Environ Dev Sustain (2013) 15:1099–1127
DOI 10.1007/s10668-012-9430-0

# Environmentally extended social accounting matrix for Chile

**Alvaro Gallardo · Cristian Mardones**

Received: 24 August 2012 / Accepted: 12 December 2012 / Published online: 3 January 2013


**Abstract** This study uses information from the input–output tables 2008, national accounts, household survey, and environmental pollutant emissions to elaborate an environmentally extended social accounting matrix for Chile. A linear multisector model is then generated in order to determine the effects that a sectoral shock on demand would have on economic development. The results show the typical economic trade-offs, concluding that it is necessary to consider economic relationships in order to assess the full impact of a sector on economic activity, income distribution, and pollution. The sectors commerce, construction, and food industry strongly increase economic growth and employment and decrease inequality. Nonetheless, when also considering the environmental effects, no sectors can be identified that contribute systematically and significantly to all the areas of economic development.

**Keywords** Social accounting matrix · Environment · Economic development

**JEL Classification** C67 · Q56 · R58

## 1 Introduction

Social accounting matrices (SAMs) capture the disaggregation of an economy by representing all the monetary transactions occurring within a given period. These matrices are one of the formal tools available for analyzing the effects of diverse economic shocks.

The use of SAMs has also broadened to include environmental variables (Resosudarmo and Thorbecke 1996; Weale 1997; Xie 2000; Manresa and Sancho 2004) to evaluate the

A. Gallardo · C. Mardones (✉)
Departamento de Ingeniería Industrial, Facultad de Ingeniería, Universidad de Concepción, Edmundo Larenas 215, Ciudad Universitaria, Concepción, Chile
e-mail: crismardones@udec.cl

A. Gallardo
e-mail: alvargallardo@udec.cl

repercussions on the environment with multipliers of the SAM or alternatively as input data for calibrating computable general equilibrium models (Pyatt 1988).

In this study, we elaborate a SAM for Chile, base year 2008, that includes 34 economic sectors, seven productive factors, enterprises, and five typical households represented by the income quintiles. This SAM is also extended environmentally by including air pollutants and water effluents generated by the productive processes of each economic sector.

The objective of this paper is to carry out an exhaustive analysis of the economic relationships and their environmental effects on a country such as Chile, which has middle-low income (per capita income based on purchasing power parity of around US $18,000) and faces important disjunctions on the road to development, mainly in terms of its poor distribution of income and environmental regulations. In particular, the methodology proposed allows the quantification of the trade-offs between growth, equality, and pollution for each branch of economic activity. This is useful for designing appropriate strategies of sectoral economic support. Moreover, it is important that Chile has an environmentally extended SAM since this constitutes the basic information required to calibrate more sophisticated economic models such as CGE, which permit specific analyses of diverse policies (e.g., simulating the effects of a tax on $CO_2$ emissions).

This matrix is used to develop a linear multisectoral economic model that identifies which sectors have the greatest impact on linkages of production, employment, income distribution, and contamination given an exogenous increment or decline in demand. As a multisectoral model, the SAM includes direct, indirect, and induced effects, thereby permitting a complete analysis of economic development (growth, equality, and environment).

The results show that all sectors of the economy present trade-offs among the elements that constitute economic development. Furthermore, the implications of this work allow a critical discussion of recent Chilean public policies on productive support.

The study is organized as follows. After this introduction, the second section presents a review of the literature related to social accounting matrices, including data on their elaboration and the inclusion of environmental accounts. Then, we describe the different models used to analyze productive linkages, the classification of productive sectors, the Hypothetical Extraction Method, the effect of employment and wages, income distribution, and environmental effects. The third section provides the results and an analysis of the indicators mentioned in the previous section, discusses the impact of each sector on the distinct elements of economic development, and contains a critical discussion of recent Chilean support policies. Finally, in the fourth section, we report the main conclusions.

## 2 Materials and methods

### 2.1 Input–output tables

An input–output table (IOT) reflects economic transactions through tables of supply and the utilization of products and services. The IOT is based on studies done by Leontief (1941) and Stone (1963). These tables are made up of sub-tables: products and services produced domestically or imported (total supply); intersectoral transactions between the activities (intermediate demand); payment for the productive factors in the transformation process (value added); and the end use of the products and services (final demand).

The IOT can be used to obtain multipliers, linkages and to identify key sectors and clusters, among others (Schuschny 2005). Moreover, an analysis with multipliers can provide a complete description of an economic structure in terms of the employment generation caused by an external shock (Kim 2011).

Because IOTs represent all the transactions of a country, these tables require varied and broad statistical information. In many cases, this is difficult to obtain and its collection is time-consuming. In Chile, the last available IOT corresponds to the year 2008; this IOT was published recently (November 2011) by the Chilean Central Bank. The analysis herein is based on that IOT.

### 2.2 Social Accounting Matrix (SAM)

A SAM is defined as a representation of the sequence of accounts and the interrelationships among economic flows in a matrix that represents all the transactions performed in a country. SAMs are more comprehensive than IOTs in their coverage of the way in which an economy works so that IOTs are a component of SAMs.

To elaborate a SAM, data are collected from different sources of information and not only from an IOT. The main sources of information include employment surveys, household surveys, public finance statistics, national accounts, and others. The SAM should show at least some minimum disaggregations at the household level. Thus, the SAM has the particularity of being called "social" because Stone coined the term social accounting matrix in deference to the work of Hicks on "The social framework".

Pyatt and Round (1977) formalized the concept and provided the bases for the development of SAMs in Sri Lanka, Iran, and Swaziland. Nonetheless, the works done are based on the principles of Richard Stone over national accounts as well as other authors (Miyazawa 1976; Paukert et al. 1976). For a more thorough look at the beginnings of SAMs, see Polenske (1989).

Hartono and Resosudarmo (2008) indicated that, despite their simplicity, the coefficient multipliers of the SAM adequately describe the impact of an economic policy on the income of households and, therefore, on the income distribution. With a SAM, redistributive aspects and spending patterns can be emphasized (Keuning et al. 1991), although the SAM is not able to incorporate a model of behavior for households and enterprises (Partridge and Rickman 2010).

In the literature, SAMs have been widely applied to: analyze the sensitivity of income and the multipliers of employment (Batey and Weeks 1987; Batey et al. 1987); show the effects of employment on the redistribution of income (James and Khan 1993); analyze economic growth for countries in development (Robinson 1986; Vos and Jong 2003; Tarp et al. 2003); perform micro-simulations for detailed modeling of the behavior of individual households (Cockburn 2001; Robilliard et al. 2001); identify the quantity of the net indebtedness of a country and analyze its relationship with the balanced budget of government subsectors (Santos 2004); and analyze how the sectoral structure of growth contributes to the inequality of workers and households (Pieters 2010).

### 2.3 Elaborating a SAM for Chile

Elaborating a social accounting matrix for Chile for 2008 first required the elaboration of a macro SAM 2008 to show the relationships among Chile's main aggregated economic accounts using data from the national accounts of the Central Bank (See "Appendix"). The matrix was then disaggregated as detailed in the following.

The SAM 2008 obtained for Chile was based largely on the IOT 2008, developed by the Central Bank of Chile. Disaggregations of 34 economic sectors were chosen, using the corresponding groupings of their economic activities as defined in the IOT 2008.

To obtain the disaggregated intermediate consumption, we used the IOT 2008 quadrant of total intermediate use at basic prices. Disaggregated capital was obtained from the IOT 2008 quadrant of value added as a gross operating surplus. For the labor factor, a disaggregation was done by gender and skill level (unskilled, semi-skilled, and skilled) based on the survey CASEN 2009[1] for each activity. Specifically, the CASEN survey provided information on remunerations for each worker by economic sector, gender, and skill level. Later, using the expansion factors of the sample, the labor incomes were added up for each economic sector, gender, and skill level, which allowed us to establish the relative participation of each labor category over the total payment to the sectoral labor that was given by the IOT 2008.

The disaggregation of the value added tax was based on the IOT 2008 pre-quadrant of total supply at user prices, whereas the disaggregation of the tax on production was obtained from the IOT 2008 value added quadrant (e.g., net taxes over production for each activity). The disaggregation of imports was obtained from the IOT 2008 pre-quadrant of total supply at basic prices.

The disaggregated tariffs were obtained from the IOT 2008 pre-quadrant of total supply at basic prices. The disaggregation of the specific tax on products was obtained from the IOT 2008 value added quadrant.

The payment of the capital factor to the households was disaggregated in function of a study by Cantallopts et al. (2007), in which those authors obtained the distribution of the different components of the income from 2003. In this case, we were interested in the retained utilities. After calculating the percentage of participation in the quintiles, these were then multiplied by the payment of the capital factor to the households of the SAM, obtaining the required disaggregation.

The payment of the labor factor to the households was disaggregated in function of the CASEN 2009, from which we obtained the participation of each quintile for the different skill levels and genders. Specifically, using the expansion factors of the sample, all the labor incomes were added up for each economic sector, gender, skill level, and income quintile, which allowed us to establish the relative participation of each income quintile over the total payment to the labor given by the IOT 2008, disaggregated by labor category and gender. The payment of the enterprises to the households was disaggregated in function of a study by Cantallopts et al. (2007), from which we obtained the distribution of the different components of the income from 2003. In this case, we were interested in the dividends and the withdrawal of benefits. We calculated the percentage of participation in the quintiles and later multiplied them by the payment of the enterprises to the households of the SAM.

Household consumption was disaggregated in relation to the participation in the consumption of goods or services of each quintile; this was obtained from the VI Survey of Family Budgets. The direct taxes paid by the households were disaggregated with two sources of information: Cantallopts et al.'s (2007) study, which gave the income tax from 2003[2] by income decile, and the CASEN 2009, which reported average incomes by decile. Later, these two values were multiplied to obtain the participation of the quintiles. Household savings were also disaggregated in function of the VI Survey of Family Budgets.

The disaggregation of government consumption of products and services was based on the IOT 2008 quadrant of total end use at user prices. The payment of the government to the

[1] The following disaggregation was used in the CASEN 2009: Unskilled: no formal, incomplete basic, or complete basic education. Semi-skilled: incomplete high school, incomplete technical-professional high school, complete high school, or complete technical high school education. Skilled: incomplete technical or university or complete technical or university education. The same disaggregation was used for the other subsectors.

[2] Given the lack of information for 2008.

households was disaggregated based on the CASEN 2009, from which monetary subsidies were obtained by quintile. Later, the proportion of the subsidies was calculated in each quintile. The exports were disaggregated based on the IOT 2008 quadrant of total end use at basic prices.

The payment of the rest of the world to the labor factor was disaggregated in function of the average participation at the country level, since data for persons who labored abroad were not available. This same methodology was used for the payment of the rest of the world to the quintiles, but with the percentage of inputs that were paid for all types of labor in each quintile. For the payment of domestic interest to the households, we used the same percentage as for the payment of the capital factor to the households, given the lack of other sources of information.

Finally, we based the disaggregation of the gross fixed capital formation and inventories variations on the IOT 2008 quadrant of total end use at user prices and at basic prices, respectively.

When reconciling diverse sources of information in a SAM, the matrix usually presents an imbalance between the sum of the total for the rows (inputs) and columns (outputs). Thus, the cross-entropy method was applied to obtain the balanced matrix.

### 2.4 Environmentally extended social accounting matrix

To analyze the structural relations that are produced between economic activities and the environment in which they are developed, we use an environmentally extended social accounting matrix (ESAM).

The objective of developing an ESAM is to provide integrated, coherent information describing the relationships between economic activities and pollutant emissions. ESAMs are also used as modeling tools for analyzing policies, especially those related to contamination (Xie 2000).

When we analyze sustainable development along with economic growth, we should consider two relevant aspects in the environmental realm: the scarcity of natural resources that could threaten the sustainability of the economy and the degradation of the environmental quality due to contamination (Bartelmus et al. 1993).

As with SAMs, ESAMs are subject to restricted information, having different levels of disaggregation that influence the validity of their conclusions. Therefore, in some countries, efforts have been made to incorporate natural resources and contamination into traditional accounting, which has translated into satellite accounts in physical units such as accounts of energy, water, and natural resources.

In an extension of a traditional SAM, Resosudarmo and Thorbecke (1996) incorporated air pollutants and data on health costs. Weale (1997) added degradation (e.g., the capitalized value of damaged lands, the loss of biomass by the felling of timber in $m^3$, and the exhaustion of oil reserves in thousands of millions of barrels) to the SAM of Indonesia. Xie (2000) elaborated an ESAM for China that included costs of reducing contamination, environmental taxes, and environmental investment. Rodríguez et al. (2005) obtained the multipliers of production for Spain and its effects on greenhouse gas emissions and water consumption. ESAMs have also been developed for Latin American countries such as Brazil (Lenzen and Schaffer 2004), Mexico (González et al. 2008), and Bolivia (Alarcón et al. 2000).

An ESAM contains rows and columns that are identical to those obtained in a SAM. They relate production and consumption activities, obtaining flows in the monetary units of the economy. ESAMs also have environmental divisions in which we can see accounts such as environmental abatement (by households, enterprises, or government), taxes on contamination, substances that harm the environment, and others. The accounts of substances and environmental emissions vary in their depth of agreement with the information available, being able to incorporate distinct contaminants. The sum of the column of substances represents the supply or origin of emissions, whereas the sum of the row of substances represents their absorption or destination.

To consider the availability of environmental information in the present study, we include the emissions and pollutant substances that affect the air and water generated by fuel consumption and industrial processes. We consider seven air pollutants: respirable particulate material ($PM_{10}$), carbon monoxide (CO), carbon dioxide ($CO_2$), nitrogen oxides ($NO_x$), volatile organic compounds (COV), sulfur oxides ($SO_x$), and ammonia ($NH_3$). We also consider three categories of water pollutants: oils and fats, chlorides, and sulfates. These pollutant substances and emissions from each economic sector in Chile were obtained from the RETC (National Registry of Contaminant Emissions and Transfers).

## 2.5 Intersectoral economic indicators

The indicators of productive linkages are based on models generated from the data of the IOT. The Leontief model is based on the following accounting identity:

$$x = A \cdot x + y \tag{1}$$

where $x$, vector with the domestic production value; $A$, matrix of direct technical coefficients; its elements indicate the proportion in which an input is required to generate a unit of product; $y$, vector with final demand (includes private consumption, investment, and variation of inventories, public spending, and exports).

Reordering, we get:

$$x = (I - A)^{-1} \cdot y = L \cdot y \tag{2}$$

The matrix $L = (I - A)^{-1}$ represents the Leontief matrix or that of total requirements (direct and indirect). This matrix relates production with demand or final production. Therefore, the total production should satisfy the needs of the final demand and of the other sectors. Each element $b^{ij}$ conveys the production required of sector $i$ to satisfy one unit of final demand of the $j$th sector.

The value of backward linkages corresponds to the sum of the elements of the column of the Leontief matrix. This indicator shows the effect on the production of all the sectors, given an increment of one unit on the final demand of sector $j$.

$$BL_j = \sum_{i=1}^{n} b_{ij} \tag{3}$$

Miller and Blair (2009) recommended the Ghosh inverse matrix for calculating forward linkages. In the Ghosh model (Ghosh 1958), the accounting identity from the input side can be written as:

$$x' = x' \cdot B + v' \tag{4}$$

where $B$, matrix of allocation coefficients, which is calculated as a ratio of intersectoral intermediate inputs to the total inputs (raw sums of IOT). $v'$ is the vector of primary factors, which includes capital, labor, and imports.[3]

Reordering, we get:

$$x' = v' \cdot (I - B)^{-1} = v' \cdot G \tag{5}$$

[3] The symbol $'$ denotes matrix transposition.

**Table 1** Identification of key sectors

| | $\pi_j < 1$ | $\pi_j \geq 1$ |
|---|---|---|
| $\tau_i \geq 1$ | Strategic sectors | Key sectors |
| $\tau_i < 1$ | Independent sectors | Driving sectors |

*Source*: Schuschny (2005)

The matrix $G = (I - B)^{-1}$ represents the Ghosh inverse matrix. Each element $g_{ij}$ of $G$ is interpreted as measuring the direct and indirect value increase in output in sector $j$ due to a unit increase in price of the primary inputs in sector $i$. The $i$th row sum of $G$ is interpreted as the increase in the value of total output in all sectors per unit price increase of primary inputs in sector $i$. The total forward linkage of sector $i$ is defined as:

$$FL_i = \sum_{j=1}^{n} g_{ij} \tag{6}$$

The backward and forward linkages allow us to identify the sectors with the greatest impact on the economy, but these linkages also reveal how the impacts of a sector are distributed or dispersed throughout the entire economy.

The power of dispersion, $\pi_j$, measures the direct and indirect effects that are dispersed by the entire economic system as a result of changes in total production, influenced by an increment in the final demand. That is, $\pi_j$ indicates how an increment in production "pushes" the economic system. The power of dispersion is defined as $\pi_j = BL_j / \overline{BL}$, where $\overline{BL}$ corresponds to the average $BL_j$. If $\pi_j > 1$, the stimulus is greater than average; otherwise, it is lower.

The sensitivity of dispersion is defined as $\tau_i = FL_i / \overline{FL}$, where $\overline{FL}$ corresponds to the average $FL_i$. If $\tau_i > 1$, the increased value of total output in all sectors per unit price increase in primary inputs in sector $i$ is greater than average; otherwise, it is lower.

The power and sensitivity of dispersion allow us to classify the sectors into four categories (Table 1).

To identify the key sectors in the economy, the previously discussed indicators are used as a first approximation, but should be complemented with more refined indices of linkages that incorporate the weight of the sector in the overall economy. At present, one method that has been used increasingly to measure linkages is the Hypothetical Extraction Method (HEM), as proposed by Cella (1984). This method suggests measuring the "total linkage effect" of sector $i$ upon comparing the current productive structure of the economy with respect to a hypothetical productive structure that would occur if sector $i$ did not sell or buy any intermediate input toward or from the other economic sectors.

To estimate the importance of sector $i$ on the economy, this sector is hypothetically removed from the production system. In practical terms, the $i$th row and the $i$th column of input matrix $A$, as well as the $i$th element of the vector of final demand $y$, are annulled. The reduction in production is then calculated given this hypothetical case. The input matrix and adjusted vector of final demand are denoted as $A^{-i}$ and $y^{-i}$. Production prior to the removal is $x = L \cdot y$ and production after the removal is $x^{-i} = L^{-i} \cdot y^{-i}$. The difference in the total production of the economy before and after the removal is called the total linkage of sector $i$, and this measures the importance of the sector for the economy. A standardized measure of the total linkages that indicates the percentage reduction of the aggregated product due to the extraction of sector $i$ is obtained by dividing by the total product of the economy.

### 2.6 Income effect

The income effect captures the impact of all the sectors on wages caused by a unitary change in the final demand of the product of any sector $j$. The income effect of sector $j$ is defined as:

$$I_j = \sum_{i=1}^{n} w_i \cdot b_{ij} \tag{7}$$

with

$$w_i = \frac{l_i}{x_i} \tag{8}$$

where $l_i$, payment to the labor factor (salaries, wages, and social security) by sector $i$.

### 2.7 Employment effect

The employment effect captures the impact of all the sectors on the level of employment caused by a unitary change in the final demand of the product of any sector $j$. The employment effect of sector $j$ is defined as:

$$E_j = \sum_{i=1}^{n} \lambda_i \cdot b_{ij} \tag{9}$$

with

$$\lambda_i = \frac{n_i}{x_i} \tag{10}$$

where $n_i$, level of employment of sector $i$; $\lambda_i$, coefficient of direct employment requirements.

### 2.8 Analysis of multipliers of the SAM

An analysis of multipliers that is based on the IOT only captures the direct and indirect effects, making it necessary for the SAM to capture the "induced effect".

The model of Pyatt and Round (1979) based on the SAM and used herein requires defining the accounts as endogenous or exogenous. Exogenous accounts are those defined as outside of the economic system; these are instruments of economic policy and can be related to the government, investment, and exterior commerce. The rest, therefore, are considered to be endogenous. Given that more accounts are treated as endogenous than with the typical Leontief model, there is more money circulating in the economy. Therefore, the multipliers of the SAM tend to be slightly larger than those generated using only the IOT.

For this work, we consider the branches of activity, productive factors, and households to be endogenous accounts, whereas those of government, investment, and the external sector are considered to be exogenous accounts.

Table 2 presents a partitioned SAM based on endogenous and exogenous accounts.

$N$ is a matrix of the SAM that represents the transactions between endogenous accounts, $y$ is a vector that represents injections from an exogenous account to endogenous accounts, $S$ is a matrix of leaks from endogenous to exogenous accounts, and $r$ is a vector of transactions of the SAM between exogenous accounts.

**Table 2** Interrelationship between endogenous and exogenous accounts

| | Endogenous accounts | Exogenous account | Total |
|---|---|---|---|
| Endogenous accounts | $N = A_n \cdot \hat{x}_n$ | $y$ | $x_n = A_n \cdot \hat{x}_n + y$ |
| Exogenous account | $S = A_S \cdot \hat{x}_n$ | $r$ | $x_k = A_S \cdot \hat{x}_n + r$ |
| Total | $x_n' = (1'A_n + 1'A_S) \cdot \hat{x}_n$ | $x_k' = 1'y + 1'r$ | |

*Source*: Pyatt and Round (1979)

The matrix of multipliers of the SAM is a square matrix in which the number of rows and columns is equal to the selected endogenous accounts. The matrix of average propensities of spending, $A_n$, can be obtained by dividing each element of matrix $N$ by the sum total of its respective column. With a little matrix algebra, we can get to the following model:

$$x_n = (I - A_n)^{-1} \cdot y \equiv M \cdot y \tag{11}$$

where $M$ is the matrix of multipliers. The elements of this matrix, $m_{ij}$, show the increment of the endogenous account, $i$, caused by the increment in one monetary unit of the exogenous account.

## 2.9 Analysis of multipliers using ESAM

As in the previous section, to obtain the multipliers with ESAM, it is necessary to define the exogenous and endogenous accounts.[4] However, in this case, we add the environmental accounts to the endogenous accounts, as shown in Table 3.

It is possible to relate the environmental accounts with the economic variables in physical terms, assuming that the environmental variables are in direct proportion to the production of the branches of activities. Thus, we have the vector of technical coefficients of emissions to the environment ($\varepsilon_{il}$):

$$\varepsilon_{il} = c_{il} \cdot \hat{x}_i^{-1} \tag{12}$$

where $c_{il}$, vector of emissions or the dumping of pollutant $l$ into the environment by sector $i$. $\hat{x}_i^{-1}$ denotes a diagonal matrix with the inverse of the elements of the vector $x$.

Equation (12) is defined as the variation of the level of the pollutant $l$ emitted by sector $i$, per unit of production.

The vector of technical coefficients of the capture of resources from the environment ($\mu_{ih}$) can also be defined as:

$$\mu_{ih} = d_{ih} \cdot \widehat{x}_i^{-1} \tag{13}$$

where $d_{ih}$, vector of resources captured from nature for resource $h$ by sector $i$.

Equation (13) represents the variation of resource $h$ perceived by sector $i$.[5]

We can analyze how environmental accounts respond given variations in the exogenous accounts through the matrix of environmental multipliers:

4 Thus, the total effects on the environmental accounts are greater than those estimated with an Input–Output model.

5 The technical coefficient of the capture of resources is not used in this paper due to the lack of data for Chile.

**Table 3** Division of the ESAM into endogenous and exogenous accounts

| ESAM | | SAM Endogenous accounts | Exogenous account | Total | E Environmental endogenous account |
|---|---|---|---|---|---|
| S | Endogenous accounts | $N$ | $y$ | $x_n$ | $d$ |
| A | Exogenous account | $S$ | $r$ | $x_k$ | – |
| M | Total | $x'_n$ | $x'_k$ | – | $dt$ |
| E | Environmental endogenous account | $c$ | – | $ct$ | – |

*Source*: Rodríguez (2004)

$$x_n = M^{\mathrm{ESAM}} \cdot y \tag{14}$$

From which we obtain:

$$\varepsilon_{il}^{D} = \sum_j m_{il}^{\mathrm{ESAM}} \cdot \varepsilon_{il} \tag{15}$$

$$\mu_{ih}^{D} = \sum_j m_{ih}^{\mathrm{ESAM}} \cdot \mu_{ih} \tag{16}$$

which capture the variations of levels of pollutants and resources, considering the direct, indirect, and induced effects on the environment.

## 3 Results and discussion

This section offers a descriptive analysis of the results found in terms of productive linkages, effects on employment and income, and the impact on income distribution and pollutant emissions. Later, we present a discussion in terms of the disjunctions that Chile faces on its road to development considering its current productive structure, identifying the economic sectors that face the least and greatest trade-offs among growth, equality, and environmental protection based on the matrix of countable multipliers.[6]

### 3.1 Impacts of productive linkages

As can be seen in Table 4, using only the IOT data, the sectors that have the greatest backward linkages are the aquaculture (3.10), passenger transport (2.80), timber (2.37), forestry (2.27), and food industry (2.24). The sectors with the least backward linkages are fuel (1.17), public education (1.20), public health (1.35), transport (1.35), and services (1.38). The value of the backward linkage means that if a sector (e.g., the aquaculture industry) receives a shock that increments its final demand in 1,000 million pesos (MM $), the final demand of the Chilean economy will increase finally in MM $3,100,[7] which is 3.1 times the initial increment in the aquaculture industry sector. A sector with a high backward linkage is capable of transmitting the benefits of any increment in its final demand to the rest of the sectors.

[6] The results are exemplified using an increment in the demand of 1,000 million pesos of production; the same methodology is used for a decline of the demand in 1,000 million pesos of production.

[7] This value includes an increment of 1,000 million pesos due to the increase in the final demand of the aquaculture industry sector.

The sectors with the greatest forward linkages are other industry (4.37) and those related to the exploitation of natural resources: aquaculture (3.00), oil and gas extraction (2.88), electricity (2.87), and coal (2.70). One sector with high forward linkages reflects a high increment in the value of the total production of the economy generated by a unitary increment in the price of the inputs of this sector. For example, given the value of the forward linkages of the sector other industries (4.37), if we increase the price of the inputs in this sector, the value of the total production will increase to MM $4,370.

Using the indicators of power and sensitivity of dispersion, we found that the Chilean sectors that could be classified as key sectors are other industry, aquaculture, electricity, non-metal mining industry, forestry, telecommunications, and basic metal. These sectors have the capacity to lever up the other sectors through their backward or forward linkages. The sectors defined as driving are pulp, passenger transport, timber, commerce and hotels, food industry, textile and leather, and furniture. All of these sectors drive the economy through their high intermediate consumption and product supply required to meet the final demand. The independent sectors are other mining, transport, chemical industry, water, construction, other services, copper, private health, public administration, private education, public health, and public education. These sectors consume few intermediate inputs and their production is mostly used to satisfy the final demand, so that they neither pull along nor are pulled along by the other sectors. Finally, the strategic sectors are oil and gas extraction, coal, extractive fishing, fuel elaboration, services, agriculture, metal mechanical and financial services. Although these sectors do not have a large demand for inputs, they supply substantial inputs to the other sectors.

The above analysis has the limitation that, when simulating a unitary shock, the weight of each economic sector is not weighted. Therefore, using the IOT data in Table 5, we present the importance of the economic sectors based on the Hypothetical Extraction Method that simulates the disappearance of each productive sector and its substitution by imports.

The results show that the hypothetical removal of the sectors commerce and hotels would generate the greatest reduction in the PIB (17.38 %), followed by services (16.88 %), the food industry (14.05 %), copper (14.04 %), construction (13.99 %), transport (8.27 %), electricity (5.64 %), financial services (5.14 %), agriculture (5.11 %), and the chemical industry (5.07 %), as the most relevant.

## 3.2 Impacts on wages and employment

Table 6 shows the income and employment effects for the different sectors in Chile. To calculate these indicators, we use the procedure presented in Sects. 2.6 and 2.7,[8] but the accounting multipliers of the SAM.

The greatest effect on wages in all the economy is produced when the final demand increments in sectors such as commerce and hotels (2.70), public education (2.62), public administration (2.37), construction (2.03), and other industry (2.02). The least impact is produced when the final demand increments in sectors such as the fuel industry (0.02), electricity (0.08), other mining (0.10), basic metal (1.12), and pulp (0.13). These results, which are not highly intuitive, can be explained by the value of the wages relative to the value of the production, as well as by the countable multipliers.

The greatest effect in the level of employment for the entire economy is produced when the final demand increases in sectors such as commerce and hotels (0.74), other services

[8] The number of jobs per activity was obtained from the CASEN 2009. In the case of public and private health and education, we use the sectoral participation in the GDP to disaggregate the values in public and private.

**Table 4** Linkages, measures of dispersion, and classification of sectors

| Sector | Linkages | | $\pi_i$ | $\tau_j$ | Classification |
|---|---|---|---|---|---|
| | Backward | Forward | | | |
| Agriculture | 1.7441 | 2.0565 | 0.9830 | 1.1188 | Strategic |
| Forestry | 2.2737 | 2.2212 | 1.2815 | 1.2084 | Key |
| Aquaculture | 3.0995 | 2.9980 | 1.7470 | 1.6310 | Key |
| Extractive fishing | 1.4241 | 2.2919 | 0.8027 | 1.2469 | Strategic |
| Coal | 1.6258 | 2.6973 | 0.9164 | 1.4674 | Strategic |
| Oil and gas | 1.5751 | 2.8835 | 0.8878 | 1.5687 | Strategic |
| Copper | 1.5920 | 1.1786 | 0.8973 | 0.6412 | Independent |
| Other mining | 1.4698 | 1.7973 | 0.8284 | 0.9778 | Independent |
| Food industry | 2.2394 | 1.4369 | 1.2622 | 0.7817 | Driving |
| Textile and leather | 1.8174 | 1.2842 | 1.0244 | 0.6987 | Driving |
| Timber | 2.3717 | 1.5564 | 1.3368 | 0.8468 | Driving |
| Pulp | 2.0222 | 1.7019 | 1.1398 | 0.9259 | Driving |
| Fuel | 1.1712 | 2.1433 | 0.6601 | 1.1660 | Strategic |
| Chemical industry | 1.5451 | 1.6341 | 0.8709 | 0.8890 | Independent |
| Non-metal mining industry | 1.9985 | 2.3309 | 1.1264 | 1.2681 | Key |
| Basic metal | 1.9625 | 1.8928 | 1.1061 | 1.0298 | Key |
| Metal mechanical | 1.3894 | 1.9962 | 0.7831 | 1.0860 | Strategic |
| Furniture | 2.1221 | 1.1542 | 1.1961 | 0.6279 | Driving |
| Other industry | 2.0756 | 4.3724 | 1.1699 | 2.3788 | Key |
| Electricity | 2.0960 | 2.8696 | 1.1814 | 1.5612 | Key |
| Water | 1.4694 | 1.4307 | 0.8282 | 0.7783 | Independent |
| Construction | 1.7553 | 1.2329 | 0.9894 | 0.6708 | Independent |
| Commerce and hotels | 1.8164 | 1.5464 | 1.0238 | 0.8413 | Driving |
| Passenger transport | 2.8017 | 1.6428 | 1.5791 | 0.8937 | Driving |
| Transport | 1.3546 | 1.7659 | 0.7635 | 0.9607 | Independent |
| Telecommunications | 2.1480 | 2.0272 | 1.2107 | 1.1029 | Key |
| Financial services | 1.4102 | 1.8880 | 0.7948 | 1.0271 | Strategic |
| Services | 1.3833 | 2.0655 | 0.7797 | 1.1237 | Strategic |
| Public administration | 1.4257 | 1.0107 | 0.8036 | 0.5499 | Independent |
| Public education | 1.2000 | 1.0000 | 0.6764 | 0.5440 | Independent |
| Private education | 1.4367 | 1.0000 | 0.8098 | 0.5440 | Independent |
| Public health | 1.3463 | 1.0000 | 0.7588 | 0.5440 | Independent |
| Private health | 1.6539 | 1.1741 | 0.9322 | 0.6387 | Independent |
| Other services | 1.5062 | 1.2147 | 0.8489 | 0.6609 | Independent |

*Source*: own elaboration

(0.70), public education (0.48), other industry (0.41), passenger transport (0.38), and construction (0.36). The lowest impact is produced when the final demand increases in sectors such as the fuel industry (0.001), electricity (0.01), pulp (0.01), copper (0.01), and other mining (0.02).

## 3.3 Analysis of the income distribution

Table 7 presents the impact that an increment in the demand of MM $1,000 in each sector has on the incomes. When using the model of Pyatt and Round (1979), the results reflect

**Table 5** Simulated effects of the disappearance of each sector based on the hypothetical extraction method

| Sector | Normalized total linkage | Direct effect (% GDP) | Total effect (% GDP) |
|---|---|---|---|
| Agriculture | 0.9489 | 2.05 | 5.11 |
| Forestry | 0.9895 | 0.18 | 1.05 |
| Aquaculture | 0.9844 | 0.22 | 1.56 |
| Extractive fishing | 0.9940 | 0.09 | 0.60 |
| Coal | 0.9999 | 0.00 | 0.01 |
| Oil and gas | 0.9985 | 0.01 | 0.15 |
| Copper | 0.8596 | 14.42 | 14.04 |
| Other mining | 0.9821 | 1.18 | 1.79 |
| Food industry | 0.8595 | 9.69 | 14.05 |
| Textile and leather | 0.9901 | 0.79 | 0.99 |
| Timber | 0.9796 | 1.04 | 2.04 |
| Pulp | 0.9644 | 1.91 | 3.56 |
| Fuel | 0.9714 | 1.64 | 2.86 |
| Chemical industry | 0.9493 | 3.36 | 5.07 |
| Non-metal mining industry | 0.9849 | 0.07 | 1.51 |
| Basic metal | 0.9644 | 1.41 | 3.56 |
| Metal mechanical | 0.9744 | 1.22 | 2.56 |
| Furniture | 0.9955 | 0.32 | 0.45 |
| Other industry | 0.9986 | 0.09 | 0.14 |
| Electricity | 0.9436 | 1.17 | 5.64 |
| Water | 0.9945 | 0.43 | 0.55 |
| Construction | 0.8601 | 11.75 | 13.99 |
| Commerce and hotels | 0.8262 | 11.50 | 17.38 |
| Passenger transport | 0.9785 | 0.82 | 2.15 |
| Transport | 0.9173 | 6.00 | 8.27 |
| Telecommunications | 0.9691 | 1.70 | 3.09 |
| Financial services | 0.9486 | 3.30 | 5.14 |
| Services | 0.8312 | 8.25 | 16.88 |
| Public administration | 0.9591 | 4.76 | 4.09 |
| Public education | 0.9797 | 2.84 | 2.03 |
| Private education | 0.9848 | 1.77 | 1.52 |
| Public health | 0.9848 | 1.89 | 1.52 |
| Private health | 0.9789 | 2.10 | 2.11 |
| Other services | 0.9731 | 2.65 | 2.69 |

*Source*: own elaboration

the marginal income distributed to each quintile after the shock, including direct, indirect, and induced effects.

The results show that the sectors that intensively exploit natural resources (e.g., forestry, coal, agriculture, fishery extraction, and aquaculture) are those that improve the distribution of income (inequality) in the greatest proportion. Other sectors that also decrease inequality are furniture, timber, textile and leather industry, food industry, and construction. The sectors that most increase inequality are financial services, public health, public education, private health, and private education.

**Table 6** Employment effect and income for the economic sectors of Chile

| Sector | $w_i$ | Income effect ($I_j$) | $\lambda_i$ | Employment effect ($E_j$) |
|---|---|---|---|---|
| Agriculture | 0.151 | 0.526 | 0.100 | 0.349 |
| Forestry | 0.363 | 0.610 | 0.077 | 0.129 |
| Aquaculture | 0.080 | 0.164 | 0.031 | 0.064 |
| Extractive fishing | 0.121 | 0.148 | 0.040 | 0.049 |
| Coal | 0.307 | 0.309 | 0.100 | 0.101 |
| Oil and gas | 0.273 | 0.295 | 0.016 | 0.017 |
| Copper | 0.078 | 0.458 | 0.002 | 0.013 |
| Other mining | 0.062 | 0.099 | 0.009 | 0.015 |
| Food industry | 0.083 | 0.796 | 0.015 | 0.140 |
| Textile and leather | 0.179 | 0.287 | 0.095 | 0.153 |
| Timber | 0.076 | 0.199 | 0.018 | 0.046 |
| Pulp | 0.044 | 0.133 | 0.004 | 0.013 |
| Fuel | 0.012 | 0.022 | 0.000 | 0.001 |
| Chemical industry | 0.090 | 0.287 | 0.008 | 0.025 |
| Non-metal mining industry | 0.077 | 0.161 | 0.011 | 0.024 |
| Basic metal | 0.034 | 0.124 | 0.006 | 0.022 |
| Metal mechanical | 0.200 | 0.422 | 0.034 | 0.071 |
| Furniture | 0.235 | 0.303 | 0.108 | 0.140 |
| Other industry | 1.453 | 2.019 | 0.296 | 0.412 |
| Electricity | 0.023 | 0.079 | 0.003 | 0.012 |
| Water | 0.134 | 0.163 | 0.027 | 0.033 |
| Construction | 0.221 | 2.034 | 0.039 | 0.358 |
| Commerce and hotels | 0.266 | 2.695 | 0.073 | 0.742 |
| Passenger transport | 0.415 | 0.949 | 0.167 | 0.383 |
| Transport | 0.106 | 0.378 | 0.015 | 0.054 |
| Telecommunications | 0.082 | 0.230 | 0.023 | 0.065 |
| Financial services | 0.264 | 0.931 | 0.015 | 0.054 |
| Services | 0.169 | 1.390 | 0.016 | 0.134 |
| Public administration | 0.564 | 2.369 | 0.054 | 0.228 |
| Public education | 0.846 | 2.615 | 0.155 | 0.479 |
| Private education | 0.550 | 1.145 | 0.152 | 0.317 |
| Public health | 0.673 | 1.492 | 0.086 | 0.190 |
| Private health | 0.213 | 0.446 | 0.066 | 0.139 |
| Other services | 0.515 | 1.580 | 0.229 | 0.703 |

*Source*: own elaboration

### 3.4 Analysis of environmental impacts

Table 8 presents the direct emissions in tons, given an increment of MM $1,000 in the final demand of each economic sector. Table 9 presents the total emissions, including direct, indirect, and induced effects.

An attractive result of this analysis is that, although some sectors seem to contaminate very little in terms of direct impact, they are actually leaders in the generation of emissions when considering the indirect and induced emissions incurred by requiring inputs from other polluting sectors. For example, the direct contributions of sectors such as construction, commerce, and services are 0.00, 0.01, and 0.00 tons of $PM_{10}$, respectively, given an increment of MM $1,000 in their demand. However, when including their indirect and induced contributions, these sectors are transformed into those with the greatest total emissions (construction: 14.10, commerce: 11.82, services: 10.6 tons of $PM_{10}$), lower only than the emissions generated by the transport of passengers. The sector of passenger transport has the highest direct $CO_2$ emissions (5,820.11 tons), with $CO_2$ emissions reaching 6705.52 tons when including the indirect and induced effects. However, other sectors (e.g., services, commerce, and construction) contribute relatively few direct emissions (5.61, 18.92, and 41.36 tons, respectively) given an increment in their demand of MM $1,000, but when including the indirect and induced effects, they contribute 4,658.13, 5,521.33, and 5,248.16 tons, making them the second, third, and fourth sectors in terms of the greatest total $CO_2$ emissions. Tables 8 and 9 can be used to find more examples similar to those presented here.

### 3.5 Trade-offs among the different elements of economic development

If we use a SAM without including environmental accounts, it is only possible to obtain the combined impacts for employment, inequality, and productive linkages generated by changes in the sectoral demand. Figure 1 shows that most of the economic sectors face significant trade-offs. For example, we can see that the service sector generates a high productive linkage with mid-level increments in employment, but strongly elevates inequality, or that a sector such as passenger transport increments employment and decreases inequality but generates very few productive linkages. Most importantly, SAMs also allow us to determine which sectors do not face economic trade-offs (without including their environmental impacts). For Chile, in decreasing order, these are: commerce, construction, and the food industry. These sectors strongly increase employment, decrease inequality, and significantly stimulate the other economic sectors.

Unlike a SAM, an ESAM (such as that developed for Chile) allows calculating indicators associated with direct, indirect, and induced pollution generated by the sectoral production, thereby constituting an appropriate tool for evaluating the trade-offs involved in economic development, since this ESAM includes elements such as economic growth, equality, and environmental protection. Thus, with the indicators generated in this study and the preferences of society for each element, we can build rankings of the economic sectors that face the least disjunctions or are the most beneficial for development.

Nonetheless, each pollutant can have different effects on the health of the population and externalities over consumption or other productive sectors. Moreover, each pollutant can have local, regional, or global effects on the air or bodies of water. Therefore, instead of presenting a single indicator that groups the environmental effects, we present several figures that show an analysis for each pollutant, but for purposes of space, we prioritize in one figure those that for diverse reasons are the most important in Chile.

Among the pollutants emitted into the air, at the local level, $PM_{10}$ is heavily regulated in large urban areas, whereas $SO_x$ generates regional pollution effects through acid rain, negatively affecting a variety of species through the acidity of the bodies of water and the soil, as well as producing deterioration and the corrosion of materials. Given its importance at the global level, $CO_2$ has generated much attention in this country. Chile's energy matrix has become more coal-based in recent years due to scarce hydric resources, restrictions on importing natural gas from Argentina, and the increment of oil prices. This could, in the

**Table 7** Impacts on the income by quintile

| Sector | Q1 | Q2 | Q3 | Q4 | Q5 | Index Q5/Q1 |
|---|---|---|---|---|---|---|
| Agriculture | 0.068 | 0.075 | 0.072 | 0.054 | 0.032 | 0.475 |
| Forestry | 0.020 | 0.022 | 0.021 | 0.016 | 0.009 | 0.472 |
| Aquaculture | 0.015 | 0.017 | 0.016 | 0.013 | 0.008 | 0.543 |
| Extractive fishing | 0.006 | 0.007 | 0.006 | 0.005 | 0.003 | 0.511 |
| Coal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.473 |
| Oil and gas | 0.002 | 0.002 | 0.003 | 0.002 | 0.002 | 0.809 |
| Copper | 0.094 | 0.114 | 0.117 | 0.105 | 0.093 | 0.986 |
| Other mining | 0.010 | 0.012 | 0.012 | 0.011 | 0.009 | 0.871 |
| Food industry | 0.124 | 0.142 | 0.143 | 0.114 | 0.074 | 0.599 |
| Textile and leather | 0.012 | 0.014 | 0.015 | 0.012 | 0.007 | 0.597 |
| Timber | 0.023 | 0.026 | 0.025 | 0.020 | 0.013 | 0.571 |
| Pulp | 0.023 | 0.028 | 0.028 | 0.025 | 0.019 | 0.822 |
| Fuel | 0.004 | 0.005 | 0.006 | 0.005 | 0.004 | 0.925 |
| Chemical industry | 0.031 | 0.038 | 0.040 | 0.034 | 0.025 | 0.806 |
| Non-metal mining industry | 0.010 | 0.012 | 0.012 | 0.010 | 0.007 | 0.725 |
| Basic metal | 0.021 | 0.026 | 0.028 | 0.025 | 0.020 | 0.921 |
| Metal mechanical | 0.025 | 0.030 | 0.032 | 0.027 | 0.020 | 0.793 |
| Furniture | 0.006 | 0.007 | 0.007 | 0.005 | 0.003 | 0.566 |
| Other industry | 0.005 | 0.006 | 0.007 | 0.008 | 0.006 | 1.197 |
| Electricity | 0.024 | 0.029 | 0.031 | 0.028 | 0.025 | 1.053 |
| Water | 0.005 | 0.006 | 0.006 | 0.005 | 0.004 | 0.752 |
| Construction | 0.168 | 0.193 | 0.193 | 0.156 | 0.104 | 0.617 |
| Commerce and hotels | 0.234 | 0.278 | 0.287 | 0.238 | 0.155 | 0.665 |
| Passenger transport | 0.030 | 0.036 | 0.037 | 0.030 | 0.019 | 0.636 |
| Transport | 0.066 | 0.079 | 0.080 | 0.066 | 0.044 | 0.659 |
| Telecommunications | 0.026 | 0.032 | 0.035 | 0.032 | 0.028 | 1.074 |
| Financial services | 0.044 | 0.057 | 0.065 | 0.070 | 0.064 | 1.453 |
| Services | 0.146 | 0.182 | 0.197 | 0.191 | 0.166 | 1.138 |
| Public administration | 0.074 | 0.093 | 0.102 | 0.095 | 0.068 | 0.916 |
| Public education | 0.042 | 0.055 | 0.064 | 0.069 | 0.056 | 1.329 |
| Private education | 0.022 | 0.028 | 0.032 | 0.032 | 0.026 | 1.198 |
| Public health | 0.023 | 0.031 | 0.036 | 0.038 | 0.031 | 1.351 |
| Private health | 0.017 | 0.021 | 0.024 | 0.025 | 0.022 | 1.312 |
| Other services | 0.051 | 0.062 | 0.067 | 0.061 | 0.043 | 0.844 |

*Source*: own elaboration

future, affect Chile's commitments to reduce greenhouse gasses by the year 2020, its access to international markets, or the competitiveness of its exports.

Figure 2 shows that the sectors passenger transport, construction, and commerce are those that generate the most direct, indirect, and induced $PM_{10}$ emissions. Of those sectors that lead the growth of the economy and decline in inequality, the food industry sector generates, in relative terms, the least $PM_{10}$ emissions.

**Table 8** Indicator environmental of direct emissions given an increment in demand of MM $1,000

| Sector | Air pollutants | | | | | | | Water pollutants | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{10}$ | CO | $CO_2$ | $NO_x$ | COV | $SO_x$ | $NH_3$ | Oils and fats | Chloride | Sulfates |
| Agriculture | 0.002 | 0.004 | 2.639 | 0.007 | 0.000 | 0.034 | 0.001 | 0.004 | 0.000 | 0.103 |
| Forestry | 0.031 | 0.017 | 5.587 | 0.014 | 0.001 | 0.001 | 0.012 | 0.000 | 0.000 | 0.000 |
| Aquaculture | 0.229 | 2.755 | 19.217 | 3.906 | 0.145 | 0.756 | 0.024 | 8.298 | 32.056 | 0.336 |
| Extractive fishing | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.688 | 5.218 | 0.000 |
| Coal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.023 | 0.000 | 0.257 |
| Oil and gas | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Copper | 0.027 | 0.066 | 16.024 | 0.309 | 0.024 | 0.023 | 0.001 | 0.016 | 0.276 | 6.755 |
| Other mining | 0.423 | 0.327 | 630.171 | 0.999 | 0.066 | 0.254 | 0.006 | 0.000 | 0.019 | 0.244 |
| Food industry | 0.133 | 0.234 | 632.826 | 0.391 | 0.025 | 1.433 | 0.119 | 0.839 | 7.718 | 0.388 |
| Textile and leather | 0.025 | 0.056 | 16.978 | 0.016 | 0.001 | 0.072 | 0.009 | 0.013 | 0.092 | 0.143 |
| Timber | 0.310 | 0.841 | 140.388 | 0.157 | 0.022 | 0.046 | 0.137 | 0.022 | 0.022 | 0.000 |
| Pulp | 0.264 | 1.755 | 616.804 | 0.709 | 0.029 | 0.655 | 0.435 | 0.040 | 4.116 | 11.835 |
| Fuel | 0.188 | 0.797 | 107.921 | 0.702 | 0.060 | 0.763 | 0.001 | 0.008 | 0.000 | 0.000 |
| Chemical industry | 0.022 | 0.167 | 398.564 | 0.230 | 0.071 | 0.212 | 0.004 | 0.054 | 0.000 | 0.012 |
| Non-metal mining industry | 4.952 | 1.363 | 1076.310 | 4.433 | 0.037 | 4.212 | 0.097 | 0.001 | 0.043 | 0.117 |
| Basic metal | 3.285 | 0.954 | 399.149 | 2.748 | 0.021 | 92.694 | 0.049 | 0.004 | 0.076 | 1.658 |
| Metal mechanical | 0.300 | 1.117 | 138.547 | 3.386 | 0.024 | 0.646 | 0.075 | 0.031 | 0.003 | 0.086 |
| Furniture | 0.007 | 0.009 | 7.186 | 0.010 | 0.000 | 0.015 | 0.003 | 0.000 | 0.000 | 0.007 |
| Other industry | 0.047 | 0.119 | 496.595 | 0.453 | 0.008 | 0.666 | 0.023 | 0.016 | 0.012 | 0.003 |
| Electricity | 0.570 | 0.859 | 2317.159 | 5.823 | 0.223 | 15.971 | 0.508 | 1.273 | 0.035 | 0.366 |
| Water | 0.011 | 0.066 | 10.005 | 0.306 | 0.024 | 0.019 | 0.001 | 0.179 | 0.000 | 0.000 |
| Construction | 0.000 | 0.001 | 41.355 | 0.001 | 0.000 | 0.000 | 0.013 | 0.000 | 0.000 | 0.000 |
| Commerce and hotels | 0.009 | 0.031 | 18.917 | 0.136 | 0.019 | 0.015 | 0.001 | 0.107 | 0.000 | 0.004 |
| Passenger transport | 19.166 | 180.564 | 5820.114 | 41.684 | 28.900 | 0.313 | 0.816 | 0.000 | 0.000 | 0.000 |

**Table 8** continued

| Sector | Air pollutants | | | | | | | Water pollutants | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{10}$ | CO | $CO_2$ | $NO_x$ | COV | $SO_x$ | $NH_3$ | Oils and fats | Chloride | Sulfates |
| Transport | 0.002 | 0.004 | 0.010 | 0.017 | 0.000 | 0.024 | 0.000 | 0.000 | 0.000 | 0.000 |
| Telecommunications | 0.018 | 0.114 | 0.003 | 0.526 | 0.000 | 0.028 | 0.001 | 0.000 | 0.000 | 0.000 |
| Financial services | 0.000 | 0.000 | 0.308 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Services | 0.000 | 0.002 | 5.608 | 0.007 | 0.000 | 0.008 | 0.000 | 0.000 | 0.000 | 0.001 |
| Public administration | 0.001 | 0.003 | 15.008 | 0.014 | 0.000 | 0.020 | 0.001 | 0.000 | 0.000 | 0.000 |
| Public education | 0.023 | 0.044 | 364.184 | 0.066 | 0.003 | 0.041 | 0.002 | 0.003 | 0.000 | 0.004 |
| Private education | 0.019 | 0.036 | 299.908 | 0.054 | 0.002 | 0.034 | 0.002 | 0.003 | 0.000 | 0.003 |
| Public health | 0.040 | 0.314 | 565.278 | 0.403 | 0.018 | 0.112 | 0.006 | 0.006 | 0.000 | 0.000 |
| Private health | 0.034 | 0.268 | 483.437 | 0.344 | 0.015 | 0.096 | 0.005 | 0.005 | 0.000 | 0.000 |
| Other services | 0.006 | 0.031 | 0.617 | 0.132 | 0.010 | 0.007 | 0.001 | 0.359 | 0.003 | 0.008 |

Emissions in tons

*Source*: own elaboration

**Table 9** Environmental indicator of total emissions given an increment in demand of MM $1,000

| Sector | Air pollutants | | | | | | | Water pollutants | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{10}$ | CO | $CO_2$ | $NO_x$ | COV | $SO_x$ | $NH_3$ | Oils and fats | Chloride | Sulfates |
| Agriculture | 3.23 | 27.80 | 1473.10 | 8.05 | 4.37 | 3.49 | 0.21 | 1.36 | 5.62 | 0.72 |
| Forestry | 0.87 | 7.35 | 382.48 | 2.10 | 1.16 | 0.86 | 0.06 | 0.26 | 1.04 | 0.14 |
| Aquaculture | 1.08 | 10.05 | 417.88 | 6.97 | 1.21 | 1.95 | 0.09 | 11.07 | 43.27 | 0.65 |
| Extractive fishing | 0.26 | 2.21 | 116.83 | 0.64 | 0.35 | 0.44 | 0.02 | 0.76 | 5.52 | 0.05 |
| Coal | 0.01 | 0.10 | 4.92 | 0.03 | 0.02 | 0.01 | 0.00 | 0.03 | 0.01 | 0.26 |
| Oil and gas | 0.15 | 1.38 | 62.12 | 0.37 | 0.22 | 0.10 | 0.01 | 0.03 | 0.11 | 0.02 |
| Copper | 5.78 | 46.25 | 3176.09 | 15.76 | 7.30 | 15.87 | 0.48 | 1.71 | 5.65 | 8.74 |
| Other mining | 1.12 | 5.94 | 963.01 | 2.75 | 0.95 | 1.35 | 0.06 | 0.16 | 0.56 | 0.38 |
| Food industry | 7.39 | 59.31 | 3907.66 | 22.52 | 8.88 | 11.66 | 0.64 | 15.65 | 68.68 | 3.25 |
| Textile and leather | 0.65 | 5.41 | 321.07 | 1.56 | 0.84 | 0.86 | 0.05 | 0.18 | 0.76 | 0.32 |
| Timber | 1.45 | 10.13 | 691.69 | 2.91 | 1.47 | 1.51 | 0.25 | 0.33 | 1.17 | 0.21 |
| Pulp | 1.73 | 13.62 | 1657.10 | 4.73 | 1.86 | 3.84 | 0.63 | 0.48 | 6.00 | 13.70 |
| Fuel | 0.49 | 3.38 | 267.21 | 1.50 | 0.47 | 1.25 | 0.03 | 0.09 | 0.25 | 0.05 |
| Chemical industry | 2.07 | 16.77 | 1522.42 | 5.38 | 2.69 | 3.42 | 0.16 | 0.58 | 1.93 | 0.63 |
| Non-metal mining industry | 6.24 | 6.49 | 1607.41 | 6.66 | 0.82 | 6.21 | 0.16 | 0.17 | 0.60 | 0.43 |
| Basic metal | 5.32 | 12.51 | 1812.77 | 7.31 | 1.81 | 111.24 | 0.18 | 0.38 | 1.38 | 2.46 |
| Metal mechanical | 1.86 | 12.86 | 827.35 | 6.95 | 1.87 | 6.50 | 0.17 | 0.37 | 1.33 | 0.43 |
| Furniture | 0.33 | 2.47 | 148.91 | 0.74 | 0.38 | 1.11 | 0.02 | 0.07 | 0.27 | 0.08 |
| Other industry | 0.36 | 2.77 | 716.17 | 1.28 | 0.42 | 1.28 | 0.05 | 0.10 | 0.35 | 0.07 |
| Electricity | 2.58 | 14.69 | 4806.23 | 14.34 | 2.45 | 30.27 | 1.00 | 2.62 | 1.49 | 0.90 |
| Water | 0.30 | 2.47 | 158.83 | 1.05 | 0.40 | 0.52 | 0.02 | 0.26 | 0.26 | 0.05 |
| Construction | 14.10 | 78.51 | 5248.16 | 26.34 | 12.19 | 46.59 | 0.69 | 2.02 | 7.96 | 2.26 |
| Commerce and hotels | 11.82 | 101.52 | 5521.33 | 29.54 | 15.98 | 12.62 | 0.81 | 3.78 | 15.04 | 3.22 |
| Passenger transport | 21.32 | 199.65 | 6705.52 | 46.85 | 31.92 | 1.93 | 0.94 | 0.38 | 1.48 | 0.28 |

**Table 9** continued

| Sector | Air pollutants | | | | | | | Water pollutants | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{10}$ | CO | $CO_2$ | $NO_x$ | COV | $SO_x$ | $NH_3$ | Oils and fats | Chloride | Sulfates |
| Transport | 3.37 | 28.93 | 1511.83 | 8.33 | 4.56 | 3.90 | 0.21 | 0.83 | 3.26 | 0.59 |
| Telecommunications | 1.76 | 15.02 | 803.49 | 5.18 | 2.34 | 2.19 | 0.12 | 0.43 | 1.61 | 0.33 |
| Financial services | 3.34 | 29.06 | 1548.98 | 8.21 | 4.58 | 3.16 | 0.22 | 0.81 | 3.28 | 0.77 |
| Services | 10.60 | 89.80 | 4658.13 | 25.31 | 14.16 | 11.61 | 0.65 | 2.30 | 9.28 | 2.10 |
| Public administration | 5.63 | 49.53 | 2397.82 | 13.47 | 7.84 | 4.57 | 0.33 | 1.13 | 4.42 | 0.75 |
| Public education | 2.97 | 25.84 | 1705.02 | 7.30 | 4.07 | 2.61 | 0.18 | 0.76 | 3.00 | 0.48 |
| Private education | 1.61 | 13.87 | 1015.05 | 3.92 | 2.19 | 1.46 | 0.10 | 0.38 | 1.50 | 0.35 |
| Public health | 1.72 | 14.96 | 1336.89 | 4.53 | 2.33 | 1.72 | 0.11 | 0.44 | 1.73 | 0.28 |
| Private health | 1.18 | 10.08 | 1128.69 | 3.31 | 1.56 | 1.56 | 0.09 | 0.33 | 1.22 | 0.24 |
| Other services | 2.94 | 25.70 | 1322.95 | 7.31 | 4.06 | 2.64 | 0.19 | 1.10 | 2.92 | 0.57 |

Emissions in tons

*Source*: own elaboration

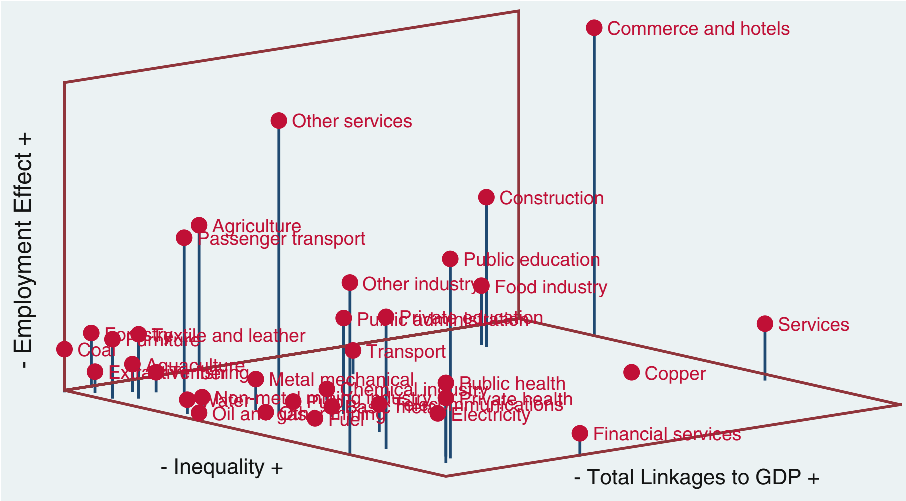


Fig. 1 Productive linkage, employment, and income distribution. *Source*: own elaboration

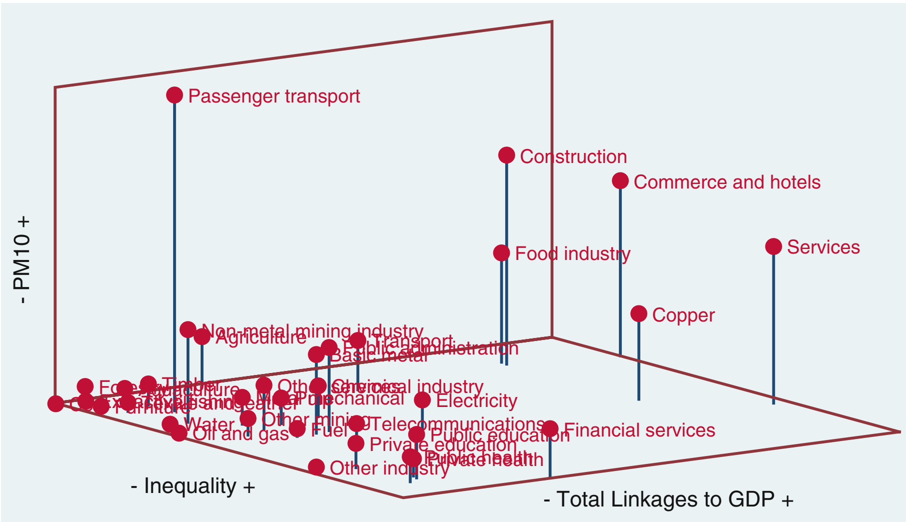


Fig. 2 Productive linkage, income distribution, and $PM_{10}$ pollution. *Source*: own elaboration

Figure 3 shows that the industries of basic metals, construction, and electrical energy are those that generate the most direct, indirect, and induced $SO_x$ emissions. For this pollutant, the sectors food industry and commerce contribute the most positively to economic development.

Figure 4 shows that the sectors passenger transport, commerce, and construction generate the greatest direct, indirect, and induced $CO_2$ emissions. For this pollutant, no sector contributes positively to all the components of economic development. Nevertheless, sectors such as agriculture, public administration, the chemical industry, and others generate medium levels of growth, equality, and relatively low $CO_2$ emissions.

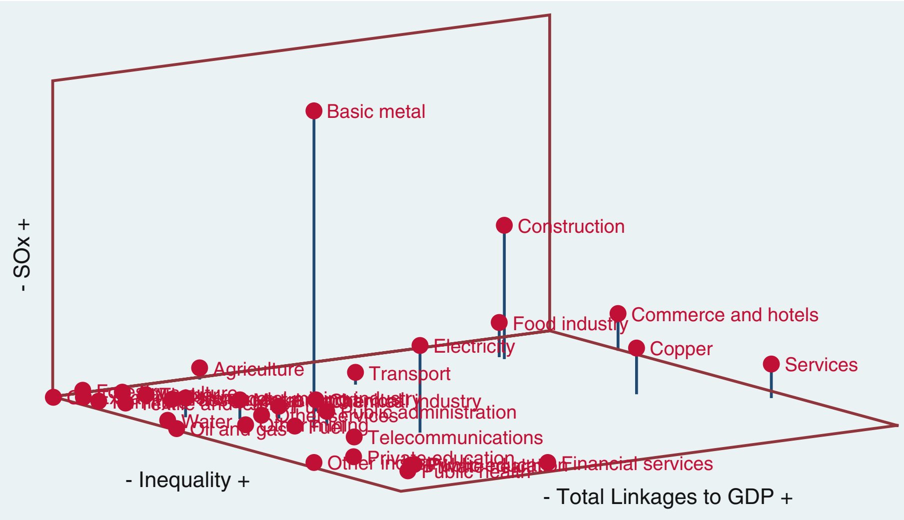


**Fig. 3** Productive linkage, income distribution, and $SO_x$ pollution. *Source*: own elaboration

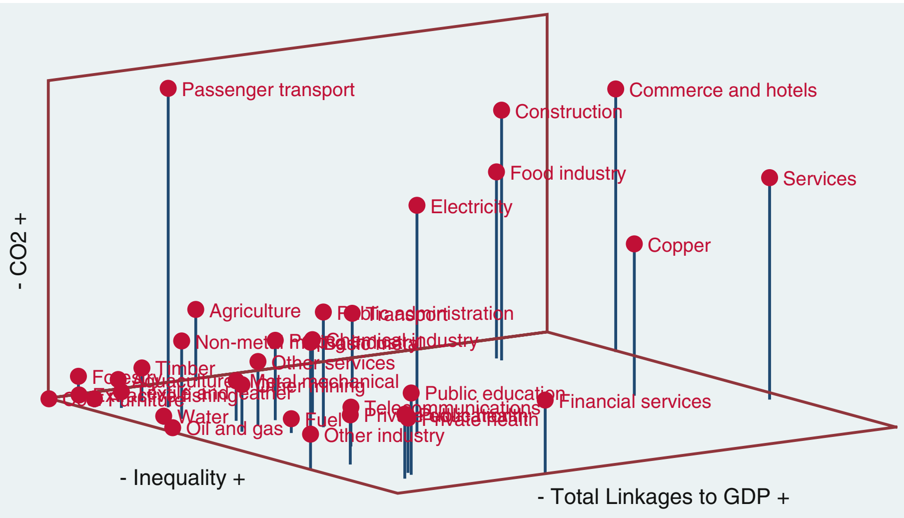


**Fig. 4** Productive linkage, income distribution, and $CO_2$ pollution. *Source*: own elaboration

Among the pollutants that affect the water, oils and fats, chlorides, and sulfates are regulated in Chile through quality standards for specific bodies of water. These pollutants affect the aquatic ecosystems, the use of water for crop irrigation, human consumption, and tourism.

Figure 5 shows that the sectors food industry, aquaculture, and commerce generate the most direct, indirect, and induced effluents of oils and fats to the bodies of water. For this pollutant, the sector construction contributes the most positively to economic development.

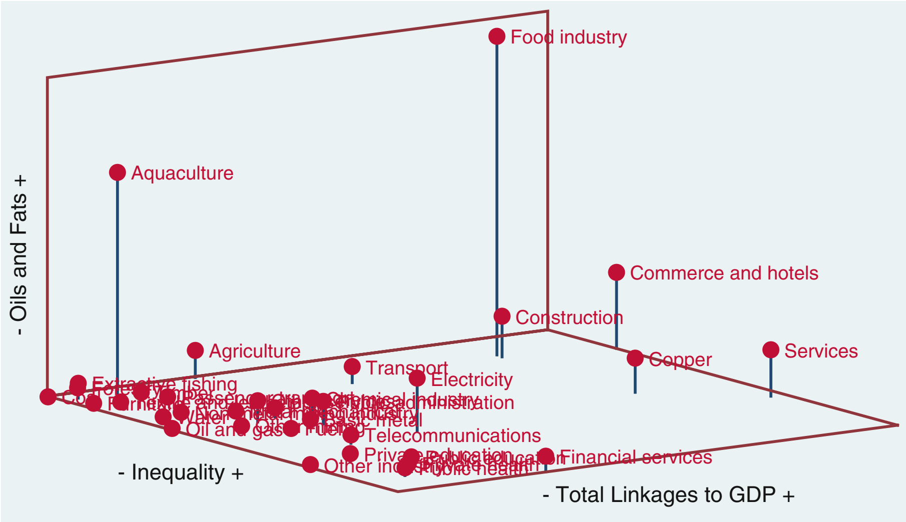


**Fig. 5** Productive linkage, income distribution, and oil and fat pollution. *Source*: own elaboration

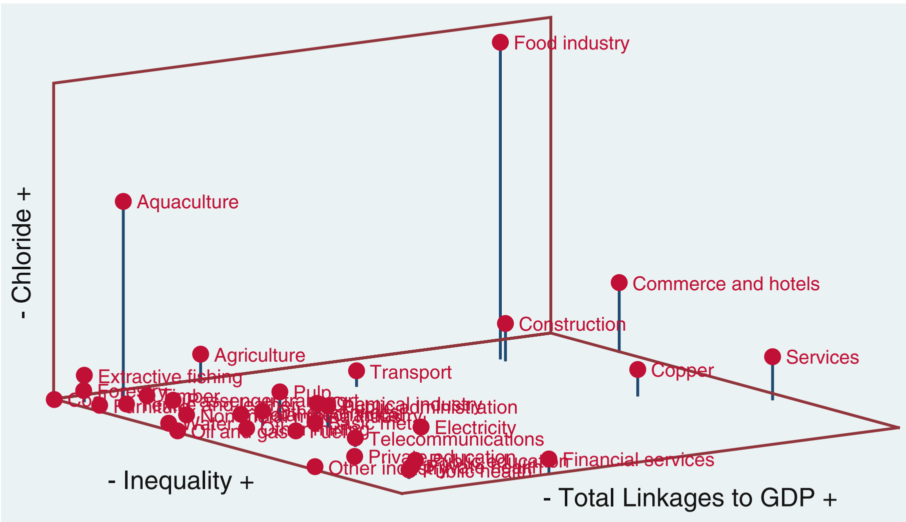


**Fig. 6** Productive linkage, income distribution, and chloride pollution. *Source*: own elaboration

Figure 6 shows that the sectors food industry, aquaculture, and commerce generate the most direct, indirect, and induced effluents of chlorides to the bodies of water. For this pollutant, the construction sector contributes the most positively to economic development.

Figure 7 shows that, in Chile, the sector of exporting commodities (e.g., pulp and copper) release the most direct, indirect, and induced sulfates into bodies of water. Of the sectors that lead economic growth and decrease inequality, the food industry and construction generate the fewest sulfate emissions in relative terms.

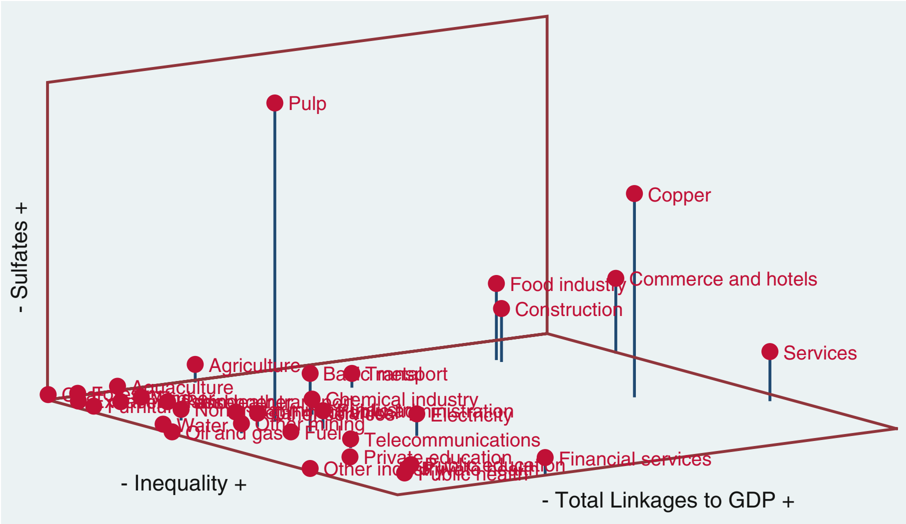


**Fig. 7** Productive linkage, income distribution, and sulfates pollution. *Source*: own elaboration

### 3.6 Implications of economic policy from the obtained results

In order to identify the sectors of the Chilean economy with the highest potential for development, the National Council on Innovation for Competitiveness (Consejo Nacional de Innovación para la Competitividad) developed the "Study of Competitiveness in Clusters of the Chilean Economy" between 2006 and 2007. This was carried out by the international consultant The Boston Consulting Group.

Among the more than 100 sectors analyzed, 11 were prioritized that had the greatest direct impact on growth and potential for linkages. Later, the National Council on Innovation for Competitiveness defined eight sectors to support in the framework of the National Innovation Strategy: aquaculture, processed foods, fruit-farming, copper mining, offshoring, pork and fowl production, financial services, and special interest tourism.

However, the present study shows that some of the sectors chosen cause heavy deterioration of the environment and/or worsened the income distribution. Furthermore, depending on the pollutants under study, few economic sectors in Chile justify this type of support policy since none of the sectors make systematic and significant contributions to the different components of national economic development.

## 4 Conclusions

In this study, we develop an Environmentally Extended Social Accounting Matrix for Chile, base year 2008, using data from different sources of information, including the IOT 2008, CASEN 2009, RETC, Budgetary Council, VI Survey of Family Budgets, Customs, SII, and others.

We then use diverse indicators based on a linear multisectoral model to analyze the impacts of each economic sector on economic development, considering elements such as economic growth, equity, and environment.

Without considering the environmental impacts, we then identify the sectors of commerce, construction, and the food industry as those that strongly increase employment, decrease inequality, and significantly stimulate the other economic sectors.

Conditioning the analysis for the most relevant pollutants, we illustrated the contributions of each economic sector to the Chile's growth and equality, concluding that no single sector maintains leadership in all areas of development, considering the existence of multiple pollutants.

Therefore, the social weight that society affords each one of these elements will allow the elaboration of rankings as to the most beneficial economic sectors for development considering the diverse indicators presented in this study.

Moreover, in terms of the implications of policies of the study, we can determine that the sectors chosen as priorities for Chile by the National Council on Innovation for Competitiveness, from the global perspective of economic development, do not justify support or stimulation policies, since some of these worsened the income distribution and/or substantially elevated the emissions of pollutants through their indirect and induced effects.

**Acknowledgments** The authors are grateful to the National Fund for Scientific and Technological Development (Fondecyt) (initiation project no. 11110007) for the finance it provided for this research.

## Appendix

See Tables 10, 11.

**Table 10** Nomenclature of macro SAM accounts

| Accounts | Meaning |
|---|---|
| A | Activities |
| C | Commodities |
| L | Labor |
| K | Capital |
| E | Enterprises |
| HH | Households |
| Gob | Government |
| ROW | Rest of the world |
| Tax-dir | Direct tax |
| Tax-va | Value added tax |
| Tax-imp | Tariffs |
| Tax-act | Activity tax |
| Tax-esp | Specific tax |
| Int-dom | Domestic interest |
| Int-row | International interest |
| Sav-E | Savings-enterprises |
| Sav-HH | Savings-households |
| Sav-gob | Savings-government |
| Sav-row | Savings-REST of the world |
| E-cap | Enterprises-capital |
| HH-cap | Households-capital |
| Gob-cap | Government-capital |
| Row-cap | Rest of the world-capital |
| Inv | Investment |
| dstck | Stock variations |

*Source*: own elaboration

**Table 11** Representation of macro SAM for Chile (million Chilean $) [Part 1 of 2]

| | A | C | L | K | E | HH | Gob | ROW | Tax-dir | Tax-va | Tax-imp | Tax-act | Tax-esp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | 189,444,981 | | | | | | | | | | | |
| C | 97,120,814 | | | | | 57,081,908 | 10,553,303 | 38,953,165 | | | | | |
| L | 34,133,031 | | | | | | | −1,672 | | | | | |
| K | 49,359,305 | | | | | | | 1,609,977 | | | | | |
| E | | | | 29,678,578 | | | | | | | | | |
| HH | | | 34,131,359 | 6,508,877 | 254,09963 | 3,073,439 | 1,572,312 | 596,624 | | | | | |
| Gob | | | | 1,249,902 | | | | 1,241,338 | 5,882,866 | 7,386,977 | 572,764 | 1,444,854 | 951,002 |
| ROW | | 37,102,495 | | 8,939,399 | | | | | | | | | |
| Tax-dir | | | | | 4,673,899 | 1,208,967 | | | | | | | |
| Tax-va | 7,386,977 | | | | | | | | | | | | |
| Tax-imp | | 572,764 | | | | | | | | | | | |
| Tax-act | 1,444,854 | | | | | | | | | | | | |
| Tax-esp | | 951,002 | | | | | | | | | | | |
| Int-dom | | | | | | | 414,632 | | | | | | |
| Int-row | | | | | | −21,944 | −422,634 | | | | | | |
| Sav-E | | | | | −405,284 | | | | | | | | |
| Sav-HH | | | | | | 10,364,836 | | | | | | | |
| Sav-gob | | | | | | | 5,909,038 | | | | | | |
| Sav-row | | | | | | | | 2,134,002 | | | | | |
| E-cap | | | | | | | | | | | | | |
| HH-cap | | | | | | | | | | | | | |
| Gob-cap | | | | | | | | | | | | | |
| Row-cap | | | | | | | | | | | | | |
| Inv | | | | | | | | | | | | | |
| dstck | | | | | | | | | | | | | |

**Table 11** continued

| | Int-dom | Int-row | Sav-E | Sav-HH | Sav-gob | Sav-row | E-cap | HH-cap | Gob-cap | Row-cap | Inv | dstck |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | | | | | | | | | | | |
| C | | | | | | | | | | | 23,178,540 | 1,183,511 |
| L | | | | | | | | | | | | |
| K | | | | | | | | | | | | |
| E | | | | | | | | | | | | |
| HH | 414,632 | | | | | | | | | | | |
| Gob | | | | | | | | | | | | |
| ROW | | −444,578 | | | | | | | | | | |
| Tax-dir | | | | | | | | | | | | |
| Tax-va | | | | | | | | | | | | |
| Tax-imp | | | | | | | | | | | | |
| Tax-act | | | | | | | | | | | | |
| Tax-esp | | | | | | | | | | | | |
| Int-dom | | | | | | | | | | | | |
| Int-row | | | | | | | | | | | | |
| Sav-E | | | | | | | | | | | | |
| Sav-HH | | | | | | | | | | | | |
| Sav-gob | | | | | | | | | | | | |
| Sav-row | | | | | | | | | | | | |
| E-cap | | | −405,284 | | | | | | | 7,058,271 | | |
| HH-cap | | | | 10,364,836 | | | | | | −1,984,889 | | |
| Gob-cap | | | | | 5,909,038 | | −8,775,194 | 3,040,125 | | −2,940,966 | | |
| Row-cap | | | | | | 2,134,002 | | | | | | |
| Inv | | | | | | | 14,244,670 | 5,339,822 | 2,265,770 | 3,710,719 | | |
| dstck | | | | | | | 1,183,511 | | | | | |

*Source*: own elaboration

## References


Alarcón, J., Van Heemst, J., & de Jong, N. (2000). Extending the SAM with social and environmental indicators: An application to Bolivia. *Economic Systems Research, 12*(4), 473–496.

Bartelmus, P., Stahmer, C., & Van Tongeren, J. (1993). Integrated environmental and economic accounting—A framework for an SNA satellite system. In E. Lutz (Ed.), *Toward improved accounting for the environment*. Washington, DC: The World Bank.

Batey, P. W. J., Madden, M., & Weeks, M. J. (1987). Household income and expenditure in extended input-output models: A comparative theoretical and empirical analysis. *Journal of Regional Science, 27*(3), 341–356.

Batey, P. W. J., & Weeks, M. J. (1987). An extended input-output model incorporating employed, unemployed, and in-migrant households. *Papers of the Regional Science Association, 62*, 93–115.

Cantallopts, J., Jorratt, M., & Scherman, D. (2007). Equidad Tributaria en Chile: Un Nuevo Modelo para Evaluar Alternativas de Reforma, mimeo.

Cella, G. (1984). The input–output measurement of interindustry linkages. *Oxford Bulletin of Economics and Statistics, 46*, 73–84.

Cockburn, J. (2001). Trade liberalisation and poverty in Nepal: A computable general equilibrium micro simulation analysis. Discussion paper 01-18, CREFA, Université Laval.

Ghosh, A. (1958). Input-output approach to an allocative system. *Economica, 25*, 58–64.

González, A., Matus, G., & González, G. (2008). Efecto de las políticas económicas en los recursos naturales y el medio ambiente en México. *Agrociencia, 42*(7), 847–855.

Hartono, D., & Resosudarmo, B. (2008). The economy-wide impact of controlling energy consumption in Indonesia: An analysis using a social accounting matrix framework. Department of Economics, University of Indonesia. Indonesian Project, Economics Division, Research School of Pacific and Asian Studies, The Australian National University, Canberra, ACT 0200, Australia.

James, J., & Khan, H. A. (1993). The employment effects of an income redistribution in developing countries. *World Development, 21*(5), 817–827.

Keuning, S., van Heemst, J., & Alarcón, J. (1991). *The social accounting framework for development, Averbury, England*. Washington, Oxford: Policies, World Bank and Oxford University Press.

Kim, K. (2011). Ex-ante evaluation of a targeted job program: Hypothetical integration in a social accounting matrix of South Africa. Levy Economics Institute of Bard College, Blithewood, Annandale-on-Hudson, NY 12504, United States.

Lenzen, M., & Schaffer, R. (2004). Environmental and social accounting for Brazil. *Environmental & Resource Economics, 27*, 201–226.

Leontief, W. (1941). *The structure of the American Economy, 1919–1929* (1st ed.). New York: Oxford University Press. (2nd edn., 1951).

Manresa, A., & Sancho, F. (2004). Energy intensities and CO2 emissions in Catalonia: A SAM analysis. *Journal of Employment, Environment and the Workforce, 1*(1), 91–106.

Miller, R. E., & Blair, P. D. (2009). *Input-output analysis: Foundations and extensions* (2nd ed.). Cambridge: Cambridge University Press.

Miyazawa, K. (1976). *Input-output analysis and the structure of income distribution*. Berlin: Springer.

Partridge, M., & Rickman, D. (2010). Computable general equilibrium (CGE) modelling for regional economic development analysis. *Regional Studies, 44*(10), 1311–1328.

Paukert, F., Skolka, J., & Maton, J. (1976). Redistribution of income patterns, consumption, and employment. In K. R. Polenske & J. V. Skolka (Eds.), *Advances in input-output analysis*. Cambridge, MA: Ballinger Publishing Co.

Pieters, J. (2010). Growth and inequality in India: Analysis of an extended social accounting matrix. *World Development, 38*(3), 270–281.

Polenske, K. R. (1989). Historical and New International Perspectives on Input-output Accounts. In R. E. Miller, K. R. Polenske, & A. Z. Rose (Eds.), *Frontiers of input-output analysis*. NewYork: Oxford University Press.

Pyatt, G. (1988). A SAM approach to modelling. *Journal of Policy Modelling, 10*(3), 327–352.

Pyatt, G., & Round, J. (1977). Social accounting matrices for development planning. *Review of Income and Wealth, 23*(4), 339–364.

Pyatt, G., & Round, J. (1979). Accounting an fixed price multipliers in a social accounting matrix framework. *Economic Journal, 89*, 850–873.

Resosudarmo, B. P., & Thorbecke, E. (1996). The impact of environmental policies on household incomes for different socio-economic classes: The case of air pollutants in Indonesia. *Ecological Economics, 17*(2), 83–94.

Robilliard, A.-S., Bourguignon, F., & Robinson, S. (2001). Crisis and income distribution: A micro-macro model for Indonesia, mimeo. The World Bank, DIAL, and IFPRI.

Robinson, S. (1986). Multisectoral models of developing countries: A survey. Working paper no. 401, *Department of Agricultural and Resource Economics*, University of California, Berkeley.

Rodríguez, C. (2004). Sistema híbrido para el análisis de las relaciones entre el medioambiente, la economía y la sociedad: Aplicación para año 2000, al recurso agua y las emisiones a la atmósfera en España. Tesis doctoral. Universidad de Sevilla.

Rodríguez, C., Cardente, M., & Llanes, G. (2005). Estimación y actualización anual de matrices de contabilidad social: Aplicación a la economía española para los años 1995 y 1998. *Estadística Española, 47*(159), 353–416.

Santos, S. (2004). *Portuguese net borrowing and the government budget balance A SAM approach*. Department of Economics, Institute of Economics and Business Administration, Technical University of Lisbon, Rua Miguel Lupi, 20, 1249-078 Lisboa, Portugal.

Schuschny, A. (2005). Tópicos sobre el Modelo de Insumo-Producto: Teoría y Aplicaciones. *Serie Estudios Estadísticos y Prospectivos*, CEPAL (37).

Stone, R. (1963). *Input-Output Relationships*. London: Department of Applied Economics, University of Cambridge.

Tarp, F., Roland-Holst, D., & Rand, J. (2003). Economic structure and development in an emergent Asian economy: Evidence from a social accounting matrix for Vietnam. *Journal of Asian Economics, 13*(6), 847–871.

Vos, R., & Jong, N. (2003). Trade liberalization and poverty in Ecuador: A CGE macromicrosimulation analysis. *Economic Systems Research, 15*, 211–232.

Weale, M. (1997). Environmental statistics and the national accounts. In P. Dasgupta & K.-G. Mäler (Eds.), *The environment and emerging development issues*. Oxford: Clarendon Press.

Xie, J. (2000). An Environmentally Extended Social Accounting Matrix. *Environmental & Resource Economics, 16*(4), 391–406.