancies, and application to schools using the digital platform	$1.3037	$2.81
	TOTAL	$1.93	$4.2

Table 2 shows the categories of costs considered in the analysis. The policy's total cost in the first year is estimated to be USD 1.9 million, of which around USD 600,000 corresponds to direct expenditure by the administrator of the process (typically the central or local government). Out of this amount, only some USD 400,000 are costs that recur annually. The costs associated with the team responsible for building the technological infrastructure are considered an initial outlay.

The remaining USD 1.3 million corresponds to the opportunity cost of the time that families invest in the process of registering and seeking vacancies[9]. This opportunity cost must be compared with that of a decentralized system.

[9] For the moment, this is assumed to take place during working hours. However, it would drop if it were assumed that it takes place, for example, during the weekend or other free time with an opportunity cost lower than the minimum wage.

In other words, the direct costs of implementing a centralized assignment system are relatively low, reaching only USD 4.2 per applicant, of which USD 2.81 directly impacts families due to the time they must invest in searching for vacancies. Below, we show how this cost compares with that of a decentralized system.

3.2 Savings

Savings are defined as all the costs of a traditional decentralized assignment system that cease to exist as a result of centralization through a digital platform. The assumptions and calculation formulas used in this estimation can be found in the appendix. All values are expressed in US dollars (USD). When available, the source of the figure is indicated in a footnote.

Table 3 shows the costs of a decentralized system that become savings when it is replaced with a centralized assignment system. They total over USD 10 million and are generated principally as a result of freeing schools from responsibility for the registration process and families of the need to apply in person.

Table 3 Savings as a result of the implementation of a centralized assignment system

	COSTS Description	Total (USD mill.)	By applicant (USD)
ADMINISTRATOR	• Monitoring of the process at the level of each school by public officials	$0.036	$0.079
SCHOOLS	• School personnel and supplies used in the application process, the review of applicants' information, the assignment process, and communication of the results	$6.298	$13.595
FAMILIES	• In-person application at three schools, including transport costs	$4.633	$10.001
	TOTAL	$10.97	$23.68

Under a decentralized system, each school must implement its own application process and families face multiple processes carried out simultaneously, each with its own rules and requirements. Moreover, because we are looking at the case of a decentralized and non-digital system, each family must visit each school in person, thereby limiting the number of establishments to which they can apply and, consequently, their chances of obtaining a place. This implies high search costs that are reflected in this savings estimate. In all, transitioning to a centralized system produces an estimated saving of USD 23.68 per applicant.

Based on the analysis and using Chile as an example, the net saving achieved can be calculated as:

Net Saving = Savings - Costs = USD 9.05 million

The implementation of a digital centralized assignment policy generates a net saving of over USD 9 million, principally as a result of the savings in the time and work of families and schools generated when moving from an in-person to an online system.[10] It is important to underline that these are annual savings and, in other words, accumulate for each year as from the policy's implementation. Their trajectory over time is discussed below.

Table 4 Savings as a result of the implementation of a centralized assignment system

	COSTS		SAVINGS	
STAKEHOLDER	Total (USD mill.)	By applicant (USD)	Total (USD mill.)	By applicant (USD)
ADMINISTRATOR	$0.56	$1.2	$ 0.036	$0.079
SCHOOLS	$0.073	$0.16	$6.298	$13.595
FAMILIES	$1.3	$2.8	$4.633	$10.001
TOTAL	$1.93	$4.2	$10.97	$23.68

[10] Albeit studied separately in this analysis, it is understood that schools receiving state funding belong in some way to the state and any expenditure they make is, therefore, also a government expenditure.

4. Benefits

In addition to this net saving, the implementation of a digital centralized assignment system generates a range of direct benefits and positive spillovers that, albeit not quantified here, further increase the net benefit and strengthen the argument that the policy is cost-effective. When they are incorporated, the policy's net impact on costs can be calculated as:

Net Impact = Benefits + Savings = USD 9.05 million

The benefits take different forms that are set out below.

4.1 Short term

The adoption of this mechanism involves the creation of a digital platform where families register and enter their information. A digital centralized system, therefore, not only reduces the tedium of the registration process and the consumption of supplies (particularly paper) but also permits the construction and updating of comprehensive databases which, due to the strong incentives families have to register their information accurately, are of higher quality than those collected through other means, such as surveys. This reduces the cost for educational institutions (Zelul, 2015) and generates a valuable asset for governments.

The contact information for families (such as WhatsApp numbers) and students contained in this database can be used to improve the quality of communication with these agents and reduce its cost. This is useful for providing information on, for example, public policies, financing programs, and subsidies in a clear, quick, efficient, equitable, and inexpensive manner. This personal and contact information can also be merged with other existing information (grades, medical history, etc.) to facilitate a series of processes carried out by the government (Tyler, 2016). This is the case, for example, of programs that require the validation of student enrollment or verification of immunization. Moreover, it enables schools to carry out the enrollment process – and, if applicable, payment of tuition fees – entirely online.

4.2 Medium and Long Term Benefits

Another positive external effect arises from an improved capacity for monitoring the process. Since there is a register of both a school's vacancies and the students applying to it, the system's efficiency can be increased by implementing quotas that ensure compliance with, for example, anti-discrimination policies. This effect can be seen in the case of Chile's Preferential School Subvention (SEP)[11] under which schools receive state resources according to their enrollments of low-income (priority) students. Under a centralized system, it is possible to monitor how many priority students enter each school each year and, based on this, adjust the amount of the subsidy accordingly.

[11] Established under Law N° 20.248.

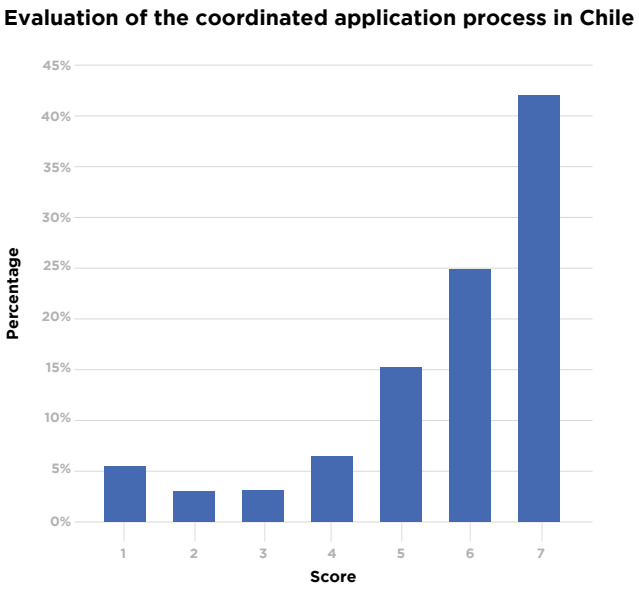
Under digital centralized systems, governments also have complete information about the location of demand for schools, enabling them to disaggregate student enrollment by geographical area and project the supply of establishments and places needed to meet current demand (Carrasco and Honey, 2019). This tool improves the government's planning capacity, facilitating decisions about, for example, the closure or opening of new schools and the need for new teachers.

Once a platform for submitting applications is in place, it becomes feasible to implement mechanisms and interventions to provide personalized information to families, reducing another of the great access barriers they face. Arteaga et al. (2021) found that the use of warnings about the possibility of not being assigned to a school reduces the risk of non-assignment by 58% for those students at risk. Other possible interventions include personalized vocational guidance for students in their final years or the incorporation of nudges to encourage certain behaviors on the part of families. Elacqua et al. (2022) studied the nudges implemented under a pilot centralized assignment system in Pernambuco (Brazil) and, among the results, found that informing families about their options through videos leads them to increase the number of applications they submit.

Along the same lines, others incorporate nudges to encourage certain behaviors in families. Elacqua et al. (2022) studied the nudges implemented during a pilot centralized assignment project in Pernambuco (Brazil), and their results found that informing families about their options through videos led to an increase in the number of applications.

Another potential benefit, which has not been quantified in this analysis, is the recovery of families' trust in the education system. The School Admission System Evaluation Survey, conducted by researchers from Princeton University and Chile's Education Ministry (MINEDUC) in 2021, included the following question: "How do you evaluate the school admission process?" Figure 1 shows that over 40% of those surveyed gave the centralized assignment process the highest possible score.[12]. This is particularly important in the case of low-income families, which are the least inclined to trust the government (Organisation for Economic Co-operation and Development [OECD], 2021).

Figure 1 Families' satisfaction with SAE



[12] On a scale of 1 to 7.

4.3 Estimation of benefits

We used a simple technical exercise to estimate one of the most promising aspects of a digital centralized assignment policy's potential benefits: the efficiency with which vacancies are assigned. Given the many barriers and frictions schools face in making themselves known and the high search costs for families, traditional decentralized systems do not allocate places efficiently because families cannot access the full offer of schools and grades. This can result in a large number of empty vacancies (available but unfilled) at the end of the admission process. If digital centralized assignment improves efficiency, this should be reflected in a drop in the rate of empty vacancies, especially in those schools that have high academic standards but, due to information frictions, cannot efficiently communicate their vacancies under a traditional system.

To estimate the rate of empty vacancies, we used publicly available data on enrollment and maximum student capacity per grade from the Chilean Education Ministry's Center for Studies. We used two measures to reflect the quality of each school: the relationship between its vacancy rate and its score in the SIMCE test[13] and its so-called value added (VA),[14] which indicates the impact of a school's quality on its students.

Chile implemented its SAE digital centralized assignment system in stages, incorporating a new region each year. It began with entry grades,[15] adding the other grades in the following year. This estimation, therefore, takes only entry grades in the Santiago Metropolitan Region[16] where the system began to operate at the end of 2019 for the 2020 admission process.

The final sample comprised 930 entry grades (pre-kindergarten, kindergarten, and first-year primary) in the Santiago Metropolitan Region, taking 2019 as the pre-SAE period and 2020 as the post-SAE period. Only those schools where the grade subject to allocation through SAE is the school's entry grade[17] were retained in the sample because, in these cases, the maximum capacity available (places or vacancies) adequately reflects the number of places to be filled through assignment, without having to consider students promoted from the previous year.

The term "rate of empty vacancies" refers to the number of places that remain unfilled in a grade as a percentage of its maximum capacity[18]:

$$vacancy\_rate_{it} = \frac{(max\_capacity_{it-1} - enrollment_{it})}{max\_capacity_{it-1}}$$

[13] The *Sistema de Medición de la Calidad de la Educación* (System of Measurement of the Quality of Education) or SIMCE seeks to contribute to educational quality and equity by reporting students' learning achievements in different areas of the national curriculum (Agencia de Calidad de la Educación [AGE], undated).

[14] The higher the VA, the better its quality.

[15] Pre-kindergarten, kindergarten, first-year primary, seventh-year primary, and first-year secondary.

[16] The country's most populous region, accounting for 40.5% of the population (INE, 2018)

[17] This implies that if a school offered kindergarten and first-year primary at the time of assignment through SAE, the sample includes only kindergarten.

[18] Maximum capacity is understood as the maximum number of students that a grade can have or, in other words, the number of places it has.

Figure 2 Comparison of the rate of empty vacancies with ***valued added*** for the periods with and without centralized assignment

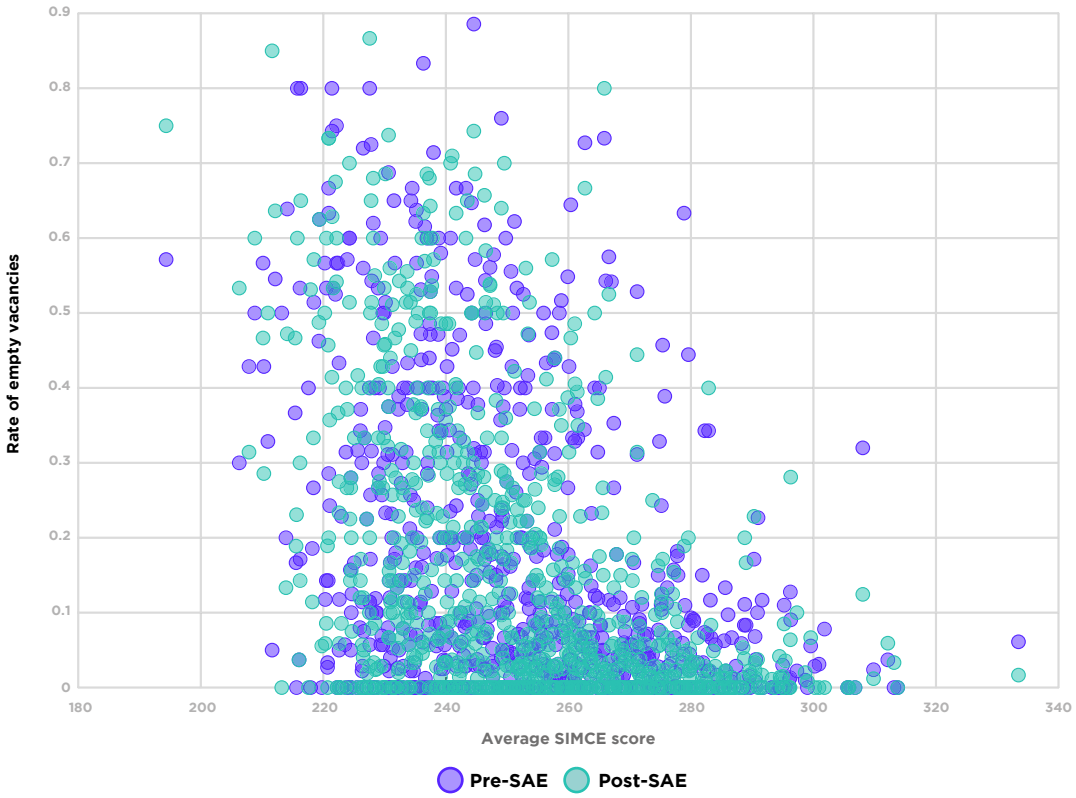


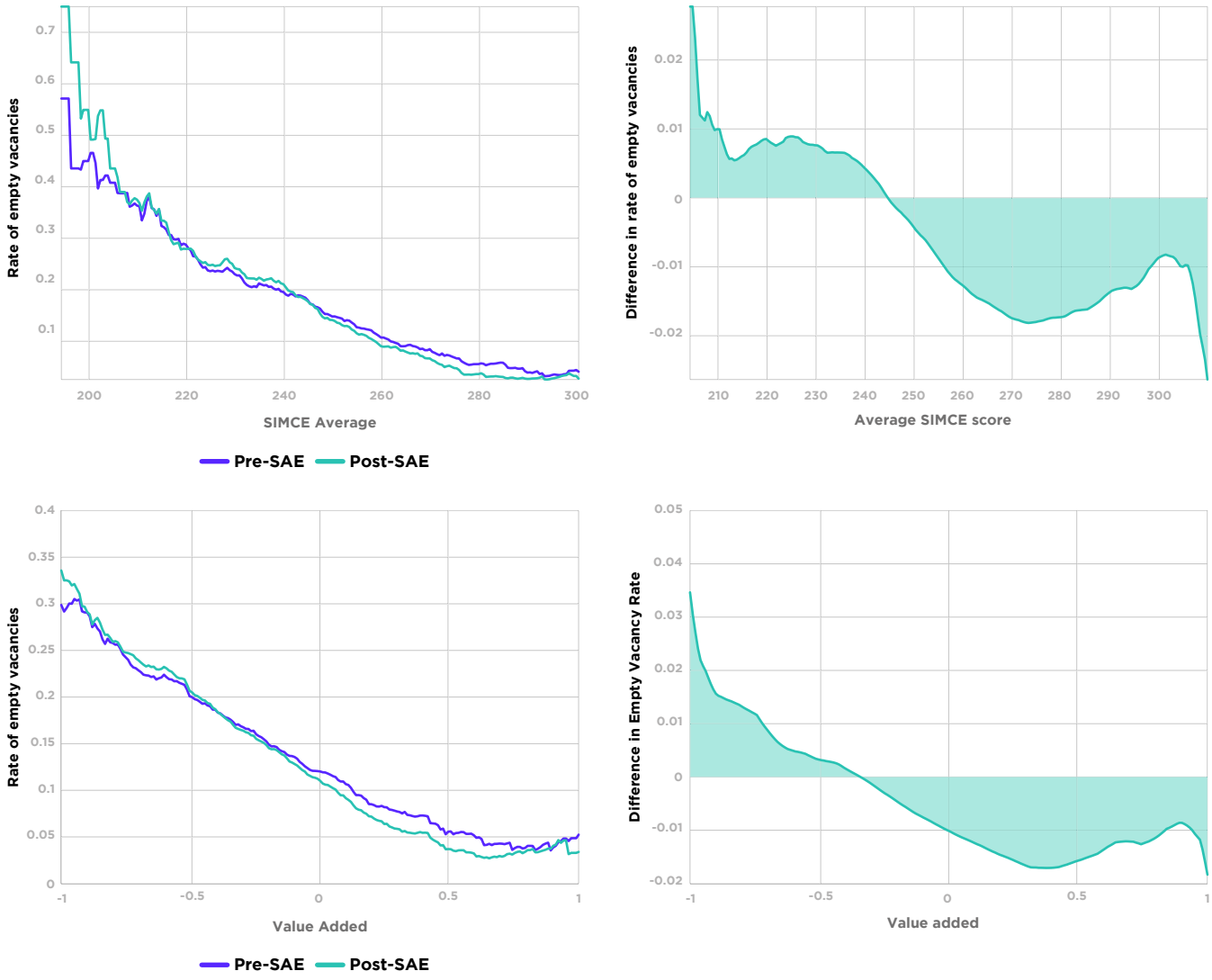
Figure 2 shows the distribution of the rate of empty vacancies in relation to each school's SIMCE score.[19] It can be seen that schools with a lower average SIMCE score tend to have a high rate of empty vacancies, while, among schools with a high average SIMCE score, those with a high vacancy rate appear to decrease in the post-SAE period. This may indicate that SAE reduces empty vacancies in better-performing schools.

To estimate the empty vacancy rate and confirm the hypothesis that centralized assignment is more efficient, we used a non-parametric estimation to calculate the vacancy rate.[20] Figure 3 shows the results of this exercise, with the panel on the left indicating how the vacancy rate changes as the SIMCE score (upper panel) and the value added (lower panel) increase, while the panel on the right shows the difference in the empty vacancy rate between the pre-SAE and post-SAE periods.

[19] Only SIMCE evaluations for fourth-year primary are considered (because they are conducted annually). A score below 243 points is considered insufficient, 243-289.5 points is considered basic and over 289.5 is considered adequate.

[20] This estimation process is explained in detail in Appendix E2.

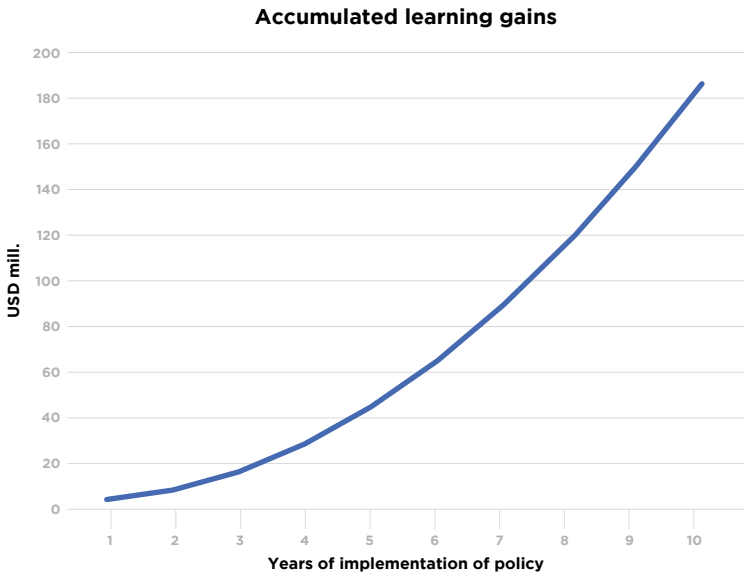
Figure 3 Estimation of the rate of empty vacancies with SIMCE score and ***value added***



This suggests that centralized assignment (in this case, Chile's SAE) represents an improvement on a traditional system in terms of student allocation. The efficiency gains stem directly from a reduction in information frictions and the learning costs typically faced by families and schools in a decentralized process.

To quantify this gain in assignment efficiency and be able to compare it with the costs and savings estimated above, we used the analysis of Neilson (2021), who studied Chile's primary education market to investigate how a **voucher** policy affects schools' incentives to improve their quality. Here, we calculate the amount that must be invested in teachers to achieve a certain level of ***value added*** (VA) and, based on this, estimate the ***learning gain*** (measured in ***value added***) that can be achieved through better assignment, with each new student receiving a benefit equivalent to their learning which, in turn, has a monetary equivalent.

Figure 4 Estimated accumulated benefits in the first ten years of the policy's implementation



To estimate this gain, we calculate the difference in student enrollment between the pre-SAE and post-SAE periods ($\Delta_{enrollment}$) since each additional student enrolled in a school represents an additional gain in aggregate learning.

The net benefit generated by learning gains is USD 4,061,606 just for these three entry grades in the Santiago Metropolitan Region in the first year of the policy's implementation. The gains are not only repeated year after year but also accumulate over time as students pass from grade to grade. Figure 4 shows a projection of this estimate for the first ten years of the policy's implementation.

Considering the costs, savings, and benefits, the net impact of the transition from a decentralized to a digital centralized system can, therefore, be expressed as:

Net Impact = Benefits + Savings - Costs

Net Impact = USD 4.061 million + USD 10.97 million - USD 1.93 million

Net Impact = USD 13.1 million

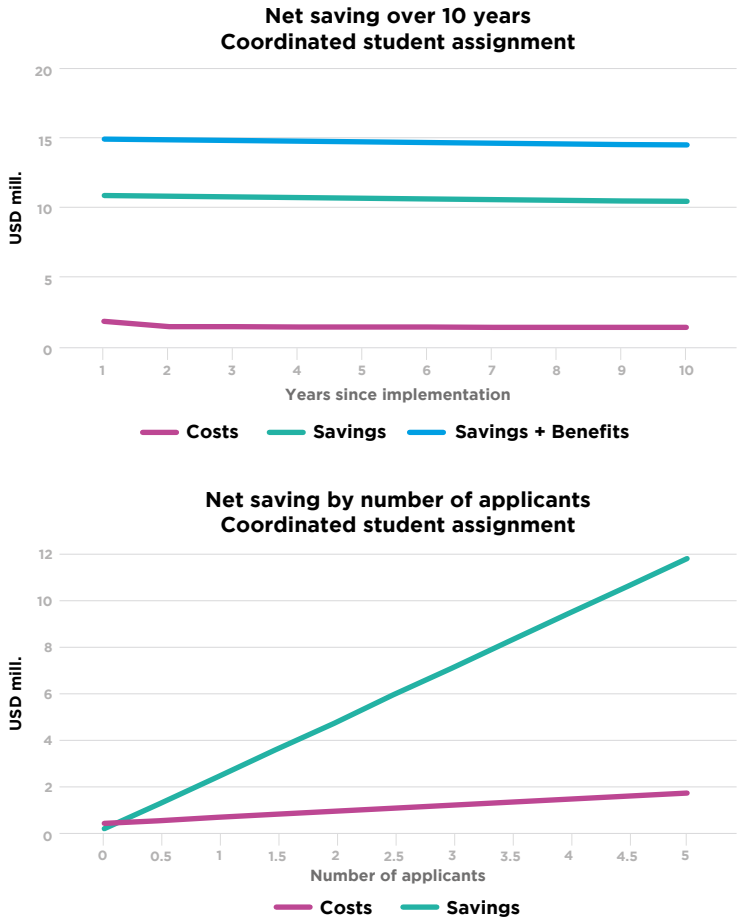
5. Extended analysis

To analyze the sustainability of this policy, the evolution of the costs and savings are evaluated in two dimensions: over time and by number of applicants. Figure 5 shows this exercise.[21]

The upper panel of Figure 5 shows the projection of costs and savings during the first ten years of the policy's implementation. It can be seen that the costs decrease during the initial years and then remain relatively constant, varying only with fluctuations in the population. The savings and benefits, on the other hand, depend directly on the number of applicants (rising as the number of applicants increases) and their downward trend reflects a population projection of a trend drop in the number of 5-18 year-olds. Despite this decline, the savings and benefits continue to exceed costs, with a difference of some USD 11.8 million.

The lower panel of Figure 5 shows the variation in costs and savings as the number of potential applicants in the system increases. Savings increase year by year because they are directly proportional to the number of applicants.

Figure 5 Projection of the policy's costs and savings over time and by number of applicants



[21] The assumptions indicated in Appendix D were used to construct these graphs.

6. Potential constraints

This technical note has assumed a smooth transition from a traditional to a digital centralized system. However, certain constraints hinder implementation of the process and increase its costs.

Digital systems require high internet penetration and a base level of digital literacy in both adults and children. Although the continent has recently surpassed average world internet penetration, a difference of around 40 percentage points exists between the poorest and richest segments of the population (Álvarez, 2022; OECD et al., 2021). Both local governments and multilateral organizations are implementing numerous initiatives to mitigate these inequalities by reducing gaps in connectivity, access to devices, and digital literacy.

In addition, digital centralization may cause some tension and/or political resistance. In the case of Chile, the presentation and approval of the bill that established SAE and its implementation occurred under two different governments with opposing stances, resulting in great internal resistance during the early years of the process. This affected collaboration between the government implementing it and organizations of school administrators and of parents opposed to its introduction (Marín et al., 2019; Ministerio de Educación de Chile, [MINEDUC], 2018). To mitigate this constraint, Elacqua et al. (2021) recommend a system's gradual implementation ensuring collaboration between public policymakers and local political and educational authorities interested in its success.

In a third potential constraint, families may encounter barriers of access to information and difficulties in understanding how to use the process. This calls for mass information campaigns about both its administrative aspects (dates, procedures, etc.) and its technical aspects. Campaigns of this type can also broaden support for the policy and thus reduce resistance.[22]

[22] This cost is included in the final estimate.

7. Conclusion

The analysis presented here uses the example of a digital centralized student assignment system in Chile, comparing the costs of its implementation with the savings generated by abandoning the traditional decentralized system. We estimate that its introduction resulted in a total net annual saving of USD 9.05 million, equivalent to a net annual saving per applicant of USD 19.48. This saving rises over time and as the number of applicants increases.

In addition, we estimate that the system's introduction produced additional benefits worth over USD 4 million, thanks to gains in assignment efficiency. This confirms that a policy of digital centralized student assignment is not only effective and efficient, as demonstrated by the evidence, but is also cost-efficient. It is important to note that this figure does not include unquantifiable savings,[23] so the impact shown here is at the lower end of the potential net benefits.

[23] Such as a reduction in corruption, an increase in the perception of transparency, and greater trust on the part of families.

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Appendixes

APPENDIX A: DATA USED

For this analysis, the following databases were used:

- **SAE:** IInformation about the supply of vacancies, the number of applicants, and the ranking of applications. The database of supply for 2019 and 2020 and the database of applicants and applications for 2019 were used. This information is publicly available and can be found in MINEDUC, 2019.

- **SAE Satisfaction Survey 2021:** The results of this survey were made available by the ConsiliumBots organization (personal communication, August 2022).

- **Enrollment by student:** Public database with information by student. For this analysis, the databases on individual enrollment for 2011-2021 were used (MINEDUC, undated).

- **SIMCE:** Private database with information by student. This analysis considered only the evaluations of fourth-year primary students in 2006, 2008, 2010, 2012, 2014, 2015, 2016, 2017, and 2018. This information can be requested through the website of Agencia de Calidad de la Educación (ACE, undated).

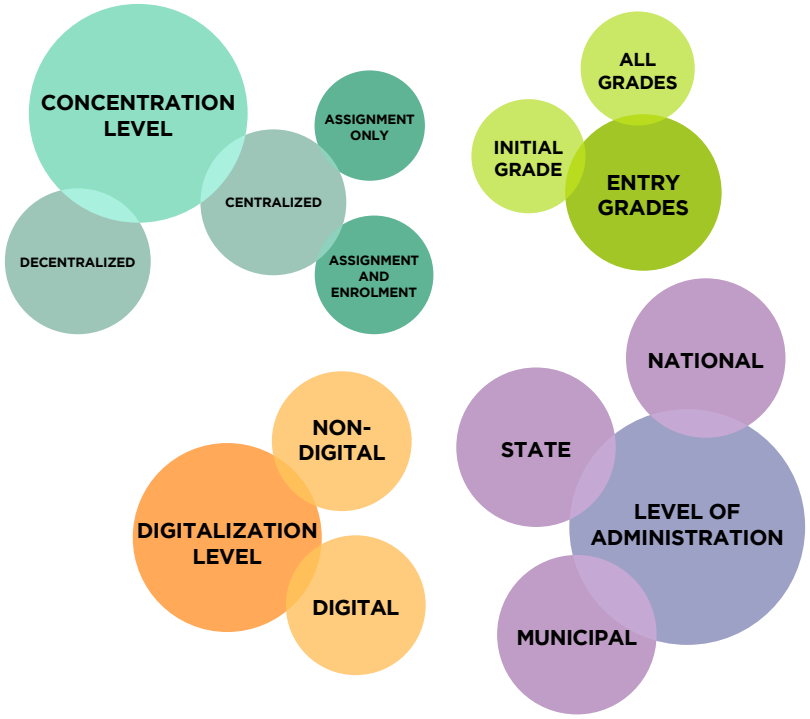
- **Value added and expenditure by increases in value added:** Private data made available by Christopher Neilson (personal communication, August 2022).

APPENDIX B: OVERVIEW OF LATIN AMERICA

For the purposes of this note, the different characteristics of student assignment systems in Latin America were simplified. In practice, however, each country has its own particular adaptations, often related directly to its administrative organization and territorial autonomy.

Figure B1 shows the different categories under which an assignment system can be classified.

Figure B1 Different types of student assignment and enrollment systems found in Latin America



B1 Administrative level

The administrative level refers to the scale on which an assignment system is implemented. This may be national or local. One of the countries with a national system is Chile: all the country operates under the same system and families can apply for a place in any establishment regardless of its location[24] and do so using the same platform under the same criteria.

Local education systems are often related to the form the state takes in each country or its geography. In Ecuador, registration with the public education system takes place under the same rules throughout the country, but the Coastal and Sierra zones each have their own process because they operate at different dates and are mutually exclusive. In another case, under the state systems found in countries with a federal system of government, student assignment is specific to the schools administered by each state or municipal government (as in Brazil) or province (as in Argentina). Finally, some systems operate at the municipal level. In these cases, the application rules apply only to schools that depend on that municipal

[24] Only schools that receive government funding.

government, and families wanting to register their children with schools in another municipal district must undertake an additional process under a different set of rules. This is the case of Colombia's Certified Territorial Entities (municipalities and departments).

National systems have the advantage of permitting the registration of students whose families move from one region to another. Local systems, on the other hand, permit the process's adaptation to the needs of each region, state, or municipality.

B2 Level of centralization

The level of concentration refers to the number of institutions that carry out the process and the number of systems of rules that exist, determining whether the process is centralized or decentralized.

In decentralized systems, numerous admission processes tend to exist simultaneously, each with its own rules.[25] In these cases, each family must submit an application directly to each of the schools in which it is interested. The least centralized case is where each school independently implements and monitors its own assignment process, according to its own rules, and families must navigate this complexity. Systems of this type can be found in public schools in the Dominican Republic and Peru.

In centralized systems, by contrast, families request enrollment through a single institution where they may be able to express their preferences among the different schools available. This permits the unification of application and assignment criteria and enables families to apply to as many schools as the system permits, doing so in a single step and with only a single set of rules to understand. At present, Chile, Ecuador, and the cities of Buenos Aires and Bogotá are examples of centralized systems of this type. It should be noted that not all centralized systems allow families to express their preferences and some apply other assignment criteria, such as distance to the school or the first-come-first-served principle.

Between these two extremes, there are systems, such as that of the state of Pernambuco in Brazil, which can be classified as semi-centralized. In this case, families submit their application in writing to the school, which forwards it to the municipal government, and, finally, the state assigns places. Given the large number of actors involved, this process is quite costly and lacks transparency.

Centralization of the process – whether at the national or local level – reduces search costs for families because a single entity gathers information about all the school vacancies available. It also standardizes application and assignment criteria, making it easier for families to navigate the system.

[25] This form of administration is typical of (but not confined to) private schools around the continent, with each school selecting pupils according to its own criteria and parameters. However, these establishments are not the focus of this note.

B3 Entry Level

Entry level refers to the criterion determining who has access to the assignment system. This may be related to the level of education the student is entering or the time the student has been in the system.

In the case of educational level, some systems only admit students in entry grades[26] and other students (such as those seeking to move from one school to another) must use a different system with a different set of rules.

The different assignment mechanisms also differentiate between students according to how long they have been in the system. They usually consider all students who are "new", whether because they are just starting their schooling or because they come from other jurisdictions or the private education system.

For example, the city of Buenos Aires only assigns new students of this type and those applying for entry grades while, in Chile, all students participate in the same system.

B4 Level of digitalization

Finally, student assignment mechanisms can be classified as digital or non-digital. In digital systems, the publication of vacancies, the registration of families, and the announcement of the results are carried out through a digital platform, with an algorithm used to allocate places. Non-digital mechanisms may publish vacancies online but do not use digital mechanisms for the registration and assignment process.

Non-digital systems, as the name indicates, conduct the process in person, often using paper forms and records, as was previously the case in Pernambuco, Brazil. Digital systems, on the other hand, tend to be combined with centralization and – unlike non-digital systems – have the advantage of allowing families to submit their applications, learn about the assignment results, and, in some cases, enroll in the assigned school from their homes during non-working hours. When digitalization is combined with centralization, it is easier for families to apply to multiple schools through a single online platform. Chile and the city of Bogotá are examples of digital centralized systems.

[26] Typically, the first year of primary and secondary education.

APPENDIX C: COSTING ASSUMPTIONS

For correct quantification, the costs that should be taken into account include personnel, supplies and equipment, physical space, transport costs, and training costs, among others (Hollands et al., 2021). This involves a series of assumptions, selected on the basis of always choosing the lower limit of the costing parameter, unless the evidence suggests otherwise. The assumptions used are as follows:

- **Exchange rate:** An exchange rate of USD 1 = 806 Chilean pesos (CLP), the closing rate on March 11, 2022, is used.

- **Student enrollment:** A universe for Chile of 3,308,635 students at non-private schools is considered.

- **Number of applicants:** This is calculated as 14% of school enrollment (only establishments with state funding) in the previous year. The figure was obtained from Chile's centralized student assignment system and, for the purposes of this analysis, corresponds to 463,209 students.

- **Number of schools:** For 2021, the analysis considers 10,941 schools using the School Admission System (SAE).

- **Parents' opportunity cost:** Chile's minimum wage in March 2022 (CLP 350,000 or USD 434.2) is used, assuming a working week of 45 hours and a working month of 180 hours.

- **Application time:** Each family is assumed to take 60 minutes per application in a decentralized system and 70 minutes for the complete process in a centralized system, carried out in both cases during working hours. The figure for the decentralized system is based on parents' testimonies (a lower limit) and, in the case of the centralized system, on the survey of parents carried out by Chile's Education Ministry.

- **Transport costs:** For decentralized systems, these are estimated considering the time it would have taken each family to go in person to each school to which they apply, based on applications in the SAE 2021 process. The cost of each journey is the fare on local public transport (CLP 750 or USD 0.93, in the case of Chile), plus the opportunity cost of the time involved.

- **Number of applications per family:** This was set at three for the decentralized system and without an upper limit for the centralized system.

- **Expenditure on salaries of teachers and other state officials:** The average wage of public-sector employees in Chile[27] (CLP 964,453 or USD 1,197) is used to quantify expenditure on administrative personnel, school directors (who participate directly in the admission process), and ministerial personnel (centralization and monitoring process). The salary of teachers is based on the Minimum Basic National Teacher Remuneration[28] for a primary teacher with a 44-hour working week (CLP 650,484 or USD 807).

[27] Alonso and Cárdenas, 2021.

[28] Municipalidad de Victoria, Departamento de Educación, 2021.

- **Monitoring:** It is assumed that, under a traditional system, monitoring takes place at the school level and takes 30 minutes per school. For a digital centralized system, the time is zero because the information is available instantaneously on the platform.

- **Time to calculate and report vacancies:** It is assumed that each school spends an hour on reviewing, calculating, and updating the available vacancies on the online platform. This task is carried out by a person who receives a wage equivalent to the average wage of a public official.

APPENDIX D: EXTENDED ANALYSIS

D1 Ten-year projection

The previous assumptions are maintained and the following additional assumptions are incorporated:

- **Population projections:** To model the number of applicants during the ten years as from the policy's implementation, the United Nations ten-year population projections[29] are used. They indicate a 6.12% contraction of the population aged 5-19 years and a 3.1% contraction of that aged 20-59 years.

- **Expenditure on information interventions:** The early years of the policy's implementation call for an additional effort to ensure that families know about the new system and become familiar with it. In the first year, spending on these activities is assumed to be 25% above that in their stationary state. It is, therefore, assumed that this spending drops by 5% in each of the first five years.

D2 Projection by size of school enrollment

The previous assumptions are maintained and the following additional assumption is incorporated:

A public transport fare of CLP 750 (USD 0.93) is used for the Santiago Metropolitan Region and CLP 375 (USD 0.47) for other regions.

[29] United Nations, Department of Economic and Social Affairs Population Division, 2022.

APPENDIX E: ESTIMATED BENEFITS

Two school admission processes in the Santiago Metropolitan Region – the 2019 process (without SAE) and the 2020 process (with SAE) – were used for this estimation. The sample included only entry grades because, in these cases, the difference between the number of places available and enrollment is a more direct indicator of the proportion of vacancies not filled by the assignment process, without the distortion that can be introduced by other factors such as approval and student exclusion.

For each grade analyzed, the maximum capacity declared in the previous year was obtained. This is available only in the SAE databases but these do not cover the years prior to the system's implementation. We, therefore, used the places declared in the 2020 admission process (with SAE) to impute places in the 2019 admission process (without SAE).

The proportion of vacancies that are not filled – that is, the rate of empty vacancies – can, therefore, be calculated as:

$$vacancy\_empty_{it} = \frac{(max\_capacity_{it-1} - enrollment_{it})}{max\_capacity_{it-1}}$$

where:

- $prop\_empty_{it}$: vacancies remaining empty in grade ***i*** after the admission process of year ***t***, as a percentage of the grade's maximum capacity

- $max\_capacityi_{t-1}$: number of places that grade ***i*** will have in year ***t***, declared towards the end of year ***t-1***

- $enrollment_{it}$: number of students enrolled in each grade ***i*** in year ***t***.

There are also two variables that indicate the quality of teaching in each school: SIMCE and ***value added***.

E1 Simce

To analyze the number of empty vacancies according to the academic performance of the school in question, an estimate of its average SIMCE score was obtained. The *Sistema de Medición de la Calidad de la Educación* (System of Measurement of the Quality of Education) or SIMCE was introduced in 1988 and seeks to contribute to educational quality and equity by reporting students' learning achievements in different areas of the national curriculum (AGE, undated).

To calculate the average SIMCE score for this analysis, only scores for fourth-year primary students in 2006, 2008, 2010, 2012, 2014, 2015, 2016, 2017, and 2018 were considered. For each year, the average of the mathematics and language scores of each student was taken to calculate an average for the school.

E2 *Value added*

An estimate of each establishment's ***value added*** was calculated based on the SIMCE tests in 2005-2016. In this way, we could analyze empty vacancies in relation to a school's quality. This calculation follows Neilson (2021).

To estimate each school's ***value added***, we performed a regression of students' SIMCE scores on a set of observable variables that included information about students' health at birth, families' demographic composition, the parents' employment situation and educational level, and the mother's university admission scores in language and mathematics tests. The relationship between the student's performance yijt, their characteristics, and the school's ability to improve performance qjt is defined as follows:

$$y_{i,j,t} = q_{j,t} + X_{i,t}\,\gamma + e_{i,j,t}$$

The estimated value of $q_{j,t}$ is each school's ***value added***. It is the component of its average score that cannot be explained by the students' individual characteristics. This measure of quality captures the school's input in terms of, for example, teacher quality, infrastructure, school climate, and any other specific characteristic of the school that has a positive impact on student performance as measured by its average SIMCE score. Insofar as the demographic composition of the school's students is important for its SIMCE results, these effects will also be included in the estimated ***value added***.

E3 Non-parametric estimation

A non-parametric estimation was carried out on the rate of empty vacancies. For this, a range was defined between the rate's minimum and maximum values, with increases at intervals of 0.01 (xgrid), together with a ***window*** of 0.75. The ***value added*** (and the SIMCE) are estimated over the following range of values of the rate of empty vacancies:

$$\left[xgrid[i] - \frac{window}{2} \; ; \; xgrid[i] + \frac{window}{2} \right]$$

Over this range, the mean and the 10th, 50th, and 90th percentiles of the ***value added*** and the SIMCE are estimated. This estimation is carried out for both the SAE and the non-SAE years and the results are shown in the left-hand panel of Figure 4.

In the right-hand panel of Figure 4, the difference in ***value added*** or SIMCE between the period with SAE (2020) and the period without SAE (2019) for each point is obtained. This difference is smoothed[30] and inverted (for didactic purposes only).

The estimate indicates that, once a digital centralized system is implemented, there is indeed a drop in the rate of empty vacancies for schools with higher value added.

[30] Carried out using the smooth function of the MATLAB software about which details can be found at **http://math-works.com/help/curvefit/smooth.html**.

E4 Benefits

To obtain a pecuniary benefit, we estimate the learning gain produced by an increase in enrollment at schools with greater ***value added***.

To estimate the value of learning gains, a prediction of the expenditure required to achieve a certain level of value added was obtained from data generated by Neilson (2021). The benefit for an institution ***i*** is calculated as follows:

$$\boldsymbol{benefit_i = value\_added_i \times \Delta enrollment_i \times spending_i}$$

where:

- ***value_added***$_i$: ***value added*** value added calculated for institution ***i***

- Δ***enrollment***$_i$: difference in enrollment between 2020 (with SAE) and 2019 (without SAE)

- ***spending***$_i$: estimated expenditure in US dollars (USD) required to achieve a level of value added equal to ***value_added***$_i$.

Four scenarios arise from the change in the efficiency with which vacancies are assigned:

- Δ***enrollment < 0 y value_added < 0***: This indicates that, between the pre-SAE and post-SAE periods, there was a drop in enrollment at low-quality schools, implying that SAE assigned students who were previously enrolled in these schools to better-quality schools. This improvement in learning quality is considered in the calculation of the benefit.

- Δ***enrollment < 0 y value_added > 0***: This indicates a drop in enrollment at good-quality schools, reducing the benefit.

- Δ***enrollment > 0 y value_added < 0***: This indicates an increase in enrollment at lower-quality schools. This may be a sign of a deterioration in learning quality or an increase in enrollment at schools that, albeit having negative value added, are of relatively better quality than others.

- Δ***enrollment > 0 y value_added > 0***: In this scenario, there is an increase in enrollment at good-quality schools and, therefore, a direct increase in benefit.