Inter-Industrial Linkage Effects of Non-Traditional Natural Resource-Based Export Sectors in Chile[♣]

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Abstract

Producing three input-output tables from 1986, 1996, and 2003, this study analyzes whether non-traditional natural resource-based export sectors in Chile, such as fish, fruit, and forestry products, produced different domestic inter-industrial linkage effects, compared with the traditional mining export sector. The findings show that the backward linkage effects of non-traditional natural resource-based export sectors increased, with the trend being especially evident in the wood and wood products, and the fish products sectors. However, the backward linkage effects of the copper sector did not increase and continued to be stably low. On the other hand, backward linkage effects of manufacturing sectors did not increase, contradicting the general assumption of the transformation of industrial structure when accompanied by economic development. Moreover, this study finds that the ratio of domestic intermediate inputs, like prepared animal feeds, substantially increased in the fish products sector. These findings corroborate the fact that salmon aquaculture has developed backward linkages with domestic suppliers.

JEL classification: D57, L16, and O13

Key words: Chile, Backward linkage effects, Non-traditional natural resource-based exports, Transformation of industrial structure

1. Introduction

Chile presents a very interesting study of economic development in Latin American and Caribbean countries (henceforth, LACs), in that it has recorded the most stable economic growth among the LACs since the mid-1980s in spite of having an economic structure that is strongly dependent on

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[♣] This paper is a revised version of Murakami (2010), originally written in Japanese.

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exports of primary products.[1] Since the 1980s, Chile's export strategy has been characterized not just by the expansion of primary products, such as copper in line with its comparative advantage, but also by the diversification of natural resources[2] contained in its export basket, in order to prevent the fluctuations in world prices of commodities from exposing the Chilean economy to external shocks (Meller, 1996). Thus, Chile has succeeded in creating new kinds of export products, such as fish, fruits, and forestry products, which were hardly exported before the economic liberalization.

This study defines the "non-traditional natural resource-based export sector," when a product sector satisfies the following two criteria. First, it defines a "non-traditional natural resource-based product" as a product derived from a natural resource, and one that is not ranked within the top ten exports in *Anuario estadístico de América Latina y el Caribe* (Statistical Yearbook for Latin America and the Caribbean) published by the Economic Commission for Latin America and the Caribbean (ECLAC) in 1975 (i.e., at the beginning of the economic liberalization), but is continuously ranked in the Yearbook during 2000–2003.[3] Second, it defines the "export sector" as a sector for which the ratio of export to total output exceeds 30% in the input-output tables published by the Central Bank of Chile.[4] However, this definition of "non-traditional natural resource-based export sector" does not strictly coincide with *exportaciones no tradicionales* defined by ProChile.[5]

We can confirm the aforementioned export diversification of natural resources and the increase in the importance of non-traditional natural resource-based products from descriptive statistics. The evolution of exports of the ten leading products from 1970 to 2003 is presented in Table 1. The share of copper (i.e., the sum of refined copper, ores and concentrates of copper, blister copper, and other unrefined copper) in total exports decreased from 78.8% in 1970 to 36.2% in 2003. On the other hand, the non-traditional natural resource-based products (i.e., fresh, chilled or frozen fish, fresh grapes, wine from fresh grapes, and sawn lumber) accounted for 17.5% of total exports in

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[1] Chile's GDP growth averaged 5.8% per year from 1984 to 2007.

[2] This study defines "natural resources" according to the classification in ECLAC (2008a), namely, as including both commodities and natural resource-based manufacturing.

[3] The entries in the Year-book are classified according to the Standard International Trade Classification (SITC) Rev.1.

[4] This definition of the export sector is based on Meller and Tokman (1996). The product sectors of the input-output table of 1986, published by the Central Bank of Chile, are classified according to the International Standard Industrial Classification (ISIC) Rev.2. However, some sectors from 1986 were aggregated in the 1996 input-output table, as explained in greater detail in Section 3.

[5] ProChile is the Trade Commission of Chile and a part of the General Directorate of International Economic Affairs of Chile's Ministry of Foreign Affairs. ProChile (2004; 2005) defines *exportaciones no traditionales* as all products except for copper, fish meal, some fruits, cellulose, iron, nitrate, metallic silver, oxide and ferromolybdenum, minerals of gold, sawn and brushed lumber, and methanol. Thus, *exportaciones no traditionales* include blueberry, salmon, chicken, dairy products, and so on. ProChile (2005) also classify *no traditionales* and *fruta* (fruits). Therefore, the definitions used in this study do not differ considerably from those of ProChile, although sawn lumber is excluded in the latter.

2003. Moreover, the export share of the ten leading products showed a decreasing trend; that is, it decreased from 89.9% in 1970 to 60.0% in 2003, although the majority of the ten leading products continued to be natural resource-based. The same is also suggested by the Herfindahl–Hirschman Index (HHI) used to measure the export concentration; the value decreased from 0.41 in 1980 to 0.27 in 2002, one of the most prominent decreases in the LACs during this period (Agosin, 2009).[6] Therefore, while Chile continues to be strongly dependent on exports of natural resources, it has succeeded in diversifying its natural resource-based exports.

Chile's development process since the 1980s lays the ground for a very relevant debate about natural resources and economic development. ECLAC, which strongly influenced development strategies of LACs, especially from the 1950s to the debt crises in the early 1980s, argues that natural resource products are intrinsically different from manufacturing products; the dependence on exports on primary products harms their economic development. The main assumptions of its argument are based on the falling long-term trend of prices of primary products in terms of manufacturing products. As indicated by the Prebisch–Singer thesis, this falling trend is mainly attributable to low income-elasticity of demand for primary products and asymmetric distribution of the fruits of technical progress (Prebisch, 1949; Singer, 1950).[7] The assumptions are also based on high price volatility, very limited back- and forward- linkage effects, and low scope for high value added for their export.[8] Regarding the linkage effects, which our study focuses on, the mining sector (nitrate prior to World War I and copper during 1930–1970) has been regarded as the "enclave", which has very limited back and forward linkage effects with the rest of the domestic economy (Meller, 1995).

However, in recent years, especially after 2000, not only Chile but other LACs also have succeeded in expanding natural resource exports; the emergence of non-traditional natural resource-based exports is evident in other LACs, such as winter vegetables from Guatemala and commercial grains from Paraguay (Carter *et al.* 1996). Those non-traditional natural resource-based products share common features in that they can be highly differentiated and processed. In this regard, recently, ECLAC has provided a positive assessment of development strategies based on

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[6] The HHI for country *j* is defined in the following manner: $HHI_j = \sum_i (\frac{x_{ij}}{x_j})^2$, where x_{ij} is the value of exports of good *i* by country *j* and x_j represents the total value of exports from country *j*. The simple average of HHI of the 17 prominent LACs decreased from 0.36 in 1980 to 0.25 in 2002. Moreover, Mexico experienced the largest decrease during this period, from 0.48 to 0.13 (Agosin, 2009).

[7] They argued that the benefits of technical progress are passed on as rising of wages in manufacturing export countries and as lowering of prices in primary export countries.

[8] For more details, see Palma (1987).

natural resource-based exports. For example, Díaz and Ramos (1998) argue that the aforementioned negative assumptions on natural resource products can be rejected as myths, and they supported "Nordic" development strategies for Chile. Ramos (1998) also argues in favor of development based on production complexes or clusters of processed natural resource products. On the other hand, Rodrik (2005) finds that an indicator, which measures the quality of the country's export basket, is highly correlated with the per capita income of that country. Agosin (2009) also finds that export diversification was positively significant in explaining per capita GDP growth during 1980–2003, after controlling for other variables that affected per capita GDP growth. These recent findings still support ECLAC's traditional view that dependence on a limited number of primary product exports harms or delays economic development.

In this regard, it is very relevant that Chile, the most successful among the LACs in terms of export-led growth based on non-traditional natural resource-based products, has produced different outcomes compared to ECLAC's traditional assumptions on natural resource-based product exports. This study focuses on the linkage effects among the aforementioned assumptions, because the nature of the countries' export sectors would show the production patterns of the economies in question (ECLAC, 1990).[9] It is also because countries that have witnessed economic development based on natural resource-based exports, such as New Zealand, Australia, Norway, Finland, and Sweden, show a common pattern, namely, that exports act as an engine of growth by creating domestic linkages and generating new associated technologies (Machinea and Vera, 2006). Therefore, the objective of this paper is to precisely analyze whether non-traditional natural resource-based export sectors in Chile, such as fish, fruits, and forestry products, have produced different domestic linkage effects, compared with the traditional mining export sector, by producing three input-output tables allowing inter-temporal comparisons.

This paper is organized as follows. Section 2 critically reviews previous studies. Section 3 describes the methodology, that is, how to reconstruct input-output tables in order to perform inter-temporal comparisons and measure the linkage effects. Section 4 analyzes the empirical results. The conclusions are summarized in Section 5.

[9] This study terms inter-industrial linkage effects alone as "linkage effects," although this term may refer to both inter-industrial and intra-industrial linkage effects.

Table 1. The evolution of exports of 10 leading products, 1970–2003 (%)

1970			1975			2000			2003		
SITC	Name	Share of total exports (%)	SITC	Name	Share of total exports (%)	SITC	Name	Share of total exports (%)	SITC	Name	Share of total exports (%)
68212	Refined copper	53.5	68212	Refined copper	37.8	68212	Refined copper	25.6	68212	Refined copper	22.3
68211	Blister copper and other unrefined copper	23.0	68211	Blister copper and other unrefined copper	14.2	28311	Ores and Concentrates of copper	13.1	28311	Ores and Concentrates of copper	12.0
2813	Iron ore and concentrates	5.8	2813	Iron ore and concentrates	5.2	0311	Fish, fresh, chilled or frozen	6.5	0311	Fish, fresh, chilled or frozen	7.0
28311	Ores and concentrates of copper	2.3	68262	Copper powders and flakes	2.8	25172	Sulphate wood pulp, bleached, other than dissolving grades	5.2	25172	Sulphate wood pulp, bleached, other than dissolving grades	3.7
0814	Meat meal and fish meal for fodder	1.3	25172	Sulphate wood pulp, bleached, other than dissolving grades	2.5	11212	Wine of fresh grapes	3.2	0515	Grapes, fresh	3.5
2712	Natural sodium nitrate	1.1	68111	Silver, unwrought or partly worked, but not rolled	2.0	0515	Grapes, fresh	2.9	11212	Wine of fresh grapes	3.3
68942	Molybdenum	0.8	0612	Refined sugar and other products of refining beet and cane (not including syrups)	1.8	24321	Lumber, sawn lengthwise, etc., conifer	1.7	51221	Methyl alcohol	2.2
6411	Newsprint paper	0.8	68942	Molybdenum	1.6	51221	Methyl alcohol	1.6	24321	Lumber, sawn lengthwise, etc., conifer	2.1
25171	Sulphate wood pulp, unbleached	0.7	2712	natural sodium nitrate	1.6	97101	Gold, non-monetary, unwrought or semi-manufactured	1.6	382	Petoroleum products	2.0
25172	Sulphate wood pulp, bleached, other than dissolving grades	0.6	6411	Newsprint paper	1.5	68211	Blister copper and other unrefined copper	1.6	68211	Blister copper and other unrefined copper	1.9
Share of top ten exported products (%)		89.9			71.0			63.0			60.0

Source: CEPAL (1989:120–121), CEPAL (2005:151)

2. Literature Review

A few studies have analyzed the evolution of linkage effects for each product sector in Chile, by reconstructing input-output tables to perform inter-temporal comparisons. For example, Albala-Bertrand (1999) performs inter-temporal comparisons by aggregating the input-output tables from 1962, and from 1977 to 1986, into 25 sectors. He also classifies these 25 sectors into primary, light manufacturing, heavy manufacturing, construction, and services sectors. He finds that the backward linkage effects for both light and heavy manufacturing decreased from 1977 to 1986, just when the Washington Consensus Model (a package of neoliberal reforms) was applied to Chile. However, these linkage effects increased from 1962 to 1977, in the era of import substitution industrialization. Moreover, the ratio of domestic inputs to total intermediations persistently decreased from 1962 to 1977, with this trend being particularly severe in the heavy industry from 1977 to 1986. Therefore, he concludes that Chile's development process since the mid-1970s, when neoliberal reforms were implemented, is in clear contrast with that of Taiwan and South Korea, where intermediate linkage effects increased systematically over time. Moreover, these intermediate linkage effects increased at a quicker rate in heavy manufacturing, although both Chile and Taiwan/South Korea stressed on export-led development. Therefore, the findings of Albala-Bertrand (1999) are striking, because linkage effects of the manufacturing sector weakened over time in Chile, in contrast to the general assumption that one of the main features of transformation of the industrial

structure when accompanied by economic development is a rapid rise in the importance of manufacturing sector. An increase in linkages of manufacturing sectors is associated with their higher output growth, as typically seen in the development process of Taiwan and South Korea (Kubo *et al.*, 1986).[10]

However, Albala-Bertrand (1999) does not analyze the differences of linkage effects among natural resources, as he aggregated the primary sector into the non-mining sector and three mining sectors. Thus, non-traditional natural resource-based products, which increased importance in the export of Chile, as discussed in the Introduction, are excluded from the analyses. Moreover, an excessive aggregation of product sectors tends to wash out meaningful inter-sectoral linkage differentials (Jones, 1976). Therefore, we should use input-output tables with as detailed sector classifications as possible, when performing inter-temporal comparisons, as discussed in the next section. Albala-Bertrand (2006) extends the analysis from 1986 to 1996. However, besides aggregating the primary sector into the non-mining sector and three mining sectors, he also aggregates the input-output tables into 28 sectors, thus presenting findings that are very similar to those of his earlier work. Thus, the excessive aggregation of product sectors persists and non-traditional natural resource-based products are excluded from his analyses.

3. Methodology

In this section, I first describe how to reconstruct input-output tables in order to perform inter-temporal comparisons of linkage effects. The 1986, 1996, and 2003 input-output tables published by the Central Bank of Chile are classified into 75, 73, and 73 sectors, respectively, and thus, the classification of 1986 differs from that of 1996 and 2003. Therefore, if the sectors are to be aggregated in another period, I aggregate multiple sectors into one sector only, in order to reconstruct input-output tables with a sector classification that is as detailed as possible. A detailed analysis of the correspondence table of the Banco Central de Chile (2001) shows that the aggregation of two sectors in 1986 into one sector in 1996 was implemented for six sectors, while that of two sectors in 1996 into one sector in 1986 was implemented for four sectors.[11] As a result of the implementation of classification adjustments, the reconstructed input-output tables from 1986, and 1996 to 2003, have 69 sectors.

Moreover, the Central Bank of Chile does not collate product-by-product or

[10] It does not mention any causality between linkages of manufacturing sectors and the sectors' total output. We may assume that the larger the linkage effects of manufacturing sectors, the higher their total output, and vice versa.

[11] The 69 sectors are calculated as $75 - 6 = 73 - 4 = 69$. For more details, see Table A-1.

industry-by-industry input-output tables, although it did collate the input coefficient matrix in the product-by-product form, and the Leontief inverse matrices in both product-by-product and industry-by-industry forms, for 1996 and 2003. Therefore, we need to convert product-by-industry input-output tables into product-by-product or industry-by-industry input-output tables, when implementing the aforementioned classification adjustments. This study produces product-by-product input-output tables in line with the industry-technology assumption that an industry uses the same technology to produce all its products. This is because there is a possibility that the elements of the produced input coefficient matrix take a negative value under the product-technology assumption. Thus, the industry-technology assumption allows for simpler mathematical operation (Bulmer-Thomas, 1982; Venegas, 1994). This study employs the methodology of Venegas (1994), which explains the conversion of a product-by-industry input-output table from 1986 into a product-by-product input-output table, and applies this methodology for the other two years also, i.e., 1996 and 2003. The product-by-industry tables exogenously give us *U*, the *V* matrix, the *e* vector, and the following balanced equations:

(1) $$\mathbf{q} = \mathbf{U}\mathbf{i} + \mathbf{e} \quad \text{and}$$

(2) $$\mathbf{g} = \mathbf{V}\mathbf{i},$$

where $\mathbf{U}$ is a 69 product × 69 industry absorption matrix, whose element *i*, *j* show that input *i* is absorbed by industry *j*, that is, it corresponds to the domestic flow matrix (Bulmer-Thomas, 1982); *e* is a 69 product × 1 column vector of net final demands (excluding imports); and $\mathbf{i}$ is a 69 × 1 unity column vector. Therefore, $\mathbf{q}$ is a 69 product × 1 column vector of domestic product output. $\mathbf{V}$ is a 69 industry × 69 product make matrix, which shows the distribution of industrial output; the element *i, j* show that *i* industry produces *j* product. It is relevant to note here that one industry does not necessarily produce one product; it also produces a secondary product. For example, the metal industry produces not only metal goods, but also chemicals and other manufacturing products. In that sense, the $\mathbf{V}$ matrix is dominated by the elements on the diagonal, which represent the principal products, while the off-diagonal elements represent the secondary products (Bulmer–Thomas, 1982). Thus, $\mathbf{g}$ is a 69 industry × 1 column vector of domestic industry output.

The industry-technology assumption is given a formal expression in the matrix items as follows:

(3) $$\mathbf{B} = \mathbf{U}\hat{\mathbf{g}}^{-1} \quad \text{and}$$

(4) $$\mathbf{D} = \mathbf{V}\hat{\mathbf{q}}^{-1},$$

where $\hat{\mathbf{g}}$ is a 69 industry × 69 industry diagonal matrix of domestic industry output $\mathbf{g}$. $\hat{\mathbf{q}}$ is a 69 product × 69 product diagonal matrix of domestic product output $\mathbf{q}$. We also term equation (4) as the market share hypothesis, which assumes that the product is supplied in fixed proportions by different contributing industries (Bulmer-Thomas, 1982). Therefore, the solution for unknown domestic input coefficient matrix $\mathbf{A^d}$ of the product-by-product input-output table is as follows. If we substitute equation (3) into equation (1), we obtain the following equation:

(5) $$\mathbf{q} = \mathbf{Bg} + \mathbf{e}.$$

Then, if we substitute the equations (2) and (4) into equation (5), we obtain the following equation:

(6) $$\mathbf{q} = \mathbf{BDq} + \mathbf{e}.$$

Therefore, we obtain equation (7).

(7) $$\mathbf{q} = \mathbf{(I - BD)^{-1}e}.$$

Now, we obtain the domestic input coefficient matrix $\mathbf{A^d} = \mathbf{BD}$ and the domestic Leontief inverse matrix $\mathbf{(I - A^d)^{-1}} = \mathbf{(I - BD)^{-1}}$ of the reconstructed 69 product-by-product input-output table. In these procedures, I choose all matrices and vectors evaluated by basic prices, according to Venegas (1994), although those evaluated at purchasers' and producers' prices are also presented in the original product-by-industry input-output tables. This is because the input coefficients evaluated at basic prices are purer; that is, they do not include any margins of distribution or indirect taxes (Venegas, 1994). The prices are deflated by the wholesale price index (June 1992 = 1).

Second, I explain how to measure the linkage effects. In line with Jones' (1976) observation, this study assumes that the column sums of the Leontief inverse matrix provide the appropriate measure of the backward linkage proposed by Hirschman (1958).[12] This study does not analyze forward linkages, because the main focus is the export sector, which is defined in the Introduction. Thus, it is meaningless to analyze the effects of the export sector, which induce attempts to utilize its output as inputs in some new domestic activities. Moreover, this study excludes

[12] Yotopoulos and Nugent (1973) assumed the column sums of the Leontief inverse matrix as the measure of the total linkage, and not backward linkage alone. Hirschman (1958) defined backward linkage effects as the economic activity that induces attempts to supply, through domestic production, the inputs needed in that activity.

imports from intermediate inputs, and uses the domestic input coefficient matrix produced previously in this section. This is very relevant for this study, because the lack of linkage effects, i.e., the "enclave" nature of underdeveloped countries, as mentioned in the Introduction, is characterized by the fact that inputs from other domestic sectors in advanced countries serve as imports to underdeveloped countries (Hirschman, 1958). Thus, this study calculates only the domestic intermediate inputs stimulated by an increase in one unit of net final demand for a particular sector. However, this study does not take into consideration heterogeneity within the same industries, i.e., the coexistence of small/medium and large firms, and the lack of linkages between them.[13]

Therefore, this study calculates the measure of backward linkage effects (henceforth, BL) of *j* sector as follows:

$$BL_j = \sum_i z_{ij}^d \,, \tag{8}$$

where z_{ij}^d denotes *i,j* elements of the domestic Leontief inverse matrix. BL_j represents the sum of direct and indirect domestic intermediate inputs stimulated by an increase in one unit of net final demand by a particular sector *j*. To compare the BL of each sector, this study normalizes the BL, by comparing the average stimulus created by sector *j* with the overall average. Thus, the normalized backward linkage effects (henceforth, NBL) are calculated as follows:

$$NBL_j = \frac{1/69 \sum_i z_{ij}^d}{1/69^2 \sum_i \sum_j z_{ij}^d} \,, \tag{9}$$

where the numerator represents the stimulus imparted to other sectors by an increase in one unit of net final demand by a particular sector *j*, while the denominator represents the average stimulus for the whole economy when all net final demands increase by one unit (Bulmer-Thomas, 1982). Therefore, in line with Albala-Bertrand (1999), for this study, if the NBL for a particular sector *j* is exceeds one, then this sector, on account of its above average BL, is said to have high BL. Conversely, if the NBL is smaller than one, then this sector, on account of its below average BL, is said to have low BL.

[13] The lack of both inter- and intra-industrial linkages among small/medium and large firms continues to be a prominent issue in Chile today. For more details, see, for example, Infante and Sunkel (2009).

4. Analysis of Empirical Results

4-1. The evolution of backward linkage effects of non-traditional natural resource-based export sectors

First, I show the evolution of the 10 highest BL and NBL by product, and the simple average of BL and NBL classified into seven sectors, that is, non-mining primary products, mining products, natural resource-based manufacturing, light manufacturing, heavy manufacturing, construction, and services sectors,[14] for 1986, 1996, and 2003 (Table 2). This will reveal the characteristics of the production structure of the entire economy for the stated period. The results show that the meat and meat products sector has the highest BL and NBL. Light manufacturing products, except for natural resource-based products, and heavy manufacturing products, are not ranked within the 10 highest BL and NBL during this period. Moreover, the heavy manufacturing sector had very small BL and NBL, and notably, it recorded the smallest BL and NBL among the aforementioned seven sectors in 1996. On the other hand, the non-mining primary products sector shows increasing trends of BL and NBL; the BL increased from 1.550 in 1986 to 1.848 in 2003. An additional striking finding is that the average BL of all products did not increase at all; on the contrary, it decreased from 1.713 in 1986 to 1.645 in 1996.

Therefore, Chile's production structure is characterized by non-increasing BL for the entire economy, while the BL of the manufacturing sector and the non-mining primary products sector decreased and increased respectively during this period in spite of sustainable growth. Thus, the transformation tendency of Chile's industrial structure, as noted by Albala-Bertrand (1999; 2006), has persisted after 1996, contradicting the general assumption of the transformation of industrial structure accompanied by economic development.

[14] Non-resource based light manufacturing products are included within the light manufacturing sector in this classification.

Table 2. The evolution of 10 highest BL and NBL by product, 1986–2003

Product	BL1986	NBL1986	Product	BL1996	NBL1996	Product	BL2003	NBL2003
Meat and meat products	2.470	1.442	Meat and meat products	2.277	1.384	Meat and meat products	2.584	1.497
Leather and leather products	2.452	1.431	Financial services	2.180	1.325	Sugar	2.227	1.290
Prepared animal feeds	2.444	1.427	Milk and milk products	2.156	1.311	Milk and milk products	2.219	1.285
Restaurant services	2.415	1.409	Prepared animal feeds	2.135	1.298	Restaurant services	2.188	1.267
Sugar	2.354	1.374	Coal	2.042	1.242	Wood and and wood products	2.160	1.251
Bakery products	2.326	1.358	Live animals and animal products	1.997	1.214	Live animals and animal products	2.111	1.223
Non-alcoholic beverages and beer	2.312	1.349	Prepared and preserved fish	1.980	1.204	Prepared animal feeds	2.092	1.212
Footwear	2.277	1.329	Restaurant services	1.967	1.196	Prepared and preserved fish	2.084	1.207
Prepared and preserved fruits and vegetables	2.116	1.235	Prepared and preserved fruits and vegetables	1.963	1.193	Bakery products	2.020	1.170
Milk and milk products	2.095	1.223	Bakery products	1.939	1.179	Financial services	2.013	1.166
Average	1.713	1.000	Average	1.645	1.000	Average	1.726	1.000
Non-mining primary products	1.550	0.905	Non-mining primary products	1.627	0.989	Non-mining primary products	1.848	1.071
Mining products	1.586	0.926	Mining products	1.696	1.042	Mining products	1.743	1.022
Natural resource-based manufacturing	2.080	1.214	Natural resource-based manufactueing	1.938	1.178	Natural resource-based manufactueing	2.028	1.174
Light manufacturing	1.996	1.165	Light manufacturing	1.622	0.986	Light manufacturing	1.740	1.008
Heavy manufacturing	1.635	0.954	Heavy manufacturing	1.534	0.933	Heavy manufacturing	1.612	0.934
Construction	1.774	1.035	Construction	1.645	1.000	Construction	1.716	0.994
Services	1.522	0.888	Services	1.526	0.928	Services	1.575	0.912

Source: Author's calculations based on data from Banco Central de Chile (1992; 2001; 2006)

Note: I refer to Banco Central de Chile (2001:215–216) for Spanish to English translations.

Second, Tables 3 to 5 provide the BL and NBL of export sectors, with an export ratio (i.e., the ratio of exports to the total output) exceeding 30%, in descending order of the export ratios. In 1986, 11 product sectors satisfied the aforementioned definition of the export sector, which included four non-traditional natural resource-based products,[15] that is, the prepared and preserved fruits and vegetables sector, the prepared and preserved fish sector (both of which had high BL), the wood and wood products sector, and the fruit products sector. The simple average of NBL among those 4 non-traditional natural resource-based export sectors (1.036) was higher than that among the 3 mining export sectors (0.918), and that of all 11 export sectors (0.936).

In 1996, 12 products sectors satisfied the aforementioned definition of the export sector. These include five non-traditional natural resource-based products, that is, the prepared and

[15] For the definition of non-traditional natural resource-based products, this study refers to *Anuario estadístico de América Latina y el Caribe* published by ECLAC, and the definition used by the input-output tables published by the Central Bank of Chile. Thus, non-traditional natural resource-based products are defined to include the following: fresh, chilled, or frozen fish products (SITC 0311) corresponding to fish products (ISIC 130) and fish product-based manufacturing, i.e., prepared and preserved fish (ISIC 3114); fresh grapes (SITC 0515) corresponds to fruit products (ISIC 111), and fruit product-based manufacturing, i.e., prepared and preserved fruits and vegetables (ISIC 3113); wine of fresh grapes (SITC11212) corresponds to distilled alcoholic beverages and wines (ISIC 3131); and sawn lumber products (SITC 24321) corresponds to wood and wood products (ISIC 331). Thus, this study defines these six product sectors as non-traditional natural resource-based products in the reconstructed 69 product-by-product input-output table.

preserved fish sector, the prepared and preserved fruits and vegetables sector, the distilled alcoholic beverages and wine sector, the wood and wood products sector (all of which had high BL), and the fruit products sector. The simple average of NBL among these five non-traditional natural resource-based export sectors (1.107) was higher than that of the three mining export sectors (0.995), that of one manufacturing sector (0.931), and that of all 12 export sectors (1.025).

Finally, in 2003, 15 products sectors satisfied the aforementioned definition of the export sector. This included six non-traditional natural resource-based products, that is, the wood and wood products sector, the prepared and preserved fish sector, the fish products sector, the prepared and preserved fruits and vegetables sector, the distilled alcoholic beverages and wine sector (all of which had high BL), and the fruit products sector. The simple average of NBL among these 6 non-traditional natural resource-based export sectors (1.111) was higher than that of the three mining export sectors (1.031), that of the three manufacturing sectors (0.951), and that of all 15 export sectors (1.019). Although the copper sector had the highest or second-highest export ratios from 1986 to 2003, the NBL of this sector were 0.962 in 1986, 0.980 in 1996, and 0.988 in 2003. Thus, it had stably low BL.

Therefore, the findings shows that, from 1986 to 2003, the number of the non-traditional natural resource-based export sectors with high BL and the average of NBL of the non-traditional natural resource-based export sectors both increased. Moreover, the non-traditional natural resource-based export sectors always had high BL. The average of NBL of non-traditional natural resource-based export sectors was always higher than the average of NBL of the mining export sectors and that of all export sectors. The NBL of the copper sector did not increase and it had stably low BL during this period. This increasing trend of NBL was especially evident in the wood and wood products, and fish products sectors. It is relevant to note here that, as per the features of non-traditional natural resource-based export sectors, the wood and wood products, and fish products sectors experienced a substantial increase in export ratios. The export ratio of the former increased from 33.0% in 1986 to 63.5% in 2003, while its NBL increased from 0.990 from 1.251 during this time. The export ratio of the fish products sector increased from only 3.0% in 1986 to 64.3% in 2003, while its NBL increased from 0.963 from 1.127.[16] This trend is also seen in the meat and meat products sector, which had the highest BL from 1986 to 2003 (as seen in Table 2). The export ratio of the meat and meat products sector increased substantially from only 2.3% in 1986 to 16.0% in 2003; thus, it was still not classified as an export sector in 2003.

[16] Thus, the fish products sector in 1986 and 1996 is not classified as an export sector. In other words, it is not ranked in tables 5-3 and 5-4.

Table 3. Backward linkage effects of export sectors, 1986

Product	Export	Total output	Export ratio	BL	NBL	Rank of NBL
Copper	800,537	932,005	0.8589	1.648	0.962	38
Prepared and preserved fish	233,576	294,544	0.7930	1.921	1.121	14
Iron	42,138	55,996	0.7525	1.499	0.875	53
Other minerals	227,550	336,246	0.6767	1.573	0.918	45
Sea transport services	152,177	236,395	0.6437	1.340	0.782	62
Fruit products	142,880	254,826	0.5607	1.367	0.798	60
Air transport services	56,228	104,937	0.5358	1.522	0.888	50
Paper and paper products	116,382	245,413	0.4742	1.699	0.992	31
Prepared and preserved fruits and vegetables	23,524	67,741	0.3473	2.116	1.235	9
Forestry products	18,230	52,665	0.3462	1.252	0.731	67
Wood and and wood products	43,670	132,298	0.3301	1.697	0.990	32
Non-traditional natural resource-based products	443,650	749,410	0.5920	1.775	1.036	
Mining products	1,070,225	1,324,247	0.8082	1.573	0.918	
Total export sectors	1,856,892	2,713,067	0.6844	1.603	0.936	

Table 4. Backward linkage effects of export sectors, 1996

Product	Export	Total output	Export ratio	BL	NBL	Rank of NBL
Sea transport services	357,725	397,254	0.9005	1.428	0.868	60
Copper	1,828,083	2,223,383	0.8222	1.611	0.980	36
Prepared and preserved fish	460,806	575,608	0.8006	1.980	1.204	7
Iron	44,984	59,583	0.7550	1.672	1.017	27
Other minerals	324,394	488,759	0.6637	1.624	0.987	35
Prepared and preserved fruit and vegetable	165,836	294,138	0.5638	1.963	1.193	9
Air transport services	153,868	277,732	0.5540	1.431	0.870	59
Fruit products	207,722	458,465	0.4531	1.468	0.893	54
Paper and paper products	273,513	629,179	0.4347	1.820	1.107	16
Wood and and wood products	205,324	496,350	0.4137	1.772	1.077	20
Distilled alcoholic beverages and wine	90,095	218,810	0.4117	1.924	1.170	11
Other manufacturing products	13,083	37,110	0.3526	1.531	0.931	44
Non-traditional natural resource-based products	1,129,784	2,043,371	0.5529	1.821	1.107	
Mining products	2,197,461	2,771,726	0.7928	1.636	0.995	
Manufacturing products	13,083	37,110	0.3526	1.531	0.931	
Total export sectors	4,125,435	6,156,372	0.6701	1.685	1.025	

Table 5. Backward linkage effects of export sectors, 2003

Product	Export	Total output	Export ratio	BL	NBL	Rank of NBL
Sea transport services	504,785	566,623	0.8909	1.290	0.747	67
Copper	2,686,517	3,270,479	0.8214	1.705	0.988	35
Prepared and preserved fruit and vegetable	169,988	222,203	0.7650	1.927	1.116	18
Prepared and preserved fish	308,597	405,573	0.7609	2.084	1.207	8
Other minerals	367,579	551,069	0.6670	1.660	0.962	41
Fish products	420,030	653,003	0.6432	1.946	1.127	16
Wood and and wood products	418,096	657,985	0.6354	2.160	1.251	5
Distilled alcoholic beverages and wine	231,631	365,162	0.6343	1.900	1.101	20
Fruit products	331,285	533,313	0.6212	1.491	0.864	53
Air transport services	314,427	534,673	0.5881	1.475	0.854	57
Iron	35,456	64,425	0.5504	1.976	1.145	12
Paper and paper products	406,731	800,183	0.5083	1.851	1.072	23
Transport equipment	64,743	134,734	0.4805	1.491	0.863	54
Basic chemicals	240,633	552,713	0.4354	1.488	0.862	55
Basic metal products	178,760	514,140	0.3477	1.946	1.128	15
Non-traditional natural resource-based products	1,879,627	2,837,237	0.6625	1.918	1.111	
Mining products	3,089,553	3,885,973	0.7951	1.780	1.031	
Manufacturing products	484,136	1,201,587	0.4029	1.642	0.951	
Total export sectors	6,679,259	9,826,277	0.6797	1.759	1.019	

Source: Author's calculations based on data from Banco Central de Chile (1992; 2001; 2006)

Note: Export and total output values are expressed as 1,000,000 Chilean pesos, at prices deflated by the wholesale price index (June 1992 = 1). Rank of NBL shows the descending order of NBL. I show the sums of the exports and total output values of non-traditional natural resource-based products, mining products, manufacturing products, and total export sectors vis-à-vis the products sector. Their BL and NBL are simple averages vis-à-vis the products sector. I refer to Banco Central de Chile (2001:215–216) for Spanish to English translations.

4-2. The evolution of domestic intermediate inputs of non-traditional natural resource-based export sectors

This sub-section discusses the products sectors associated with the high NBL of non-traditional natural resource-based export sectors discovered in section 4-1. This is accomplished by analyzing their domestic intermediate inputs. In this regard, I focus on the evolution of domestic intermediate inputs of the four highest BL among the non-traditional natural resource-based export sectors in 2003, that is, the wood and wood products sector, the prepared and preserved fish sector, the fish products sector, and the prepared and preserved fruits and vegetables sector.

The evolution of the 10 highest domestic intermediate inputs and the sum of domestic input coefficients of the aforementioned four non-traditional natural resource-based export sectors from 1986 to 2003 are presented in tables 6 to 10. The results show that the sum of domestic input coefficients of the wood and wood products, and the fish products sectors, substantially increased from 44.7% in 1986 to 62.6% in 2003, and from 39.9% in 1986 to 50.8% in 2003, respectively. The increasing trend of the sum of domestic input coefficient in the wood and wood products sector was

associated with domestic intermediate inputs from forestry products, and wood and wood products, that is, inputs from its raw material and itself (see Table 6). On the other hand, the increasing trend of the sum of domestic input coefficient in the fish products sector was associated with the manufacturing sector, such as prepared animal feeds, plastic products, and basic chemicals. The increasing trend is especially evident in the prepared animal feeds sector; it increased from 0.22% in 1986 to 24.3% in 2003. Therefore, this particular increase is the main reason for the increase in the domestic intermediate inputs of the fish products sector. Moreover, as Agosin (1997) noted, these manufacturing sectors are considered as the backward linkage industries for salmon aquaculture, which recorded a rise in fishing exports during this particular period,[17] and included nutrients, packing materials, and fish medicine. Therefore, present study's findings quantitatively concur with those of Iizuka (2005), who showed that some inputs to Chilean salmon aquaculture, such as fish feed, are locally supplied, while other inputs, such as nets, chemicals, and packing materials, are partially locally supplied, based on the field surveys conducted in early 2004 in the 10th region of Chile.

Regarding the prepared and preserved fish sector, and the prepared and preserved fruits and vegetables sector, we find that the sum of domestic input coefficients did not show an increasing trend. However, we did find increasing trends of domestic intermediate inputs from business services in these sectors. The findings may be a reflection of how knowledge intensive these sectors have become.

Table 6. The evolution of the domestic inputs coefficient of the wood and wood products sector, 1986–2003

	1986		1996		2003	
Rank	Product	Domestic input coefficient	Product	Domestic input coefficient	Product	Domestic input coefficient
1	Forestry products	0.1026	Forestry products	0.1715	Forestry products	0.1573
2	Road freight transport services	0.0928	Road freight transport services	0.0893	Wood and and wood products	0.1540
3	Wood and and wood products	0.0421	Business services	0.0494	Road freight transport services	0.0983
4	Business services	0.0292	Wood and and wood products	0.0378	Business services	0.0557
5	Trade services	0.0183	Trade services	0.0313	Trade services	0.0348
6	Basic chemicals	0.0175	Electricity	0.0192	Basic chemicals	0.0321
7	Electricity	0.0169	Other road passenger transport services	0.0129	Electricity	0.0173
8	Refined petroleum products	0.0157	Other non-metallic mineral products	0.0119	Services related to transport	0.0154
9	Sea transport services	0.0115	Other community, social and personal services	0.0107	Other chemical products	0.0096
10	Agriculture products	0.0108	Real Estate services	0.0088	Financial services	0.0083
	sum of domestic input coefficient	0.4468		0.5080		0.6256

[17] The revenues from salmon aquaculture to total fishing exports increased from 28% in 1990 to 56% in 2000 (Perez-Aleman, 2005).

Table 7. The evolution of the domestic inputs coefficient of the prepared and preserved fish sector, 1986–2003

	1986		1996		2003	
Rank	Product	Domestic input coefficient	Product	Domestic input coefficient	Product	Domestic input coefficient
1	Fish products	0.3648	Fish products	0.3334	Fish products	0.3148
2	Metal products	0.0297	Prepared animal feeds	0.0412	Business services	0.0440
3	Prepared and preserved fish	0.0289	Trade services	0.0244	Trade services	0.0336
4	Business services	0.0140	Business services	0.0234	Prepared and preserved fish	0.0315
5	Electricity	0.0130	Refined petroleum products	0.0215	Transport- related services	0.0249
6	Coal	0.0093	Metal products	0.0165	Financial services	0.0215
7	Financial services	0.0089	Road freight transport services	0.0132	Prepared animal feeds	0.0210
8	Trade services	0.0089	Electricity	0.0095	Refined petroleum products	0.0186
9	Road freight transport services	0.0086	Other community, social and personal services	0.0070	Road freight transport services	0.0131
10	Other chemical products	0.0077	Real State services	0.0070	Electricity	0.0110
	sum of domestic input coefficient	0.5513		0.5702		0.5872

Table 8. The evolution of the domestic inputs coefficient of the fish products sector, 1986–2003

	1986		1996		2003	
Rank	Product	Domestic input coefficient	Product	Domestic input coefficient	Product	Domestic input coefficient
1	Fish products	0.1562	Prepared animal feeds	0.1217	Prepared animal feeds	0.2432
2	Refined petroleum products	0.0607	Fish and other fishing products	0.0776	Business services	0.0649
3	Trade services	0.0493	Refined petroleum products	0.0372	Trade services	0.0272
4	Air transport services	0.0162	Trade services	0.0366	Refined petroleum products	0.0210
5	Transport equipment	0.0130	Business services	0.0265	Fish and other fishing products	0.0205
6	Electric machinery and equipment	0.0103	Road freigth transport services	0.0160	Plastic products	0.0204
7	Business services	0.0096	Insurance services	0.0084	Other chemical products	0.0105
8	Plastic products	0.0091	Prepared and preserved fish	0.0082	Road freigth transport services	0.0085
9	Wood and and wood products	0.0077	Textiles	0.0073	Basic chemicals	0.0082
10	Road freight transport services	0.0067	Other chemical products	0.0072	Electric machinery and equipment	0.0077
	sum of domestic input coefficient	0.3989		0.4211		0.5083

Table 9. The evolution of the domestic inputs coefficient of the prepared and preserved fruits and vegetables sector, 1986–2003

	1986		1996		2003	
Rank	Product	Domestic input coefficient	Product	Domestic input coefficient	Product	Domestic input coefficient
1	Fruit products	0.1206	Fruit products	0.2023	Fruit products	0.1535
2	Agriculture products	0.1188	Agriculture products	0.0894	Agriculture products	0.0984
3	Trade services	0.0475	Business services	0.0400	Business services	0.0600
4	Metal products	0.0473	Trade services	0.0358	Trade services	0.0426
5	Sugar	0.0440	Metal products	0.0340	Prepared and preserved fruit and vegetable	0.0409
6	Basic metal products	0.0360	Basic metal products	0.0247	Road freigth transport services	0.0326
7	Business services	0.0212	Paper and paper products	0.0169	Paper and paper products	0.0177
8	Road freight transport services	0.0208	Road freigth transport services	0.0156	Plastic products	0.0168
9	Paper and paper products	0.0205	Transport- related services	0.0152	Refined petroleum products	0.0126
10	Animal and vegetable oil	0.0167	Other food products	0.0149	Transport- related services	0.0108
	sum of domestic input coefficient	0.6624		0.6084		0.5629

Source: Author's calculations based on data from Banco Central de Chile (1992; 2001; 2006)

Note: I refer to Banco Central de Chile (2001:215–216) for Spanish to English translations.

5. Conclusions

This study analyzed whether non-traditional natural resource-based export sectors in Chile, such as fish, fruits, and forestry products, have produced different domestic inter-industrial linkage effects, compared with the traditional mining export sector, by reconstructing input-output tables from 1986, 1996, and 2003. The main findings are as follows. First, the number of non-traditional natural resource-based export sectors with high BL, and the average of NBL of the non-traditional natural resource-based export sectors, both increased from 1986 to 2003. Moreover, the non-traditional natural resource-based export sectors always had high BL, while the average of NBL of the non-traditional natural resource-based export sectors was always higher than that of the mining export sectors and that of all export sectors. The NBL of the copper sector did not increase and it had stably low BL during this period. Second, this increasing trend of NBL was especially evident in the wood and wood products, and the fish products sectors, for which export ratios notably increased from 1986 to 2003. Moreover, among those non-traditional natural resource-based export sectors with high BL, the fish products sector substantially increased domestic intermediate inputs from the backward linkage industries.

Therefore, this study found that some non-traditional natural resource-based export sectors, which have come about as a result of export diversification since the 1980s, certainly increased BL

and had higher BL than the traditional copper export sector. Among these, the fish products sector, mainly constituted by the salmon aquaculture industry, succeeded in creating BL with domestic manufacturing suppliers. In this regard, one contribution of this study is that, in contrast to all other industrial sectors, salmon aquaculture has developed BL with domestic backward linkages at the industry level. This study made this finding based on reconstructed input-output tables with products sectors classified in as detailed a manner as possible, and my finding concurs with that of Iizuka (2005), who conducted firm-level field surveys. Thus, these findings provide important counter-evidence to the "enclave" features of exports on primary products in Chile.

However, this study also showed the persistent weakness of BL of the entire economy and the manufacturing sector, especially the heavy manufacturing sector. The findings indicated the limitations of Chile's current export-led development strategy, which promotes export diversification of natural resources, according to the principles of comparative advantage, and the absence of enabling industrial policies. Therefore, it is uncertain whether the non-traditional natural resource-based export sectors with high BL will be able to establish BL of a required range and depth. In other words, it is uncertain whether the intermediate inputs of these sectors will be able to repeatedly stimulate other intermediate inputs, as Hirschman (1958) assumed in the case of manufacturing sectors. In this regard, the findings of Chenery and Taylor (1968), that small primary export-oriented countries are slower to transform their industrial structure than industry export-oriented countries, is still suggestive.

This topic clearly needs further research. First, it will be interesting to analyze how increases in BL of non-traditional natural resource-based export sectors have contributed to sustainable economic growth in Chile since the mid-1980s. Second, it will also help to analyze how increases in BL of non-traditional natural resource-based export sectors have been related to the recent changes in the production chain, especially the global commodity chain. Moreover, a focus on the sustainability of Chile's primary export-led development strategy is also necessary. Since 2007, salmon aquaculture has been hit by an infectious disease, i.e., infectious salmon anemia (ISA), although it was said that the coast of Chile was safe from ISA. The ambient contamination caused by salmon aquaculture is also of concern. While Díaz and Ramos (1998) rejected the traditional negative assumptions on natural resource products as myths, they nevertheless admitted that the primary export-led development strategy is still not immune to ambient contamination and the Dutch disease. I hope to focus on these topics in future studies.

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Appendix

Table A-1. Comparable product sectors in Chile's input-output tables for 1986 and 1996

1986		1996	
The number of original table	Product	The number of original table	Product
11 12	Stones, sand and clay products Other mining products	10	Other mining products
18	Grain milled products	16 18	Flour milling products Bread, noodles and pastas
23	Distilled alcoholic beverages and wine	21 22	Distilled alcoholic beverages Wine
22	Non-alcoholic beverages and beer	23 24	Beer Non-alcoholic beverages
38 40	Glass and glass products Other non-metallic mineral products	39	Other non-metalic mineral products
41	Basic metal products	40 41	Basic iron and steel products Basic non-ferrous products
44 46	Electrical apparatus, appliances and supplies Other professional and scientific equipment	44	Electrical machinery and equipment
52 73	Trade services Repair services not elsewhere classified	52	Trade services
4 65	Agricultural services Business services except machinery and equipment rental and leasing	65	Business services
71 72	Motion picture and other entertainment services Amusement and recreational services not elsewhere classified	72	Recreational, cultural and sporting services

Source: Author's calculations based on data from Banco Central de Chile (1992:87; 2001:207)

Note: I refer to Banco Central de Chile (2001:215–216) for Spanish to English translations.