Official Journal of the World Water Council
Water Policy

WORLD WATER COUNCIL
IWA PUBLISHING

Water Policy Vol 26 No 7, 685 doi: 10.2166/wp.2024.044

A new look at the distributive incidence of Chile's means-tested water subsidy scheme

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ABSTRACT

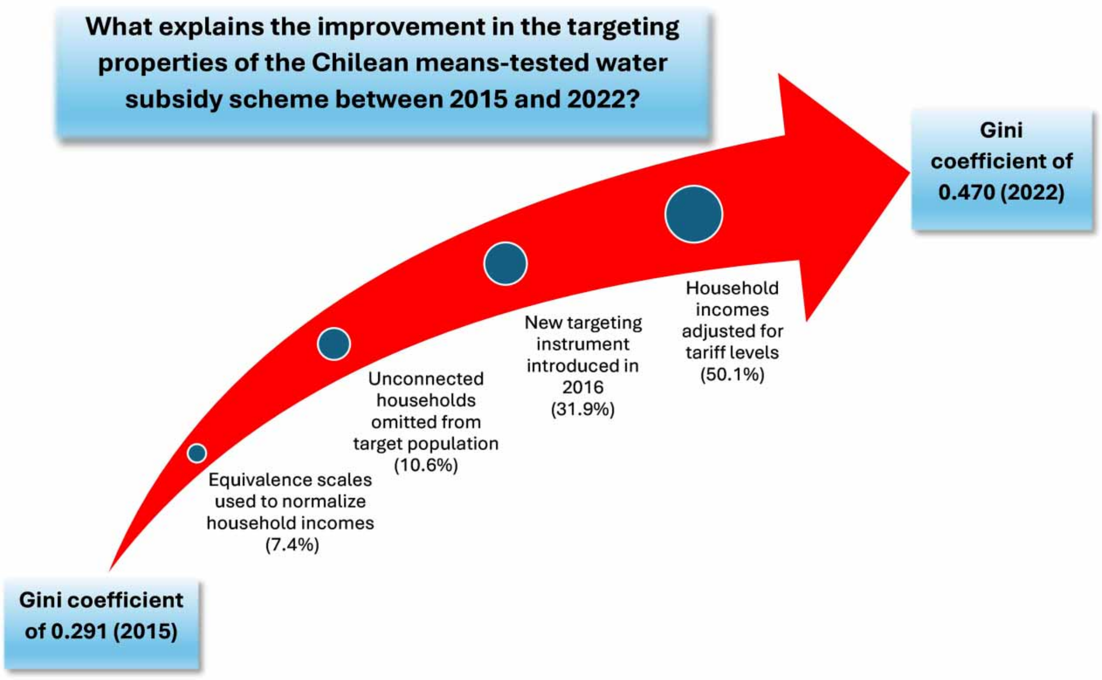
Chile employs subsidies to reduce the bill paid by lower-income households for piped water and sanitation. Previous research has concluded that this system has a lower Gini coefficient (0.29) than expected, meaning it is not appropriately targeted to low-income households. This paper takes a new approach to assessing the subsidy system, taking advantage of Chile's 2016 adoption of a new means-test instrument in the welfare system. We refine the analysis by (1) discarding data arising from rural unconnected households, on the theory that they cannot feasibly be connected to piped water systems and thus cannot use the subsidy; (2) recognizing Chile's use of an equivalence scale to adjust household incomes for household size and relative disadvantage, and (3) adjusting the analysis to reflect the different tariff levels across the country. With these adjustments, the Gini coefficient of benefits increases to 0.47, meaning that the Chilean subsidy program is in fact meeting its goal of targeting assistance to those who need it. In other words, previous research has underestimated the targeting progressivity of the Chilean subsidy scheme. We also use the Shapley value to apportion the improvement from 2015 to 2022 among the various changes introduced in the analysis.

Key words: Chile, means-tested, targeting, water subsidies

HIGHLIGHTS

- The Chilean water subsidy scheme is very well targeted when results are updated to 2022 and other changes are introduced in the analysis.
- The Gini coefficient of the distribution of benefits reaches a value of 0.47.
- This contrasts with most subsidy schemes around the world which are poorly targeted.
- Using administrative information is key to identifying beneficiaries in a means-tested subsidy.

GRAPHICAL ABSTRACT



1. INTRODUCTION

The distributive incidence of water subsidies has been an active topic of research during the last few decades. This stems from the fact that large subsidies are provided to water suppliers and users, presumably to help needy households access this service. Andres *et al.* (2019) estimate that low- and middle-income countries spend between 1.59 and 1.95% of GDP per year on water supply and sanitation subsidies. They also undertake case studies for 10 countries and find that subsidies are regressive, in the sense that they disproportionately benefit wealthier consumers. Fuente *et al.* (2016) arrive at the same conclusion for Nairobi, Kenya. They also summarize the empirical literature and conclude that, for the most part, the distributive performance of existing water subsidies in developing countries is quite poor.

Related to the above point, water subsidies are often applied by setting tariffs below cost-recovery levels without compensating public transfers (Andres *et al.*, 2019). This implies that providers do not have the financial capacity to expand the network to poor neighborhoods or informal settlements. Poor unconnected households do not benefit from these operational subsidies. Rather, they are worse off as they remain unconnected due in part to the subsidies given to relatively richer connected households. In this context, it is relevant to explore alternatives that improve the targeting performance of water subsidies. This is particularly important when policymakers wish to increase tariffs to cost-recovery levels without unduly affecting accessibility by less well-off users.

One example is the 2017 tariff reform in Lima, Peru. To increase the financial sustainability of the public service provider (SEDAPAL), subsidies to undeserving households were reduced. This was achieved by changing the rising-block tariff structure, making eligibility to the low-priced first consumption block conditional on a dwelling's location. A geographical poverty map identifying neighborhood areas of low-income households was used as the targeting instrument. This reform substantially improved the distributive properties of the water subsidy (Gómez-Lobo *et al.*, 2023) by reducing errors of inclusion (richer households who receive the subsidy).

Another example of a targeted subsidy is the case of Colombia, where housing external characteristics as well as neighborhood conditions are used to assign all dwellings to one of six categories (stratification). The lowest three categories pay a lower tariff for public services, including water, while the top two categories pay a surcharge to fund the subsidies. However, as argued by Quiñones *et al.* (2021), this targeting instrument is very rigid, as it is difficult to modify the stratification of dwellings through time. Thus, this instrument is unable to reflect changes in households' payment capacity. There is evidence that the errors of inclusion of this scheme are large and its targeting properties poor (Gómez-Lobo & Contreras, 2003; Quiñones *et al.*, 2021).

Another scheme that has received attention in the literature is the means-tested water subsidy scheme introduced in Chile more than 30 years ago (Gómez-Lobo & Contreras, 2003; Contreras *et al.*, 2018). Unlike other experiences around the world, this subsidy is funded through general taxation and eligibility is determined using a sophisticated targeting instrument developed for the general welfare system. Research has shown that this subsidy is better targeted in comparison to other existing water subsidies around the world, with the distributive incidence of monetary benefits exhibiting a Gini coefficient of close to 0.3.

Although better targeted by comparison to other world experiences, the progressivity of Chile's water subsidy is modest. This is surprising given the effort made in this country to focus welfare benefits on the most needy. Furthermore, as shown in Contreras *et al.* (2018), the targeting performance of this subsidy did not improve between 1998 and 2015 despite changes in the instrument used to identify poorer households.

Contreras *et al.* (2018) discuss several conjectures for these results. First, it could be that the targeting instrument is imperfect. Until 2016, eligibility for this and other subsidies in Chile was determined mainly based on self-reported information provided by the household head in an interview. Naturally, this information could be manipulated, distorting the ability of this instrument to identify the true social and economic condition of a household. Second, the number of subsidies allocated (and the monetary value of each subsidy) is determined not only by household income but also by tariff levels across the country. Thus, a relatively richer household in a geographical zone with high tariffs will be eligible for the subsidy while a poorer household in another area with low tariffs may not. A targeting performance measure based solely on per capita household income will give a distorted picture of the performance of the subsidy given the stated aims of this benefit. Third, it could be that a household's economic condition changes between the moment the subsidy is awarded (for 3 years) and the date the survey is undertaken. Finally, measurement errors in the survey data cannot be ruled out.

In this paper, we explore these and other hypotheses to explain the moderate targeting performance of the Chilean water subsidy scheme. To this end, we use data from the 2017 and 2022 CASEN household surveys to update the targeting performance of the subsidy.[1] This update is important since in 2016 a new targeting instrument, called the Household Social Registry (RSH for its Spanish acronym), was introduced to identify and rank households according to their socioeconomic condition. The RSH is an information system that centralizes all the administrative data for individuals from the health, pension, labor, tax and other public services. The RHS provides more reliable economic information compared to the self-reported instrument used prior to 2016.

First then, we expect an improvement in the progressivity of the subsidy transfers after 2015. In addition, since subsidies are awarded for a 3-year period, this improvement should be gradual, with a larger change in 2022 than in 2017.

[1] There was another CASEN survey undertaken in 2020 but due to the Covid-19 pandemic, it had a smaller sample size and was undertaken by telephone. This survey cannot be reliably compared to those of other years and we omit this data.

Second, we explore the effects of omitting unconnected households in the analysis. These are almost exclusively rural households where due to isolated conditions it is perhaps unrealistic to assume they will eventually be connected to a piped water network. There are special programs to provide access to potable water and sanitation services in isolated rural areas and therefore it seems reasonable to exclude these households when evaluating the performance of the subsidy scheme.

Third, we consider that the eligibility criteria used by the Chilean welfare system are not based on household per capita income. Rather, an equivalence scale is used to normalize incomes that recognizes economies of scale in household size and the presence of handicapped or other disadvantaged members in the household.

Finally, we normalize household incomes by the tariff structure in each zone to take into account differences in tariff levels when ranking households from poorest to richest. This is consistent with the stated aims of the scheme and it seems reasonable to evaluate this policy using this normalized income to calculate its targeting properties.

Our results indicate that these four changes substantially improve the targeting properties of the water subsidy. From a benchmark of 0.29 in 2015, the Gini coefficient of monetary transfers increases to 0.47 in 2022. Since the order in which the four changes are introduced in the analysis will affect their incremental impact on the Gini coefficient, we calculate the Shapley value for each one to attribute their relative importance in explaining the overall result. We find that most of the targeting improvement can be attributed to the introduction of the RSH and the normalization of household incomes by the tariff level in each locality.

The results of this paper are important for several reasons. First, they indicate that the water subsidy in Chile is well targeted, or at least much better than any other scheme analyzed in the literature. Second, it explains the moderate results found in previous studies of the targeting properties of this policy. Third, it strengthens the Chilean experience as a benchmark for the design of similar schemes in other parts of the world.

This paper is organized as follows. In the next section, we briefly describe the main features of Chile's water subsidy scheme and provide a summary of previous research on this policy experience. We then present the new survey data used in this study as well as the evolution in the number and amount of subsidies from 2015 to 2022. We follow with the empirical analysis. The paper concludes with a discussion of the main results and their policy relevance.

2. THE CHILEAN WATER SUBSIDY SCHEME

The Chilean water subsidy was introduced in 1989 to help poor households pay for a minimum water consumption level at a time when tariffs were being raised to cost-recovery levels. The benefit covers between 25 and 85% of the water and sanitation bill for the first 15 m^3 consumed per month (lowered to 13 m^3 in 2024). The exact percentage for each region or municipality is determined each year based on household incomes and tariff rates in each geographical area. The objective in this calculation is that the average household in each of the first two quintiles of the income distribution does not spend more than 5% of their monthly income on water and sanitation services.[2]

Table 1 shows the average bill (excluding any subsidies) for a basic monthly consumption of 15 m^3 and the 25th percentile of household autonomous income for all regional capitals in 2017.[3] As can be seen from the table, water tariffs differ substantially across the country, reflecting the size and density of each city as well as other

[2] There are two other beneficiary groups: elderly households who belong to the first two quintiles of the income distribution and households who are part of the *Chile Seguridades y Oportunidades* program. This last initiative is for very vulnerable households and encompasses a whole set of social and economic benefits, including a 100% subsidy for the basic water bill. The number of households in these two groups is small compared to the overall number of subsidy recipients.

[3] In 2017, Chile was divided into 14 administrative regions.

Table 1 | Monthly water and sanitation bill as a percentage of the 25th percentile of autonomous household income in each regional capital in 2017, USD

Regional capital	Region number	Bill for 15 m^3 (USD)	Autonomous income P25 (USD)	Bill/income (%)	% of clients with subsidy (%)
Copiapó	III	42.8	462.0	9.3	26.2
Temuco	IX	29.5	323.4	9.1	22.6
Coyhaique	XI	48.5	544.2	8.9	33.6
Puerto Montt	X	33.8	404.4	8.4	24.6
Valdivia	XIV	29.4	385.0	7.6	16.0
Talca	VII	29.1	392.7	7.4	19.4
La Serena	IV	29.0	415.8	7.0	16.1
Valparaíso	V	31.3	477.4	6.5	14.4
Iquique	I	36.4	569.8	6.4	22.2
Antofagasta	II	43.7	693.0	6.3	18.8
Concepción	VIII	23.8	400.4	5.9	17.2
Punta Arenas	XII	35.5	619.2	5.7	21.4
Rancagua	VI	25.1	446.6	5.6	18.7
Santiago	XIII	20.4	616.0	3.3	5.1

Source: Own calculation based on SISS, CASEN data and Central Bank of Chile. The water bill is for a basic consumption level of 15 m^3 of water and sanitation services per month. Bill/Income is the ratio of the water bill over the 25th percentile of autonomous household income per month. The water bill includes the monthly fixed charge and the water and sanitation volumetric charge. Monetary values were converted to US dollars using the average exchange rate for 2017 of 649.33 CLP/USD. The last column refers to the percentage of clients receiving a subsidy in each region.

operating conditions that affect supply costs. In a large city such as Santiago (that additionally relies on a gravity-fed system), the water bill is only US$ 20.4, while in a small regional capital such as Coyhaique it is US$ 42.8. This heterogeneity would be even more pronounced if other localities apart from regional capitals were to be included in the table.

In addition, Table 1 shows that incomes for poorer households (represented for the purpose of this table by the 25th percentile of the distribution in each region) also differ across the country. As a result, the percentage of the total budget that households must allocate to pay for the basic water bill can be as low as 3.3% in Santiago, where incomes are relatively high and tariffs are relatively low, to 9.3% in Copiapó, where incomes are lower and water tariffs are high. This heterogeneity is reflected in the percentage of residential clients that receive a subsidy. In the Metropolitan Region of Santiago, it is relatively low, at 5.1%, while in the Region of Atacama (Copiapó being its capital), it is relatively high, at 26.2%.

The above discussion is intended to show that the number of subsidies awarded in each region – and the percentage of the water bill covered by each one – will depend both on the income of poorer households and the tariff level in each locality. As will be shown below, this feature of the Chilean water subsidy scheme must be kept in mind when evaluating its targeting properties. If differences in tariff rates across localities are ignored, the distributive incidence of the subsidy will be distorted with respect to the explicit aims of this benefit.

Within each region there are two levels of subsidies. One is designed for households belonging to the first quintile of the income distribution and the other for those in the second quintile.[4] The intensity of the subsidy

[4] The exception is the Metropolitan Region of Santiago where only one type of subsidy is defined. Also, as mentioned in footnote 2 there are two other beneficiary groups, the elderly and very vulnerable households, who receive subsidies according to alternative allocation rules.

(percentage of the water bill covered by the benefit) is higher for households in the first group. The number and intensity of the subsidy is further subdivided by tariff groups; that is, localities with the same tariff level. All these calculations (number of subsidies for each locality and the intensity of each subsidy) are made annually by the Ministry of Social Development and the Family (MDSF) and the necessary funding is included in the national budget law each year. Once approved, the financial resources are allocated to each regional government who in turn distribute them to each municipality.

Operationally, subsidies are awarded by municipalities based on the number of subsidies allocated to them and the socioeconomic score of applicant households. Once awarded, the benefit lasts for 3 years before a household has to re-apply. Water companies deduct the subsidy from beneficiary clients' monthly bills and then charge each municipality in its operational area to obtain a refund of these resources.[5]

There may be differences between what is calculated and budgeted annually at the national level and the number of actual subsidies awarded by municipalities. According to the water regulator (SISS), in 2021 and 2022, only 94.6 and 96.2% of the national budget was effectively spent on this program.[6]

Table 2 shows the number of water subsidies and the total budget per year between 2016 and 2022. It also shows the average subsidy per beneficiary per month. The subsidy has benefited 675 to 736 thousand households. This is approximately 12% of all households in the country.[7] The total expenditure on the program is slightly over 100 million dollars per year rising to 110 and 122 million in 2021 and 2022, respectively. The average benefit per beneficiary is close to 13 dollars per month.

The two final rows of Table 2 present information to gauge the importance of the program relative to the overall public sector budget and social spending specifically. In both dimensions the water subsidy is quite modest, representing around 5.5% of public spending on social subsidies and a very small fraction of the overall fiscal budget.

Table 2 | Number of beneficiaries and total budget by years 2016–2022

	2016	2017	2018	2019	2020	2021	2022
No. of beneficiaries	690,924	675,669	683,872	697,679	692,244	723,777	736,074
Annual subsidy expenditure (MM US$)	104.5	103.2	101.8	107.5	108.0	110.8	122.5
Average per beneficiary per month (US$)	12.6	12.7	12.4	12.8	13.0	12.8	13.9
% of fiscal budget	0.13%	0.12%	0.12%	0.12%	0.12%	0.10%	0.13%
% of total public subsidies	5.6%	5.3%	5.4%	5.5%	5.4%	5.3%	5.5%

Source: Own calculations based on information from SISS and DIPRES. Monetary figures were expressed first in Chilean pesos of 2022 and converted to US dollars using the average exchange rate for the 2016 to 2022 period (727.6 CLP per USD). Annual subsidy expenditure is the actual distributed amount, not the budgeted amount.

[5] More details of the history and administrative operation of the water subsidy can be found in Contreras *et al.* (2018) and Guernica Consultores (2017).

[6] Under spending on the subsidy is possible if aggregate calculations by the MDSF are not perfectly accurate or if target households do not apply for the benefit. The opposite, that more subsidies are awarded than those available each year is not possible. If a municipality has an excess demand for subsidies (net of those already awarded in previous years), it allocates them according to the socioeconomic rank of applicants on a first-come first-served basis.

[7] In 2017 there were 5,651,637 households in the country. See INE, Censo 2017, www.ine.gob.cl.

2.1. Targeting instrument

A key issue is how to determine whether a household is eligible for the benefit. That is, how to determine the socioeconomic condition of an applicant household. Until 2015, this was done using information gathered in an interview undertaken by municipal social workers at each applicant's dwelling and using a set questionnaire, the last of which was called the *Ficha de Protección Social* or FPS. When available, administrative records were also used to gather data on the household. A socioeconomic score was then calculated which was used to rank applicants.[8]

One problem with this approach was that it relied on self-reported information that could be manipulated for strategic reasons. When first introduced in the 1970s, the interview approach may have been effective as a targeting instrument as Chile was poorer and it was easier to determine the socioeconomic condition of a household. For example, living in a dwelling with a dirt floor – which was easily spotted by an interviewer – was a sufficient indicator of poverty. However, as the country grew and households became more affluent, better housing quality and universal ownership of durable goods (refrigerators, televisions, gas cookers and even cars) made the determination of socioeconomic conditions more challenging. The system increasingly relied on self-reported information – such as incomes, employment status and other relevant data – that could easily be misreported by applicants, reducing its effectiveness as a targeting instrument.

In 2016, the *Registro Social de Hogares* (RSH) was introduced to complement the FPS targeting approach. The RSH is a centralized information system run by the MDSF that consolidates administrative data from the tax service, health service, pension system, educational system, and the unemployment insurance institution, and that are relevant to the socioeconomic status of individuals and households. The introduction of the RSH has not completely displaced the interview approach since it is still a relevant source of information for some individuals; for example, those that work in the informal sector. However, the RSH has provided the welfare system with more reliable information to determine a household's socioeconomic condition. It is also easier to update without having to periodically interview households.[9] By August 2021, the RSH covered around 84.4% of the national population (MDSF, 2022).

One of the main hypotheses of the current paper is that the measured targeting properties of the water subsidy should have improved after the introduction of the RSH in 2016. Since previous research on this topic terminates in 2015 (Contreras *et al.*, 2018), we use data from the 2017 and 2022 household surveys to test this proposition.

Another aspect of the Chilean welfare system is that the socioeconomic ranking of households is not based on income per capita. Rather, an equivalence scale approach is used to normalize incomes that recognizes economies of scale in household size and the added financial burden imposed by having one or more family members with some type of disability.[10] A Socioeconomic Classification Index (CSE for its Spanish acronym) is then calculated as total household income divided by the equivalence scale. It is this index that is used to rank households by socioeconomic level and to determine eligibility for social benefits such as the water subsidy (MDSF, 2019).

Previous research on the incidence of the Chilean water subsidy used income per capita to rank households in the income distribution (Gómez-Lobo & Contreras, 2003; Contreras *et al.*, 2018). However, using the equivalence scale approach is a more rigorous methodology to determine relative household welfare (Blundell *et al.*, 1994; Deaton, 1997). In addition, it is the way socioeconomic ranking is undertaken in the Chilean welfare system. Therefore, it seems appropriate to estimate the incidence of the water subsidy scheme using the equivalence

[8] More details of this targeting instrument and its evolution through time can be found in Contreras *et al.* (2018).

[9] One interesting feature of the RSH is that households can register and update some of their information online.

[10] Income per capita implicitly uses the total number of household members as the equivalence scale. See Blundell *et al.* (1994) and Deaton (1997) for more details on equivalence scales.

scale approach. Below we present more details on the calculations of the CSE and test whether this makes a difference in the incidence analysis.

3. DATA

Following previous research on the Chilean water subsidy, we use the 2017 and 2022 waves of the CASEN household survey to update the incidence analysis. This survey is statistically representative at the regional and national level, and records the incomes, social benefits, demographic characteristics and other variables pertaining to the socioeconomic condition of households. Crucial for our research, it also records the (monthly) amount received from the water subsidy scheme. A zero value for this variable is taken as an indicator that the household does not receive this benefit.[11]

We use data from the 2015 survey as a benchmark. As shown in Contreras *et al.* (2018), using survey information from 1998 to 2015 reveals that the incidence of the water subsidy did not change much during that period, with a Gini coefficient of benefits close to 0.30. Therefore, using the 2015 data as a benchmark is sufficient for the purpose of this paper.

There was another CASEN survey undertaken in 2020 during the Covid-19 pandemic. However, this survey may not be comparable to the others. For one, reported incomes that year may be distorted due to the generous public income support that was given during this period. In addition, people were able to withdraw funds from their individual pension accounts, further distorting incomes. Finally, the 2020 survey was undertaken by telephone rather than face-to-face interviews. For these reasons, we do not use this wave of the survey in this paper.

Since the CASEN survey data is self-reported, there could be errors or biases in the recorded information giving rise to potential measurement error in our study. This is inevitable in any survey since there are cognitive, social and survey characteristics that may affect individuals' responses (Bound *et al.*, 2001). Therefore, we complement the survey information with administrative data pertaining to the water subsidy.[12]

Table 3 contrasts the administrative information with the survey data for each of the three waves used in this study. At the national level, the number of beneficiary households reported by the surveys is very similar to the administrative records. However, at the regional level there are differences. Following previous research (Contreras *et al.*, 2018) we assume that these differences are random and not systematically biased by income level. To make the survey data coincide with the administrative information, we multiply the subsidy amount received by each household by the ratio of the number of subsidies registered by administrative information to the number of beneficiaries accounted for in the survey for each region.

4. RESULTS

In this section, we present the incidence results using relative concentration curves and their associated Gini coefficient. These curves present the cumulative proportion of a variable (e.g. the monetary transfers) to the proportion of ranked values of another variable (e.g. income per capita of households). It is a common way to compare the targeting properties of a benefit or tax.

In our application, if the relative concentration curve is perfectly diagonal then the monetary transfer has a neutral targeting incidence. That is, the 20% lowest income households receive 20% of the benefit, the 40%

[11] The 2022 survey questionnaire is somewhat different. It includes two questions. One asking whether the household receives the water subsidy and another asking for the monthly amount of the benefit. There were some observations for this year that answered yes to the first question but did not register an amount answering the second question. For these observations, a subsidy amount was imputed using nearest neighbor matching per region. Details are available upon request.

[12] This information was gathered from the *Informes de Gestion* published by the sectoral regulator (SISS). See www.siss.gov.cl.

Table 3 | Number of subsidies reported in each survey versus administrative records by region and year

	2015			2017			2022		
Region	**CASEN**	**SISS**	**Ratio**	**CASEN**	**SISS**	**Ratio**	**CASEN**	**SISS**	**Ratio**
Antofagasta	28,680	41,792	0.69	35,209	32,959	1.07	36,857	41,215	0.89
Araucanía	62,005	58,465	1.06	51,120	55,894	0.91	66,805	60,755	1.10
Arica y Parinacota	9,904	16,543	0.60	9,458	15,860	0.60	15,637	16,544	0.95
Atacama	20,456	27,197	0.75	18,247	23,614	0.77	22,454	26,121	0.86
Aysén	11,436	10,170	1.12	10,484	9,489	1.10	11,488	10,415	1.10
Bíobio	128,664	122,191	1.05	86,447	86,647	1.00	90,712	94,783	0.96
Coquimbo	51,355	41,100	1.25	36,338	37,653	0.96	44,518	39,908	1.12
Los Lagos	41,898	39,745	1.05	37,674	36,269	1.04	43,316	40,000	1.08
Los Ríos	20,951	20,996	0.992	16,252	20,161	0.785	25,008	21,161	1.18
Magallanes	9,549	13,263	0.720	11,008	11,371	0.968	10,840	12,268	0.88
Maule	72,270	55,300	1.30	63,942	53,226	1.20	75,012	56,064	1.34
Metropolitana	107,752	129,618	0.83	113,598	120,057	0.95	93,465	127,996	0.73
Ñuble	-	-	-	30,160	28,043	1.08	36,444	29,920	1.22
O'higgins	40,535	32,500	1.25	35,885	30,564	1.17	38,830	34,774	1.12
Tarapacá	15,361	26,240	0.59	16,366	22,091	0.74	24,443	24,844	0.98
Valparaíso	93,359	99,820	0.94	89,998	91,771	0.98	92,765	99,306	0.93
Total	714,175	734,940	0.97	662,109	675,669	0.98	728,594	736,074	0.99

Source: Different waves of the CASEN survey and data from SISS. The Ñuble region was created in 2018 by splitting the Bíobio region. The number of subsidies was not recorded in the SISS data for this region in 2017, so the number was inferred based on the average value between 2019, 2020 and 2021.

lowest receive 40% of the benefit and so on. If the relative concentration curve is concave and above the diagonal (45° line) then the benefit is progressive in the sense that lower-income households receive proportionately more of the total monetary transfer compared to higher-income households. The more concave the relative concentration curve the higher the progressivity of the subsidy. This can be summarized with the Gini coefficient which measures the area between the concentration curve and the 45° line to the total area above the 45° line (negative area if the curve is below the diagonal line). This coefficient can take values between -1 and 1, with a positive value implying a progressive distribution.

We present the results sequentially. First, we estimate the incidence of the subsidy following the same approach of previous research (Contreras *et al.*, 2018). That is, we use income per capita to rank households in the income distribution. This will give some indication of the potential effect of the introduction of the RSH in 2016. Since subsidies are awarded for a 3-year period, we expect any improvement in the targeting properties of the subsidy to be gradual through time, with a larger effect in 2022 than in 2017. The second change is to omit unconnected households that are primarily in rural areas where it may be unrealistic to expect that they will eventually be connected to a piped water system. In other words, we analyze the impact of limiting the target population to those households that have a piped water connection (either in urban or rural areas). Third, we measure the additional impact on the incidence of the subsidy when we rank households according to their income normalized by an equivalence scale rather than income per capita. Finally, we examine the effects of including water tariffs to normalize income to better capture the stated aims of the program.

Since the incremental impact of the above four methodological innovations will depend on the order in which they are sequentially applied, we also present the Shapley value for each change. This allows us to summarize the relative contribution of each of the four considerations in changing the incidence results between 2015 and 2022.

4.1. Benchmark analysis updated to 2022

We begin by updating the incidence results up to 2022. For comparability with previous research, we assume the total number of households in the country as the target population and use household income per capita to rank households from poorest to richest. Any improvement in the incidence of the subsidy could potentially be attributed to the introduction of the RHS, although we cannot be certain since other changes may have occurred simultaneously during this period. We come back to this issue when discussing the results.

Table 4 presents a first approximation. It shows the percentage of the aggregate subsidy amount distributed by decile. The first three deciles (poorest) received a higher proportion of the total benefit in 2017 than in 2015 while the highest seven deciles received less. This is encouraging as it points to an improvement in the targeting incidence of the subsidy between those 2 years. By 2022, there is an additional increase in the proportion of the subsidy received by the poorest four deciles.

The last row of the table shows the Gini coefficient per year. Consistent with the share of the subsidy by decile, we see a marked improvement in this parameter. Whereas in 2015 it was 0.291, it increased to 0.317 in 2017 and then to 0.350 in 2022. Furthermore, the increase is gradual, with a higher coefficient in 2022 than in 2017. This is what we would expect if the improvement was due to the introduction of the RSH. Households who obtained the subsidy before 2016 can expect to have the benefit for 3 years without having to re-apply. Thus, a household that obtained the benefit in 2015 with the previous targeting mechanism would not be re-evaluated with the RSH until 2018.

Figure 1 shows the relative concentration curves of the total monetary amount distributed. The 2017 and 2022 curves are more concave and above the 2015 curve, indicating an improvement in the targeting of the benefit. However, it may be difficult to clearly see the difference in the curves across the income distribution. Therefore, in the Supplementary Material to this paper, we contrast these curves and show that both the 2017 and 2022 curves are statistically different from the 2015 curve at most points of the income distribution.

Table 4 | Proportion of total subsidy amount received by decile, 2015–2022

Decile	2015	2017	2022
1 (poorest)	16.0	16.6	18.1
2	15.7	17.2	17.5
3	14.5	15.8	15.8
4	14.1	13.4	14.2
5	11.9	11.2	10.9
6	10.1	9.6	9.5
7	7.8	7.6	7.2
8	5.7	4.9	4.5
9	3.3	3.0	1.9
10 (richest)	0.8	0.7	0.3
Gini coefficient	0.291	0.317	0.350

Source: Own calculations based on the CASEN surveys. Households ranked according to income per capita. Survey weights are used to calculate results.

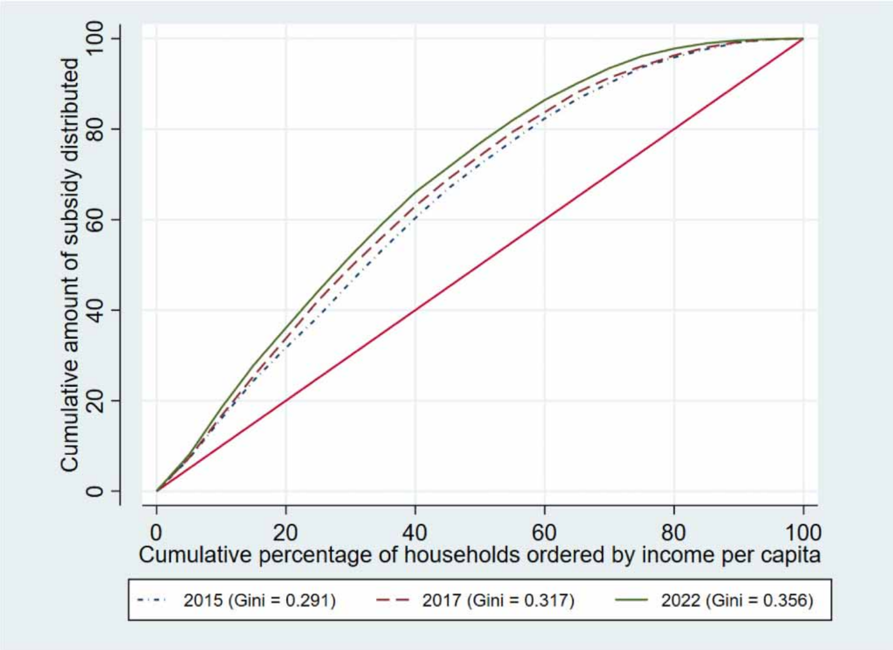


Figure 1 | Relative concentration curves (monetary transfers).

Figure 2 shows the concentration curves with respect to the number of beneficiaries, irrespective of the amount of the subsidy received by each one. The interpretation of these curves is that for a given centile of the income distribution, the vertical axis measures the percentage of the total number of beneficiaries that are below this ranking in the distribution. Thus, for example, for 2022 it indicates that close to 40% of beneficiaries were in the bottom 20% of the income distribution. Once again, the curves for 2017 and 2022 are more concave and above the curve for 2015, indicating an improvement in the targeting of the subsidy. This is also evidenced by the Gini coefficient of beneficiaries, rising from 0.301 in 2015 to 0.318 in 2017 and then 0.363 in 2022. In the Supplementary Material, we contrast the last curves and also conclude that the 2017 and 2022 curves are statistically different from the 2015 curve at most points of the income distribution.

These results indicate that there was an improvement in the targeting properties of the water subsidy between 2015 and 2022. The change from a Gini coefficient of 0.291 in 2015 to 0.350 in 2022 is quite noteworthy considering that the incidence of this benefit hardly changed between 1998 and 2015 (Contreras *et al.*, 2018). Although we cannot be certain that this improvement can be attributed to the introduction of the RSH, it is highly suggestive that this was the case. First, there was a gradual improvement between 2015 and 2022, as expected given that beneficiary households only need to re-apply for the benefit every 3 years. Second, we cannot identify any other change in the program or the Chilean welfare system that could explain the targeting improvement.

4.2. Excluding unconnected households from the target population

The above analysis does not consider that by design the water subsidy can only be given to households that have a piped water connection to their dwelling. Table 5 breaks down the number of households in the 2022 CASEN survey that are connected and unconnected to the water network and whether they were beneficiaries to the water subsidy or not. Almost all households who declared to have received the subsidy are also connected, as

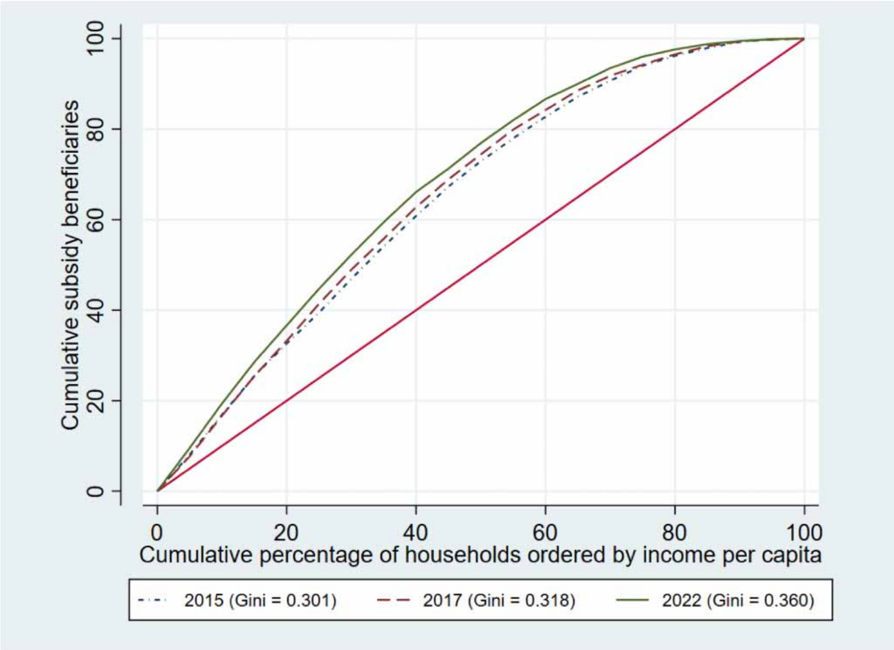


Figure 2 | Relative concentration curve (beneficiaries).

Table 5 | Households connected to a public piped water network, 2022

	Water network	
Beneficiary of water subsidy	**Not connected**	**Connected**
No	6.03%	83.59%
Yes	0.13%	10.30%
Total	6.16%	93.84%

Source: Own calculation using the 2022 CASEN survey.

is to be expected.[13] Table 6 in turn shows that of the 6.16% of unconnected households, 4.92% reside in rural areas.[14]

It can be argued that unconnected rural households are not part of the target population since they may reside in very low-density areas and cannot be economically connected to a public piped water system. There are other government programs that help rural households access potable water supply.[15] Therefore, poor rural

[13] The small percentage of beneficiary households (0.13%) that declared they did not have a connection must be erroneous, since it is not possible to receive the benefit if the dwelling is not connected to a piped water network.

[14] These figures are very similar for 2015 and 2017. In fact, in those years all unconnected households are in rural areas.

[15] The *Agua Potable Rural* or APR program is a public initiative to help rural communities develop communal water systems.

Table 6 | Households connected to the water network by area, 2022

	Water network		
	Not connected	**Connected**	
Zone	Rural	4.92%	6.47%
	Urban	1.24%	87.37%
	Total	6.16%	93.84%

Source: Own calculation using the 2022 CASEN survey.

unconnected households that do not receive the water subsidy should not be considered as a targeting error. We therefore omit unconnected households that do not receive the water subsidy from the analysis.[16]

Table 7 presents the results. The second column reproduces the 2015 benchmark estimates from Table 4. Excluding unconnected non-beneficiary households improves the targeting properties of the subsidy. The impact in 2015 is marginal, increasing the Gini coefficient from 0.291 to 0.308. However, the impact in 2017 and 2022 is larger. In the first case, the coefficient increases from 0.317 to 0.341, while in the second case, it increases from 0.356 to 0.373. Therefore, the potential effect of the RSH and omitting unconnected non-beneficiary households increases the Gini coefficient by 28% (0.373 compared to 0.291). Figures 3 and 4 present the distribution curves of monetary transfers and the number of beneficiaries, respectively.

Table 7 | Proportion of total subsidy amount received by decile omitting unconnected households that do not receive the subsidy, 2015–2022

Decile	**2015 Original**	**2015**	**2017**	**2022**
1 (poorest)	16.0	17.4	18.4	19.4
2	15.7	15.9	17.4	18.3
3	14.5	14.5	14.5	15.6
4	14.1	13.7	14.1	13.5
5	11.9	11.8	11.9	11.2
6	10.1	9.9	10.1	9.1
7	7.8	7.6	7.8	6.5
8	5.7	5.3	5.7	4.3
9	3.3	3.0	3.3	1.7
10 (richest)	0.8	0.8	0.9	0.3
Gini coefficient	0.291	0.308	0.341	0.373

Source: Own calculations based on the CASEN surveys. Households ranked according to income per capita. Survey weights used to calculate results.

[16] We still include those households that received the subsidy but declared to be unconnected to the piped water network.

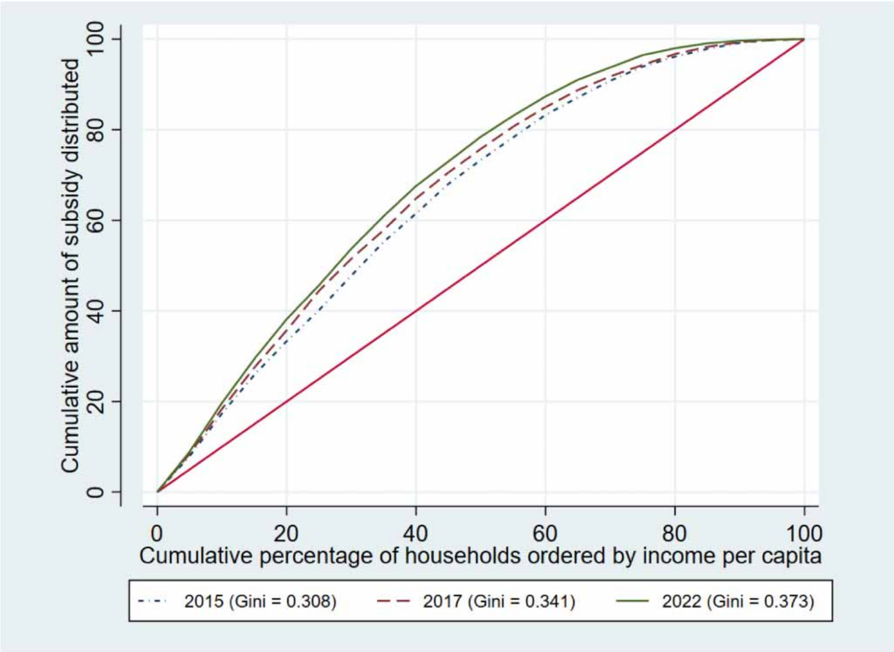


Figure 3 | Relative concentration curves (monetary transfers).

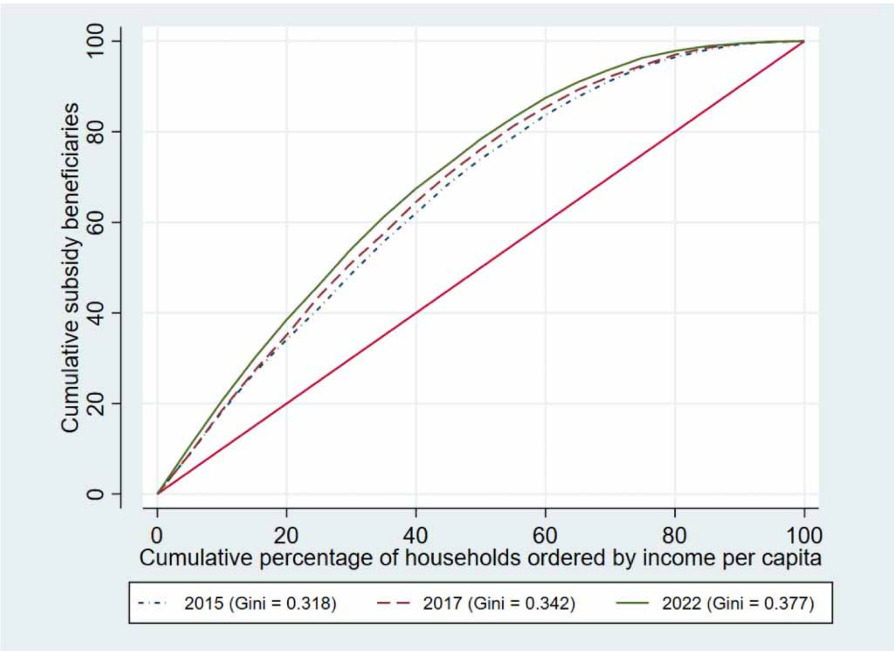


Figure 4 | Relative concentration curve (beneficiaries).

4.3. Introducing equivalence scales

As mentioned in Section 1, the Chilean welfare system does not rank households according to income per capita. Rather, it uses an equivalence scale to normalize total household income to determine socioeconomic status. Besides being in principle a better approach to gauge differences in household welfare (Blundell *et al.*, 1994; Deaton, 1997), it seems correct to determine the targeting properties of the subsidy using the same metric as used in the general welfare system.

The methodology used by the RSH is more involved (MDSF, 2019) but we can replicate the main features with the CASEN data. To this end, we use the following equivalence scale to normalize household income:

$$IN = N^{0,7} + Y_1 + Y_2 + Y_3 + \cdots + Y_N$$

where N is the number of household members. Implicitly this formula recognizes that there are economies of scale in household size. That is, expenditure increases less than proportionally with the number of people in a household. The Y_i variables are factors related to each household member indicating whether they have some type of disability or dependency. Table 8 gives the values depending on the age and disability/dependency of each household member for 2017.

Once the IN indicator is calculated, total household autonomous income is divided by this value to obtain a normalized household income measure:[17]

$$AI_1 = \frac{\text{Income}}{IN}$$

It is this last adjusted income measure that we now use to rank households in the income distribution. The results are shown in Figures 5 and 6 for monetary benefits and beneficiaries, respectively. These results exclude non-connected households so they are cumulative with respect to those of the last section. Since we have only calculated the equivalence scales for 2017 and 2022, the Gini coefficient for 2015 remains unchanged.

The results indicate that the targeting property of transfers improves even further, from a Gini of 0.341 to 0.354 in 2017 and from 0.373 to 0.391 in 2022. For beneficiaries, the equivalent improvements are from 0.342 to 0.374 in 2017 and from 0.377 to 0.408 in 2022.

4.4. Adjustment for tariff levels

As discussed in Section 2, the objective of the Chilean water subsidy scheme is to keep the water and sanitation bill below 5% of total household income. Therefore, besides incomes, tariffs are an important variable determining the number and amount of subsidies. In this section we make an adjustment to rank households not only by income but also by tariff levels.

To this end we further adjust the normalized income of the last section by the 20 m^3 monthly consumption bill in each household's supply area. Formally:

$$IA_2 = \frac{\text{Income}}{(20\,\text{m}^3\ \text{water bill}) \cdot IN}$$

Autonomous income is specific to the household while the bill for 20 m^3 of monthly consumption is specific to

[17] Implicitly the use of income per capita to rank households is equivalent to using an index *IN*=*N*.

Table 8 | Individual factor values for the calculation of equivalence scales, 2017

Age	Level of dependency or disability	Value
0–5	No disability	0.40
	With disability	0.60
6–14	No disability or dependency	0.29
	Mild disability	0.34
	Moderate disability or dependency	0.48
	Severe disability or dependency	0.60
15–17	No disability or dependency	0.11
	Mild disability	0.34
	Moderate disability or dependency	0.48
	Severe disability or dependency	0.60
18–59	No disability or dependency	0.00
	Mild disability	0.34
	Moderate disability or dependency	0.48
	Severe disability or dependency	0.60
60–74	No disability or dependency	0.60
	Mild disability	0.68
	Moderate disability or dependency	0.79
	Severe disability or dependency	0.98
75+	No disability or dependency	0.75
	Mild disability	0.77
	Moderate disability or dependency	0.79
	Severe disability or dependency	0.98

Source: Ministerio de Desarrollo Social y la Familia.

the residential location of the household. Implicitly, the above approach will rank two households with the same income and demographic characteristics differently, depending on the water tariffs in their local area. One way to interpret this is that we are ranking households in the income distribution according to how many 'bundles' of 20 m^3 of water services they can purchase with their normalized income.[18]

The bill assigned to each observation corresponds to the tariff level in the household's municipality of residence. In a few minor cases, there are different tariff zones within the same municipality. We were able to assign a tariff to 95.7% of observations in 2017 and 95.8% in 2022. For the remainder, we could not define the tariff since there were multiple tariff groups within the municipality. We opted to drop these observations in what follows.

[18] Calculating the adjusted income using a bill for 20 m^3 is arbitrary. However, since the volumetric charge for all water suppliers in Chile is constant for all levels of consumption (there are no rising-block tariffs) it would make no difference in the ranking if we use another consumption volume, say 15 m^3. The tariff structure does include a fixed charge, but they are small relative to the overall bill.

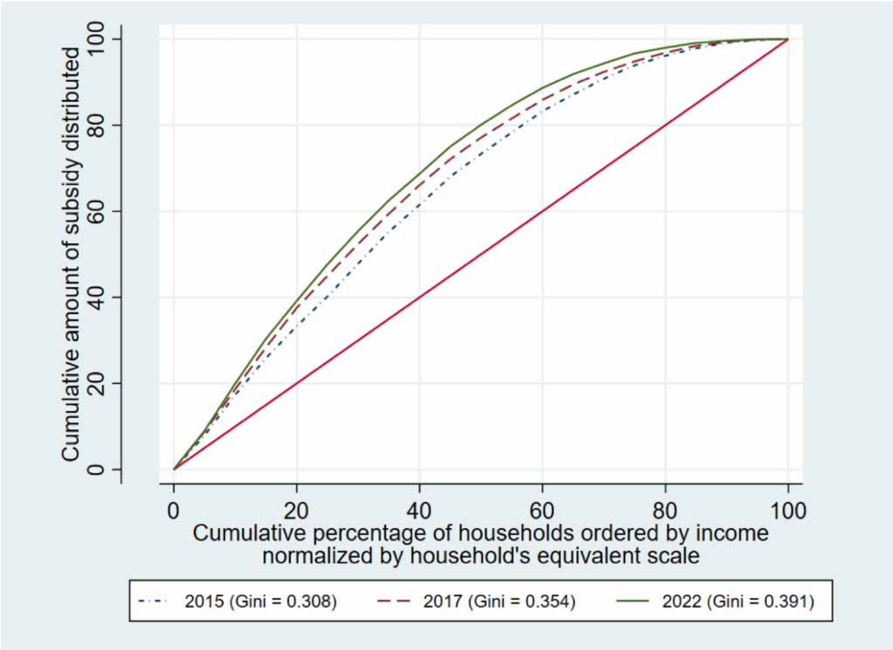


Figure 5 | Relative concentration curves of monetary transfers using equivalence scales.

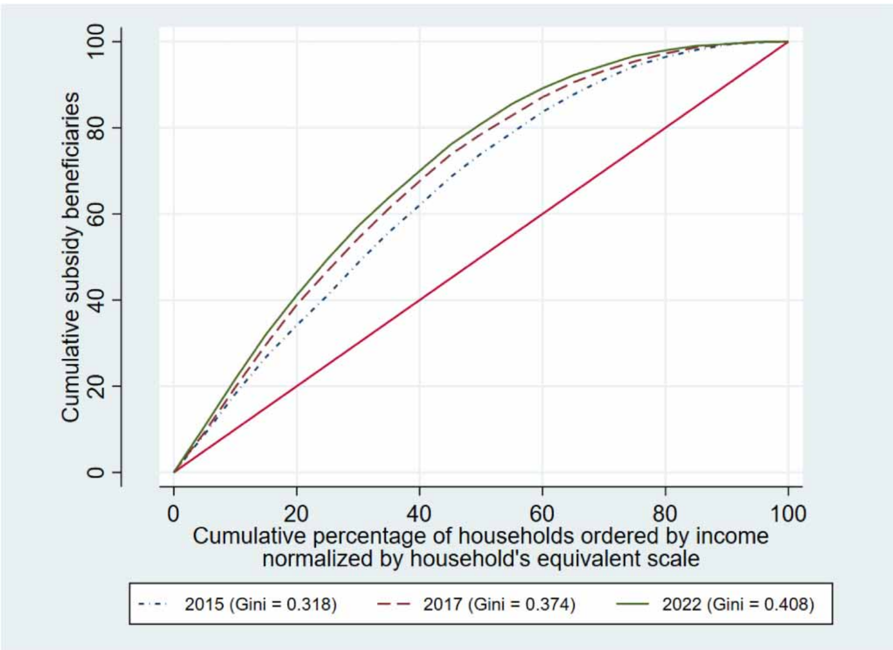


Figure 6 | Relative concentration curve of beneficiaries using equivalence scales.

The results are presented in Figures 7 and 8. From these, we can see that the Gini coefficient for monetary transfers increases to 0.436 in 2017 and to 0.470 in 2022. For beneficiaries the coefficients increase to 0.430 and 0.462 in each year, respectively.

These last results are quite impressive. From an initial estimate of the targeting properties of the subsidy of 0.291 for the Gini coefficient in 2015 (for monetary transfers), we obtained a final value of 0.470 in 2022. The results for the targeting properties in terms of beneficiaries are very similar.

5. SHAPLEY VALUE OF THE RELATIVE CONTRIBUTION OF EACH FACTOR

We have shown above that from an initial Gini coefficient value of 0.291 in 2015, we obtain a final Gini coefficient of 0.470. In this section, we present the relative importance of each change in the analysis in explaining the increase in the Gini coefficient.[19] There were four changes made:

1. The use of 2022 data, as a way to measure the impact of the introduction of the RSH as the new targeting instrument
2. The exclusion of unconnected households who did not receive a subsidy, since they are almost all rural households
3. The introduction of equivalent scales to normalize household income
4. The adjustment of relative incomes by the tariff level in each area

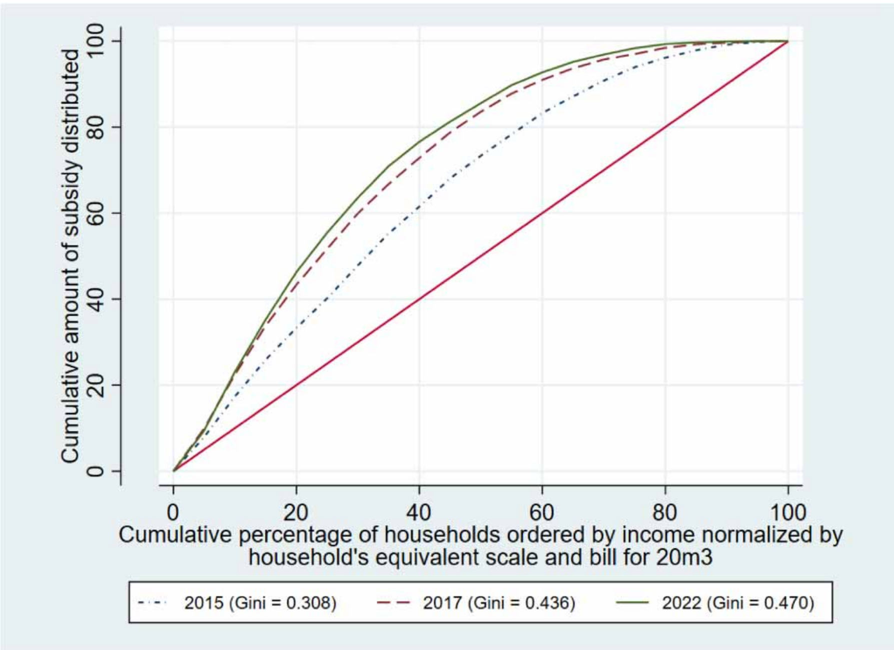


Figure 7 | Relative concentration curves of monetary transfers using equivalence scales and adjusting for tariff levels.

[19] Since the results using the number of beneficiaries are not very different from those using the subsidy transfers, this section is only concerned with this last variable.

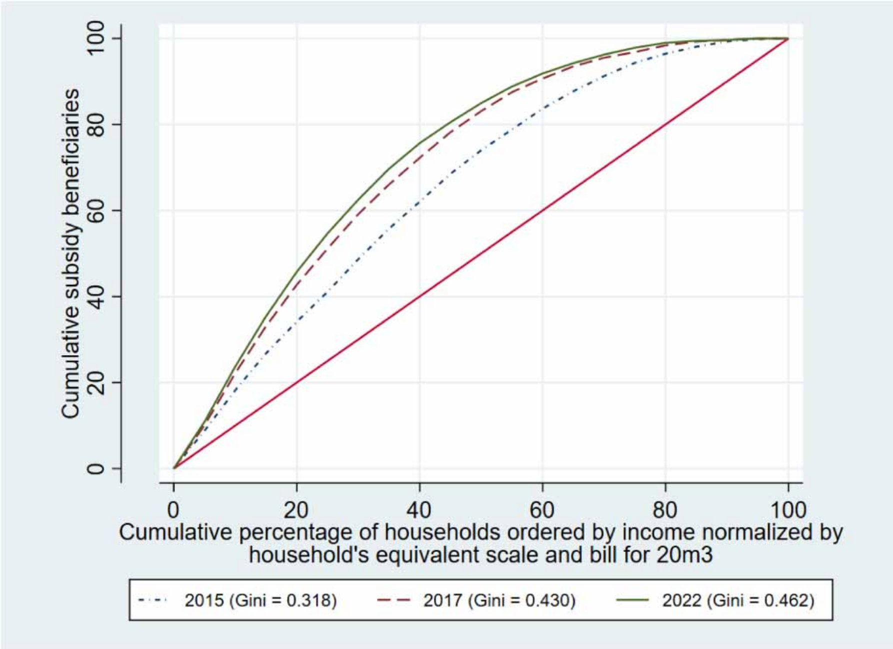


Figure 8 | Relative concentration curve of beneficiaries using equivalence scales and adjusting for tariff levels.

The impact of these four changes will depend on the order in which they are introduced in the analysis. For example, we could exclude unconnected households, introduce equivalence scales and tariffs, all using the 2015 data, and then use the 2022 data with all these changes. Or we can rearrange the order of the changes. The incremental effects of each will depend on the order in which they are applied.

Therefore, to obtain their relative importance we calculate the Shapley value of these modifications (Shapley, 1951). The Shapley value is a way to assign a 'fair' value to each economic agent in a joint production process given their relative incremental contribution. By 'fair' it is understood that the value assignment meets certain ex-ante axioms. For example, if a certain agent does not generate an incremental value, its value assignment is zero. In addition, the sum of assigned values should be exactly equal to the aggregate production value.

In practice, the Shapley value is calculated as the average incremental effect of each agent for all possible permutations of these agents. In our context, this implies calculating the Gini coefficient for the different possible permutations in the order in which the above four changes are introduced in the analysis and then taking the average of the incremental effect of each change.

Unfortunately, it was not possible to calculate the 2022 equivalent scale using the 2015 data. There are no variables in this last survey to determine the disability of household members. Thus, we calculate the Shapley value for the other three changes and add the impact of the equivalence scales at the end.

The results are shown in Table 9. The largest effect is due to the normalization of incomes using the tariff level faced by each household. This explains over 50% of the increase in the Gini coefficient. Next in importance is the impact of introducing the new targeting instrument (RSH). These two changes explain over 80% of the improvement in the targeting of benefits. Omitting unconnected households and using equivalence scales has a relatively small impact in the analysis.

Table 9 | Relative value of the four changes introduced in the analysis using the Shapley value

	Gini	Change	% of total change
Initial (2015)	0.291		
Change from new targeting instrument (RSH)		0.057	31.9
Change from dropping non-connected households		0.019	10.6
Change from normalizing by tariffs		0.090	50.1
Change from using equivalence scales		0.013	7.4
Final (2022)	0.470		100.0

Source: Own calculations. The change due to using equivalence scales is not a Shapley value but rather introduced at the end.

6. CONCLUSIONS

In this paper, we have shown that the distributive incidence of the Chilean water subsidy scheme improved after 2015, particularly so by 2022. We also make several changes to the incidence analysis used in previous research and find that these modifications further improve the targeting properties of this subsidy.

The improvement between 2015 and 2022 can be attributed to the change in the targeting instrument used to determine socioeconomic vulnerability in the Chilean welfare system. The new system introduced in 2016, called the *Registro Social de Hogares*, relies primarily on administrative data from various public and private institutions. Therefore, this information is more reliable compared to the self-reported information provided by household interviews used prior to 2016. It is interesting to note that between 1998 and 2015, there was hardly any improvement in the targeting incidence of the subsidy, despite several changes in the welfare instrument used (Contreras *et al.*, 2018). However, with the introduction of an information system based on administrative data, there is a measurable improvement in the targeting of the water subsidy.

This last result has important policy implications. The targeting of a means-tested subsidy will only be as good as the instrument used to determine the socioeconomic condition of an individual or household. If the instrument is deficient, then it is unlikely that its use will result in a well-targeted benefit. The Chilean experience indicates that using administrative information is more reliable than other forms of data to determine socioeconomic vulnerability. This is also something that Quiñones *et al.* (2021) recommend for improving the targeting properties of the public service subsidies in Colombia.

The other empirical innovations of this paper were to exclude unconnected households, use equivalence scales to rank households in the income distribution and adjust this ranking also for differences in the water tariff paid by each household.

As for the first change, in Chile almost all unconnected households reside in rural areas. Given the low population density in some of these areas, it is questionable whether they could be served by a piped public water network in the future. In addition, there are other government programs aimed at providing water supply for rural communities. Therefore, it seems reasonable to measure the performance of the water subsidy scheme using only connected households as the beneficiary population. However, this would probably not apply in the context of other countries in the region, where there is still a large gap in water connections in urban and semi-urban areas. In these cases, a water consumption subsidy to connected households is probably regressive given that it does not benefit the unconnected urban poor.

The second change was to use equivalence scales to normalize incomes before ranking households in the income distribution. Previous research on the Chilean water subsidy used households' income per capita. However, there are good reasons to use equivalence scales. First, in principle, it is a better way to compare welfare among households. Second, equivalence scales are used in the Chilean welfare system to determine the socioeconomic ranking of households and thus their eligibility to receive different social benefits. It seems reasonable then to use this same metric to evaluate the targeting properties of the water subsidy.

Finally, the last innovation we introduce is to further normalize household incomes by the water tariffs in each area. The motivation for this is that the explicit aim of the water subsidy scheme is to keep water bills below 5% of household incomes. Thus, a relatively richer household in a high-tariff area may be eligible for the subsidy while a lower-income household in a low-tariff area may not. Just using normalized incomes to rank households would attribute this last hypothetical case to a targeting error when in reality it is correctly targeted given the objectives of the subsidy.

Is it correct to adjust the analysis for the stated purpose of the scheme? This depends on the particular case under analysis. We would argue that if the stated objectives are explicit and they are reasonable from a welfare perspective, then they should be considered. The Chilean program meets these two criteria. The percentage of household income taken up by the water and sanitation bill is widely recognized as a valid affordability threshold for tariffs. Therefore, evaluating the targeting properties with respect to this explicit benchmark seems reasonable. However, this may not be true in other contexts. If it were the case that the explicit or implicit objective of a water subsidy in a particular city or country was to benefit all users, then from an equity and welfare perspective it may not be reasonable to accept this as a valid criterion to evaluate the scheme.

We find that the Gini coefficient for the distribution of monetary benefits of the Chilean subsidy scheme reaches a value of 0.470. This is significantly higher than the 0.291 value calculated for 2015 in previous research. The most important factors behind this improvement are the use of water tariff levels to normalize household incomes and the introduction of a better targeting instrument in the Chilean welfare system. These two factors account for over 80% of the increase in the Gini coefficient compared to earlier (2015) results.

The remaining targeting errors could be due to problems with the CASEN data, certain features of the scheme (such as conferring the benefit for a 3-year period before re-evaluation) or remaining errors with the targeting instrument and procedures. However, by international standards, the Chilean subsidy scheme is impressively well targeted. Over 75% of benefits accrue to the 40% of households in most need of this assistance. Furthermore, it is not realistic to expect perfect targeting of a real-world social benefit. Thus, the Chilean scheme remains an interesting experience and a benchmark for those countries that wish to improve the social and distributive impact of their water subsidy programs.

ACKNOWLEDGEMENTS

We thank Dante Contreras, Esteban Puentes and Ben Solis for very useful comments. The usual disclaimers apply.

DATA AVAILABILITY STATEMENT

All relevant data are available from an online repository or repositories. Casen surveys: https://observatorio.ministeriodesarrollosocial.gob.cl/encuesta-casen; SISS data: https://www.siss.gob.cl/.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

Andres, L., Thibert, M., Lombana Cordoba, C., Danilenko, A. V., Joseph, G. & Borja-Vega, C. (2019). *Doing More with Less: Smarter Subsidies for Water Supply and Sanitation*. Ed. by DC. The World Bank Washington. http://hdl.handle.net/10986/32277.

Blundell, R., Preston, I. & Walker, I. (1994). *The Measurement of Household Welfare*. Cambridge University Press, Cambridge, UK.

Bound, J., Brown, C. & Mathiowetz, N. (2001). Measurement error in survey data. In: *Handbook of Econometrics* (Heackman, J. J. & Leamer, E., eds.), Vol. 5. Elsevier, Amsterdam, pp. 3705–3843.

Contreras, D., Gómez-Lobo, A. & Palma, I. (2018). Revisiting the distributional impacts of water subsidy policy in Chile: A historical analysis from 1998–2015. *Water Policy 20*(6), 1208–1226.

Deaton, A. (1997). *The Analysis of Household Surveys, a Microeconomic Approach to Development Policy*. The John Hopkins University Press, Baltimore, MD.

Fuente, D., Gakii Gatua, J., Ikiara, M., Kabubo-Mariara, J., Mwaura, M. & Whittington, D. (2016). Water and sanitation service delivery, pricing, and the poor: An empirical estimate of subsidy incidence in Nairobi, Kenya. *Water Resources Research 52*(2), 4845–4862. doi: 10.1002/2015WRO18375.

Gómez-Lobo, A. & Contreras, D. (2003). Water subsidy policies: A comparison of the Chilean and Colombian Schemes. *The World Bank Economic Review 17*(3), 391–407.

Gómez-Lobo, A., Serebrisky, T., Sosa, B. S., Cárdenas, H., Martínez, M. O. G. & Antonio, S. A. H. (2023). Reducing leakage: Subsidies and tariff reform in water and sanitation services in Metropolitan Lima, Peru. *Water Economics and Policy 2350004*, 1–37. doi: 10.1142/S2382624X23500042.

Guernica Consultores (2017). *Evaluación de Impacto del Subsidio al Pago del Consumo de Agua Potable y Servicios de Alcantarillado y Tratamiento de Aguas Servidas*. Tech. rep., Dirección de Presupuesto, Ministerio de Hacienda, Chile. https://www.dipres.gob.cl/597/articles-163133_informe_final.pdf.

MDSF (2019). *Orientaciones al RSH No 8: Cálculo de la Calificación Socioeconómica*. Spanish. https://registrosocial.gob.cl/docs/Orientaciones-complementarias-N8_calculo-CSE_VF.pdf.

MDSF (2022). *Informe Final Panel de Expertos para Mejoras al Instrumento de Focalización*. Spanish. https://registrosocial.gob.cl/docs/220117_Informe_de_Comisi%C3%B3n_CSE_VF.pdf.

Quiñones, M., Martínez, L. M., Duque, J. C. & Mejía, O. (2021). A targeting policy for tackling inequality in the developing world: Lessons learned from the system of cross-subsidies to fund utilities in Colombia. *Cities 116*, 103306. doi: 10.1016/j.cities.2021.103306.

Shapley, L. S. (1951). Notes on the n-Person Game II: The value of an n-Person Game. In: *RAND Corporation*. RM-670.

First received 8 February 2024; accepted in revised form 19 June 2024. Available online 6 July 2024