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Public Investment for Sustainable Development in Chile

Building on the National Investment System

Ehtisham Ahmad
Hernan Viscarra

Institutions for Development Sector

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Contacts: Ehtisham Ahmad, seuahmad@gmail.com; Hernan Viscarra, hviscarra@iadb.org.

Abstract[*]

The Chilean National Investment System (Sistema Nacional de Inversiones, or SNI), is a model of consistent and transparent investment appraisal. However, the investment outcomes have exacerbated spatial and interpersonal inequalities, increasing informality, congestion, and pollution in metropolitan areas. This paper argues that the project selection methods used do not account for inequality aversion, congestion, and externalities. The manner in which funds are allocated to regions also has an impact on the outcomes. Using a generalization of the theory of reform and shadow prices by Drèze and Stern (1987), this paper presents a method to generate economy-wide shadow prices that can be linked to a desirable green growth strategy, as well as price and tax reforms to generate sustainable and inclusive investment outcomes. This can build on the strengths of the SNI method and investment management. The analysis includes a range of alternative estimates for critical economy-wide accounting ratios that could allow for a better linkage with sustainable growth.

Keywords: economy-wide shadow prices, national investment system of Chile, public investments, spatial and interpersonal inequalities, sustainable growth, tax reforms, urban hubs

[*] Ehtisham Ahmad is Senior Fellow at the University of Bonn and the London School of Economics and Pao Yu-Kong Professor at Zhejiang University. Hernan Viscarra is a consultant for the Inter-American Development Bank (IDB). The authors are grateful to Emilio Pineda and Axel Radics for their support, to Nicholas Stern for his review and discussion of issues in this paper, and to F. Cartes and Viviana Espinoza of the Chilean Ministry of Social Development for discussion.

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Acronyms

ARs	Accounting ratios
CIF	Cost, insurance, and freight
ECLAC	Economic Commission for Latin America and the Caribbean
ELES	Extended Linear Expenditure System
FNDR	National Fund for Regional Development (Fondo Nacional de Desarrollo Regional)
FOB	Free on board
LM	Little-Mirrlees
SNI	National Investment System (Sistema Nacional de Inversiones)
VAT	Value Added Tax

SNI and Its Effects

Chile's National Investment System (Sistema Nacional de Inversiones, or SNI) is based on a project appraisal system and parallel allocation of investment resources.[1] One of the sources of funding allocation is the National Fund for Regional Development (Fondo Nacional de Desarrollo Regional, or FNDR), which provides resources to regional governments. Others organizations and funds that provide resources to regional councils may take a political approach to selecting projects. However, the SNI facilitates a uniform approach to project selection throughout the country, apart from very small-scale projects; public investments must pass through the SNI filter. This mechanism ostensibly prevents abuse of the system and has been praised by international agencies, including The World Bank. In addition, one of the most systematic allocation mechanisms, the FNDR, is based on objective criteria to allocate resources based on multiple factors of need (e.g., the number of poor and female-headed households) as well as differential costs.

However, both the SNI and the FNDR have favored investment in metropolitan areas, or in mining, leading to growing dependence on primary exports (OECD, 2004). Indeed, while the magnitude of exports rose three-fold between 1995 and 2014, dependence on primary commodities did not change, and if anything, the potential linkages with the rest of the economy appear to have declined (Chart 1). Reduced linkages made the economy particularly vulnerable to a fall in demand, for example from Asia, which has been the case since 2014. Moreover, the net result of the investments was to enhance spatial inequalities, without making full use of Chile's abundant natural resources and human capital.[2]

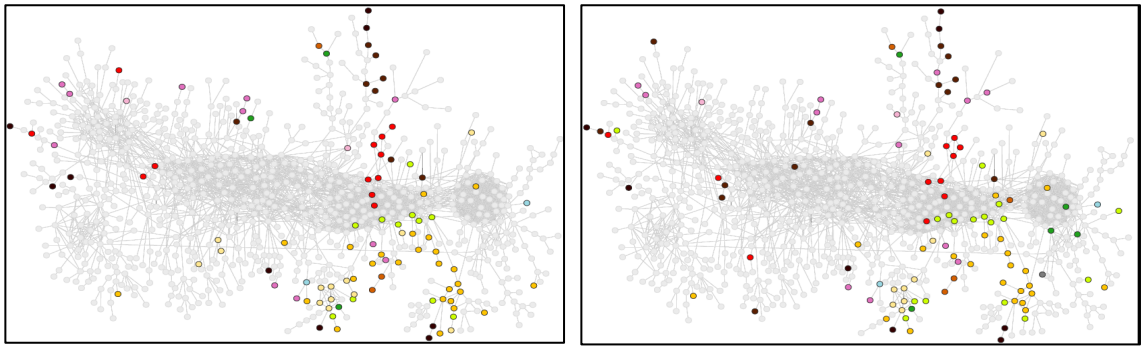
As discussed by Ahmad and Zanola (2015), the availability of employment opportunities in the metropolitan areas attracts migration from lagging regions, leading to expanding shanty towns. Given the funding formulas, the expanding population generates more FNDR resources for the relatively well-off metropolitan areas. The resulting interactions between public investments and effective service delivery continue to disadvantage less well-developed areas, and the expectation is that income gaps across regions, which are among the highest in Latin America, would continue to widen. Any possible "convergence" of GDP per capita is a result of slowing growth in the more advanced areas, given costs related to congestion, rather than accelerating activities in the poorer regions (Ahmad and Zanola, 2015). Increased spatial inequalities contribute to the "middle income trap" highlighted by Lagos (2013).

[1] The SNI is a set of norms, techniques, and procedures that govern public investment.

[2] The FNDR is an important way of redistributing resources to local jurisdictions in Chile; however, lagging regions received insufficient funding from the FNDR.

Chart 1: Chile—Complexity of Production and Exports

2014 (US$73.2B) **1995** (US$15.6B)



Legend by color:

Source: Atlas of Economic Complexity, Harvard University.

This paper examines how a modification of the SNI (and the associated FNDR) process could better reflect Chile's official Green Growth Strategy and possibly generate incentives to enhance economic and social convergence by stimulating sustainable growth in Chile's poorer regions. The modification would address issues associated with both the middle income trap and sustainable structural change. The authors focus on changing the simple SNI methodology into a more general and consistent approach based on an economy-wide shadow price system (Drèze and Stern, 1987). The economy-wide shadow price system is linked to the Green Growth Strategy, addresses spatial inequality, and focuses on developing sustainable urban hubs. The authors' modification would also include an appropriate policy framework to facilitate private investment and structural change.

The next section focuses on the positive and negative characteristics of the current SNI process. Then the analytics behind an economy-wide system of shadow prices are presented along with the associated directions for reforms to improve the welfare of all Chilean citizens. The following section provides some illustrations of the method for Chile. Some of the next steps are provided for developing more concrete proposals for Chile, and the need for complementary policy actions—particularly better local governance and effective service delivery for sustainable urban hubs. Finally, conclusions include lessons for other countries in Latin America and further afield, such as Indonesia and China.

Characteristics of SNI

Positive Characteristics

Chile's SNI has been praised by international organizations, such as The World Bank, as a public investment system that has managed to promote growth and maintain discipline by using standard and uniform evaluation methods (Ley, 2006). These are reputed to have prevented the manipulation of project selection criteria to favor particular regions (rent-seeking).

The SNI is administered jointly by the Ministry of Social Development and the Ministry of Finance. The former evaluates social projects mainly on the basis of cost–benefit analysis. Chile's Law Decree 20.530 mandates that the capital budget sent by the Ministry of Finance to Congress includes only projects assessed and approved by the SNI (Chile, 2016).

The SNI evaluates each project using the efficiency approach developed by Harberger (1976), Contreras (2004), and Vizzio (2000). The main policy goal is economic growth, and the project appraisal method does not consider distributional effects and territorial inequalities (Chile, 2015). This implies that redistribution has to be addressed using other policy tools that are beyond the scope of the chosen project appraisal method.

The SNI uses a simple cost–benefit approach, largely based on market prices (Table 1). It determines the market and non-market social benefits and costs of each program individually (partial equilibrium approach) using predefined conversion factors to calculate shadow prices, making some allowances for emissions and skills. The SNI assesses the overall viability of public interventions looking at the social value generated by its implementation. The social value is calculated as the net present value using a social discount rate, which was 6 percent in 2015 (though it was higher in the past at 8 percent in previous years and 12 percent earlier) and linked to expected private rates of return rather than the opportunity cost of raising public funds.[3]

Table 1: SNI Conversion Factors

Goods/Inputs	Conversion Factor
Social discount rate	6% per year (8% and 12% in previous years)
Exchange rate	1.01
Emissions ($C0_2$)	2.213 pesos per ton of equivalent carbon emission
Land	Market value (without any correction)
Domestic goods and inputs	Market value − VAT
Importable materials	(Market value − Duties) × currency conversion factor
Fuels	Depends on the type of fuel and vehicle
High-skill labor	Market value × factor of conversion for high-skilled labor (0.98)
Medium-skill labor	Market value × factor of conversion for medium-skill labor (0.68)
Low-skill labor	Market value × factor of conversion for low-skilled labor (0.62)
General expenses and profits	Market value − VAT

VAT = Value Added Tax
Source: Chile, 2015.

The SNI complements the economic analysis of projects using the cost-effectiveness method. The FNDR has been used to complement the SNI by ostensibly directing resources toward regions on the basis of objective criteria (but see Ahmad and Zanola, 2015, for a critique). The FNDR was expected to offset the regional biases caused by the SNI methodology, but in fact it tends to accentuate the biases given the large number of poor people in the metropolitan regions, which continue to attract migrants.

[3] Benefits tend to be higher and costs lower in areas with more beneficiaries. Normally, the costs are higher in less populated areas due to poor connectivity and relatively sparse populations (Chile, 2015).

Some Lacunae

The SNI has relied on the FNDR and other sources of funds to address interpersonal and spatial equality concerns. However spatial inequalities, congestion, and pollution in metropolitan areas are increasing concerns (Ahmad and Zanola, 2015).

The efficiency approach used by the SNI favors projects that generate higher profits and does not include inequality aversion parameters in the appraisal formulas. Implicitly, the SNI method uses an inequality aversion parameter of 0, which values an additional peso to the poorest as equal to a peso to the richest household. This immediately generates a bias toward regions with the lowest cost—and these happen to be the coastal metropolitan areas. The labor market and investment dynamics create more congestion and pollution in the metropolitan areas, as well as spatial inequalities.

A project-by-project appraisal approach is used. This is likely to fail to build on the preconditions needed for new sustainable hubs. The case of Chiloé Island illustrates the issues well. This large island off the southern coast of Chile has a temperate climate and natural harbors. With the decline of the whaling and railway tile industries, there has been significant out-migration over the past century. A bridge to the mainland over the Chacao Channel was proposed in 1972, but not initiated until the administration of Ricardo Lagos in 2000. It was cancelled in 2006, only to be revived in 2012.

While it is clear that the Chilean authorities see Chiloé Island as a potential hub that could open up and revitalize the lagging southern region, public investment in ports and other facilities on the island is not feasible without the bridge to the mainland. And the latter is unlikely to be economical without the complementary investment on infrastructure on the island. Further, the private investment needed to drive sustainable development will not occur without ramping up public services (e.g., education, health care, water supply, and electricity) to attract the requisite skills and workers. Without the complementary public investment on the island and local public services, establishing the Chaco Channel Bridge, at a cost of over US$750 million, may only achieve faster out-migration, rather than a sustainable hub for Chile's southern region.

Complementary local investments (spokes to the hubs) and effective service delivery are a function of local own-source revenues as a means to ensure appropriate choices and efficient management. Such revenues need to be accompanied by an equalization framework so that the regions with poor revenue bases and higher costs are not disadvantaged relative to the metropolitan areas. In other words, Chiloé Island needs to be able to provide similar levels of public service at similar levels of tax effort (Ahmad, Letelier, and Ormeño, 2015) in order to attract labor and investment from the least-cost areas.

Own-source revenues are also needed to anchor any access to credit needed for efficient intertemporal allocation of resources for local investments. In addition, the local tax agenda is critical in discouraging activities and emissions that might damage the

island's delicate ecological balance. Thus, a package approach is needed for a sustainable investment agenda in new hubs.

Further, when the marginal social cost of public funds is at historical lows, using a real rate of return of 6 or 8 percent (reduced recently from 12 percent) as a cut-off criterion would create a bias toward projects with high private returns—again largely in the metropolitan areas. Using the true marginal social cost of public funds, which is likely to have been very much lower than the rates of return chosen by SNI, would affect financing, especially for long-gestation public sector investments. The Chacao Channel Bridge is an example of how using private cost–benefit analysis could lead to cancelling a project that might be acceptable under social cost benefit approach.

Despite having a rigorous and impartial method to establish the social profitability of every project, the SNI's partial analysis cannot be used to reflect more general effects of public interventions in the economy. Partial equilibrium or individual-based approaches fail to include effective taxes, cumulative cross-sector effects, inequality, and environmental concerns in the welfare function of individuals affected by variations in public supply.[4]

Consequences of the Current SNI Model and Investment Allocations

The consequence of ignoring distributional concerns is concentration of investment in metropolitan areas, with negative implications for more efficient use of regional comparative advantages relating to natural resources and labor. As argued in Ahmad and Zanola (2015), far from offsetting the SNI's absence of distributional criteria, the FNDR exacerbates the trend toward spatial inequalities, despite its use of seemingly objective criteria. Thus, a comprehensive approach to sustainable development is necessary to build on the existing sound foundations of a common approach to project appraisal and selection.

An Integrated Model for Sustainable Development

In this section, we apply the more general framework of Drèze and Stern (1987) to derive economy-wide shadow prices for Chile. The model is not fully determined and a range of shadow prices arise as a result of assumptions about the treatment of sectors. Consequently, it is essential to place the calculations in the context of a sustainable development strategy (e.g., Chile's Green Growth Strategy, which was adopted during the preceding administration, but ratified by the Bachelet government).

This general approach overcomes the constraints of the project-specific method used by the SNI to assess public interventions. The use of economy-wide shadow prices allows the general effects of public interventions to be assessed, shedding light on the sectors

[4] According "Actual Social Prices 2015" published by Chile's Ministry of Social Development, most of the products on the domestic markets are subject to taxes and subsidies. Moreover, basic inputs such as the labor force, petroleum products, and diesel also have to be adjusted using conversion factors.

more suitable for reforms, taking into account effects on households, producers, and government. In contrast, the SNI (see Table 1 above) uses ad-hoc social prices and methods for each sector.[5]

However, after these benefits are estimated, they can also be incorporated in the economy-wide system. One of the main challenges is the proper inclusion of economies of scale effects in determining costs. The production relationships among produced inputs and outputs were assumed to be fixed, which depicts a fixed technology to combine factors and inputs in certain industries. A more dynamic approach needs to be addressed in further research.

Generate Accounting Ratios—Generalizations of Little and Mirrlees

Following Drèze and Stern (1987), the government needs to assess projects based on preferences among different states of the economy reflecting valuations of environmental costs, as well as distributional characteristics. The decisions are made based on maximizing a welfare function subject to market clearing restrictions and evaluated at shadow prices. The planners' objective function (V) takes the Bergson-Samuelson form, and the social welfare function depends on household consumption levels. Consumption is a function of prices, income, taxes, and demand and supply constraints. Therefore, the aggregated utility of any project is calculated as the welfare-weighted sum of individuals' marginal willingness to pay for the project. The objective function can be more general and include a variety of objectives that reflect the government's perspectives, say, on environmental damage.

$$\begin{aligned} &Max\, V(s,w) \\ &subject\ to\ E(s,w) = z \end{aligned} \tag{1}$$

$V(s,w)$ is the social welfare function, which depends on endogenous variables (s) and exogenous variables (w). Under certain conditions, maximization can be solved using the Lagrangian method:

$$L(s,w) = V(s,w) - v'[E(s,w) - z] \tag{2}$$

In the Lagrangian equation, v' represents the shadow price or the increase in the value of social welfare function when an extra unit of public output is available (the social opportunity cost). The first order conditions to maximize the function imply that the net effect on welfare due to variations in (s) or (w) includes the costs related to changes in demand evaluated at shadow prices.

$$dV = \frac{\partial V}{\partial w}dw + \frac{\partial V}{\partial s}ds = \left[\frac{\partial V}{\partial w} - v'\frac{\partial E}{\partial w}\right]dw \tag{3}$$

[5] One of the advantages of using the SNI method is the possibility of incorporating non-market benefits and costs, which are project specific, using revealed or stated willingness to pay methods in the analysis.

Once the vector of responses is defined, it is possible to assess how private agents would respond (which is reflected in changes in net demand and supply) and the consequent effects on their utility function. In general, the model estimation is subject to two types of constraints. First, scarcity constraints require the economy to be in equilibrium (matching supply and demand). Second, side constraints include any other limitations.

The shadow cost, $v' \frac{\partial E}{\partial w}$ of the extra demand can also be represented as the difference between $p'y$ (actual profits) and $q'x$ (household expenditures), which represents government tax revenues (R_v). The shadow cost may be rewritten as $-'R=R_v$.

$$dV = \left[\frac{\partial V}{\partial w} + \frac{\partial R_v}{\partial w}\right] dw \tag{4}$$

Therefore, the total effect on welfare can be seen as the direct change in welfare plus the change in shadow revenue, representing the general equilibrium adjustments associated with the reform. This method can be used in a broad set of applications, and for this case, including tax reforms as shown by Ahmad and Stern (1984). In this particular case, changes in w would be represented as changes in a vector t or taxes on goods.

$$dV = \left[\frac{\partial V}{\partial t} - v' \frac{\partial x}{\partial t}\right] dt \tag{5}$$

Considering derivatives hold lump-sum incomes constant, and that $q=p-t$, and assuming that producer prices are proportional to shadow prices equation (5) can be rewritten as:

$$dV = \left[\frac{\partial V}{\partial t} - \gamma \frac{\partial}{\partial t}(t'x)\right] dt \tag{6}$$

$$\frac{\partial V}{\partial t} - \gamma \frac{\partial}{\partial t}(t'x) > 0 \tag{7}$$

If equation (7) is greater than 0, social welfare is increased by raising the i^{th} tax or increasing its price. Declines in social welfare are offset by the extra revenue raised.

The value of γ can be used to identify directions of reform.

$$\gamma_i = -\frac{\frac{\delta V}{\delta t_i}}{\frac{\delta R}{\delta i_i}} \tag{8}$$

$\frac{\delta V}{\delta t_i} = -\sum_h \beta^h x_i^h$, where β^h represents the social marginal utility of income for households, and x_i is demand for commodity i by household h, and $\frac{\delta R}{\delta i_i} = -\sum v_j \frac{\delta x_i}{\delta t_i}$ can

be represented as variations in consumption due to changes in taxes or public supplies at shadow prices.

This method has the advantage of incorporating the degree of inequality aversion in the welfare function by assigning different weights to the additional consumption by groups at different levels of income. A high degree of interpersonal inequality aversion is also expected to favor lagging regions. The effects of a project on the welfare function depend on the social marginal utility of household expenditures and the demand for each commodity by households.

While there are several ways to estimate the welfare weights, this proposal uses the method proposed by Ahmad and Stern (1984). The welfare weights are normalized to the welfare weight for the poorest household (unity) and adjusted by an inequality aversion parameter so that a marginal expenditure by the rich is less valuable than that by the poor.

$$\beta^h = (\frac{I^1}{I^h})^e \qquad (9)$$

$I^h$is the per-capita expenditure of the h^{th} household and I^1 is the normalized welfare weight of the poorest household. Therefore, β^h represents the marginal social value of a unit of expenditure to household h relative to household 1. The parameter e represents the Atkinson inequality aversion parameter, where $e=0$ implies that a unit of income to the richest is seen as equivalent to a unit received by the poorest; $e=1$ indicates that, if $I^h$is twice I^1, then a marginal unit to h is worth half that to household 1, and so forth.

Applying Drèze and Stern (1987) and the related theory of reform enunciated by Ahmad and Stern (1984, 1991) requires:

- Market prices to be converted to the shadow prices needed to assess sectoral social profitability. The method extends that based on Little and Mirrlees (1974) (for details of the methodology see Appendix 1).

  and

- The corresponding changes in taxes/relative prices that might be needed to generate and support welfare-improving structural reforms to be evaluated using the additional estimation of household responses.

Direction of Reform Reflecting Effective Prices and Different Levels of Inequality Aversion

The Ahmad and Stern (1984, 1991) and Drèze and Stern (1987) methods permit different scenarios using different inequality aversion parameters. The shadow prices also permit a set of additional objectives linked, for example, to a sustainable development agenda. The results of this general approach can be compared with an

extension of the SNI scenario (or a simplified LM method), with zero inequality-aversion and absence of inter-industry effects.

The accounting ratios calculated to incorporate inequality aversion parameters given by equation (9) and the cross-industry effects by using economy-wide shadow prices generate a new pattern of public investment allocations. Accounting ratios linked to the development agenda, and estimated taking into account general effects on the economy, should favor economic convergence and sustainable growth. In addition, economy-wide accounting ratios should provide directions for tax reform, giving policymakers a tool that links government revenues and the effects of consumption and production patterns, and generates incentives for good governance. The economy wide shadow prices also requires an equalization transfer framework to facilitate effective local service delivery in the new growth hubs.

Some Illustrations for Chile

The data used to estimate shadow prices and associated tax reforms were the 2008 input-output matrix and the Household Budget Survey. The input-output matrix was used to calculate the economy-wide shadow prices and the survey to estimate household demand responses and welfare-improving directions of associated tax reforms.

The 2008 input-output matrix was provided by the Central Bank of Chile. It was composed of 111 sectors and the values were expressed as basic prices.[6] The input-output matrix included the intermediate production and the final consumption values. Import values and duties were separated by industry in a different row, and the total value of each activity was decomposed into net taxes, payments to labor, and profits. The matrix also incorporated the net taxes paid for products in a separate row.

In Chile, the main indirect taxes are the VAT, import duties, fuel taxes, and the tobacco tax. The income tax and VAT represent the largest proportion of government income.[7] In this analysis, only the non-deductible VAT, which is paid by the final consumers, was taken into account. It was calculated using the supply and demand tables expressed as consumer and producer prices.

The 2006–07 Household Budget Survey was used to calculate demand responses. This survey was composed of all the household expenses at purchaser prices in the previous two weeks. The classifications of expenses in the survey were: individual (high- and low-frequency purchases), self-supply goods, household goods and services, financial

[6] Basic prices do not include taxes, producer prices include the net taxes (taxes−subsidies), and consumer prices include the commercial margins and the VAT.

[7] According to ECLAC (2013), revenue from indirect taxes accounted for 9.8 percent of GDP, including only the Central Government; the VAT (taxes on general and specific goods and services) accounted for 9.5 percent; and taxes on commerce and international transactions were 0.2 percent.

expenses, and insurance expenses.[8] The non-frequent expenses were retrieved by directly asking the head of the household. The reference periods for these goods were three, six, and twelve months. This survey has national sampling representation, including the metropolitan area of Santiago and the regional capitals.

Estimation of Economy-Wide Shadow Prices

The first step was to group the input-output matrix into 45 sectors to calculate the accounting ratios. For the demand analysis, only sectors that entered into final consumption were used to match with the Budget Income Survey, as these already incorporate the inter-industry effects. This amounted to 40 categories.[9]

To estimate the shadow prices using the LM method, the input-output groups were classified into tradable and non-tradable sectors. This categorization presented several difficulties. Although each group was classified either as a tradable or non-tradable sector, they were composed of a mixture of tradable and non-tradable goods. In addition, market restrictions and domestic trade policies can affect the free movement of products. Even though some sectors are export-oriented, quota restrictions, taxes, and other regulations make them behave as non-tradable.[10]

Table 2: Number of Sectors Treated*

	Import	Export	Non-traded	Total Sectors
Case 1	8	5	27	40
Case 2	5	4	31	40
Case 3	3	15	22	40

*For more details see Appendix 3.

Source: Authors' elaboration.

A simple strategy was used to classify each group as tradable or non-tradable using commerce indicators: imports to GDP, and imports plus exports to GDP. Therefore, groups that were mainly export-oriented according to these indicators were classified as tradable. Within tradable products, a similar criterion was implemented to classify

[8] The database does not distinguish between payments made in cash or by using credit cards. For those expenses paid using credit cards, the price value was registered as if the total amount were paid at the moment the survey was held. The expenses related to assets such as houses or valuable objects, the rents paid by households, domestic services, and payments for insurance, and donations were also included in the survey. Data was collected over 15 days. The Institute of Statistics provided a notebook in which the household head filled out the expenditures each day.

[9] See Appendix 2.

[10] As a reference, in 2014, the main exports were metals (30.3 percent of total exports), minerals (26 percent), vegetables (9.2 percent), animal products (8 percent), wood (7.9 percent), food products (5.6 percent), and chemicals (4 percent). The main imports were machinery and electricity (21.6 percent), fuels (21.2 percent), transportation (12.8 percent), chemicals (8.4 percent), textiles and clothing (5.8 percent), plastic and rubber (5.5 percent). In 2013, Chile applied a flat tariff of 6 percent to all products. After reviewing the trade information from The World Bank, IDB, and other sources, the authors did not find restrictions on exports in any sector of the economy. Exports are zero-rated for the VAT.

between import and export goods; however, the classification could be somewhat arbitrary. Therefore, the analysis considered three different classification scenarios. For all three cases, services were treated as non-tradable (see Appendix 3) .

Import shadow prices were exogenously determined using the CIF (cost, insurance, and freight) prices found in the input-output matrix. The estimation of the export and non-tradable sectors' shadow prices were endogenously determined by a system of non-linear equations. As explained in the previous section, non-tradable shadow prices required the valuation of the added-value components. The input-output matrix included the profits and labor added value for each sector. The profit component was disaggregated into land and capital added value. The former used the assumptions made in Ahmad, Coady, and Stern (1987) using a weight of 0.4 for those sectors considered land-intensive and 0 for the others. The proportion of capital was calculated with the investment matrix database provided by the Central Bank of Chile. The residual was assumed to be transfers.

Once the total added value was disaggregated into land, labor, capital, and profits, shadow prices were estimated using the simple LM extension of the SNI conversion factors. The land accounting ratio was considered equal to the market value without any correction (conversion factor of 1). For labor, the market value was multiplied by a conversion factor depending on the skill level. The capital and residual social values were estimated subtracting VAT from the market price.[11]

For the sensitivity analysis, we used the variation in the conversion factor proposed by Ahmad et al. (1987) in the study developed for Pakistan, and Coady, Flores, and Seade (1988) for Mexico. The conversion factor for land was considered 1 throughout. For labor, we used variations of +/−0.25 from the conversion factors provided by the SNI with an upper bound of 1. For capital, they used a factor of 0.81 as suggested by the SNI, and alternative scenarios of 0.5 and 0.25 as suggested by Ahmad et al. (1987). Finally, for residuals, the conversion factors were considered transfer payments with no social cost, and therefore were valued as 0.[12]

The next step was to construct a non-linear system of equations to estimate the accounting prices for exports and non-tradable goods.[13] The accounting ratios for

[11] The currency conversion factor was applied to all the values using the value provided by the Ministry of Social Development of Chile. The conversion factor for labor was applied considering the level of qualification, taking into account the SNI parameters, and the social profits and capital conversion factors were based on the VAT value, which is 19 percent (market value−VAT). The VAT has a single rate and has almost no exclusions.

[12] By definition, shadow prices are the social marginal cost. In the model, marginal and average costs are equal.

[13] As explained in equation (20), the export accounting ratio equations include the margin costs evaluated at shadow prices as an unknown parameter. For the non-tradable-goods equations, the unknown parameters were the accounting ratios for non-tradable and tradable inputs and the added value transformed to shadow prices. The input-output relationships between products were defined by the technical coefficients a_{ij} of the input-output matrix.

imports were less than but very close to 1 in all sectors (Table 3). The exports ratios were close to 1 for all groups except fruits (0.54), where the distortion was significant.[14] In general, we expected accounting ratios close to 1 for products with small net taxes.

The accounting ratios for non-tradable products ranged between 0.21 and 1.05. Most of the ratios were lower than 1 (except dairy products and education). Financial services, construction, commerce, entertainment, and services to companies exhibited the lowest ratios. Conversely, basic public services, electricity, and rents exhibited the highest ratios.

All else being equal, the non-traded sectors with high positive (negative) residuals will exhibit low (high) accounting ratios. The negative residuals can be attributed to relatively high social input costs compared to the value of output. For example, electricity (1.051) exhibits no social profits, which might be attributed to the high costs (capital and fuels) or the subsidies received by the electricity sector (generation of electricity specifically). In the case of tobacco (0.46), the social cost of inputs (mainly labor) was much lower than the total value generated.

In general, the added-value decomposition analysis showed that non-tradable groups relied relatively more on labor than on capital, especially in the service sectors such as transportation, financial services, education, and medical and health services. The accounting ratios of non-tradable sectors such as electricity and rents varied more with changes to capital conversion factors.[15] As shown in Table 3, the sectors classified as "import categories" did not experience changes in their ratios because the shadow prices depend only on CIF prices. The ratios for the exportable sectors experienced slight variations due to changes in the transportation accounting ratio, which was classified as a non-tradable group for all cases.

Table 3: Accounting Ratios, Sensitivity Analysis

Groups	Class	K=0.81			K=0.5			K=0.25		
		L=0.37 M=0.40 H=0.70	L=0.62 M=0.68 H=0.98	L=0.87 M=0.90 H=1.00	L=0.37 M=0.4 H=0.7	L=0.62 M=0.68 H=0.98	L=0.87 M=0.90 H=1.00	L=0.37 M=0.40 H=0.70	L=0.62 M=0.68 H=0.98	L=0.87 M=0.93 H=1.00
Flour, pasta, cereals	IM	0.986	0.986	0.986	0.986	0.986	0.986	0.986	0.986	0.986
Vegetables	EX	0.934	0.929	0.929	0.935	0.931	0.93	0.936	0.932	0.932
Fruits	EX	0.541	0.538	0.537	0.542	0.539	0.539	0.543	0.54	0.539
Meats, sausages	IM	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988	0.988
Dairy products, cheese, eggs	NT	0.988	1.134	1.208	0.954	1.074	1.174	0.927	1.047	1.147
Edible oils, fats	IM	0.987	0.987	0.987	0.987	0.987	0.987	0.987	0.987	0.987
Fish, crustaceans, mollusks	EX	0.985	0.982	0.981	0.986	0.983	0.982	0.987	0.984	0.983
Animal feed	NT	0.635	0.755	0.86	0.611	0.73	0.836	0.591	0.711	0.816
Fuels	IM	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991	0.991
Other food products	IM	0.977	0.977	0.977	0.977	0.977	0.977	0.977	0.977	0.977

[14] The export market price is evaluated at producer prices, which do not include taxes, and the shadow price is the border price minus the trade and margins social price.

[15] The labor conversion factor depends on market conditions, presenting higher (lower) values in tighter (more abundant) labor supply, which is reflected in the underlying social opportunity cost.

Groups	Class	K=0.81			K=0.5			K=0.25		
		L=0.37 M=0.40 H=0.70	L=0.62 M=0.68 H=0.98	L=0.87 M=0.90 H=1.00	L=0.37 M=0.4 H=0.7	L=0.62 M=0.68 H=0.98	L=0.87 M=0.90 H=1.00	L=0.37 M=0.40 H=0.70	L=0.62 M=0.68 H=0.98	L=0.87 M=0.93 H=1.00
Liquor**	EX	0.961	0.953	0.952	0.965	0.956	0.955	0.967	0.958	0.957
Non-alcoholic beverages (c)	NT	0.550	0.661	0.682	0.513	0.625	0.645	0.484	0.595	0.616
Tobacco	NT	0.464	0.556	0.585	0.437	0.529	0.558	0.415	0.507	0.536
Textiles, clothing, footwear	IM	0.982	0.982	0.982	0.982	0.982	0.982	0.982	0.982	0.982
Material for conservation, repair of dwelling	IM	0.949	0.949	0.949	0.949	0.949	0.949	0.949	0.949	0.949
Stationery, office supplies	EX	0.975	0.969	0.968	0.977	0.971	0.97	0.978	0.973	0.972
Printing, publishing	NT	0.653	0.846	1.014	0.63	0.823	0.991	0.611	0.805	0.973
Pharmaceutical products	NT	0.678	0.856	0.888	0.652	0.829	0.861	0.631	0.808	0.84
Toiletries, cosmetics	NT	0.847	1.064	1.098	0.827	1.044	1.078	0.811	1.028	1.062
Glassware, crystal; tableware, household utensils	NT	0.535	0.639	0.65	0.498	0.602	0.613	0.468	0.572	0.583
Electronic artifacts, large size tools, equipment for the household	NT	0.664	0.83	0.853	0.644	0.81	0.833	0.627	0.794	0.817
Electronic artifacts, small size tools, equipment for the household	NT	0.692	0.853	0.87	0.675	0.837	0.853	0.662	0.824	0.84
Furniture	NT	0.655	0.847	1.012	0.592	0.785	0.95	0.542	0.735	0.899
Other electronic artifacts, tools, equipment for the household	NT	0.563	0.686	0.793	0.54	0.662	0.77	0.521	0.644	0.751
Electricity	NT	1.051	1.111	1.121	0.784	0.845	0.855	0.569	0.63	0.64
Gas supply	IM	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995
Basic public services (b)	NT	1.043	1.248	1.27	0.896	1.100	1.122	0.776	0.981	1.003
Repair of household goods	NT	0.732	0.936	0.969	0.71	0.913	0.946	0.691	0.894	0.927
Hotels, restaurants	NT	1.036	1.232	1.389	0.999	1.193	1.352	0.968	1.163	1.321
Transportation	NT	0.645	0.79	0.811	0.593	0.738	0.759	0.55	0.696	0.717
Mail, courier services (b)	NT	0.541	0.758	0.938	0.509	0.725	0.905	0.482	0.699	0.879
Telephone services	NT	0.877	1.026	1.059	0.72	0.868	0.902	0.593	0.741	0.775
Financial services	NT	0.41	0.525	0.539	0.386	0.501	0.516	0.367	0.482	0.497
Assurance, reinsurance services	NT	0.706	0.893	0.918	0.651	0.838	0.863	0.607	0.794	0.819
Services to companies	NT	0.570	0.709	0.728	0.518	0.656	0.675	0.475	0.614	0.633
Rents (apartments, houses) (b)	NT	1.026	1.031	1.032	0.702	0.708	0.708	0.441	0.446	0.447
Education (b)	NT	0.820	1.066	1.091	0.793	1.039	1.064	0.772	1.018	1.043
Medical, health services (b)	NT	0.768	0.985	1.011	0.735	0.952	0.978	0.708	0.926	0.952
Entertainment (b)	NT	0.673	0.911	1.121	0.621	0.859	1.069	0.579	0.817	1.027
Other services	NT	0.217	0.282	0.336	0.191	0.256	0.31	0.17	0.235	0.288
Mining	EX	0.981	0.976	0.976	0.982	0.978	0.977	0.983	0.979	0.978
Construction	NT	0.563	0.713	0.845	0.543	0.693	0.824	0.526	0.676	0.807
Commerce	NT	0.553	0.734	0.87	0.518	0.699	0.834	0.489	0.67	0.806
Chemical industry	IM	0.989	0.989	0.989	0.989	0.989	0.989	0.989	0.989	0.989
Basic industry metals	EX	0.974	0.97	0.969	0.976	0.972	0.971	0.977	0.973	0.972

L = low-skilled labor; M = medium-skilled labor; H = high-skilled labor.

IM = importable sectors; EX = exportable sectors; NT = non-tradable sectors.

Source: Authors' elaboration. Calculations based on the input-output matrix 2008, Central Bank of Chile.

Table 4 shows the variations in the accounting ratios to changes in the classification process. Three cases were evaluated and compared to the simple LM extensions of the SNI accounting ratios.[16] Case A favored the non-tradable category, while Case C favored the tradable category. Therefore, Cases B and C presented more tradable goods than Case A.

Table 4 shows that the reclassification from import to export categories and vice versa did not produce relevant changes in the accounting ratios. However, the reclassification from tradable to non-tradable or vice versa changes the ratios significantly.[17]

Food and beverages sectors

Among the food and beverages groups, some sectors, such as vegetables, fruits, and fish, were classified as exportable across all cases. Other groups, such as meats and sausages; and dairy products, cheese, and eggs, were reclassified from tradable to non-tradable groups or vice versa depending on the classification criteria. In general, the accounting ratios for tradable goods tended to be close to 1 because of small distortions in their prices. Conversely, the ratios for the non-tradable sectors were further from 1 (below or above) depending on the accounting ratios for their inputs and value-added components.[18]

The LM accounting ratios were similar for imports, but slightly different for exports due to differences between the shadow and market prices of the trade and transport margins.[19] In general, for the non-tradable goods, the ratios in Case A were lower than the simple LM ratios, reflecting larger distortions when taking into account economy-wide shadow prices.

Table 4: Accounting Ratios, SNI, and Different Categorization Scenarios

Conversion factors (K=0.81, L=0.62, M=0.68, H=0.98)

Groups	Simple LM AR	Case A		Case B		Case C	
		Class	AR	Class	AR	Class	AR
Flour, pasta, cereals	0.986	IM	0.986	IM	0.986	EX	0.822
Vegetables	0.952	EX	0.930	EX	0.930	EX	0.925
Fruits	0.555	EX	0.538	EX	0.538	EX	0.534
Meats, sausages	0.988	IM	0.988	NT	0.954	EX	0.978
Dairy products, cheese, eggs	0.840	NT	1.134	NT	0.793	IM	0.989
Edible oils, fats	0.987	IM	0.987	IM	0.987	EX	0.970
Fish, crustacean, mollusks	1.000	EX	0.982	EX	0.982	EX	0.978
Animal feed	0.840	NT	0.755	NT	0.733	IM	0.992

[16] The SNI accounting ratios were calculated using the conversion factors found on its webpage. The estimations are a general approximation of the accounting ratio using its methodology (Chile, 2015).

[17] For example, the changes in the accounting ratios for meats and sausages (to 1.6 from 0.98) and other food products (to 1.1 from 0.53) were significant. The gas ratio did not change significantly (from 0.99 to 1.0).

[18] The ratio for the meats and sausages sector was 0.988 when it was classified as importable; it increased to 1.256 when it was reclassified as non-tradable. To calculate the account ratios, "importable" only took into account the CIF price and import duties, while "non-tradable" took into account the shadow price of all of the inputs (tradable and non-tradable items) to produce meat and sausages, mainly in the flour, pasta, and cereals; and animal feed sectors.

[19] According to Tax Law Decree No. 825 on Sales and Services, export goods are zero-rated for the VAT.

Groups	Simple LM AR	Case A		Case B		Case C	
		Class	AR	Class	AR	Class	AR
Fuels (a)	0.980	IM	0.991	IM	0.991	IM	0.991
Other food products	0.977	IM	0.977	NT	0.808	IM	0.977
Liquor**	1.000	EX	0.953	EX	0.953	EX	0.944
Non-alcoholic beverages (c)	0.775	NT	0.662	NT	0.645	IM	0.983
Tobacco	0.840	NT	0.557	NT	0.557	IM	0.990
Textiles, clothing, footwear	0.982	IM	0.982	IM	0.982	EX	0.846
Material for conservation, repair of dwelling	0.949	IM	0.949	IM	0.949	EX	0.927
Stationery, office supplies	1.000	EX	0.968	EX	0.968	EX	0.963
Printing, publishing	0.840	NT	0.900	NT	0.845	NT	0.969
Pharmaceutical products	0.840	NT	0.857	NT	0.847	IM	0.986
Toiletries, cosmetics	0.840	NT	1.065	NT	1.061	IM	0.990
Glassware, crystal; tableware, household utensils	0.840	NT	0.640	NT	0.640	IM	0.988
Electronic artifacts, large size tools, equipment for the household	0.840	NT	0.830	NT	0.830	IM	0.984
Electronic artifacts, small size tools, equipment for the household	0.840	NT	0.853	NT	0.853	IM	0.984
Furniture	0.840	NT	0.847	NT	0.847	IM	0.984
Other electronic artifacts, tools, equipment for the household products	0.840	NT	0.686	NT	0.677	IM	0.985
Electricity	0.840	NT	1.111	NT	1.111	NT	1.940
Gas supply	0.995	IM	0.995	IM	0.995	IM	0.995
Basic public services (b)	1.000	NT	1.247	NT	1.247	NT	1.330
Repair of household goods	0.840	NT	0.936	NT	0.936	NT	1.203
Hotels, restaurants	0.840	NT	1.232	NT	1.156	NT	0.835
Transportation	0.840	NT	0.790	NT	0.790	NT	0.930
Mail, courier services (b)	1.000	NT	0.758	NT	0.758	NT	0.862
Telephone services	0.840	NT	1.026	NT	1.024	IM	0.992
Financial services	0.840	NT	0.525	NT	0.525	NT	0.566
Assurance, reinsurance services	0.840	NT	0.894	NT	0.894	NT	0.943
Services to companies	0.840	NT	0.709	NT	0.709	NT	0.761
Rents (apartments, houses) (b)	1.000	NT	1.032	NT	1.032	NT	1.036
Education (b)	1.000	NT	1.060	NT	1.064	NT	1.120
Medical, health services (b)	1.000	NT	0.985	NT	0.985	NT	1.130
Entertainment (b)	1.000	NT	0.911	NT	0.905	NT	1.037
Other services	0.840	NT	0.283	NT	0.283	NT	0.321
Mining	0.999	EX	0.912	EX	0.976	EX	0.978
Construction	0.840	NT	0.713	NT	0.713	NT	0.693
Commerce	0.840	NT	0.735	NT	0.735	EX	3.230
Chemical industry	0.989	IM	0.989	IM	0.989	EX	0.974
Basic industry metals	0.993	EX	0.969	EX	0.970	EX	0.981

The SNI accounting ratios were estimated using the base case categorization, the shadow prices determined by the SNI, and Tax Law Decree No. 825 on Sales and Services.

According to Law No. 825 (article 42), on top of the VAT, sales and import of alcoholic beverages pay a fee of 31.5 percent; wine, 20.5 percent; and non-alcoholic beverages, 10 percent. In the base case, liquor (which includes wine) is treated as exportable, thus this tax did not apply. See also Yañez (2010).

a) The data for petroleum and diesel market prices was retrieved from the National Institution of Energy (http://reportes.cne.cl/reportes?c). The market value was calculated as the average value of the prices in January and February 2016. The shadow cost was retrieved from the Ministry of Social Development.

b) Exempt from VAT (Law No. 825).

c) Additional 10 percent taxes (Law No. 825).

NT = non-tradable; IM = import; EX = export.

Source: Authors' elaboration.

Fuel, gas, and electricity

Chile's net fuel and natural gas imports were reflected in the classification process.[20] The accounting ratios obtained for both industries were practically 1 for all three cases, reflecting the small amount of import duties imposed on these sectors in 2008. When compared with the simple LM accounting ratios, the values were very similar for both industries.[21] Finally, the electricity accounting ratio for Case A (1.1) was higher than the simple LM ratio, which might be explained by subsidies in this sector or for its inputs.

Services: basic public services, transportation, financial services, and education

The accounting ratios for basic public services were similar across cases and exhibited values higher than 1. These ratios were also higher than the simple LM accounting ratios, reflecting the distortions that occur when taking into account economy-wide shadow prices by including the ratios of inputs (electricity, transportation, and services). In the transportation and finance sectors, the accounting ratios were similar across scenarios and lower than the simple LM ratios. The only considered the VAT distortion, while the economy-wide shadow prices took into account the distortion caused by the input-output interactions between sectors.

Social Profitability

The inputs and outputs of each sector were evaluated at shadow prices to derive their shadow profits or losses. For non-traded goods, the methodology assumed zero net profits at shadow prices. The results were presented for Cases A and C. Social profitability for all non-tradable sectors is presented in Tables 5 and 6, as well as the sensitivity analysis for different conversion factors for labor and capital. As explained in Ahmad et al. (1987), social profits depend on indirect taxes, the conversion factors of inputs, and the accounting ratios of both inputs and outputs.

For Chile, indirect taxes were not important because the taxes for imports and exports were low in most cases (except for the fruit sector). The case where the capital and labor conversion factors were the lowest (A3) exhibited the highest shadow costs, with an average accounting ratio applied to input costs of around 0.87. Roughly, this implies that accounting ratios for outputs below this threshold might present negative social profits. As shown in Table 5, the accounting ratios for all sectors except for fruits were positive. The low/negative social profit of the fruit sector was due to its low accounting ratio.

Fish, crustaceans, and mollusks; meats and sausages; tobacco; and non-alcoholic beverages, meats and dairy products exhibited the lowest social profits. Despite the

[20] Chile is a net importer of gas and one of the main providers has been Argentina, mainly after signing the gas interconnection agreement in 1995. In addition, according to the Latin American Energy Association, the oil industry prices have been free of export taxes since 1978 (Kosulj, 2004; OLADE, 2012).

[21] The SNI accounting ratio for fuels was calculated as the ratio between the shadow cost provided by SNI and the average petroleum market price for January and February 2016 provided by the Energy Commission of Chile. The gas accounting ratios for the SNI were calculated using CIF prices.

potential comparative advantages of the fishery sector in Chile, it exhibited a low social profit. The input-output matrix shows that this sector presented small profits (value-added component) compared to other food sectors, as well as weak linkages to other sectors. Another reason might be the high accounting ratio (0.98) of one of its main inputs (aquiculture, which accounted for almost 50 percent of total inputs). Similarly, the low social profit of the meats and sausages sector was due to the high ratios of its inputs, which were sub-products of this same sector. Conversely, the high social profit of the fuel sector was a consequence of its high accounting ratio and low ratios of its main inputs.[22]

Table 5: Social Profitability: Case A

	K=0.81 (A1)			K=0.5 (A2)			K=0.25 (A3)		
Groups	**L=0.37 M=0.43 H=0.73**	**L=0.62 M=0.68 H=0.98**	**L=0.87 M=0.93 H=1**	**L=0.37 M=0.43 H=0.73**	**L=0.62 M=0.68 H=0.98**	**L=0.87 M=0.93 H=1**	**L=0.37 M=0.43 H=0.73**	**L=0.62 M=0.68 H=0.98**	**L=0.87 M=0.93 H=1**
Flour, pasta, cereals	0.404	0.409	0.321	0.435	0.445	0.351	0.459	0.470	0.376
Vegetables	0.395	0.380	0.316	0.430	0.426	0.351	0.458	0.454	0.379
Fruits	−0.030	−0.089	−0.317	0.046	0.006	−0.240	0.108	0.067	−0.178
Meats, sausages	0.255	0.260	0.182	0.280	0.299	0.207	0.301	0.320	0.227
Oils, fats	0.354	0.355	0.311	0.368	0.369	0.325	0.379	0.380	0.336
Fish, crustaceans, mollusks	0.228	0.242	0.154	0.244	0.257	0.170	0.257	0.270	0.183
Fuels	0.847	0.852	0.837	0.864	0.869	0.854	0.877	0.882	0.868
Other food products	0.523	0.535	0.461	0.546	0.557	0.482	0.563	0.574	0.499
Liquor	0.474	0.505	0.416	0.503	0.533	0.445	0.526	0.556	0.468
Textiles, clothing, footwear	0.494	0.497	0.385	0.523	0.527	0.414	0.547	0.550	0.438
Material for conservation, repair of dwelling	0.451	0.460	0.383	0.479	0.488	0.411	0.502	0.510	0.433
Stationery, office supplies	0.478	0.502	0.398	0.514	0.538	0.435	0.544	0.567	0.465
Mining	0.538	0.545	0.512	0.596	0.603	0.569	0.643	0.649	0.616
Chemical industry	0.527	0.539	0.505	0.568	0.580	0.547	0.601	0.613	0.586
Basic industry metals	0.491	0.496	0.455	0.509	0.513	0.472	0.523	0.527	0.493

Source: Authors' elaboration.

The social profitability analysis was also estimated for Case C, which classified more sectors as tradable. The effect of classifying more sectors as tradable reduced the social profits of all sectors. Tradable sectors exhibited larger accounting ratios than non-tradable ones, affecting the social costs of inputs (see Appendix 7). Any conclusion from the social profitability analysis should be treated carefully because of the level of aggregation of each sector and changes in the categorization of groups.

The analysis is partial because it assessed only the producer side and does not take into account the consumer and government responses. In the next section, consumer decisions and effects on revenues will be incorporated into the analysis, according to the theory of reform methodology.

[22] The fuel sector's main inputs were transportation and services to companies, which accounted for almost 40 percent of the total costs and had an average accounting ratio of 0.65. The ratio for fuels was 0.99.

Theory of Reform and Demand Analysis

To this point, we only consider effects on producers through shadow prices. For the full reform assessment, effects on consumers also need to be incorporated (following Ahmad and Stern, 1984, 1991). For this, we estimated a complete demand system.

The demand responses (uncompensated own- and cross-price elasticities) can be estimated using aggregate demand models that rely on expenditure data at the household level. There are several methodologies, such as Deaton and Muellbauer's (1980) Almost Ideal Demand System (AIDS), the Rotterdam model (Theil, 1976), the Transcendental Logarithmic Production Frontier model (Christensen, Jorgenson, and Lawrence, 1973), and the Linear Expenditure System (LES) (Lluch, Powell, and Williams, 1977). Because of data limitations, we used an extension of the Linear Expenditure System (Extended Linear Expenditure System, or ELES) that depends on total income plus an additional equation to determine the level of savings.[23]

The ELES enables all price elasticities to be estimated in the absence of price data assuming all consumers face identical prices. Since prices normally change regionally, the demand estimations were divided into metropolitan areas and other regions.[24] One of the limitations of the model is that it assumes that all households face the same prices, which is not plausible in a context of territorial heterogeneity. To address this issue, the estimations were implemented by cluster or groups of similar households. For more detail on the methodology, see Appendix 4.

The estimations of the aggregate elasticities were calculated using a simple average of the elasticities estimated for each cluster. We could have applied weighted averages, but that requires a proper estimation of the weights, and the results depend on their selection. For comparison, we calculated the aggregate elasticities for Mexico using the marginal propensity to consume of the clusters as weights.

The clusters exhibited differences regarding income per capita and education level, as well as in the composition of male/female heads of household. For those regions with a

[23] Demand systems obtain average estimates of consumption and savings for a "representative consumer." To determine average estimations, demand models rely on multiple assumptions. First, the so-called "adding-up" property, which states that the sum of expenditures on individual commodities is equal to total expenditures. Second, a set of restrictions follows from the maximization of a general utility function subject to a budget constraint: homogeneity of degree zero of the demand functions and symmetry of the income-compensated cross-price effects. Third, in the case of Linear Expenditure Demand Systems, a set of restrictions that depend on the linearity of the utility function. The method assumes that additional satisfaction or utility obtained from consuming an additional unit of a commodity does not depend on the level of consumption of other commodities, which is inconsistent with the empirical evidence. To tackle this issue, the authors confined the estimation to broad commodity classes and clusters, where the assumption of additive utility has greater validity.

[24] Ahmad, Ludlow, and Stern (1988) proposed using ELES with cross-section data that depend on household characteristics and can be estimated separately for metropolitan and lagged regions, urban and rural areas.

higher average education level and with a larger proportion of male population, the monthly income was higher. On the other hand, for those groups that exhibited a lower level of education and with a larger female population, the monthly income was lower compared to the remaining clusters.[25]

Table 6: Demand Estimates

	Subsistence Expenditures in Pesos chilenos (S)	Household Income in Pesos chilenos (I)	S/I (%)	Marginal Propensity to Consume	Elasticity of Saving with Respect to Income	Elasticity of Total Expenditure with Respect to Income	Frisch Parameter
Cluster 1	184,429	235,954	78.1	1.15	1.03	1.29	−1.03
Cluster 2	327,776	601,335	54.5	1.22	1.05	1.34	−1.04
Cluster 3	152,372	222,934	68.3	1.27	1.02	1.42	−1.01
Cluster 4	335,846	723,557	46.4	1.10	1.06	1.23	−1.06
Cluster 5	77,068	189,540	40.6	1.05	1.02	1.17	−1.01
Cluster 6	169,385	228,663	74.1	1.11	1.03	1.24	−1.03

Source: Authors' elaboration.

The marginal propensity to consume was above 1 for all clusters and was higher for clusters 2 and 4, which comprised the highly educated with a high income. The remaining clusters presented lower saving elasticity. Finally, the Frisch parameter was negative, as required by the utility function.

The own- and cross-price elasticities were computed using the results obtained by the demand system of equations. The own-price elasticities were less than unity, as required by the utility function, and they were slightly higher (measured in absolute values) for clusters 1, 3, 5, and 6, and lower for clusters 2 and 4.

Directions of Reform

The directions of reform take into account the effects of changes in relative prices or taxes on both producers and households. This permits the explicit introduction of inequality-aversion measures across households. Thus, the inequality aversion parameter (marginal social value of a unit of expenditure of household h relative to the poorest household β_h) can be directly introduced in the utility function. The sample design does not permit a further regional disaggregation, although this may be a possible extension in the future.

For an inequality aversion parameter of $e=0$, the consumption of the poorest and richest households are considered equal. This is the implicit assumption that is used by the SNI. For parameter $e=1$, the welfare weight for the i^{th} household is proportional to the distance with respect to the poorest household. For inequality parameters higher (lower)

[25] After applying the K-means algorithm, the authors found that three of the six clusters were in Santiago, and the remaining two in "other regions." A more detailed geographical disaggregation would be needed to perform a more robust spatial analysis, but the Household Budget Survey only divided the sample into those two areas.

than 1, the welfare weight is lower (higher) compared to the one calculated with $e=1$. For $\beta_h < 1$ the marginal expenditure by the rich is seen as less valuable than that by the poor. Values of $e=5$ begin to approach Rawlsian "maximin" or an exclusive concern for the welfare of the poorest.

The social marginal cost of each sector shows possible directions of reform that can be addressed by policymakers. The social marginal values changed depending primarily on the chosen aversion parameter, which mainly reflects the importance given to consumption inequalities among households. The major differences in the social marginal cost's values were observed mainly when compared to $e=0$ with the other aversion parameters ($e=0.5,\ 1,\ 2,\ 5$).[26] *Choosing inequality-aversion parameters >0 produced significant variations in the social costs and, consequently, in the appropriate directions of reform.*

The social marginal values did not change when selecting different classification categories. The correlation of the social cost rankings across the three categories, using the same aversion parameter (e) was above 0.95. The classification between tradable and non-tradable sectors ended up not being relevant in assessing possible directions of reform.

Regardless of the level of the inequality aversion parameter, rent services exhibited the highest social marginal cost, which means that is the least appealing sector to tax. When using an inequality aversion parameter of $e=0$, transportation, telephone services, hotels and restaurants, education, health, and other types of services were attractive sectors for taxation. In general, fuels, fish, and edible oils exhibited the lowest social marginal costs, which made them more attractive to tax, provided inequality was not a concern.

Table 7: Social Marginal Cost Ranking for Different Inequality Parameters

(1 being the highest social cost and 40 the lowest)

Groups	*e=0*	*e=0.5*	*e=1*	*e=2*	*e=5*
Rents (houses, apartments)	1	1	1	1	1
Transportation	2	3	15	21	19
Other services	3	17	24	24	24
Education	4	23	25	25	25
Telephone services	5	16	22	23	23
Hotels, restaurants	6	11	16	18	18
Textiles, clothing, footwear	7	7	12	14	8
Health	8	13	18	16	10
Meats, sausages	9	5	4	6	9
Public basic services	10	2	2	2	2
Financial services	11	14	17	15	14
Flour, pasta, cereals	12	6	5	17	17
Entertainment	13	26	26	26	27

[26] The correlation between the ranking results using an inequality parameter of $e=0$ with the rest of alternatives ($e=0.5,\ 1,\ 2,\ 5$) was weak (<0.2 for all cases). However, when comparing the correlations between each of the other inequality aversion parameters (i.e., not including $e=0$), the correlations were >0.9.

Groups	*e=0*	*e=0.5*	*e=1*	*e=2*	*e=5*
Electricity	14	4	3	5	7
Vegetables	15	9	11	12	15
Non-alcoholic beverages	16	8	7	7	6
Pharmaceutical products	17	21	21	20	20
Dairy products, cheese, eggs	18	10	10	11	13
Other food products	19	19	20	19	22
Gas	20	12	8	10	12
Liquor	21	15	6	3	3
Fruits	22	18	13	8	5
Tobacco	23	25	23	22	21
Toiletries, cosmetics	24	27	27	27	26
Fish, crustaceans, mollusks	25	20	9	4	4
Oils, fats	26	22	14	9	16
Fuels	27	24	19	13	11

Source: Authors' elaboration.

However, with a positive or higher inequality aversion parameter, the social marginal cost of taxing fish increases, making it among the least attractive to tax. Other food products, such as fruits; dairy products, cheese, and eggs; and oils and fats, also presented higher social costs compared with the case with no concern for inequality. With respect to services, higher inequality aversion parameters caused increases in the social marginal cost of electricity, gas, and public services.

Interestingly, tobacco products are attractive to tax at all levels of inequality aversion—this is in line with an externality or health-based approach. Similarly, transportation exhibited significantly lower social marginal costs compared with the values estimated using an inequality aversion parameter of $e=0$.

For fuels, the social cost increased when using inequality-aversion parameters above 0, but the values were still low. Therefore, transportation and fuels might be attractive candidates as sources of extra revenue, suggesting a correspondence between the welfare effects on households as well as environmental concerns that typically need to be treated separately. More importantly, possible tax reforms in these sectors might also contribute to reducing congestion and pollution in metropolitan areas given the highest fuel consumption in the country. This suggests the need for both a national and a sub-national tax reform agenda.

Although these results give policymakers a good sense of the possible directions of reform taking into account inequality concerns, care should be taken in interpreting the results. For example, education is seen as a good candidate to tax with greater inequality aversion, and this may appear to contradict the government's growth and policy focus.[27] However, this is not the case, which reflects the design of actual spending on health care by rich and poor households as well as the peculiarities of the VAT. Public schools do not charge fees, and there is very little actual spending on education by the poor. The rich send their children to expensive private schools, and this is reflected in the marginal welfare analysis above. Consequently, taxing education

[27] This pattern was also seen in Mexico (Urúza, 2005).

reduces inequality—the poor still are not affected by the change (indeed the costs for public schools are reduced as they can now offset the VAT on inputs), whereas the rich now pay an additional VAT on tuition for private education. Similarly, subjecting health care to the VAT is important as hospitals incur significant expenditures on expensive inputs and are consequently able to offset VAT on inputs against VAT on services provided, reducing costs. Again, with free health care, the poor do not pay but are cross-subsidized by the rich.

On the other hand, products like liquor are also consumed by the poor, which is shown by the higher social cost when increasing the inequality-aversion parameter. But, given the health externalities, it may still be useful to impose excises on liquor. In many countries, the same pattern applies *for carbon products. However, as seen above in Chile, both environmental and welfare considerations move in the same direction.*

The Next Steps

Using the New Accounting Ratios to Reevaluate Existing Projects

The economy-wide shadow prices provide one of the components of a more comprehensive strategy to improve the SNI appraisal method. We expect that the application of economy-wide shadow prices will address systemic, individual, and spatial inequalities as well as environmental concerns. First, the economy-wide accounting ratios should be tested by evaluating real projects and comparing the results with the ones obtained by the SNI. Given that these accounting ratios take into account the inter-sectoral effects, they should deliver a better sense of which projects should be accepted and incorporated in the national investment plan.

The FNDR can be responsible for financing poor and lagging regions to reduce spatial inequality and to develop new sustainable hubs. However, the allocation of funds to local governments should reflect the structural reform strategy, or convergence according to a green growth agenda, as described for Chile in Ahmad and Zanola (2015).

Further studies need to address the choice of projects within spatial and geographical concerns to address economic convergence more appropriately. This is crucial to address interlinked sets of projects or more comprehensive programs across regions and sectors. In this sense, single projects might not be approved when appraised alone without including complementary projects. Therefore, a useful extension is to incorporate appraisal methods for a set of projects, along with spatial analysis. Due to restrictions in the databases, which did not present a detailed regional disaggregation, a proper spatial analysis was not possible for this paper.

Can a Reformed SNI Link to a "Convergence Process" with Sustainable Growth Impact?

As was the case in China, reliance on coastal hubs risks generating inequalities along with congestion and pollution. However, while China managed to develop diversified export and manufacturing hubs, the Chilean growth strategy has largely been sustained

by primary commodity exports with limited development of domestic linkages. In addition, spatial and interpersonal inequalities and the consequent growing congestion and pollution in metropolitan areas, are leading to the middle-income trap, or a reduction in Chile's growth potential.

Convergence depends on private and public action, and the latter has a major role to play in investment in human and physical capital. Investment in lagging regions along with appropriate incentives should generate appropriate private investment, take advantage of supply chain effects, and boost the diversification of the productive base.

In this context, Ahmad and Zanola (2015) proposed a medium-term perspective to develop sustainable hubs to help lagging regions converge, as well as a package of policy measures, including a revision of the project appraisal mechanism. The use of a general framework, linked to Chile's development strategy, should address sustainable growth concerns, favoring allocation of funds toward lagging regions, and creation of new hubs to favor convergence.

However, changes in the appraisal mechanism are not enough to achieve convergence and sustainable growth. Other policy measures need to be implemented to complement the application of economy-wide shadow prices and to align incentives for successful convergence.

The Need for Complementary Emphasis on Local Service Delivery

The regional concentration of activities in metropolitan areas has been influenced by differences in the quality of public service delivery among sub-national governments and poor facilities outside of metropolitan areas. To complement improvements in investment allocation, any potential new hubs need to have a critical mass of public services. This involves using local own-source revenues for better accountability and to anchor access to credit for investments (Ahmad, Brosio, and Pöschl, 2015). But equalization frameworks also need to be put in place to provide local administrations with a similar ability to provide local services at similar levels of revenue effort. This implies revamping the Common Municipal Fund (FCM) transfers (Ahmad, Letelier, and Ormeño, 2015) and applying comprehensive policies to achieve the structural convergence strategy objectives.

Public investment directed toward lagging regions and hubs by applying economy-wide shadow prices, along with improved quality of public service delivery, could change the endowments and the private sector's willingness to invest in these areas. Private investment, which is a crucial piece in the convergence puzzle, will not take place in regions with low-quality public services.

Conclusions

Chile's growth strategy has largely been sustained by primary commodity exports, with limited development of domestic linkages, and is very sensitive to demand for copper,

for instance in East Asia. The Green Growth Strategy, as well as the Bachelet manifesto, states the need to implement comprehensive strategies to promote sustainable growth by addressing spatial inequality and environmental issues, and that this will lead to a diversification of the economy. The strategy should also, in large part, address the concerns of the middle-income trap in Chile (Lagos, 2013).

Chile's SNI has been praised by international financial institutions as a transparent mechanism to appraise investments. The uniformity of the evaluation system has prevented rent-seeking in investment decisions; however, the absence of a focus on spatial and interpersonal inequalities, and very superficial attention to environmental concerns, has, not surprisingly, led to increasing concentrations of activities in the metropolitan areas, with attendant congestion and pollution. This concentration has attracted the poor to these areas, thus FNDR acts on the effects rather than the causes of need, which accentuates concentration in metropolitan areas (Ahmad and Zanola, 2015).

Even a simple extension of the SNI to the LM method clearly improves the information available to policymakers in their project selection process. In this paper, the authors illustrate a generalization of the LM model by Drèze and Stern (1987) to estimate economy-wide shadow prices, providing sensitivity to some of the key variables involved. As stressed, a more complete structural reform strategy (based on the government's Green Growth Strategy) is needed to help enhance the options the authors illustrate.

This paper used the 2008 input-output matrix provided by Chile's Central Bank and the Household Budget Survey to estimate new accounting ratios, the social profitability of sectors, and welfare-improving directions for reform. There were several challenges in applying this method in relation to aggregating products, classifying tradable and non-tradable goods, and estimating demand responses. Consequently, policymakers should see the calculations in this paper as illustrations of the method rather than detailed recommendations for immediate application.

The estimated accounting ratios are sensitive to the classification of goods (tradable versus non-tradable) and, to a lesser extent, to changing the assumptions about the conversion factors for capital and labor. Most of the non-tradable sectors were relatively sensitive to variations in the labor conversion factor. The labor added-value component was relatively larger for almost all sectors compared to the capital and land factors, except for electricity and telephone services.

The social profitability using economy-wide accounting ratios suggests the importance of fuel; commerce; electronic artifacts, tools, and equipment; the chemical industry; other food products; liquor; toiletries and cosmetics; and non-alcoholic beverages. This calculation represented a first approximation for sectors that might be more suitable to reform or expand. It is clear that a strategy that develops these sectors would go a long way toward diversifying the economy, both for imports and exports. As mentioned above,

this would also help address the middle-income trap and dependency that concerned Ahmad (2013).

The effects of policy reforms on households and inequality need to be considered in conjunction with the analysis of social profitability. In this context, the theory of reform methodology (Ahmad and Stern, 1991) was used to assess the welfare effects, measured as variations in consumption patterns, produced by changes in production supply. Demand responses were calculated using the ELES methodology, and welfare weights were estimated using different aversion parameters. Demand estimations were implemented in different clusters to tackle the utility linear aggregation concern.

In general, in the absence of a concern for inequality ($e=0$) food products (except meats and sausages), electricity, and public services are attractive to tax. However, with a concern for inequality, fish and housing exhibit the highest social marginal costs at higher levels of inequality aversion, reflecting consumption patterns. Interestingly, the environmental and welfare considerations in Chile both suggest the importance of taxing carbon products at the national and local levels.

The methods described above can usefully be used together with an analysis of spatial convergence (Ahmad and Zanola, 2015) that becomes a mechanism to formalize the Green Growth Strategy. As an example, if Chiloé Island is chosen as a hub, then the joint consideration of the Chacao Bridge and local investments in ports and infrastructure would need to be evaluated together. The tax agenda is important in discouraging environmentally damaging projects and the consumption of negative social and environmental products. The tax agenda is also useful in keeping local governments honest and accountable (see Ahmad, Brosio, and Pöschl, 2015, for a general discussion) but must be placed in a more general equalization framework that addresses unavoidable differences in tax bases and unit costs.

In short, both a re-orientation of the SNI and FNDR, together with a local tax agenda and a greater equalization of the FCM to increase public service quality are needed for a more effective investment strategy linked to Chile's Green Growth Strategy. The methods illustrated in this paper should also be useful to examine investment strategies in other emerging market countries in Latin America, as well as in countries like China and Indonesia.

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Appendix 1: Little and Mirrlees Method

The LM method calculates shadow prices for import goods using CIF border prices and for exports using FOB (free on board) prices minus margin costs evaluated at shadow prices. For non-tradable goods, it uses their marginal cost of production taking into account the costs of inputs, which can be tradable and non-tradable at shadow prices.[28] For tradable goods the shadow price would be:

$$p_i^s = p_i^{cif} \tag{10}$$

$$p_i^s = p_i^{fob} * (1 - a_{ri} * p_i^r) \tag{11}$$

The shadow price is adjusted by a_{ri}, which represents the trade and transport margins for exportable goods as a percentage of the FOB prices, and p_i^r, the shadow value of these margins, expressed as accounting ratios (domestic price over shadow price):

$$p_i^d = p_i^{cif} * (1 + t_i^m) \tag{12}$$

$$AR_1^m = \frac{1}{1+t_i^m} \tag{13}$$

However, the database provides basic prices, thus the taxes are not included in the calculation, and the accounting ratio would be:

$$p_i^a = p_i^{fob}(1 - a_{ri}.p_i^r)$$

where p_i^a represents domestic prices of commodity I and t_i^m represents import taxes.

$$p_i^d = p_i^{fob} * (1 - a_{ri} - t_i^x) \tag{14}$$

$$AR_1^x = \frac{(1-a_{ri}*p_i^r)}{(1-a_{ri}-t_i^x)} \tag{15}$$

As in the case of imports, the export accounting ratio does not include the tax component because the values are expressed as basic prices.

$$AR_i^x = \frac{1-a_{ri.}p^r}{1-a_{ri}} \tag{16}$$

The exportable accounting ratios and transport shadow prices have to be estimated simultaneously because they are interdependent. The ratios for imports can be determined exogenously. According to the LM method, the treatment of shadow prices for non-tradable goods involves calculating the marginal cost of an extra unit valued at shadow prices. The methodology assumes constant returns to scale and perfect competition among producers.

[28] The use of shadow prices is suitable for policy decisions in markets that present distortions, such as trade and connectivity or environmental concerns, or taxes. The presence of distortions—subsidies, taxes, quotas, and regulations, among others—in factors or input prices ensures that producer costs do not accurately reflect the underlying opportunity cost.

On the other hand, calculating the shadow prices of non-traded goods requires the decomposition of the total value into its constituent elements: taxes, payments for tradable and non-tradable goods, and payment for each factor. The input-output matrix disaggregates the inputs into payments to labor, profits, and net taxes to producers.

$$p = pA^{NX} + p^a A^{MN} \tag{17}$$

Where p is the vector of shadow prices for non-tradable and exportable goods $[p_1^n + \cdots., p_N^n, p_1^a + \cdots., p_j^a]$ and A^{NX} is the matrix that denotes the use of non-tradable and exportable inputs in non-tradable goods, and transport margins into exportable products. On the other hand, p^a is the vector of shadow prices of importables and factors $[p_1^m + \cdots., p_M^m, p_1^f + \cdots., p_F^f]$ and A^{MN} is the matrix coefficient that denotes the use of factor and importable into non-traded products.

There are *n+j* non-linear equations with *n+j* unknowns, and the required decomposition is given by the equation above as:

$$p_1^{nt} = (p_1^{nt} a_{11} + \cdots + p_n^{nt} a_{n1}) + (p_1^x a_{11}^x + \cdots + p_j^x a_{j1}^x) + (p_1^i a_{11}^i + \cdots + p_k^i a_{k1}^i) + (p_1^f a_{11}^f + \cdots + p_l^f a_{l1}^f) \tag{18}$$

$$p_n^n = (p_1^n a_{1n} + \cdots + p_{nn}^n) + (p_1^x a_{1n}^x + \cdots + p_j^x a_{jn}^x) + (p_1^i a_{1n}^i + \cdots + p_k^i a_{kn}^i) + (p_1^f a_{1n}^f + \cdots + p_l^f a_{ln}^f) \tag{19}$$

$$p_1^x = -p^r a_{r1} + \cdots \ldots .0 \ldots . \ldots \ldots \ldots 0 \ldots \ldots \ldots \ldots 0 \ldots \ldots \ldots \ldots \ldots \ldots 0 \ldots \ldots \ldots \ldots + p_1^{fob} \tag{20}$$

$$p_j^x = -p^r a_{rj} + \cdots \ldots .0 \ldots . \ldots \ldots \ldots 0 \ldots \ldots \ldots \ldots 0 \ldots \ldots \ldots \ldots \ldots \ldots 0 \ldots \ldots \ldots \ldots + p_j^{fob} \tag{21}$$

$p_1^x \ldots p_j^x$ = *accounting ratios for exportables*
$p_1^{nt} \ldots p_n^{nt}$ = *accounting ratios for non-tradable goods*
$p_1^i \ldots p_k^i$ = *accounting ratios for importables (exogenous determined)*
$p_1^f \ldots p_l^f$ = *accounting ratios for factors (exogenous determined)*
p^r = *margin accounting ratios. Classified as non-tradable.*
a_{ij} = *total coefficients*
–i^{th} input per unit production of the j^{th} good
(taken from the Input-Output Matrix)

The accounting ratios for exportable goods require the calculation of the transport margins that were classified as a non-tradable. In addition, the accounting ratio for non-tradable goods is composed of importable, exportable, and other non-tradable inputs. The input-output coefficients—i^{th} input per unit production of the j^{th} good—were used to weight the relative importance of each good into the accounting price of the j^{th} good.

Appendix 1: Grouping of Products

1. Flour, pasta, cereals	2. Electronic artifacts, large size tools, equipment for the household
3. Vegetables	4. Electronic artifacts, small size tools, equipment for the household
5. Fruits	6. Furniture
7. Meats, sausages	8. Other electronic artifacts, tools, equipment for the household
9. Dairy products, cheese, eggs	10. Electricity
11. Edible oils, fats	12. Gas
13. Fish, crustaceans, mollusks	14. Public basic services
15. Animal feed	16. Repair of household goods
17. Fuels	18. Hotels and restaurants
19. Other food products	20. Transportation
21. Liquor	22. Mail and courier services
23. Non-alcoholic beverages	24. Telephone services
25. Tobacco	26. Financial services
27. Textiles, clothing, footwear	28. Assurance and reinsurance services
29. Material for conservation, repair of dwelling	30. Services to companies
31. Stationery, office supplies	32. Services to households
33. Printing, publishing	34. Education
35. Pharmaceutical products	36. Medical, health services
37. Toiletries, cosmetics	38. Entertainment
39. Glassware, crystal; tableware, household utensils	40. Other services

Note: Some sectors were not used in the calculations because they did not appear in both surveys. For example, those sectors related to minerals, which are mainly exported, and real estate and construction, which were not surveyed to households.

Source: Authors' elaboration.

Appendix 2: Product Groups and Classification into Tradable and Non-tradable

Groups	Case 1	Case 2	Case 3
Flour, pasta, cereals	Import	Import	Export
Vegetables	Export	Export	Export
Fruits	Export	Export	Export
Meats, sausages	Import	Non-tradable	Export
Dairy products, cheese, eggs	Non-tradable	Non-tradable	Import
Edible oils, fats	Import	Import	Export
Fish, crustaceans, mollusks	Export	Export	Export
Animal feed	Non-tradable	Non-tradable	Import
Fuels	Import	Import	Import
Other food products	Import	Non-tradable	Import
Liquor	Export	Export	Export
Non-alcoholic beverages	Non-tradable	Non-tradable	Import
Tobacco	Non-tradable	Non-tradable	Import
Textiles, clothing, footwear	Import	Import	Export
Material for conservation, repair of the dwelling	Import	Import	Export
Stationery, office supplies	Export	Export	Export
Printing, publishing	Non-tradable	Non-tradable	Non-tradable
Pharmaceutical products	Non-tradable	Non-tradable	Import
Toiletries, cosmetics	Non-tradable	Non-tradable	Import
Glassware, crystal; tableware, household utensils	Non-tradable	Non-tradable	Import
Electronic artifacts, large size tools, equipment for the household	Non-tradable	Non-tradable	Import
Electronic artifacts, small size tools, equipment for the household.	Non-tradable	Non-tradable	Import
Furniture	Non-tradable	Non-tradable	Import
Other electronic artifacts, tools, equipment for the household	Non-tradable	Non-tradable	Import
Electricity	Non-tradable	Non-tradable	Non-tradable
Gas	Import	Non-tradable	Import
Basic public services	Non-tradable	Non-tradable	Non-tradable
Repair of household goods	Non-tradable	Non-tradable	Non-tradable
Hotels, restaurants	Non-tradable	Non-tradable	Non-tradable
Transportation	Non-tradable	Non-tradable	Non-tradable
Mail, courier services	Non-tradable	Non-tradable	Non-tradable
Telephone services	Non-tradable	Non-tradable	Import
Financial services	Non-tradable	Non-tradable	Non-tradable
Assurance, reinsurance services	Non-tradable	Non-tradable	Non-tradable
Services to companies	Non-tradable	Non-tradable	Non-tradable
Services to households	Non-tradable	Non-tradable	Non-tradable
Education	Non-tradable	Non-tradable	Non-tradable
Medical, health services	Non-tradable	Non-tradable	Non-tradable
Entertainment	Non-tradable	Non-tradable	Non-tradable
Other services	Non-tradable	Non-tradable	Non-tradable

Source: Authors' elaboration.

Appendix 4: Extended Linear Demand System (ELES)

The authors assumed the Stone-Geary utility function v (.), treating savings as an endogenous variable with subsistence or committed quantity equal to 0. For other goods, the authors imposed a minimum consumption of subsistence or subsistence quantity of commodity *j*, $\emptyset_j$

$$Max\ v(q,s) = \sum_j^{n+1} \theta *_j \log(q_j - \emptyset_j) \quad (22)$$

Subject to $x^*=s+p'q$; $\theta *_j > 0$ and $q_j - \emptyset_j > 0$

$$\emptyset_{n+1} = 0\ and\ \theta *_1 + \cdots \theta *_{n+1}$$

$$s = p_{n+1}q_{n+1}$$

The solution for maximization is the first order conditions calculated by deriving the Lagrangian function: $ב = v(q,s) - \gamma(x^* - \sum_{j=1}^{n+1} p_j q_j)$:

$$p_j q_j = p_j \emptyset_j + \theta_j^*(x^* - p'\emptyset) \quad (23)$$

$$s = \theta_n^*(x^* - p'\emptyset) \quad (24)$$

$\frac{\delta s}{\delta x} = \theta_{n+1}^*$ is the marginal propensity to save, $\mu = 1 - \theta_{n+1}^*$ is the marginal propensity to consume, and $Q_j = \frac{Q_j^*}{\mu} = \frac{\delta p_j q_j}{\delta X^*} / \frac{\delta p1}{\delta X^*}$ is the marginal budget share, which $\theta_1 + \cdots + \theta_n = 1$.

(1) Elasticity of demand for commodity *j* with respect to total expenditures:

$$n_{jT} = \theta_j p'q / p_j q_j$$

$$Own\ price: n_{jj} = \frac{(1-\mu\theta_j)p_j\emptyset_j}{p_j q_j} - 1 \quad (25)$$

$$Cross\ price: n_{jk} = -\frac{\mu\theta_j p_k \emptyset_k}{p_j q_j} \quad (26)$$

(2) Elasticity of total expenditures with respect to income:

$$n_{T*} = \mu x^* / p'q$$

(3) Elasticity of saving with respect to income:

$$income: n_{s*} = \frac{x^*}{x^* - p'\emptyset} \quad (27)$$

$$price\ commodity\ j: n_{sj} = -p_j\emptyset_j/(x^* - p'\emptyset) \quad (28)$$

Appendix 5: K-means Algorithm

Because of the survey's data limitations, four groups were created for the metropolitan region and four groups for the other regions.

The K-means clustering algorithm has as input a finite set S C R^d (Euclidian space of d-dimension); integer k. The output of the algorithm is a set T C R^d with |T|=k. The cost function to be minimized is the following:

$$cost(T) = \sum_{x \in S} min_{z \in T} ||x - z||^2$$

The result of reducing the distance between groups resulted in eight homogeneous groups that were supposed to have similar demand behavior for this analysis. The cluster groups can be modified using a different number of groups or variables, which can yield different results.

Appendix 6: Cluster Groups

Cl	Obs.	Income	Educ. (1-4)	Employ ment	Area	Age (1-6)	Civil status	Gender	Proxy_ congestion
1	1,771	235,954	2.87	NO	Other R.	5.34	1.88	0.41	31,273
2	1,371	601,335	4.00	SI	Other R.	4.50	1.42	0.71	106,999
3	2,903	222,934	2.76	SI	Other R.	4.70	1.49	0.68	34,341
4	970	723,557	4.00	SI	Santiago	4.50	1.48	0.66	122,276
5	2,077	189,540	2.69	SI	Santiago	4.73	1.49	0.64	24,871
6	1,228	228,663	2.75	NO	Santiago	5.40	1.94	0.38	26,644

Education: 1= Prekinder, 2 = Primary, 3 = Media, 4 = Higher.
Age categories: 1 = 0–10, 2 = 11–20, 3 = 21–30, 4 = 31–40, 5 = 41–64, 6 = 65+.
Civil status: 1 = Married, 2 = Single, 3 = Divorced.
Gender: 0 = Female, 1 = Male.
Proxy congestion: This variable is the sum of the consumption of fuels and transport.

Source: Authors' elaboration calculated from the Household Budget Survey.

Appendix 7: Social Profitability: Case C

(Classification with the most non-tradable sectors)

	K=0.81			K=0.5			K=0.25		
Groups	**L=0.37 M=0.43 H=0.73**	**L=0.62 M=0.68 H=0.98**	**L=0.87 M=0.93 H=1**	**L=0.37 M=0.43 H=0.73**	**L=0.62 M=0.68 H=0.98**	**L=0.87 M=0.93 H=1**	**L=0.37 M=0.43 H=0.73**	**L=0.62 M=0.68 H=0.98**	**L=0.87 M=0.93 H=1**
Flour, pasta, cereals	0.100	0.044	0.012	0.128	0.078	0.039	0.150	0.100	0.061
Vegetables	0.263	0.206	0.182	0.293	0.249	0.213	0.318	0.273	0.237
Fruits	−0.408	−0.569	−0.675	−0.347	−0.489	−0.613	−0.298	0.439	-0.564
Meats, sausages	0.128	0.085	0.063	0.147	0.109	0.082	0.162	0.124	0.097
Dairy products, cheese, eggs	0.219	0.173	0.152	0.234	0.194	0.167	0.245	0.206	0.179
Edible oils, fats	0.252	0.221	0.201	0.264	0.234	0.213	0.274	0.244	0.223
Fish, crustaceans, mollusks	0.114	0.079	0.053	0.124	0.089	0.062	0.131	0.096	0.070
Animal feed	0.340	0.317	0.299	0.348	0.325	0.306	0.354	0.331	0.313
Fuels (a)	0.813	0.799	0.797	0.829	0.815	0.813	0.841	0.828	0.826
Other food products	0.415	0.376	0.348	0.431	0.392	0.364	0.444	0.405	0.377
Liquor	0.406	0.349	0.319	0.429	0.372	0.343	0.447	0.390	0.361
Non-alcoholic beverages (c)	0.379	0.329	0.320	0.398	0.347	0.338	0.413	0.362	0.353
Tobacco	0.243	0.214	0.207	0.254	0.225	0.218	0.263	0.234	0.227
Textiles, clothing, footwear	0.114	0.040	−0.015	0.139	0.066	0.010	0.159	0.086	0.031
Material for conservation, repair of the dwelling	0.264	0.214	0.182	0.289	0.239	0.207	0.309	0.259	0.227
Stationery, office supplies	0.243	0.197	0.167	0.270	0.225	0.195	0.292	0.247	0.217
Pharmaceutical products	0.345	0.271	0.258	0.359	0.285	0.272	0.370	0.297	0.284
Toiletries, cosmetics	0.351	0.280	0.266	0.363	0.292	0.278	0.373	0.301	0.288
Glassware, crystal; tableware, household utensils	0.289	0.249	0.245	0.313	0.273	0.268	0.332	0.292	0.288
Electronic artifacts, large size tools, equipment for the household	0.388	0.321	0.314	0.400	0.333	0.326	0.409	0.343	0.336
Electronic artifacts, small size tools, equipment for the household.	0.535	0.476	0.470	0.544	0.485	0.479	0.552	0.492	0.486
Furniture	0.268	0.213	0.174	0.291	0.236	0.196	0.309	0.254	0.215
Other electronic artifacts, tools, equipment for the household	0.473	0.422	0.384	0.484	0.434	0.396	0.494	0.444	0.405
Gas	−0.394	−0.411	−0.413	−0.031	−0.049	−0.051	0.261	0.244	0.241
Mining	0.432	0.400	0.396	0.487	0.455	0.451	0.531	0.499	0.496
Commerce	0.799	0.762	0.740	0.808	0.772	0.749	0.815	0.779	0.761
Chemical industry	0.400	0.372	0.369	0.439	0.411	0.408	0.471	0.443	0.447
Basic industry metals	0.318	0.287	0.283	0.330	0.299	0.296	0.340	0.309	0.312

Source: Authors' elaboration.