INTERNATIONAL MONETARY FUND

Growth and Production Network in Chile

Chile

Si Guo

SIP/2025/010

IMF Selected Issues Papers **are prepared by IMF staff as background documentation for periodic consultations with member countries.** It is based on the information available at the time it was completed on January 16, 2025. This paper is also published separately as IMF Country Report No 2025/038.

2025
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SELECTED ISSUES PAPER

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IMF Selected Issues Paper
Western Hemisphere Department

Growth and Production Network in Chile
Prepared by Si Guo*

Authorized for distribution by Andrea Schaechter
February 2025

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ABSTRACT: Productivity growth depends not only on technological innovation but also on production networks that amplify its impact. Theory and cross-country evidence indicate a positive relationship between productivity growth and the use of intermediate inputs, a measure of network connectedness. We find that Chile's intermediate input utilization is significantly lower than that of OECD peers, such as Korea and the Czech Republic, and declined during 2008-21. This is primarily due to weak domestic producer connections and the smaller presence of the manufacturing sector. We argue that diversifying exports from mining, reducing trade costs, and improving contract enforcement could strengthen network linkages and boost growth.

RECOMMENDED CITATION: Guo,Si. Growth and Production Networks in Chile. IMF Selected Issues Paper (SIP/2025/010). Washington, D.C.: International Monetary Fund.

JEL Classification Numbers:	O40
Keywords:	Chile; Productivity; Input-output.
Author's E-Mail Address:	sguo@imf.org

* The author would like to thank Simon Guerrero, Andrea Schaechter, and the seminar participants at the Central Bank of Chile for their valuable discussions.

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Prepared by Si Guo (WHD)

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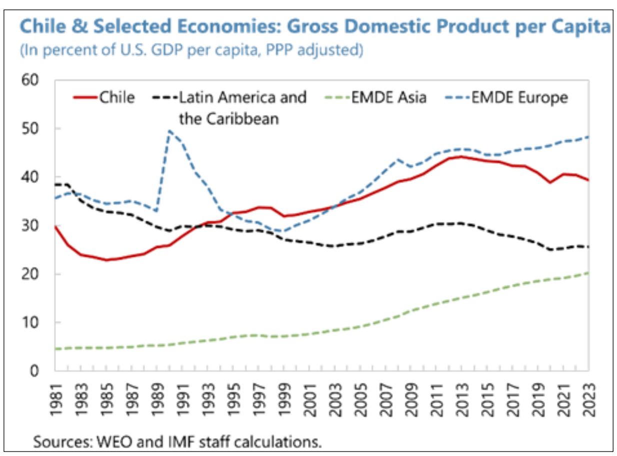
GROWTH AND PRODUCTION NETWORK IN CHILE[1]

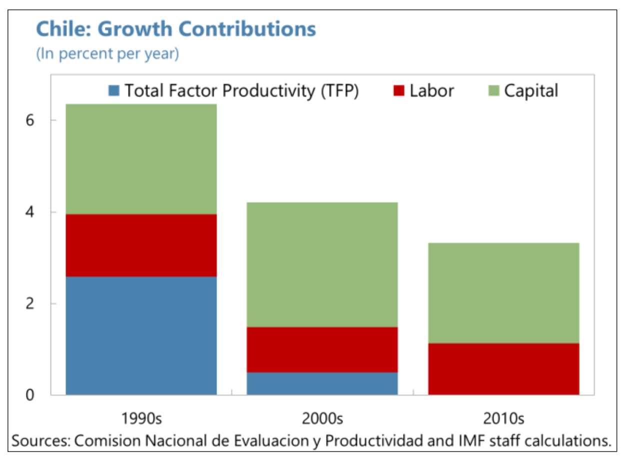
Productivity growth depends not only on technological innovation but also on the production networks that amplify the impact of technological progress. Theory and cross-country evidence indicate a positive relationship between productivity growth and the use of intermediate inputs, a measure of network connectedness. Our analysis reveals that Chile's intermediate input utilization is significantly lower than that of OECD peers, such as Korea and Czech Republic, and declined during 2008-21. This lower intensity is primarily due to weak connections among domestic producers and limited export contributions to the strength of the production network linkages. We argue that better contract enforcement and diversifying exports from mining could strengthen production network linkages and boost potential growth.

A. Growth Slowdown in Chile

1. **Chile's economic growth slowed down considerably after the 2000s.** The average annual real GDP growth rate fell from 6.2 percent during 1991-99 to 4.2 percent during 2000-09, and further to 3.3 percent during 2010-19.[2] For the 2020s, the growth rate averaged 1.9 percent during 2020-23, which is close to the central bank's projected potential growth rate of around 2 percent for the next ten years (Central Bank of Chile 2024). Although the global slowdown in economic growth has played a role, Chile's stalled income convergence with higher-income countries suggest that country-specific factors are also contributing to this trend.



Chile & Selected Economies: Gross Domestic Product per Capita
(In percent of U.S. GDP per capita, PPP adjusted)
Sources: WEO and IMF staff calculations.



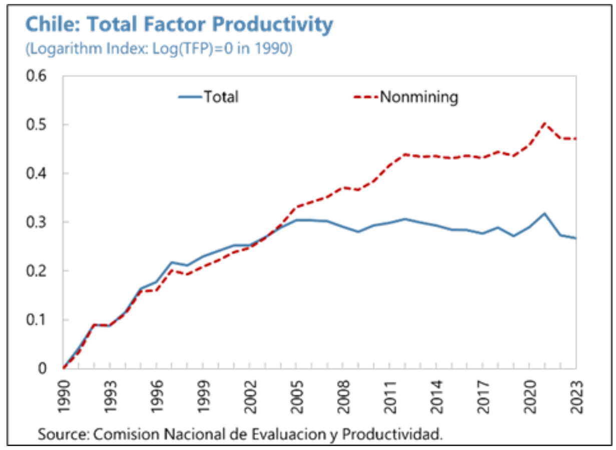
Chile: Growth Contributions
(In percent per year)
Sources: Comision Nacional de Evaluacion y Productividad and IMF staff calculations.

2. **The main driver of this deceleration has been a marked slowdown in total factor productivity (TFP) growth.** According to the estimates of National Commission of Evaluation and Productivity (CNEP), compared to the 1990s, the average annual contribution of TFP to growth declined by 2.5 percentage points in the 2010s, while the contributions of labor and capital each fell by just 0.2 percentage points.

[1] Prepared by Si Guo.

[2] Data from IMF World Economic Outlook.

Additionally, the slowdown in capital accumulation is likely also linked to sluggish TFP growth. For instance, in a simple Solow growth model with a capital share of 0.5, a 2.5 percentage point drop in TFP growth would predict a 5-percentage point reduction in capital accumulation along the balanced growth path. However, actual annual capital growth only decelerated by 0.2 percentage points between the 1990s and 2010s, outperforming this prediction.



3. **A few studies have explored the causes of productivity growth slowdown at the industry level in Chile.** For example, CNEP (2017) highlights declining productivity in the copper mining sector and recommends improvements in project permit timelines, as well as the establishment of standards for suppliers, contractors, and labor training. CNEP (2020a) documents the inefficiencies in the construction sector, including the planning of public works, uncertainty around building permits, and the low adoption of digital tools. Additionally, CNEP (2020b) identifies suboptimal utilization of surgical rooms, which contributes to longer wait times for surgeries. Asturias et al. (2023) highlight the impact of entry barriers on manufacturing sector productivity growth in Chile. Most of these studies emphasize policies to enhance sectoral and industrial productivity instead of the interconnectedness of these industries and its impact on aggregate productivity growth.

4. **This paper examines economic growth through the lens of cross-industry input-output linkages.** Aggregate productivity growth is influenced not only by productivity improvements of individual industries and producers, but also by the structure of the production network that can amplify the effects of individual producers' productivity changes. We compare Chile's production network with that of other OECD peers, such as Korea and Czech Republic, and analyze how Chile's production network has evolved over time. Due to data limitations, our focus is the input-output matrix, which details transactions among producers but is aggregated by industry. Most of our analysis will concentrate on intermediate input use as share of gross output, and its one-to-one mapping, gross output-to-value added (VA) ratios, as these metrics best summarize the input-output linages at the aggregate level.

B. Input-Output Linkage and Growth: Theoretical Background

5. **Input-output linkages could amplify the impact of firm or industry-level productivity changes on aggregate productivity growth.** For illustrative purposes, take a simplified example of agricultural production, e.g., rice, to demonstrate how input-output linkage impact growth. Assume fertilizer ($x_{fertilizer}$) is used as the only intermediate input, alongside labor l_{rice}, in a Cobb-Douglas production function: $q_{rice} = a_{rice} l_{rice}^{1-\sigma} x_{fertilizer}^{\sigma}$. Technology progress in rice production, represented by an increase in a_{rice}, not only enhances the productivity of famers but also that of the fertilizer.

With the quantities of labor and intermediate inputs held constant, a one percentage point rise in a_{rice} would result in a one percentage point increase in the rice producer's real gross output. Because the amount of fertilizer (intermediate input) remains unchanged, the real value added of this rice producer will increase by $1/(1-\sigma) > 1$ percentage points. Therefore, the use of fertilizer as an intermediate input creates a multiplier effect: for every one percent increase in technology a_{rice}, the value-added increases by more than one percentage point.

Box 1. Growth Multiplier Under Cobb-Douglas Production Function

For each producer i, assume its production function is given by:

$$q_i = a_i l_i^{1-\sigma_i} x_i^{\sigma_i}$$

where l_i represents the quantity of labor input and x_i denotes the quantity of intermediate inputs used by producer i. Taking the logarithm of both sides and then differentiating over time, yields:

$$\Delta \log(q_i) = \Delta \log(a_i) + (1-\sigma_i)\Delta \log(l_i) + \sigma_i \Delta \log(x_i) \qquad (1.1)$$

Let y_i represent the real value-added of producer i. Under the Cobb-Douglas production function assumption, the share of intermediate inputs is fixed at σ_i. Therefore, we can also express the growth of output as:

$$\Delta \log(q_i) = (1-\sigma_i)\Delta \log(y_i) + \sigma_i \Delta \log(x_i) \qquad (1.2)$$

By combining equations (1) and (2), we obtain:

$$\Delta \log(y_i) = \Delta \log(a_\mathrm{i}) / (1-\sigma_\mathrm{i}) + \Delta \log(l_\mathrm{i})$$

Hence, the TFP growth of producer i, following conventional growth accounting, is:

$$\Delta TFP_i = \Delta log(a_i)/(1-\alpha_i)$$

With an economy with multiple producers (i=1, 2, ..., N), the aggregate TFP growth is:

$$\Delta TFP = \sum (Y_i/Y) \cdot \Delta TFP_i = \sum (Q_i/Y) \cdot \Delta \log(a_i) \qquad (1.3)$$

In the second equality, we use the fact that $Q_i = Y_i/(1-\alpha_i)$.

Equation (1.3) shows that aggregate TFP growth is a weighted average of individual producers' technology improvements, with producer i's contribution weighted by its *gross output* as a share of aggregate GDP, rather than its value-added as a share of GDP. Generally, the term $\sum \mathrm{Q_i}/Y > 1$ due to the use of intermediate inputs, which implies that the production network amplifies the effect of technological progress of individual producers on aggregate TFP growth.

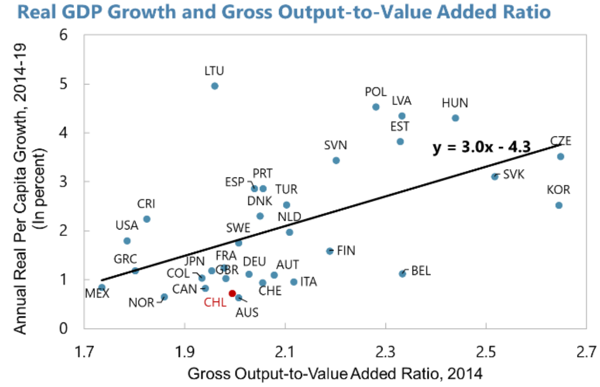
6. **More formally, theoretical studies have shown that gross output-to-GDP ratio serves as a measure of the production network's multiplier effect on aggregate productivity growth.** This line of research dates to Hulten (1978) and is further generalized by Baqee and Farhi (2020). These studies demonstrate that, to a first-order approximation, if each producer i's production function is $q_i = a_i F_i(k_i, l_i, x_i)$ where a_i is the Hicks-neutral technology, (k_i, l_i) are the factor inputs, and x_i is the vector of intermediate inputs used by producer i, the aggregate TFP can be proved to be the weighted sum of each producer's technological changes:

$$\Delta \log(TFP) = \sum_i \lambda_i \Delta \log(a_i) \qquad (1)$$

where $\Delta \log(a_i) = \log(a_{i,t+1}) - \log(a_{i,t})$ is the growth rate of i's technology; $\lambda_i = Q_i/Y$ is the ratio of producer i's nominal gross output (Q_i) to the economy-wide nominal value-added (Y), commonly referred as the "**Domar weight**" of producer i. It should be noted that the sum of Domar weights, $\sum_i \lambda_i$, equals to the economy-wide gross output-to-GDP ratio (Q/Y) and is typically greater than one, due to the use of intermediate inputs. This implies that when the technology improves by 1 percent for every producer, the economy wide TFP will increase by $\sum_i \lambda_i$ percentage points. This is why $\sum_i \lambda_i$ is considered a measure of the multiplier effect of the production network. Box 1 provides a formal derivation or of this property under a special case of Cobb-Douglas production function with a single type of intermediate input, following the setup in Basu and Fernald (2002).

7. The positive correlation between the gross output-to-value added (Q/Y) and economic growth is also supported by cross-country data. The text chart compares the gross output-to-GDP ratio in 2014 with real GDP per capita growth during 2014-19 for OECD countries.[3] As predicted by theory, countries with a more interconnected production network experienced faster growth. Text Table 1 presents the cross-country OLS regression results, with each country's real GDP per capita growth rate during 2014-19 as the dependent variable and the gross output-to-value added ratio as the independent variable. The coefficients in Column (1) of Text Table 1 imply that a 0.1 increase in the gross output-to-GDP ratio is associated with an around 0.3 percentage point increase in real GDP per capita growth. This relationship remains robust even after controlling for countries' income per capita levels proxied, as shown in Column (2) of Text Table 1.[4] There are also significant cross-country variations in gross output-to-GDP ratios: Korea and several Eastern European countries had ratios ranging from 2.4 to 2.7 in 2014, while Chile and G7 countries had ratios around 2.0, slightly higher than Mexico and Costa Rica, which were around 1.8.

Chile & Selected Economies: Cross-Country Per Capita Real GDP Growth and Gross Output-to-Value Added Ratio



Sources: OECD and IMF staff calculations.

Text Table 1. Dependent Variable: Average Real GDP per capita Growth Rates 2014-19

Independent Variables	(1)	(2)
Gross output-to-VA	3.04***	2.90***
Log(GDP per capita) in 2014, PPP adjusted	-	-1.13**
Constant	-4.29	7.79

Note: *** (**) stands for p value<1% (5%).

Source: IMF staff estimations.

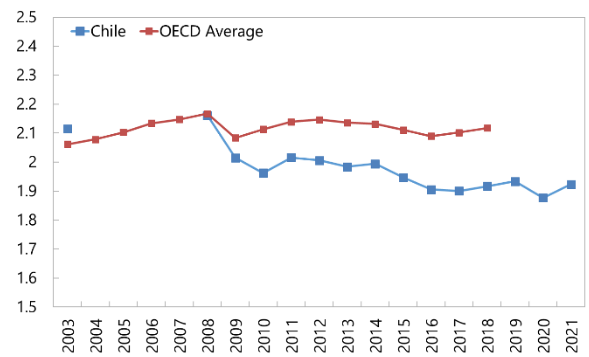
[3] The data for Chile is provided by the BCCh. Annex I provides the details of the data sources of gross output-to-value added ratio and real GDP per capita growth rate for other countries.

[4] As a robust check for the reference years and country coverage, McNerny et al. (2022) also find the positive correlation between gross output-to-GDP ratio in 1995 and real GDP per capita grow during 1995-2000, using a sample 40 countries covered by the WOID dataset (which includes non-OECD countries such as China and Brazil but excludes a few OECD countries such as Chile and Colombia).

C. Input-Output Linkages in Chile: An Overview

8. Chile's input-output linkage, measured by gross output-to-GDP ratio, is slightly weaker than the OECD average. In the 2010s, Chile's gross output-to-output ratio (Q/Y) averaged around 2.0 based on the input-output tables compiled by the BCCh, compared to the OECD's 2.1 during the same period.

Chile: Gross Output-to-Value Added Ratio



Sources: BCCh, OECD Statistics, and IMF staff calculations.

9. Moreover, Chile's intermediate input use is significantly less intensive compared to Korea and Czech Republic, both of which experienced faster income convergence. In 2018, Chile's gross output-to-value added ratio was lower than that in Korea (Czech Republic) by 0.47 (0.62). The reason we choose Korea and Czech Republic as comparators is that their income levels are closer to Chile than most other OECD countries. The relevance of income level stems from the fact that as a country's income increases, its economy typically shifts from industrial sectors to service sectors, which tends to result in a decline in the measured aggregate Q/Y ratio.[5] The gap could be quantitatively relevant: based on the elasticity (2.9) in Column (2) of Text Table 1, the lower Q/Y ratio in Chile would translate into a slower annual real GDP per capita growth than Korea (Czech Republic) by 1.4 (1.8) percentage points. Obviously, this does not mean that intermediate input use is the sole factor behind the growth per capita differences between Chile, Korea, and Czech Republic. Other factors, such as business dynamism, innovation, and technology adoption, could also play a significant role. The cross-country elasticity between Q/Y and real GDP growth rate presented in Text Table 1 also does not necessarily represent an empirically causal relationship, although the theory in Box 1 predicts a causal relationship between Q/Y and real GDP per capita growth rate. Still, the comparison of production networks highlights that the impact of intermediate input use on growth can potentially be substantial.

10. Moreover, Chile's input-output linkage has been on a declining trend. From 2008 to 2021, the gross output-to-value added ratio in Chile fell from 2.16 to 1.92, based on the input-output tables complied by the BCCh. While high fossil fuel price in 2008 may have contributed to the high gross output-to-value added to some extent, the declining trend since 2009 remains clear.[6]

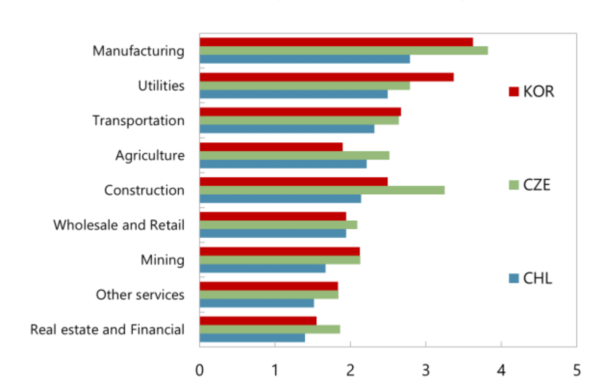
[5] Ideally, we would also like to compare Chile's production networks with countries like Australia who has a more substantial mining sector. According to data from the Penn World Table, Chile's GDP per capita (PPP adjusted) in 2019 is comparable to Australia's GDP per capita (PPP adjusted) in the early 1980s. Unfortunately, we do not have input-output data for Australia from that period.

[6] To exclude the impact of copper and oil prices on the calculated output-to-value-added (Q/Y) ratio, we also computed the Q/Y ratio for a hypothetical economy without the mining and utility sectors. In such a non-mining and non-utility economy, the Q/Y ratio would have declined by 0.19 between 2008 and 2013, compared to a 0.18 decline in the actual economy that includes all sectors. This comparison indicates that fluctuations in copper and oil prices combined were not the primary drivers of the decline in the aggregate Q/Y ratio in Chile over time.

The elasticity in Text table 1 implies that the lower intensity of intermediate input use in 2021 compared to 2008 would translate into a deceleration in annual real GDP per capita growth by 0.7 percentage points.

11. Chile's lower use of intermediate inputs, compared to Korea and Czech Republic, stems from its smaller manufacturing share and less input usage across several industries. The left chart shows the gross output-to-valued added ratio by sector in the three countries, with the sectors on the horizontal axis ordered by their gross output-to-value ratios. While the manufacturing sector has the highest ratio among all sectors, Chile's manufacturing sector plays a much smaller role for its economy than in Korea (right text chart) and Czech Republic, and this difference in manufacturing share contributes to Chile's lower gross output-to-value added ratio. Additionally, except for agriculture, Chile's producers demonstrate a lower intermediate input intensity, particularly for manufacturing production.

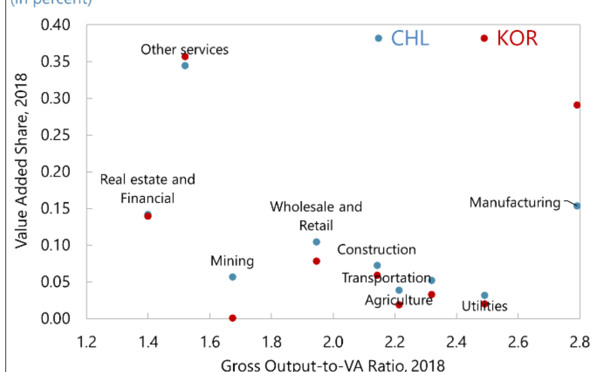
Chile & Selected Economies: Output-to-Value Added by Sector



Sources: OECD and IMF staff calculations.

Chile and Korea: Gross Output-to-Value Added Ratio by Sector

(In percent)



Sources: : OECD Statistics and IMF staff calculations.

12. The weakening of input-output linkage over time mainly reflects producers' reduced use of intermediate inputs over time instead of a compositional shift of sectoral shares. We can decompose the change in aggregate Q/Y ratio between t and t+1 as follows with nominal gross output at time t denoted as Q^t and value-added at time t as Y^t:

$$\Delta(Q/Y) = \sum_i \Delta(Q_i/Y_i) \cdot \left(Y_i^{t+1}/Y^{t+1}\right) + \sum_i Q_i^t/Y_i^t \cdot \Delta(Y_i/Y) \qquad (2)$$

The first term on the right-hand side of Equation (2) captures the change in the aggregate Q/Y driven by changes to the gross output-to-value added ratio at the sector level, weighted by sectoral value-added shares. The second term accounts for changes to sectoral composition, holding each sector i's Q_i/Y_i constant, reflecting the "composition shift" effect. Using this decomposition, the change in aggregate Q/Y during 2008-2019 (-0.24) was mainly driven by the fewer intermediate input use at the sector level (-0.52), while the changes to sectoral composition contributed to an increase in aggregate Q/Y (by +0.28) over time.

D. Input-Output Linkages in Chile: Demand Side Decomposition

13. What explains the cross-country differences in input-output linkages? In vector term, we show that the Domar weights have to satisfy

$$\lambda = \Psi(\beta + \tilde{e}\delta) \qquad (3)$$

Where $\lambda = \{\lambda_i\}$, $\beta = \{\beta_i\}$, and $\delta = \{\delta_i\}$ for i=1, 2, 3, ..., N.[7] For each i, $\beta_i = C_i/C$ is i's share in total final demand. The term $\tilde{e}\delta$ represents export's contribution to Domar weights, with $\tilde{e} = E/Y$ standing for the economy-wide export-to-VA ratio and $\delta_i = E_i/E$ representing export composition over different products. The term $\Psi = (I - \Omega')^{-1} = I + \Omega' + \Omega'^2 + \Omega'^3 + \cdots$, where Ω is the input-output coefficient matrix with its (i,j)th element defined as $\Omega_{ij} = X_{ij}/Q_i$. Ψ is also called the Leontief inverse, measuring the input-output linkages among domestic producers and is readily available from input-output tables along with Ω. Because the gross output-to-VA ratio is simply the sum of Domar weights across all producers, with the help of Equation (3), we can decompose the differences in Q/Y ratios between Chile and Korea (or Czech Republic) into three components: the differences in domestic input-output linkages (captured by $\Psi = (I - \Omega')^{-1}$), differences in final demand distribution over industries (captured by β), and differences in total exports and export composition (captured by $\tilde{e}\delta$). Annex II provides the detailed deviation of this decomposition.

14. There are several key distinctions between the demand-side decomposition in equation (3) and the supply side decomposition in equation (2). First, the demand-side decomposition breaks down changes in the gross output-to-value added ratio into domestic final demand, domestic intermediate demand, and exports, all of which can be better linked to exogenous factors. For example, the distribution of domestic final demand across different industries is influenced by household consumption and investment patterns, as well as government expenditure composition. Such a demand-side framework enables the possibility of conducting counterfactual policy experiments. Second, the demand-side decomposition accounts for each industry's impact on the sizes of its upstream industries. For instance, a robust basic metal industry typically boosts the growth of its upstream sectors, such as electricity and mining. In contrast, the supply-side decomposition abstracts from the interconnectedness of industries and treats the value-added share of each industry as exogenous.

15. A cross-country comparison indicates that Chile's lower intermediate input use mainly reflects its less intensive input-output linkages among domestic producers. In 2018, Korea's economy-wide gross output-to-value added ratio was 2.42, about 0.47 higher than that of Chile. Of this difference, 0.34 can be attributed to the variations in the intensity of domestic demand for domestically produced intermediate input (captured by Ω); 0.16 is due to Chile's lower total export-to-value added and smaller share of manufacturing exports that tend to have stronger input-output linkages than other industries. The final demand composition in Chile is slightly more favorable to the use of intermediate input than Korea (-0.03). This is because Chile's public consumption as share

[7] Annex II provides the derivation of Equation (3).

of total final demand is smaller than that in Korea, and public consumption tends to concentrate on service sectors with the lowest input output linages. The comparison to Czech Republic yields a broadly similar pattern: the difference in the economy-wide gross output-to-value added ratio was 0.62 in 2018, of which 0.2 is explained by the differences in domestic demand for domestically produced intermediate inputs, 0.61 by exports, and -0.2 by domestic final demand distribution (Text Table 2, first two rows).

Text Table 2. Differential in Gross Output-to-Value Added (Q/Y) Ratio

	Total Q/Y differential	Explained by domestic IO linkages (ψ)	Explained by exports and exports composition (eδ)	Explained by final demand distribution (β)
Korea, 2018 - Chile, 2018	0.47	0.34	0.16	-0.03
Czech, 2018 - Chile, 2018	0.62	0.20	0.61	-0.20
Chile, 2021 - Chile, 2008	-0.23	-0.09	-0.13	-0.01

Sources: OECD Statistics and IMF staff calculations.

16. Comparisons across time suggest that domestic input-output linkages and exports account for the decline in aggregate intermediate input use in Chile between 2008 and 2021. Of the total decline of 0.23 in the gross output-to-value added ratio, approximately 0.09 can be attributed to changes in less domestic intermediate input demand (i.e., changes to Ψ). Exports explains a 0.13 decline in gross output-to-value added ratio, as export-to-value added ($\tilde{e}$) declined by 9 percentage points. Export composition (δ) also shifted further shifts industries with weaker input-output linkages: mining's share in total exports increased by 12 percentage points while manufacturing's export share decreased by 5 percentage points. Finally, shifts in the distribution final demand over industries only has a minor impact (0.01) on the cross-time changes to gross output-to-value added ratio during 2008-21 (Text Table 2, last row).

E. Policy Implications

17. Our analysis suggests that stronger input-output linkages within the production network could enhance productivity growth. Efforts to raise intermediate input use hinge on the three components of Equation (3): domestic input-output linkage (Ψ), exports and export composition ($e\delta$), and the composition of final demand (β). Admittedly, there could be many policies that affect either one or more of these factors. For example, transportation infrastructure and trade costs, as highlighted by Clark et al. (2004), are critical for promoting exports (e). Additionally, enhancing competition and reducing monopolistic power, achievable through streamlining the permit process to lower the entry barriers, would also have a profound impact on domestic input-output linkage (Ψ), as highlighted in Baqaee and Farhi (2020). For the scope of this paper, we complement these studies by focusing on two specific aspects: contract enforcement, which is likely to influence Ψ, and export composition that directly targets δ.

Domestic Input-Output Linkage and Contract Enforcement

18. In theory, improved contract enforcement could facilitate the use of intermediate inputs by reducing transaction costs. Weaknesses in the contract enforcement system increase costs for both buyers (when sellers' products do not fully meet standards) and sellers (when buyers default or delay payments), raising the prices of intermediate inputs and incentivizing in-house production. For instance, Boehm and Oberfield (2020) document that in India, plants tend to shift to in-house production when courts are more congested.

19. Whether contract enforcement is a relevant factor for intermediate input use in Chile remains to be examined. For Chile, World Bank Doing Business Survey (2020) points out a few *de jure* weaknesses related to contract enforcement in "court structure and proceedings" (e.g., whether there is a dedicated court division for hearing commercial cases) and "mediation and conciliation". However, a key question is whether contract enforcement is a de facto factor for the use of intermediate inputs in a country with a relatively strong institutional framework.

20. We follow Boehm (2022) to examine whether contract enforcement *de facto* reduced the use of intermediate inputs in Chile. Boehm (2022) constructs an industry-specific contract litigation frequency index and shows that this index, when interacted with the World Bank's country-specific contract enforcement score, significantly predicts intermediate input intensity in cross-country regressions. We apply the litigation index to classify industries into two groups: those with a high likelihood of contract litigation and those with a low likelihood (H and L groups). We then compare the use of intermediate inputs by industry in the U.S. and Chile, based on the assumption that Chile has weaker contract enforcement than the U.S. In particular, we calculate

$$\Delta = (\lambda_H^{US} - \lambda_H^{CHL}) - (\lambda_L^{US} - \lambda_L^{CHL})$$

where the first (second) term on the right-hand side is the difference in median gross output-to-value added ratio between the U.S. and Chile in high(low) litigation industries. A positive Δ would indicate that contract enforcement lowers the intermediate input use intensity in Chile.

21. Our analysis shows that contract enforcement has had an impact on Chilean producers' intermediate input use. Economy wide, Chile's gross output-to-GDP ratio in 2018 is higher than the U.S. by 0.09. Matching the industry classification used in Boehm (2022) with the OECD industry classification, we rank of 24 industries by litigation index and define the top (bottom) 12 industries as the "high" ("low") litigation industries. For Chilean producers in high-litigation industries, their gross output-to-GDP ratio gap (using U.S. producers in the same industries as a benchmark) is 0.21 lower than those in low-litigation industries (Δ = 0.21), suggesting that contract enforcement indeed has had a tangible impact on intermediate input use in Chile.

Policies Related to Exports and Export Composition

22. The concentration of exports on mining output places Chile at a disadvantage regarding the growth multipliers of its production network. Mining exports account for around 50 percent of Chile's total exports. However, the sector's input-output linkages with other industries are weaker than the economy-wide average, as it uses fewer intermediate inputs. Based on the simulations of the model in Annex III, in 2021, for every dollar of mining output, only 31 cents and 4 cents are spent on intermediate inputs produced by domestic and foreign producers, respectively. In contrast, for every dollar of manufacturing exports, 49 cents and 23 cents are spent on domestic and imported intermediate inputs. Moreover, there is a compounding effect: manufacturing producers often source intermediate inputs from other manufacturing firms, creating additional multiplier effects. For instance, a one-dollar increase in manufacturing demand results in an increase of $2.60 in total domestic output, whereas a one-dollar increase in mining output only leads to an increase of $1.90 in total domestic output, derived from the 2018 input-output table.

23. Counterfactual analysis reveals that growth differences can be attributed to export composition. Using a general equilibrium model[8] with input-output linkages, we simulate the equilibrium changes resulting from a hypothetical shift in export composition from the actual composition observed in 2021 (60 percent mining, 27 percent manufacturing) to 100 percent manufacturing. Such a shift, which is chosen for illustrative purposes, would lead to an increase of 0.24 in the gross output-to-value added ratio, corresponding to a 0.7 percentage point difference in annual real GDP per capita growth rate based on the coefficients in Table 1. In addition, the manufacturing output-to-aggregate value-added ratio would rise by 0.39, and the export-to-value added ratio (which mirrors the import-to-value added ratio due to the balanced trade assumption in the long-run) would rise by 0.07, reflecting the higher export (and import) intensity of the manufacturing sector. Conversely, if all exports were shifted to mining, the gross output-to-value added ratio would decline by 0.07, due to the mining sector's lower multiplier effect than manufacturing (Text Table 3).

24. Developing high-value service exports is unlikely to significantly boost long-term growth rates. In a counterfactual exercise where all exports are shifted to financial and business services, the gross output-to-VA ratio would decline by 0.4 compared to the current level, and the export-to-VA ratio would decrease by 0.26. This outcome is largely due to the low interconnectedness of service industries with their upstream sectors: a one dollar increase in financial and business services would only result in a 1.5 dollar increase in aggregate output. This does not imply that service industries are not important in helping countries catch up to higher-income levels: facilitating more low-skilled workers to move toward higher-skilled and higher-salary professions (even in service sector) would still contribute to the increase in income per capita. Rather, the analysis suggests that, on a balanced growth path, an economy with a concentration of exports in services that have weak linkages with other industries is likely to experience lower growth rates compared to a country with exports focused on manufactured goods or the other high-interconnectedness industries.

[8] Annex III provides the detail of the model used for counterfactual analysis.

Text Table 3. Counterfactual Exercises

Scenarios	Export composition (δ)	Gross output-to-GDP (Q/Y)	Export-to-GDP (E/Y)	Sectoral output as share of aggregate GDP (λi)			Implied Changes to Annual Real GDP Per Capita Growth (in percentage point) 1/
				Manufacturing	Mining	Business services	
Actual Data in 2021	Mining (60%), Manufacturing (27%), Business Services (1%)	**1.88**	34%	34%	24%	14%	-
Full manufacturing exports	Manufacturing (100%)	**2.12**	43%	73%	3%	14%	**0.7**
Full mining exports	Mining (100%)	**1.80**	31%	23%	35%	13%	**-0.2**
Full business service exports	Business service (100%)	**1.76**	31%	22%	1%	45%	**-0.3**

Source: IMF staff calculations.

1/ The growth effect is calculated based on the simulated changes in Q/Y ratio (compared to the actual 2021 level) in Column 3 and the elasticity estimated in Table 1.

25. A larger and more diversified export sector could enhance interconnectedness and boost potential growth. While Chile's remote geographic location may pose challenges to its trade, the country's ongoing efforts in negotiating trade agreements, along with maritime concessions, coastal shipping reforms, and the promotion of standardizations and certifications, have the potential to reduce trade costs and increase interconnectedness.

Annex I. Data

Input-Output Matrix

There are three data sources for the input-output tables used in this paper. The BCCh compiles annual input-output tables for the years 2008-2021 with 111 industries and 12 sectors. The OECD Statistics provides input-output tables for all OECD countries, with transactions aggregated into 45 industries. The World Input-Output Dataset (WIOD) includes input-output tables for the 40 largest economies globally (excluding Chile), aggregated into 56 industries. Notably, WIOD's cross-border input-output transaction data captures bilateral transactions, such as Chile's imports of textiles from Korea.

The selection of different input-output table sources reflects a balance between data availability, comparability, and the level of industry disaggregation. For Chile-specific analyses, such as the cross-time changes in the gross output-to-value added (VA) ratio, we primarily rely on the BCCh data. For comparisons involving Chile, Korea, and Czech Republic, we utilize the input-output tables from the OECD Statistics to ensure a consistent industry classification across these countries. In calculating the gross output-to-GDP ratios, we primarily use the input-output tables from the WIOD dataset, supplemented by OECD Statistics for countries not covered by WIOD and Chilean input-output tables complied by the BCCh.

Note that the input-output tables are compiled based on establishment or enterprise-level gross transactions without consolidation. Consequently, while the data is aggregated by industry, the transaction amounts still capture the input-output linkages at the enterprise or establishment level, including the transactions among producers within the same industry.

Real GDP Per Capita Growth Rate

The real GDP per capita growth rates are sourced from OECD Statistics, with the reference period set from 2014 to 2019. This timeframe is chosen to exclude the effects of the global financial crisis (which affected growth rates prior to 2014) and the COVID-19 pandemic (which impacted growth rates after 2019). Ireland has been excluded from the sample due to the potential distortions of the large presence of multinational enterprises assets on its GDP growth rates.

Annex II. Demand-Side Decomposition of Domar Weights $\{\lambda_i\}$

For each product i, the market clearing condition requires that the total supply of output q_i equals the sum of final demand c_i, the intermediate input demand of all other domestic producers, $\sum_j x_{ji}$, and export demand e_i:

$$q_i = c_i + \sum_j x_{ji} + e_i$$

In nominal terms, this turns to

$$Q_i = C_i + \sum_j X_{ji} + E_i$$

Making use of $\Omega_{ji} = X_{ji}/Q_j$, which represents intermediate input i's share in the production of output j, we have

$$Q_i = C_i + \sum_j \Omega_{ji} Q_j + E_i$$

Divided by aggregate nominal value added Y, we get the Domar weight for producer i,

$$\lambda_i = \beta_i + \sum\nolimits_j \Omega_{ji}\,\lambda_i + \tilde{e}_i$$

where $\beta_i = C_i/C$ is i's share in total final demand. The term $\tilde{e}\delta_i$ represents export's contribution to Domar weight, with $\tilde{e} = E/Y$ standing for the economy-wide export-to-VA ratio and $\delta_i = E_i/E$ representing export composition over different products.

In vector terms, define $\lambda = \{\lambda_i\}$, $\beta = \{\beta_i\}$, and $\delta = \{\delta_i\}$, where i=1, 2, ..., N, we can solve the Domar weights as

$$\lambda = \Psi(\beta + \tilde{e}\delta)$$

where $\Psi = (I - \Omega')^{-1} = I + \Omega' + \Omega'^2 + \Omega'^3 + \cdots$ is the Leontief inverse.

Economy wide gross output-to-GDP ratio is simply the sum of Domar weights over i:

$$Q\backslash Y = \sum_i \lambda_i$$

To compare the gross output-to-VA ratios in Korea and Chile, we can decompose the difference between the two countries' sums of Domar weights into:

$$\sum_{\mathrm{i}} \lambda_i^K - \sum_{i} \lambda_i^C = \sum_{\mathrm{i}} \left(\beta_{\mathrm{i}}^{\mathrm{C}} + \tilde{\mathrm{e}}\delta_{\mathrm{i}}^{\mathrm{C}}\right) \Delta\Psi_{(\mathrm{i})} + \sum_{\mathrm{i}} \Psi_{(\mathrm{i})}^{\mathrm{K}}\, \Delta\tilde{\mathrm{e}}\delta_{\mathrm{i}} + \sum_{\mathrm{i}} \Psi_{(\mathrm{i})}^{\mathrm{K}}\, \Delta\beta_{\mathrm{i}}$$

where the term $\Psi_{(i)}$ stands for the sum of the i[th] row of Leontief inverse Ψ.

The first term on the right-hand side of the equation above reflects the difference in Korea and Chile's gross output-to-VA ratios explained by the variation of Ψ, the second term reflects the contribution variation in exports and export composition over different industries, and the third term reflects the variations in final demand composition over different industries.

Annex III. A Structural Model for Counterfactual Analysis

Our model is built upon Jones (2011) and Fadinger et al., (2022).

Production Network

Final goods sector. There is one final good c produced by competitive producers using domestically produced intermediate inputs and imported good c_f.

$$c = c_1^{\beta_1} c_2^{\beta_2} \dots c_N^{\beta_N} c_f^{\beta_f}$$

where $\sum_i \beta_i + \beta_f = 1$.

Given the prices of intermediate goods and imports $\{p_i\}$ and p_f, the final good producers choose the quantities of inputs to maximize their profits:

$$\text{Max } \pi_C = \text{pc} - \sum_i p_i c_i - p_f c_f$$

Intermediate goods producers. Producers of the ith type of intermediate goods maximize their profits

$$\text{Max } \pi_i = p_i q_i - \sum_j p_j x_{ij} - p_f x_{if}$$

Subject to the production function

$$q_i = a_i l_i^{\sigma_{iL}} x_{i1}^{\sigma_{i1}} x_{i2}^{\sigma_{i2}} \dots x_{iN}^{\sigma_{iN}} x_{if}^{\sigma_{if}}$$

Where weights $\sigma_{iL} + \sum_j \sigma_{ij} + \sigma_{if} = 1$.

Market clearing conditions require that for each domestically produced intermediate goods i, we have

$$q_i = c_i + \sum_j x_{ji} + e_i$$

International Trade. We assume there is a "trading" sector whose inputs are the exports of other sectors while its output is the economy's imports.

$$q_f = a_f e_1^{\sigma_{f1}} e_2^{\sigma_{f2}} \dots e_N^{\sigma_{fN}}$$

Where $\sum_j \sigma_{fj} = 1$.

Nominal exports and imports in this economy are hence $p_e \text{e} = \sum_i p_i e_i$ and $P_f Q_f$. Because our analysis focuses on long-term growth, we assume balanced trade: $p_e e = p_f q_f$. Imported household consumption is used as a residual term to ensure the balanced trade holds.

Characterization of the Equilibrium

Firms' profit maximization problems lead to

For the price of final good: $\log(p_c) = \sum_{\mathrm{i}} \beta_{\mathrm{i}} log(p_{\mathrm{i}})$

For the price of intermediate good i: $log(p_i) = -a_i + \sigma_{Li}\log(\mathrm{w}) + \sum_j \sigma_{ij}\, log(p_j) + \sigma_{if} log(p_f)$

For the price of imports: $\log(p_f) = -a_f + \sum_{\mathrm{i}} \sigma_{\mathrm{fi}} \log(\mathrm{p_i})$.

Define the Domar weight $\lambda_i = \frac{\mathrm{Q_i}}{\mathrm{C}}$, we have

$$\lambda_i = \beta_i + \sum_j \sigma_{ji}\,\lambda_j + \sigma_{fi}\lambda_f$$

$$\lambda_f = \beta_f + \sum_j \sigma_{jf}\,\lambda_j$$

In vector expression,

$$\lambda = (\mathrm{I} - \Omega')^{-1}(\beta + \mathrm{e_y}\sigma_{\mathrm{f}})$$

Calibration. The model is calibrated to match the key data moments in Chile in 2018. The domestic input-output coefficients, Ω, and the export-to-VA ratio, $\mathrm{e_y}$, are readily available from the input-output table. The consumption distribution over industries (captured by β) is pinned down by the industrial share in final demand. The export distribution over industries (captured by σ_{f}) is pinned down by each industry's share in total exports.

Counterfactual analysis. In the counterfactual exercise to switch the composition of export demand from the current composition to all manufacturing exports, we let $\sigma_{fi} = 1$ for i=manufacturing and $\sigma_{fi} = 0$ for i=other industries, while keeping (Ω, β) unchanged. Exports-to-GDP ratio e_y is endogenous.

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