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Assessing firm heterogeneity within industries for the Chilean economy

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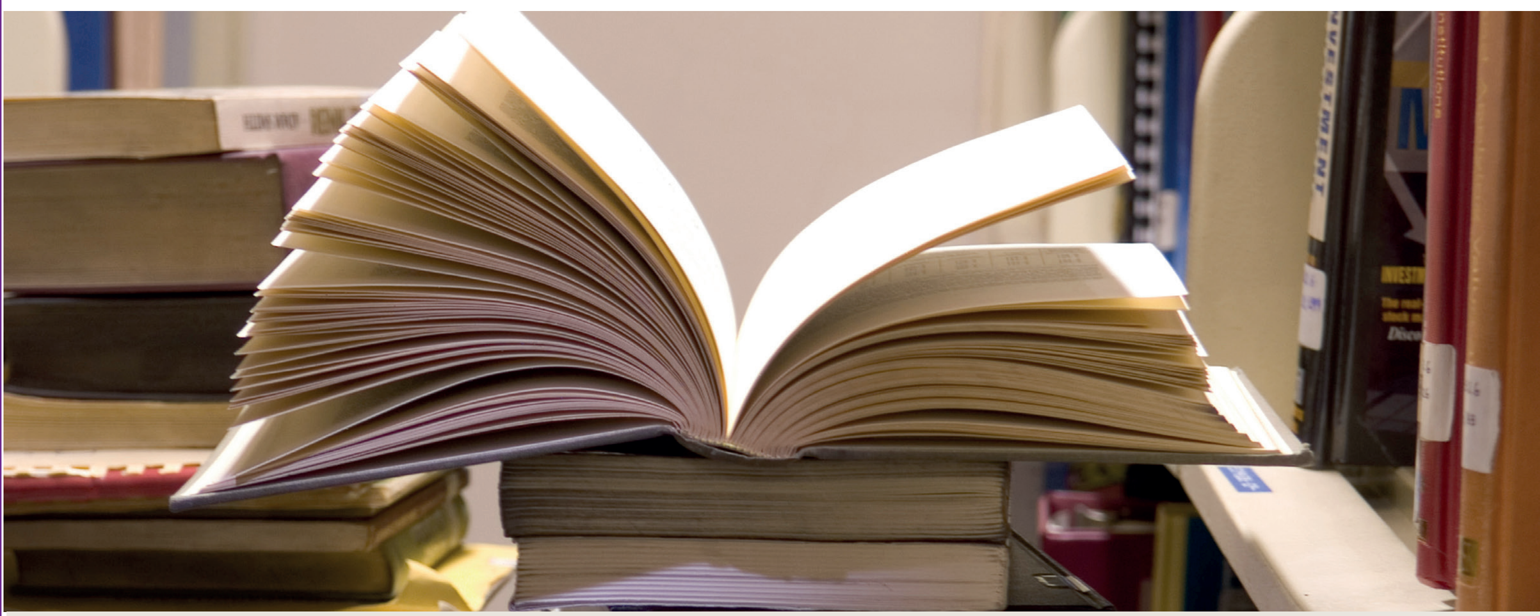

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Assessing firm heterogeneity within industries for the Chilean economy[1]

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Resumen

Los esfuerzos recientes en la medición del valor agregado en el comercio internacional han puesto en jaque los supuestos de producción homogéneos detrás de la matriz de insumo producto (MIP). El presente trabajo propone un método que permite identificar la presencia de heterogeneidad entre las diferentes industrias. Utilizando datos para Chile, se calculan coeficientes técnicos relativos a la orientación de mercado, tamaño de la empresa y propiedad. Este método es capaz de superar la naturaleza agregada de la MIP logrando una caracterización más detallada de las empresas de acuerdo las tres dimensiones mencionadas anteriormente.

Abstract

Current efforts to measure Trade in Value Added (TiVA) using Input-Output Tables (IOT) have come across challenges regarding the homogenous production functions assumptions embedded in them. This work proposes a method to account for the heterogeneity within industries for the Chilean economy, providing technical coefficients related to market orientation, firm's size and ownership. This method is capable of overcoming the aggregate nature of the IOT, and reports a more detailed characterization of firms addressing the three dimensions aforementioned. By doing this, the proposal is capable of showing the heterogeneity in production functions within industries.

[1] I thank Felipe Aviles, Simón Guerrero, Felipe Labrin and an anonymous referee for their comments and insights. The views expressed in this paper are solely those of the author and not necessarily those of the Central Bank of Chile. Email: dvivanco@bcentral.cl.

1. Introduction

At its beginning, the concept of heterogeneity within industries emerged as a response to rising concerns about the dynamics of Foreign Direct Investment (FDI) in economic activity (Hymer, 1976). Through this concept, it became possible to harmonize the idea of enabling financial flows between nations with similar capital endowments, even if foreign trade is deteriorated. Soon after, it expanded to include productivity at firm-level as a driver of FDI engagement (Helpman et al., 2004). Nowadays, heterogeneity in the context of Trade in Value Added (TiVA) has been widely recognized in academic circles, statistical offices and business communities as a field with increasing opportunities in delivering more accurate Global Value Chains (GVC) figures.

As Baldwin and Lopez-Gonzalez (2015) points out, GVC have revolutionized global economic relations. Cross-border flows of goods and services are hiding complex production relations among nations that defy researchers and policy makers (Johnson, 2014). The challenge of measuring GVC involves the measurement of the increasing fragmentation of the production processes in a vertical trading chain that stretches across many countries (Hummels et al, 2001; Jones and Kierzkowski, 2001; Koopman et al, 2008; OCDE, 2015). Each nation takes part in the production chain sequence depending on their comparative advantages. This phenomenon is called vertical specialization, term that traces back to Hummels et al (2001).[1]

According to Ahmad et al (2011), vertical specialization induces firms to internalize in their profit maximization function, the benefits of establishing subsidiaries abroad or outsourcing certain parts of the process to non-affiliated companies located overseas. Hence, the concept of country of origin, in this context, has also become questionable, since different countries and companies contribute to the production of a single product. Emerging and developed countries participate in the GVC in different stages of production were the latter ones appear were the value added is higher (Mudambi, 2008).

Despite the above, GVC have not been at the center of concerns related to international trade for different reasons. Likely, the most relevant is that conventional measures of trade suffered

[1] See World Bank (2017)

from "*cross borders"* difficulties, which implies that valuation of goods and services is overestimated, since goods cross borders several times before final products become available (Hummels et al, 2001; Koopman et al, 2012; OCDE, 2014). Thus, multiple counting masks the contribution of exports to GDP, ignoring the fact that some part of the export value is not generated domestically, but corresponds to imported inputs used in the exportable production of goods and services (Lanz et al, 2009; Johnson and Noguera, 2012).

The joint OECD – WTO Trade in Value-Added initiative (2012) addressed this issue by giving the methodological guidelines to measure the import content of exports through Input-Output Tables[2] (IOT). The use of IOT allows to separate exports into domestic value added and the contribution of import content at industry level, considering both, direct and indirect imports (embedded in domestic inputs) by using the Leontief matrix.[3]

This method has allowed a better accounting of the internalization and fragmentation of production, and the development of new trade statistics that identify the value added by each country in GVCs. Nevertheless, IOT compiled by statistical offices make use of the underlying assumption that within a given industry, the production functions of firms are homogenous. This hypothesis has generated a new agenda of experimental research and highlights the need for countries to exert complementary efforts in order to identify dimensions that could constrain the robustness of TiVA indicators (Fetzer and Strassner, 2015; Ma et al, 2015; Piacentini and Fortainer, 2015).

For instance, if the firms producing goods or services for foreign markets have differences in their production functions from those firms which produce the same goods or services for domestic markets, results from IOT can be questioned. Therefore, an approach capable of providing a more detailed characterization of firms (Fetzer et al, 2016; Michel et al, 2018),

[2] Actually, the TiVA initiative has constructed an International Input-Output table based on official national statistics to measure value added embodied in gross international trade flows by their source country and industry, to obtain better insights into how countries fit into global value chains. The main conclusions from TiVA are that imported intermediates are important for export success, that services account for roughly half of all value added embodied in international trade (often indirectly), and that bilateral trade balances look very different when observed from a value added perspective.

[3] The TiVA initiative has caught the attention of government authorities too. For instance, the Central Bank of Chile held in 2017 a statistical conference on "Measuring the Economy in a Globalized World".

while achieving a reasonable approximation to official statistics, could be a contribution in the elaboration of TiVA indicators.

Recent literature has account for firms' heterogeneity and its effect on international trade. For instance, Tang et al (2016) by means of extended IOT shows that state-owned firms and small and medium enterprises in Chine have higher value added exports to gross exports ratios, compared to the rest of the economy. Michel et al (2018), also using extended IOT, finds that in Belgium export oriented manufacturers are more involved in GVC as they have backward linkages that are stronger than other firms. For the United States, Fetzer et al (2018) using experimental IOT find that value added as a share of output is lower for foreign-owned firms compared with domestic-owned firms and that exports and imports as a share of output is larger for foreign-owned firms.

This paper proposes a method to assess heterogeneity within industries for the Chilean economy based on administrative records at firm-level. In addition, this work provides estimations for the import value embodied in output, while linking different sources of information such as administrative records and business surveys.

By means of exploiting the granularity of microdata and addressing the existence of different dimensions of heterogeneity, this paper is capable of building upon existing proxies for national accounts aggregates, and thus it is readily positioned to be used for future Extended Supply and Use Tables (ESUTs) research.

The remainder of this document is organized as follows. Section 2 presents the theoretical framework and stylized facts about heterogeneity of firms, in the context of TiVA. Section 3 applies the proposed method to assess heterogeneity for the Chilean economy, including the sources and treatment of data. It also identifies the main limitations found, which are directly related with the information available from microdata. Section 4 shows and comments on the results with a breakdown for 15 industries. Finally, section 5 presents concluding remarks.

2. TiVA in the context of heterogeneity

2.1. Theoretical framework

In an Input-Output framework, the relation between producers and consumers can be written as follows:

$$y = A^d \times y + e.$$

Where y is a $n \times 1$ vector of the output of n industries and A^d is a $n \times n$ matrix known as the technical coefficients matrix. Elements of A^d are denoted by a_{ij}^d and represent the ratio of domestic inputs from industry i that are required in the production of one unit of industry j. Finally, e is a $n \times 1$ vector of final demand (including exports).Then, solving for y in the above equation leads to:

$$y = (I - A^d)^{-1} \times e.$$

Where $(I - A^d)^{-1}$ is known as the Leontief inverse matrix. This represents the total requirements (direct and indirect) of domestic inputs to produce one unit of final demand.

In order to determine the import content of exports, it is necessary to estimate the import content of domestic production or direct requirements. Let A^f be the $n \times n$ imported coefficient matrix. Any element a_{ij}^f of A^f denotes the imported inputs from industry i used to produce one unit of industry j's output. Then, the Leontief inverse matrix allows to measure the value of the imported inputs used indirectly in the production of an exported good. That is, imported inputs may be used in one sector, whose outputs are employed in a second, then a third, and eventually embodied in an export good. Formally:

$$L^f = A^f \times (I - A^d)^{-1}$$

Once the import content of the final demand is determined, it is possible to proxy the import content of exports (M_x) as follows:

$$M_x = L^f \times e^X$$

Where e^X is a $n \times 1$ vector of exports of goods and services.

This framework can be seen in Figure 1, which shows the IOT for Chilean economy in 2013 (reference year).

Figure 1: Chile, Input-Output Table 2013 (*)
(billions of Chilean pesos)

	Intermediate demand **(A)**		Final demand **(e)**		Use **(x)**
Domestic (D):	Goods	Services	Other uses	Exports	
Goods	44.1	10.7	35.1	35.7	**125.6**
Services	23.5	19.1	73.3	7.6	**123.4**
Total Domestic $(\boldsymbol{i}' \times \boldsymbol{D})$	67.6	29.8	108.3	43.3	**249.0**
Imports (M) :					
Goods	16.3	4.1			
Services	1.1	3.1			
Total Imports $(\boldsymbol{i}' \times \boldsymbol{M})$	17.4	7.2	108.3	43.3	
Taxes	0.1	2.3			
Value added	61.0	63.4			
Output **(y)**	**146.2**	**102.7**	**249.0**		

(*) Reference year 2013. Central Bank of Chile
IOT at basic prices, industry by industry

Results for the import content of exports are presented below, illustrating the technical coefficients matrices and the total imports embodied directly and indirectly within exports:

Where $A^d = \begin{bmatrix} 0.30 & 0.10 \\ 0.16 & 0.19 \end{bmatrix}$; $A^f = \begin{bmatrix} 0.11 & 0.04 \\ 0.01 & 0.03 \end{bmatrix}$; $L^f = \begin{bmatrix} 0.18 & 0.07 \\ 0.02 & 0.04 \end{bmatrix}$ and $M_x = \begin{bmatrix} 6.8 \\ 1.0 \end{bmatrix}$

According to the above, while gross exports reached 34.8% of GDP, domestic value added recorded in exports, accounts for 28.4%. This implies that import content of export –or foreign value added in exports– accounted 6.3% of GDP in 2013.[4]

Introducing IO techniques, is surely a step forward compared to conventional trade statistics, where the later can provide a misleading view of foreign trade size and its effects on economic growth.

However, in spite of this advance, current TiVA measures have a restrictive assumption inherent to the compilation of IOT: Non-exported GDP for domestic market is assumed to have the same import content as exports (represented in A^f). This implies a homogenous structure within firms in a given industry, which can lead to biases in the estimation of domestic value added in exports.

In order to account for heterogeneity, this method can be further develop, as follows: the technical coefficients matrix A^d of size $(n \times n)$ is defined as containing $\tau = 1, \dots, T$ possible dimensions of heterogeneity within output of n industries. Therefore, the dimension of A^d is $Tn \times Tn$. Analogously, the imported coefficient matrix (A^f) for a given input along n industries will be transformed in the same way. This matrix is multiplied with the Leontief inverse matrix (L^f) and as a result, an import content matrix M_x is obtained controlling for the heterogeneity in production. In short, we have:

$$A^d = \begin{bmatrix} a^d_{11,11} & \dots & a^d_{11,Tn} \\ \vdots & \vdots & \vdots \\ a^d_{n1,11} & \dots & a^d_{nT,nT} \end{bmatrix}_{Tn \times Tn} \quad A^f = \begin{bmatrix} a^f_{11,11} & \dots & a^f_{11,Tn} \\ \vdots & \vdots & \vdots \\ a^f_{n1,11} & \dots & a^f_{nT,nT} \end{bmatrix}_{Tn \times Tn}$$

[4] Rébora and Vivanco (2016) found that 1) Domestic value added fell from 31.5% of GDP in 2008 to 29.2% in 2012 at current prices, accounting in average 31% of GDP for this period; 2) Excluding "Copper mining", "Business services" and "Transport" are the sectors that contribute most to domestic value added; 3) the content of imported input by industry indicates that Chilean economy is highly dependent on energy commodities and products with low technological content, which are involved in exports of commodities and basic manufacturing products. This suggests low participation of Chile in the "circular" trade of technological products, where inputs are shipped abroad and then come back as more processed products to be used again as input.

$$L^f = \begin{bmatrix} l^f_{11,11} & \cdots & l^f_{11,nT} \\ \vdots & \vdots & \vdots \\ l^f_{n1,11} & \cdots & l^f_{nT,nT} \end{bmatrix}_{Tn \times Tn}$$

Where $a^d_{i\tau,j\sigma}$ ($a^f_{i\tau,j\sigma}$) is the ratio of domestic (imported) inputs from industry i and group τ that is required in the production of one unit of industry j and group σ. Matrix L^f contains all possible imported coefficients (directly and indirectly) within exports. Therefore, the focus of interest in this exercise is τ, which defines the dimensions of heterogeneity.

2.2. Empirical evidence

A broad review of recent (and limited) evidence allows to group sources of heterogeneity in three possible dimensions: Market orientation, size of firm and ownership.

2.2.1. Market orientation

In the IOT, the production for the domestic market is assumed to have the same import content as exports. However, given the relevance of the exportable production in the measurement of domestic value added, a broad formulation must include the identification of exporters and non-exporter at its starting point.

Specifically, exporters might be expected to exhibit higher shares of intermediate consumption compared to non-exporters. This can be caused, at least partially, by the upper integration of exporters in the vertical fragmentation of production, which allows them access to wider global networks and technological markets (Ahmad and Araujo, 2011; Ma et al., 2015; Piacentini and Fontainer, 2015; Satoru, 2015).

2.2.2. Size class of firm

Firms' heterogeneity can be addressed by recognizing that firms have different size measured by the labor content in their production. A common way of grouping firms by size is splitting the sample in two groups: Small and Medium Enterprises (SMEs), and larger firms. This characterization tries to grasp the level and evolution of the import content and export intensity (measured as the ratio between exports and turnover). Moreover, this characterization of firms keeps track of the distribution of value added across firms as well.

Stylized facts show that export share is positively correlated with firm size, with small companies displaying export values of almost zero and large firms displaying very high export shares. However, despite the imported intermediate consumption ratio also increases with firm size, evidence on the correlation between this dimension and value added share appears to be inconclusive. Whilst Ahmad et al (2011) find that a larger firm is likely to generate a higher value added per unit of output than micro and small firms, Piacentini and Fontainer (2015) show that in OECD members, 60% of the countries exhibit a negative correlation between firm size and value added.

2.2.3. Ownership

Previous research has also used domestic and foreign ownership as a relevant feature among firms (Bernard et al, 2009; Ahmad and Araujo, 2011; Fetzer and Strassner, 2015; Ma et al., 2015; Piacentini and Fontainer, 2015; Satoru, 2015; Fetzer et al., 2016). Below we present three common findings regarding production function components and its relation to the ownership.

First, intermediate consumption of foreign-owned firms exhibits a higher share with respect to output than domestic-owned firms, which makes their value added coefficient smaller. Secondly, estimated shares of imported inputs seems to be larger in foreign owned firms. Finally, the third result arises from the fact that exports as a share of output are typically larger, on average, for foreign-owned firms than for domestic-owned firms.

In addition, the correlation between ownership and firm size shows that the distribution of import content and export intensity for domestic companies follows a similar pattern to the distribution for smaller firms, while the foreign-owned firms' distribution mimics that of larger firms.

3. Data and method

3.1. Data

The Microdata used in this work was collected from different administrative records already available and other sources of information. The first database used is the income statements from the Tax Revenue Service, which contains information at firm-level on the value of total operating revenues, direct costs, and the value of employee's wages for 2013.[5]

Through matching income and wage statements using a common identifier for firms, it was possible to obtain the number of employees for each firm. Then, an industry classification (ISIC REV.4) was added to the previous forms using the business register, from National Accounts. Nevertheless, some validations and imputations were carried when information stated in both forms was inconsistent:

- When none of the forms reported payments, the owner was assumed to be the only employee.
- When a firm stated wage payments in the income statement, but not in wage statement, the number of employees was imputed using the median wage by industry and size (measured in sales).

The second source used was the value added tax (VAT) statements database at firm-level, which reports monthly sales (debits) and operation costs (credits). This statement contains a breakdown for sales (including exports), and purchases of goods and services (including imported inputs).[6]

Then, both VAT and income databases were matched for 2013 via a common identifier for firms. This implied 559,935 firms for the whole Chilean economy.

Finally, other sources of information used were the set of annual business surveys collected by the National Statistics Office[7] (INE) and a FDI flows survey, collected by the Central

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[5] Raw data were edited (outliers) and imputed (non-responding units) using the Hidiroglou and Berthelot Method (1986).

[6] Imports of capital goods are excluded from imported inputs on the assumption that these are not considered in the intermediate consumption of National Accounts.

[7] Annual business surveys include the following industries: manufacturing, mining, wholesale trade and services.

Bank of Chile. Among other variables business surveys report information on the distribution of capital property (domestic or foreign) and the FDI flows survey data provides statistics on transactions between parent companies and their affiliates. More specifically, on direct investment positions, and on the financial and operating characteristics of the firms involved[8].

3.2. Method

In the first stage of the process, the database described above is used to approximate several aggregated variables of the production function. The value of output is proxied by the operating revenues, which is available in the income statements[9]. Similarly, intermediate consumption is obtained with the direct costs of goods and services from the income statement.

With respect to the compensation of employees (value added component), wage statements include salaries, health and social security contributions, family allowances, pension benefits, amounts received as compensation for years of service, study grants, meals and mobilization or accommodation provided to the employee.

To measure intermediate imports by firms, purchases of imported goods and services are used. However, some limitations must be considered: 1) only direct imports can be captured in VAT database. Hence, goods imported through wholesale and retail trade are not identified[10]; 2) imports can embody domestic value added which cannot be separated and 3) some imported inputs can be produced locally yet sold in foreign markets (re-imported). Despite the magnitude and direction of these effects are unknown, this may not present a relevant impact on the results, considering the low participation of Chile in the circular trade of technological products (Rébora and Vivanco, 2016).

[8] This data is also used to estimate the amount of direct investment income and financial transactions for the balance of payment and international investment position.
[9] Excludes extraordinary financial profits such as interests and dividends.
[10] This can be problematic in industries such as Transport, where the most relevant input is imported fuel through wholesale trade.

The second stage is the main contribution of this paper, which consists in the characterization of firms using administrative records and business surveys. This allows to assess the heterogeneity in the three dimensions described by computing the following indicators:

- **Market orientation:** Exporters and non-exporters are defined by a threshold: If a firm exports more than a 30% of its turnover, it is classified as an exporter. Although this thresholds could be arbitrary[11], an analysis of what are the changes in the results under different assumptions is presented in the Appendix A.
- **Size of firms:** Administrative records allow the characterization of firms by size class. Following the OECD Structural Business Statistics, the proposed breakdown is small and medium enterprises (SMEs: 1-249 employees) and large enterprises (more than 249 employees).
- **Ownership:** The first step was to identify firms involved in FDI flows. Most of them were holdings and financial subsidiaries. Then, these FDI firms were linked with their related enterprises, delivering an improved register of foreign and domestic Multinationals (MNEs). Simultaneously, the use of annual business surveys allows to increase the classification of firms by ownership. In particular, affiliates of foreign MNEs were identified, but not domestic enterprises with foreign affiliates. Therefore, the proposed breakdown in this work is MNE and non-MNEs.

Although it is impractical to estimate the domestic value added content at the product level (due the lack of information between intermediate firms and the reconciliation of data), the proposed method has the potential to overcome some limitations of IOT described in section 2. On the one hand, whilst it does not meet the requirement of being based on national accounts, it has the flexibility necessary to avoid the limitation of homogenous structure at the industry level. On the other is mostly built upon administrative records, which are regularly available in time series or cross sectional analysis. Then, controlling by different dimensions of heterogeneity can give some light about the impact of more detailed technical coefficients in the context of an economy intensive in natural resources such as Chile.

[11] Actually, there is not a "golden rule" about market orientation. An exporter can be defined as an enterprise that exists in foreign trade data from customs. A more restricted definition can be the regularity in terms of exportable production. Even, a minimum amount of income can be defined as a threshold.

Hence, the type of assertions that this method allows are not exactly the same as in the IOT framework, since it's not possible to identify the degree of involvement in Global Value Chains. The contribution of this work, is to assess that within industries it is more or less likely that a firm operates with a different production function than another, or that is more or less intensively importer (exporter) in relative terms.

3.3. Limitations of the study

Since this study is based mostly on administrative records, results are subject to the different issues concerning the use of such sources of information:

- Inconsistencies between administrative records and official national accounts statistics:
    - Concepts, definitions and methods between national accounts and tax-revenue accounting are different.
    - Production Accounts from national accounts are subject to the balancing of Supply and Use Tables (SUTs). Hence, they include a number of corrections and adjustments to reflect reporting errors, such as incorrect reporting information from firms, and adjustments to reflect the non-observed economy, among others.
- Results are based on aggregated variables, therefore their potential use in SUTs and IOT is limited.
- The releasing of tables including the analyzed dimensions could generate conflicts with the due protection of confidential information, specially, in those industries with a high concentration.
- The assumption used in this work is that enterprises at firm-level data are also the basis for constructing IOT. Even though for most businesses the enterprise and the establishment is one and the same, this is not always the case, particularly for larger enterprises in the manufacturing sector.

4. Results and discussion

The basic data for 2013 is grouped with a breakdown of 42 activities. Nevertheless, for illustrative purposes, a breakdown of 15 activities is used. Also, some industries (financial services, wholesale trade and public sectors) are excluded from the analysis due to limitations of administrative records in terms of the measurement of national accounts aggregates.[12]

The analysis is primarily focused on establishing statistical differences within selected dimensions in order to identify relevant breakdowns for IOT, yet the analysis of industrial characterization is useful itself to appreciate the composition within aggregate production functions.

4.1. Market orientation

The general results for the whole economy are presented in Table 1, illustrating aggregate technical coefficients of the production function (with respect to output) for exporter and non-exporter firms.

The coefficients on each group indicate how exporters and non-exporters are producing and distributing their value added. For example, exporter firms exhibited a higher intermediate consumption (69%) in relative terms than non-exporters (59%), which is consistent with a larger value added share in the latter. Also, despite the similarity in the distribution of gross operating surplus between the two categories, the compensation of employees was significantly smaller for exporter firms. Nevertheless, as an opposite pattern to what international evidence suggests, intermediate imports seem to be higher in non-exported GDP for domestic market.

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[12] While financial services revenues include expenses from financing charges - which are not possible to separate using administrative records – the output of wholesale trade corresponds, mostly, to trade margins. With respect to public sectors, the use of tax statements is limited, since their output is proxied, generally, as the sum of intermediate consumption, compensation of employees, consumption of fixed capital and taxes on production. This information does not contain full tax statements for each statistical unit.

Table 1
Technical coefficients by market orientation, 2013
(share of output in %)

	Exporter	**Non-exporter**	**Total**
Intermediate consumption (%)	69	59	61
Intermediate imports (%)	4	8	7
Vale added (%)	31	41	39
Compensation of employees (%)	8	18	15
Gross operating surplus (%)	24	23	23
Output (billions of Chilean pesos)	**45**	**141**	**186**

Source: Author's calculations using microdata from Tax Revenue Service.

An alternative analysis to verify the import content result is to present the correlation coefficient between this variable and the export intensity at firm-level by industry. This index renders characterized correlations using export intensity and import embodied in output, avoiding the effect that any threshold could have on aggregate technical coefficients.[13]

Table 2 shows the correlation figures and the import content (share of output) for exporters and non-exporters by industry.

Results indicate a positive and significant correlation between the share of output exported for the selected industries and the import content ratio (0.0272). Similarly, at industry level, the results were consistent within "Agriculture, forestry and fishing", and "Manufacturing", especially in "Textiles, textile products, leather and footwear", "Non-metallic mineral products and basic metals" and "Fabricated metal products, machinery and equipment, rest of industry".

The exception was "Fuels" since its production is destined completely to the domestic market and its intermediate consumption is mainly accounted by foreign inputs (due to the lack of domestic extraction of petroleum). This implies that the aggregated coefficient for non-exported firms (18%) is directly influenced by fuels' production.

[13] The aggregation bias could affect the comparison between exporter and non-exporter firms. This is frequently the case when activities that 1) are intensive in imported inputs, and 2) produce for domestic markets are included in the estimation of technical coefficients.

Table 2

Stylized facts between import content and export intensity by industry, 2013

(correlation index and technical coefficients with respect to output)

Description	Correlation	Exporter	Non-exporter
		(share of output in %)	
Agriculture, forestry and fishing	0.0119*	2	1
Manufacturing			
Food products, beverages and tobacco	0.0943*	3	9
Textiles, textile products, leather and footwear	0.1176*	19	22
Wood and paper products	0.0471*	3	13
Fuels	n.a.	n.a.	65
Chemicals, rubber and plastic	0.0504*	36	23
Non-metallic mineral products and basic metals	0.1183*	7	15
Fabricated metal products, machinery and equipment, rest of industry	0.1280*	27	16
Total	**0.0272***	**9**	**18**

Note: *Correlation is significant at the 95% level of confidence.

Finally, Table 3 compares the share of imported inputs for exporter firms from goods-producing industries against the aggregate technical coefficients (across all firms in each sector) obtained from IOT for 2013. For consistency, imported inputs through wholesale trade are excluded from the comparison between sources.

On average, the import embodied in exports were 36% lower, matching IOT coefficient with the share from exporters using administrative records. Nevertheless, comparisons must be made excluding the "Fuels" industry. Once this sector is excluded, the import embodied in exports reached 0.8% higher comparing IOT coefficient and the share from microdata.

At industry level, exporter firms from "Agriculture, forestry and fishing" doubled the import content from IOT. Also "Manufacturing" exhibited significant differences in the distribution within industries, but not in the aggregate.

A first group formed by "Food products, beverages and tobacco", "Wood and paper products" and "Non-metallic mineral products and basic metals" reduce their intermediate imports ratio when using the administrative records. On the contrary, as a compensatory effect, "Textiles, textile products, leather and footwear", "Chemicals, rubber and plastic" and "Fabricated metal products, machinery and equipment, rest of industry" presented a higher coefficient with respect to IOT.

Table 3
Technical coefficients of import content: IOT and administrative records, 2013
(share of output in %)

Description	IOT	Exporter firms
Agriculture, forestry and fishing (%)	1	2
Manufacturing (%)	17	10
Food products, beverages and tobacco	7	3
Textiles, textile products, leather and footwear	12	19
Wood and paper products	8	3
Fuels	81	n.a.
Chemicals, rubber and plastic	25	36
Non-metallic mineral products and basic metals	13	7
Fabricated metal products, machinery and equipment, rest of industry	12	27
Total (%)	**14**	**9**
Total excluding Fuels (%)	**9**	**9**

Sources: Author's calculations using aggregations of IOT with a breakdown of 111 activities (foreign expenditures through wholesale trade are excluded) and microdata from Tax Revenue Service.

4.2. Size of firm

Table 4 shows the overall results by controlling for firms' size. A first finding is related to the aggregate share of intermediate consumption after splitting enterprises by the number of employees. While SMEs reached 57% of output, large enterprises recorded 65%. This indicates a difference in the coefficient of value added among groups, but not in the gross operating surplus, since the compensation of employees is higher in SMEs firms.

On a different aspect, the export intensity seems to increase with firm size, with SMEs displaying a lower export coefficient (5%) compared to large firms (29%). Likewise, the concentration of total exports is still more evident, since 89% of exportable production comes from larger firms. This finding is particularly relevant considering that IOT for exporter industries probably do not require a breakdown of firm size. Regarding intermediate import ratio, the differences between groups are not significant, but show a greater intensity in the larger companies.

Table 4

Technical coefficients using size of firm, 2013

(share of output in %)

	SMEs	Large	Total
Intermediate consumption (%)	57	65	61
Intermediate imports (%)	6	8	7
Value added (%)	43	35	39
Compensation of employees (%)	18	14	15
Gross operating surplus (%)	25	22	23
Export intensity (%)	5	29	19
Output (billions of Chilean pesos)	**77**	**109**	**186**

Source: Author's calculations using microdata from Tax Revenue Service.

To clarify this further, the same analysis performed in the previous dimension can be realized with the correlation coefficient, by using the number of employees per firm, instead of defining strata which can hide the underlying correlation between selected indicators.

As Table 5 shows, the size of firm is positively correlated with the export intensity in the whole economy, but this also holds when considering industries separately (Mining, Manufacturing and Services). Similarly, the import embodied shows a positive and significant correlation for most of the industries considered.

In the case of intermediate consumption, the results do not support any correlation with size. In fact, by controlling for it, significant differences are not observed. This allows to verify that results for this variable taking the aggregate coefficient, could be influenced for the presence of certain firms, which can lead to biases in the estimation of heterogeneity within industries.

Table 5

Correlation index controlling by size of firm, 2013

Correlation between	**Whole economy**	**Mining**	**Manufacturing**	**Services**
Size of firm and				
Intermediate consumption	-0.0002	-0.0016	-0.0009	-0.0002
Intermediate imports	0.0259*	0.0237	0.0586*	0.0204*
Value added	0.0002	0.0016	0.0009	0.0002
Compensation of employees	0.0011	-0.0021	-0.0008	0.0015
Export intensity	0.0689*	0.3216*	0.1942*	0.0154*

Note: *Correlation is significant at the 95% level of confidence.

4.3. Ownership

The breakdown of firm ownership (Table 6) between MNEs and non-MNEs indicates no significant differences in the intermediate consumption coefficient. This result is influenced by the fact that import embodied in output reached 7% in both groups. However, regarding value added its distribution is uneven: while MNEs have a capital intensive composition (higher gross operating surplus) compared to non-MNEs, the latter is more labor-intensive in relative terms. Also, the export intensity of MNEs is much larger (35%) than the export share of non-MNEs (11%), which is consistent with the empirical evidence.

Unlike the previous dimensions, the concentration of total exports among groups is not evident. While 65% of exportable production comes from MNEs, 35% is produced by Non-MNEs.

Table 6

Technical coefficients using ownership, 2013

(share of output in %)

	MNEs	**Non-MNEs**	**Total**
Intermediate consumption (%)	64	60	61
Intermediate imports (%)	7	7	7
Vale added (%)	36	40	39
Compensation of employees (%)	8	20	15
Gross operating surplus (%)	28	20	23
Export intensity (%)	35	11	19
Output (billions of Chilean pesos)	**67**	**119**	**186**

Source: Author's calculations using administrative records from Tax Revenue Service.

Regarding the industrial breakdowns, Table 7 shows that the export share of MNEs is higher compared in almost all goods-producing industries, except in "Food products, beverages and tobacco". By relevance terms, besides "Mining", the sector-specific weight of MNEs companies is particularly high in the "Wood and paper products" industry, where they account for more than half of exports. A significant share of exports from "Chemicals, rubber and plastic" and "Fabricated metal products, machinery and equipment, rest of industry" is also carried by MNEs firms (higher than 25%).

Results are robust to the incorporation of services-producing industries, revealing that the export intensity in output is higher in MNEs, especially in "Transportation, information and communication".

Considering import embodied in output, even though the differences in coefficients are lower in this case than for export intensity (excluding "Fuels" industry), MNEs firms source a higher share of their inputs abroad, compared with non-MNEs companies. For example, whilst "Textiles, textile products, leather and footwear" and "Fabricated metal products, machinery and equipment, rest of industry" exhibit a coefficient around 40%, non-MNEs firms reached barely 14-20%.

Following a similar pattern with respect to export intensity, the imports embodied in the services industry seems to show a positive correlation with respect to MNEs ownership, even though its magnitude is not significant compared to goods-producing industries. "Electricity, gas, water supply and sewerage" has the highest coefficient (10%), followed by "Construction" (6%) and "Transportation, information and communication" (4%).

Table 7

Technical coefficients of import content and export intensity by ownership, 2013

(share of output in %)

Description	**MNEs**	**Non-MNEs**	**MNEs**	**Non-MNEs**
	Import content		Export intensity	
Agriculture, forestry and fishing (%)	2	1	20	13
Mining (%)	3	2	73	66
Manufacturing (%)	15	20	27	12
Food products, beverages and tobacco	8	7	14	21
Textiles, textile products, leather and footwear	41	20	20	3
Wood and paper products	7	8	57	7
Fuels	n.a.	65	n.a.	n.a.
Chemicals, rubber and plastic	33	20	29	12
Non-metallic mineral products and basic metals	11	15	18	4
Fabricated metal products, machinery and equipment, rest of industry	39	14	25	6
Electricity, gas, water supply and sewerage (%)	10	3	0	1
Construction (%)	6	1	n.a.	n.a.
Accommodation and food service activities (%)	1	0	3	4
Transportation, information and communication (%)	4	1	20	6
Business services (%)	2	2	3	1
Other services (%)	0	0	0	0
Whole economy (%)	**7**	**7**	**35**	**11**
Whole economy excluding Fuels (%)	**7**	**4**		

Source: Author's calculations using administrative records from Tax Revenue Service.

4.4. Testing heterogeneity

A crucial aspect of this work is to verify the presence of heterogeneity within industries in order to evaluate potential breakdowns of IOT. Although some results were suggested in the analysis of the selected dimensions, it's important to formalize them through an independent mean t-test that tells us whether there are statistically significant differences between them[14]. Table 8 presents the results for the whole economy, controlling for market orientation, size of firm and ownership, respectively.

Table 8
Mean t-test by dimension, 2013
(p-values)

p-value of	Market orientation	Size of firm	Ownership
Intermediate consumption	0.0000	0.0000	0.0000
Intermediate imports	0.2405*	0.0000	0.0000
Value added	0.0000	0.0000	0.0000
Compensation of employees	0.0000	0.0000	0.0000
Exports	0.0000	0.0000	0.0000

Note: Significant differences are observed when p-value is less than 0.05. *0.000 by excluding "Fuels" industry.

Firstly, it shows significant differences for each variable selected, when the breakdown between exporters and non-exporters is considered. The exception is the intermediate imports, which raises concerns about aggregation bias described in the market orientation dimension. By excluding "Fuels" industry from "Manufacturing", the p-value of intermediate imports reached 0.000 which means that significant differences are observed between exporter and non-exporter firms for this component.

In the case of firm's size, the comparison between groups (SME and large enterprises) confirms the presence of heterogeneity for each production function variables.

Analogously, the identification of MNEs and non-MNEs verifies the existence of statistical differences within the whole economy for selected dimensions of heterogeneity.

[14] Before using an independent t-test, some assumptions were verified to proceed appropriately: 1) No significant outliers are observed due the implementation of Hidiroglou and Berthelot Method (1986); 2) dependent variables are approximately normally distributed using the Shapiro-Wilk test of normality; and 3) the presence of homogeneity of variance are assumed using the Levene's test.

The t-test for an aggregate is not useful for industrial analysis as the identification of production functions is not possible. To overcome this problem, a breakdown of 9 activities is carried in the Appendix B, which presents the previous analysis for the reference year (Table B).

The latter exercise allows for two main statements:

- With respect to goods-producing industries, significant differences in each selected variable are observed in most dimensions. However, imports embodied in output exhibit divergent results between exporters and non-exporters, influenced by the inclusion of “Fuels” industry within “Manufacturing”. Likewise, for “Mining” industry, ownership seems not to be a relevant dimension.
- For service-producing industries, as expected, market orientation is not a relevant dimension, since most variables do not present sizable differences. On the contrary, the presence of heterogeneity is observed in terms of firms’ size and ownership.

5. Concluding remarks

Heterogeneity in the context of TiVA has generated a research agenda with increasing opportunities to improve the robustness of GVC figures. On this line, an approach capable of giving a more detailed characterization of firms, while achieving a reasonable approximation to national accounts, could be a relevant contribution in the construction of IOT.

In this context, and based on administrative records, this paper proposes a method to assess heterogeneity within industries in the Chilean economy, providing evidence in three selected dimensions: Market orientation, size of firm and ownership.

This work allows for an identification of heterogeneities within industries showing simultaneously what breakdowns, and variables are potentially relevant for TiVA indicators and industrial characterization. In addition, considering the limited resources contexts within statistical offices, this approach could motivate the development of more detailed IOT that adequately reflect this heterogeneity and provide the basis for improvements in the economic data.

According to the results, despite the heterogeneity observed on each dimension, in the context of an exporter economy intensive in natural resources such as Chile, it seems that current breakdowns of IOT (111 activities) would be enough to measure properly the domestic value added.

In fact, following the market orientation criteria, the difference between import content comparing IOT coefficients and the share obtained from microdata was not significant in aggregated terms. The intuition is as follows: the industries with high export shares (Mining, Food products and Wood and paper products) are identified with the breakdown of IOT, therefore, the aggregation bias from the homogeneity assumption is certainly reduced.

Analogously, considering that 89% of exportable production comes from larger firms, aggregate technical coefficients from IOT are a reasonable proxy to internalize the difference between SMEs and large companies.

Probably the most relevant source of bias is found when controlling for firms' ownership. In this case, the export share and import content of MNEs is higher in almost all goods and services-producing industries compared to non-MNEs.

Nevertheless, despite the fact that in some cases specific comparisons appear to be irrelevant, the possibility to improve IOT coefficients for manufacturing industries and certain services is surely a contribution for the development of TiVA indicators, but also for industrial characterization, especially when it is intended to guide users to more detailed information.

The research agenda on this method is promising. Firstly, our results call for a further exploration of more variables to assess the presence of heterogeneity within sectors and firms. Secondly, this work could be improved in the future with the incorporation of further administrative records and business survey, in order to allocate imports from trade to the user industry and to obtain commodity breakdowns from aggregate variables, such as output and intermediate consumption. Lastly, the use of numerical methods and optimization to balance the results of this work with the Supply and Use Tables (SUTs).

Appendix

- **Appendix A: Testing different thresholds for exporters**

To analyze the effects of assuming different exports threshold within technical coefficients, as well as the effect on t-test (p-value), six simulations are realized. These are compared against the current threshold (more than 30%), considering changes between 0 and 50%.

Table A1

Changes in heterogeneity results under different exports threshold

(technical coefficients with respect to output and p-values)

		(1)	(2)	(3)	(4)
1) More than 0%					
	Exporter	68	11	9	23
	Non-exporter	56	3	21	23
p-value		0.0*	0.0*	0.0*	
2) More than 10%					
	Exporter	69	5	9	23
	Non-exporter	58	8	18	23
p-value		0.0*	0.0*	0.0*	
3) More than 20%					
	Exporter	69	4	8	23
	Non-exporter	59	8	18	23
p-value		0.0*	0.0*	0.0*	
4) More than 30%					
	Exporter	69	4	8	24
	Non-exporter	59	8	18	23
p-value		0.0*	0.0*	0.0*	
5) More than 40%					
	Exporter	69	4	8	23
	Non-exporter	59	8	18	23
p-value		0.0*	0.0*	0.0*	
6) More than 50%					
	Exporter	69	4	7	24
	Non-exporter	59	8	18	23
p-value		0.0*	0.0*	0.0*	

Note: (1) Intermediate consumption; (2) intermediate imports; (3) Compensation of employees; (4) Gross operating surplus. Variables are presented as shares with respect to output *Differences are significant at the 95% level of confidence.

- **Appendix B**

Table B

Mean t-test within dimensions and industries, 2013

(p-values)

1) Market orientation	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Agriculture, forestry and fishing	0.0000	0.3806	0.0000	0.0000	0.0003
Mining	0.0000	0.0055	0.0000	0.0000	0.1370
Manufacturing	0.0000	0.6983	0.0000	0.0000	0.0000
Electricity, gas, water supply and sewerage	0.8038	n.a.	0.7036	0.8079	0.0030
Construction	n.a.	n.a.	n.a.	n.a.	n.a.
Accommodation and food service activities	0.0002	0.5370	0.0000	0.0000	0.0000
Transportation, information and communication	0.0000	0.5668	0.1753	0.0000	0.1639
Business services	0.2172	0.5495	0.1514	0.0251	0.0280
Other services	0.8032	0.6033	0.9177	0.8438	0.0403
2) Size of firm					
Agriculture, forestry and fishing	0.0000	0.0000	0.0000	0.0000	0.0000
Mining	0.0000	0.0003	0.0000	0.0000	0.0012
Manufacturing	0.0000	0.0000	0.0000	0.0000	0.0000
Electricity, gas, water supply and sewerage	0.0000	0.0552	0.0000	0.0000	0.0023
Construction	0.0000	0.0000	0.0000	0.0000	0.0000
Accommodation and food service activities	0.0000	0.0000	0.0000	0.0000	0.0000
Transportation, information and communication	0.0000	0.0000	0.0000	0.0000	0.0000
Business services	0.0000	0.0010	0.0000	0.0000	0.0000
Other services	0.0000	0.0000	0.0000	0.0000	0.4833
3) Ownership	0.0000	0.0000	0.0000	0.0000	0.0000
Agriculture, forestry and fishing	0.0000	0.0000	0.0000	0.0000	0.0000
Mining	0.0000	0.1286	0.0000	0.0000	0.2532
Manufacturing	0.0000	0.0071	0.0000	0.0000	0.0000
Electricity, gas, water supply and sewerage	0.0000	0.2463	0.0000	0.0000	0.6563
Construction	0.0000	0.0000	0.0000	0.0000	n.a.
Accommodation and food service activities	0.0000	0.0001	0.0000	0.0000	0.0000
Transportation, information and communication	0.0000	0.0000	0.0000	0.0000	0.0000
Business services	0.0000	0.0150	0.0000	0.0000	0.0000
Other services	0.0000	0.0000	0.0000	0.0000	0.5901

Note: (1) Intermediate consumption; (2) intermediate imports; (3) value added; (4) compensation of employees; (5) exports. Significant differences are observed when p-value is less than 0.05

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