Productive investment in Chile's economic development: trend and challenges[1]

Ricardo Ffrench-Davis and Álvaro Díaz

Abstract

This article reviews the trend of investment in Chile and its relationship with economic growth since the 1973 coup d'état; and it documents how investment remains the main growth driver. Notwithstanding that fact, innovation helps to mitigate diminishing returns from natural resources, while technology-intensive investment, such as broadband infrastructure, helps to diversify the production matrix. The article shows how a persistent increase in the investment ratio in 1990–1998 supported GDP growth of 7.1% per year; but since 1999 investment has wavered, and average growth dropped to below 4%. The article examines the macroeconomic environment and its real instability since 1999, along with investment in infrastructure, the quality of natural resources and environmental services; and it identifies challenges for boosting both investment and innovation, diversifying the production matrix and its agents, and moving towards inclusive growth.

Keywords

Investments, economic growth, productivity, macroeconomics, capital formation, natural resources, natural resources development, physical infrastructure, investment promotion, Chile

JEL classification

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I. Introduction

Most studies of economic growth in Chile reference the neoclassical Solow-Swan model (Solow, 1956; CNP, 2017) which subdivides growth factors into labour, capital and a residual. The latter represents total factor productivity (TFP), which is interpreted as the result of technological change and resource reallocation.[2] This approach to growth accounting is used by many analysts to assess the importance of productivity in fuelling the economic growth process.

In this approach it is common to find claims that TFP is the key driver of growth, ahead of investment. Nonetheless, this statement is based on traditional methodologies that underestimate the contribution made by capital and overestimate the contribution of TFP. The LA-KLEMS project, coordinated by the Economic Commission for Latin America and the Caribbean (ECLAC), which uses more advanced methodologies, has found that capital contributed more to growth than TFP in 1981–2010. Moreover, the traditional measurement of TFP predominantly reflects fluctuations in the rate of existing capacity utilization, which generates a procyclical estimate. In other words, if greater use can be made of idle productive capacity, then growth can occur without investment —but only until there is no underused installed capacity left.

Traditional thinking on TFP also fails to adequately capture fluctuations in relative natural-resource wealth, which may be affected by the ore grade or the status of ecological systems. For example, changes in copper ore grade can have significant impacts on mining productivity; and the deterioration or recovery of ecological systems and externalities can impact the trend of GDP (see Sotelsek and Laborda, 2010). For this reason, for several years, the Central Bank of Chile has been making estimates that separate out mining or natural resources, which undoubtedly is very useful for understanding the domestic macroeconomic situation. In short, natural resources and the business cycle generate wide fluctuations in TFP which may have a non-technological origin (Calvo, Izquierdo and Talvi, 2006).[3]

Traditional neoclassical and modern estimations of factor contributions to economic growth recognize the decisive role that gross fixed capital formation (GFCF) —equipment, machinery, buildings and infrastructure— plays in development. A recent study to measure the long-term productivity of five Latin American countries (Argentina, Brazil, Chile, Colombia and Mexico) shows that the more accurate the measurement of directly quantifiable inputs, the less relevant is TFP in the five countries (Coremberg and Pérez, 2010). According to these authors, GFCF was the main driver of growth in the region's economies in 1990–2006.

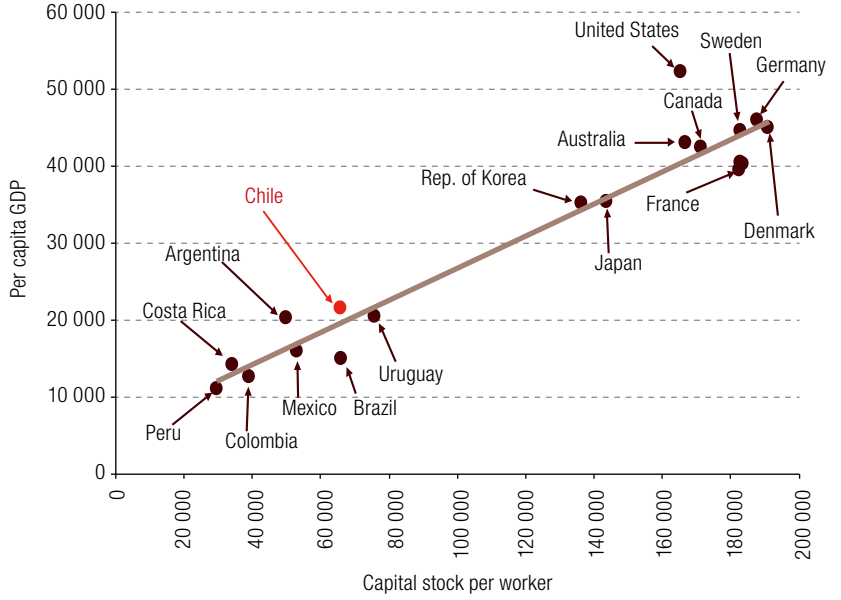
Aside from its direct growth effects, GFCF has a short-term macroeconomic impact on the level of economic activity, since it is a component of domestic demand; and this explains the importance of countercyclical policies targeted on investment.

The fact that the capital stock is a determinant of economic growth is evidenced by the much higher intensity of capital per member of the labour force in the advanced countries of the Organization for Economic Cooperation and Development (OECD) compared to those of Latin America. Figure 1, which is based on the Penn World Table, version 9.0, shows that the estimated average per capita GDP of selected OECD countries in the 2005–2014 decade (measured in 2011 United States dollars at purchasing-power-parity (PPP)) is 2.7 times the average for Latin American countries, closely reflecting the difference of 2.8 times in the capital stock per worker.

[2] In the Solow-Swan model, the growth literature has abandoned the assumptions of constant returns to scale, exogenous technical progress and the representative firm; and it has incorporated, for example, company creation and destruction, imperfect competition, technological diffusion, natural resources and pollution. Nonetheless, there are few studies that incorporate these factors for the case of Chile.

[3] These problems are compounded by structural heterogeneity between small and medium-sized enterprises (SMEs) and large firms, which has tended to increase since the 1970s; but its potential reduction offers an important source of increased average productivity. No less important is the potential impact of institutional and regulatory changes on productivity growth.

Figure 1
Latin America and selected developed countries: per capita GDP and capital stock per worker, 2005–2014
(2011 US dollars at purchasing power parity)



Source: Penn World Table, version 9.0 [online] www.ggdc.net/pwt; and R. C. Feenstra, R. Inklaar and M. P. Timmer, "The next generation of the Penn World Table", *The American Economic Review,* vol. 105, No. 10, Nashville, Tennessee, American Economic Association, 2015.

Although GFCF is decisive for growth, innovation helps overcome the obstacles that generate decreasing productivity. It also contributes new products and processes that offer opportunities for further diversification of the production matrix. In short, innovation triggers investment; but this is not always well reflected in growth accounting, for whereas robust and detailed statistics on capital and labour can be obtained, it is much harder to measure knowledge and innovation.[4]

Although decisive for GDP growth, the investment rate in Chile has fluctuated widely in recent decades, both in aggregate terms and in its composition. Changes in the trend of gross investment respond to several factors, including, from a macroeconomic standpoint, the ups and downs associated with divergences between actual and potential GDP (output or recessionary gap). To control for these fluctuations, this study examined the trends of investment and GDP in subperiods between the years in which output gaps were smallest, namely 1981, 1989, 1998, 2007/08 and 2013, in the period analysed (1974–2017).

Section II reviews the trend of total capital formation and its relation to GDP growth, firstly analysing gross investment in current prices each year, starting with global figures for the aforementioned subperiods. The mining sector is then separated out, given its importance in the national economy and the clearly defined cycles it has experienced. Foreign investment is also segregated, since its share in productive investment is clearly increasing. A distinction is made between investment that creates new capacity and investment to acquire existing assets. The figures are adjusted for inflation, and the section concludes with the net productive capital formation and the trend of the capital stock per member of the labour force.

[4] There are also measurement problems with labour and capital. In the latter case, only in the last two decades have methodologies been introduced that take account of rapid increases in quality and falls in the prices of items such as computers and telecommunications equipment, and software. This increases the contribution of capital (Jorgenson and Vu, 2001).

Section III considers the dynamics of investment in natural-resource- and infrastructure-based sectors, which generates a number of hypotheses to explain the divergences analysed in section II. The first is that, since the start of the last decade, the country has been facing a scenario of diminishing returns in the production and exportation of natural-resource-based goods and services, accompanied by a deterioration in nature's capacity to provide environmental services to restore ecosystems (such as H_2O) and to absorb emissions (CO_2, ozone, particulate matter (PM)) and both liquid and solid industrial wastes. The second is that public investment policy has lost momentum in the last decade relative to 1990–2005, particularly in terms of the ability to encourage new investments in transport infrastructure and telecommunications. In fact, it only managed to significantly boost investments in the electricity sector.

Section IV analyses the crucial role innovation plays in facilitating and encouraging —but not replacing— investment and the consequent capital accumulation. Firstly, although investment in research and development (R&D) is currently at a very low level (0.38% of GDP), a rapid and sustained increase in innovation, based on R&D, could trigger the recovery of increasing returns in natural-resource-based sectors and raise productivity in others such as transport and industry. Secondly, innovation in terms of new infrastructures (such as broadband or solar energy) can foster the development of high-productivity sectors and diversification of the production matrix. Nonetheless, this requires an entrepreneurial state to promote new public policies and institutional innovations (Mazzucato, 2013).

II. Trend of total capital formation and growth

Since the 1990s, the ratio of investment (or GFCF) to GDP in Chile has been above the Latin American average. This enabled Chile to outpace the region as a whole in 1990–2017 (4.6% annual growth compared to 2.7%), and also to surpass its own previous growth of 2.9% per year on average between 1974 and 1989. The higher investment rate prevailing since the 1990s was also reflected in an increase in the capital stock per member of the labour force, which has underpinned the growth of real wages since the return to democracy. Nonetheless, the trend of investment and the capital stock has experienced significant fluctuations and changes in its composition; and GDP growth has also fluctuated sharply throughout this period.

1. Fixed capital formation, 1974–2017[5]

The stock of capital goods is one of the variables that determines the productive capacity of an economy. The conventional definition used in the national accounts includes residential and commercial buildings, infrastructure, machinery and equipment.[6]

The capital stock is formed from gross flows of investment in productive goods and services, less depreciation or capital consumption (see Ffrench-Davis and Vivanco, 2016). Gross fixed capital formation is the most direct calculation of investment flows at current market prices, and is the information usually provided; it represents the total expenses incurred in each unit of time by productive investors operating in the domestic market. There are also three derived data items. One is GFCF expressed

[5] The reforms of the dictatorship and the changes made to economic policies since the return to democracy, along with their consequences, are discussed in Ffrench-Davis (2018).

[6] Methodological changes have required major modifications in the historical series of GDP and related variables. In the new chain-linked national accounts referenced to 2008, the central bank included products such as mining exploration and software, which generated a 5.6% increase in GFCF at current prices relative to the figure reported for the same year by the previous national accounts series (base 2003). Subsequently, further adjustments were made to the chain-linked national accounts (reference year 2013), such as repairs of machinery, mainly mining. This meant that, for 2013, GFCF in current pesos was 4.6% higher than the figure reported in the 2008-referenced series for that year. The accumulation of changes generates considerable differences; for example, in 1981–1985, the 2013-based series in current pesos reports a figure 13% higher than in the 1977 series (the base prevailing in those years).

in real terms, which enables intertemporal comparisons to be made, but entails the complex task of estimating deflators for machinery and equipment and the other components of fixed capital.[7] Another is depreciation, which is complex because of the numerous assumptions that have to be made about the useful life of the various productive assets. The third piece of data, constructed simply from the two previous ones, is the estimated capital stock, which represents the sum of the flows of GFCF minus depreciation of the existing stock.

This subsection focuses on the trend of gross and net annual investment flows and the stock of capital, from 1974 —at the start of the neoliberal reforms introduced by the dictatorship— until 2017. Given their heavy incidence and sharp fluctuations, first investment in mining and then foreign investment were disaggregated from the total. Section III makes a disaggregated analysis of the mining sector and two other sectors, starting with GFCF at current prices each year. This reflects the actual spending of economic agents who invest in productive capital, although not the trend of the purchasing power of that expenditure, which is addressed later.

Table 1 shows the trend of GFCF as a share of GDP (investment ratio), measured in current prices. Each subperiod is defined in a way that captures the trend of GDP between peaks in annual activity, to control for cyclical fluctuations in the rate of productive-capacity utilization.

Table 1
Chile: GFCF and GDP growth, 1974–2017
(At current prices[a])

Periods	Gross fixed capital formation *(percentages of GDP)* (1)	Gross fixed capital formation in the mining sector *(percentages of GFCF)* (2)	Gross fixed capital formation in other sectors *(percentages of GFCF)* (3)	GDP growth *(percentages)* (4)
1974–1989	17.3	-	-	2.9
1990–1998	25.2	-	-	7.1
1999–2003	21.3	-	-	2.6
2004–2007	20.8	14.1	85.9	5.7
2008–2013	23.7	22.8	77.2	3.8
2014–2017	23.0	21.7[b]	78.3[b]	1.7

Source: Prepared by the authors, on the basis of Central Bank of Chile, *Cuentas nacionales de Chile*, Santiago, various years; and M. Marcel and P. Meller, "Empalme de las cuentas nacionales de Chile, 1960–1985. Métodos alternativos y resultados", *Colección Estudios CIEPLAN*, No. 20, Santiago, Corporation for Latin American Studies, December 1986.

Note: Column (1) series referenced to 2013; columns (2) and (3) series referenced to 2013 until 2008 inclusive, since 2007 spliced backwards with the 2003 series; for column (4) from 1974 to 2005, the central bank series at constant 2003 prices was used, spliced with revised figures by Marcel and Meller (1986); from 2006 inclusive the percentage changes in GDP are used according to the 2013 mobile-based chain-linked series.

[a] Except column (4).

[b] Average for 2014–2016, owing to data availability.

Column (1) shows that during the 16 years of the dictatorship (1974–1989) the investment ratio was 17.3%, the lowest of the entire period covered in this article. In contrast, in the first nine years after the return to democracy (1990–1998), investment averaged 25.2% of GDP, which was the highest rate in those 44 years and also generated the most vigorous economic growth at 7.1% per year. Since 1999, the investment rate has fluctuated cyclically between the two extremes, as explained in the following subsection.

The sectoral composition of capital formation has undergone major changes. A major boom in the prices of natural resources, including copper, in recent years fuelled a significant increase in mining investment, which grew gradually from an annual average of US$ 2.505 billion in 2003–2004 to US$ 19.771 billion in 2012–2013, when that cycle ended. As a result, between the two biennia, mining investment increased from an annual average of 14.0% to 29.2% of total GFCF, financed mainly out of the sector's burgeoning profits. In 2013, the mining investment cycle entered a downswing phase (see table 2 and figure 2).

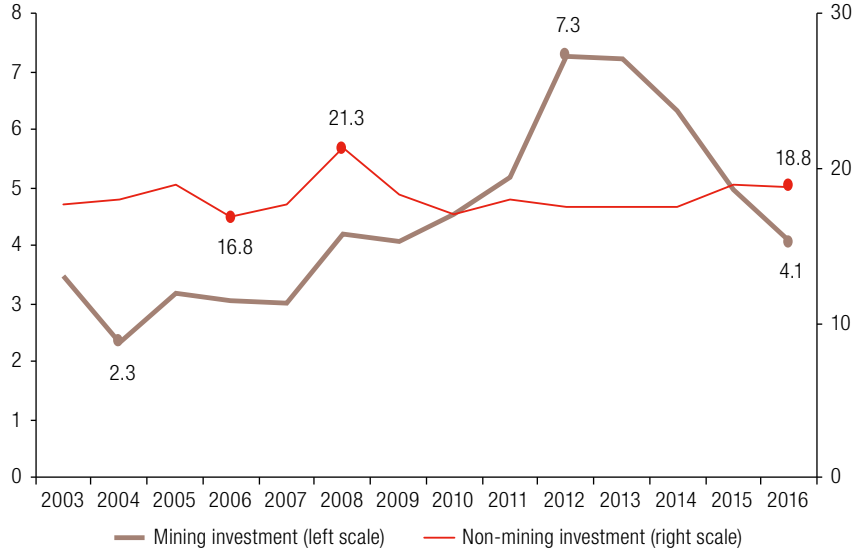
[7] Beyond this complexity, the change in the national accounts from series with a fixed base year to chain-linked series creates a set of methodological difficulties —so much so that the International Monetary Fund (IMF), the World Bank and ECLAC all still work with series that have a base year.

Table 2
Chile: mining investment and production, 2003–2017
(In current prices[a])

Periods	*GFCF (percentages of GDP)* (1)	GFCF in the mining sector *(percentages of GDP)* (2)	GFCF in other sectors *(percentages of GDP)* (3)	GFCF in the mining sector *(percentages of GFCF)* (4)	GDP of the mining sector *(percentages of GDP)* (5)	GDP of the mining sector, chain-weighted *(percentages of GDP)* (6)
2003	21.2	3.5	17.7	16.4	8.2	16.6
2004	20.3	2.3	18.0	11.6	12.5	15.7
2005	22.2	3.2	19.0	14.5	14.6	14.2
2006	19.9	3.1	16.8	15.6	20.7	13.6
2007	20.7	3.0	17.7	14.6	20.5	13.3
2008	25.5	4.2	21.3	16.5	14.0	12.4
2009	22.5	4.1	18.4	18.2	13.0	12.6
2010	21.6	4.6	17.0	21.1	15.9	12.2
2011	23.1	5.2	17.9	22.4	14.8	10.9
2012	24.9	7.3	17.6	29.3	12.5	10.8
2013	24.8	7.2	17.6	29.1	11.0	11.0
2014	23.8	6.3	17.5	26.5	10.9	11.0
2015	23.8	4.9	18.9	20.8	8.6	10.7
2016	22.9	4.1	18.8	17.8	8.1	10.3
2017	21.6	-	-	-	10.1	9.9
2003–2007	20.8	3.0	17.8	14.5	15.3	14.7
2010–2014	23.6	6.1	17.5	25.7	13.0	11.2
2015–2017	22.2	4.1[b]	18.8[b]	17.8[b]	9.1	10.1

Source: Prepared by the authors, on the basis of Central Bank of Chile, *Cuentas nacionales de Chile*, Santiago, various years.
Note: All figures in current pesos except column (6) which reports chain-linked pesos; columns (1), (5) and (6) series referenced to 2013; columns (2), (3) and (4) for 2008–2016, series referenced on 2013; since 2007 backcast using rates of change from the 2003 series.
[a] Except column (6).
[b] Average for 2015–2016, owing to data availability.

Figure 2
Chile: investment in the mining and non-mining sectors, 2003–2016
(Percentages of GDP)



Source: Prepared by the authors, on the basis of Central Bank of Chile, *Cuentas nacionales de Chile,* Santiago, various years.
Note: Until 2008 inclusive, series referenced to 2013; for 2003–2007 it is spliced using rates of change from the 2003-based series, as in table 2.

The intensity of the cyclical force of mining clearly marked capital formation in more recent years, as reflected in columns (1) and (2). In contrast, the rest of GFCF experienced less intensive changes (see column (3) of table 2 and figure 2).

As shown in column 5 (in current pesos), the share of mining production in GDP fluctuated sharply; it did so alongside the price of copper. In column 6 (real chained series), this price effect is controlled for, to reveal a real share that declines steadily from 16.6% of GDP in 2003 to 12.2% in 2010 and 9.9% in 2017. This reflects the lags that exist between investment and higher production and also sharp reductions in ore grades. In addition, a study that corrects for factors that are endogenous and exogenous to mining operations reports a drop in TFP of 1% per year in 2000–2014 (CNP, 2017). In this context, two subperiods in mining production can be identified. The first spans 1990–2003, the golden age of Chilean mining, when production expanded by a multiple of 3.1 thanks to the coming-on-stream of 27 new deposits; and the second, lasts from 2004 to 2017, when copper production grew by just 3.6%.

Investment in the mining sector has increased significantly; mining operations in the 1980s and 1990s allowed for the exploitation of nearly 30 new deposits. In a study of the world's 100 most important copper deposits launched between 1988 and 2012, 29 of them, accounting for 39% of the world's mineral reserves, were located in Chile. Although the average grade of the Chilean deposits was only 50% of that of the 71 other deposits, they contained four times more copper because of their large size. The massive presence of mineral material in the Chilean deposits enabled the deployment of technologies that maximized the exploitation of major economies of scale. That is why the aggregate net present value of the 29 new deposits in Chile was almost equivalent to the net present value added of the other 71 new large deposits elsewhere in the world (Doggett and Leveille, 2010). Most of these new deposits began operations in 1990–2003; in 2004 there were only two new deposit (greenfield investments) and the bulk of the investments involved the expansion or restructuring of existing facilities (brownfield investments).

In this context, foreign investment (FDI), which had dwindled during the dictatorship,[8] burgeoned under democracy, particularly greenfield investment generating new productive capacity. This investment (which naturally includes that of foreign mining companies), contributed to the robust growth of capital formation that occurred between 1990 and 1998. Nonetheless, foreign investment —excluding acquisitions of existing firms— only accounted for 15% of GFCF in 1991–1995 (see table 3, column (7)), while the remaining 85% was undertaken by national, private and public investors in those years of rapid and inclusive development. Subsequently, FDI increased, but takeovers of existing domestic enterprises also grew, particularly in the years following the Asian crisis (see columns (2) and (3)). For example, in the 1999–2003 recession, FDI was equivalent to 40% of GFCF, but half of this corresponded to mergers and acquisitions (M&A).

In the short term, M&A investments tend to be confined to contributing liquid funds, which are often volatile and fuel temporary exchange-rate appreciation, or else are remitted abroad during macroeconomic crisis situations, as occurred in 1999.

In the subsequent years, FDI flows continued to flourish, averaging more than one third of total GFCF in 2008–2013 (see column (6));[9] and new FDI contributed more and more to capital formation (30% in the six-year period). As a result, national investors saw their share of both new FDI and GDP decline. In fact, in that period, only 16% of GDP corresponded to capital formation carried out by the domestic public and private sectors, compared to 20.6% in 1991–1995. In turn, part of the existing capital stock was acquired by foreign investors: acquisitions accounted for 7% of GFCF in 2004–2013.

[8] The massive investment made by the La Escondida mining firm began at the end of the dictatorship, partially financed with external debt equity swaps and the implicit subsidy that this entailed (Ffrench-Davis, 2003, section I.1).

[9] Greenfield FDI accounts for a relatively small share of total investment worldwide (it has fluctuated around one tenth).

National productive investments were losing the dynamism of the 1990s, as financial investments and productive investments abroad gained sway. This was accompanied by a sharp slowdown in TFP growth (see CNP, 2016; Beltrán, 2017). In 2014–2017, the final stage of the mining investment cycle was compounded by a steep fall in nominal copper prices, decreasing returns to natural resources and slow growth of the Chilean economy.

Table 3
Chile: gross fixed capital formation, domestic and foreign, acquisitions and GDP, 1991–2017
(Current prices and percentages)

Periods	GFCF/GDP (1)	FDI/GDP (2)	M&A/GDP (3)	(FDI-M&A)/GDP (4)	National GFCF/GDP (5) = (1)-(4)	FDI/GFCF (6)	(FDI-M&A)/ GFCF (7)
1991–1995	24.4	4.8	1.0	3.8	20.6	19.4	15.2
1996–1998	27.0	8.0	2.5	5.5	21.5	29.5	20.3
1999–2003	21.3	8.6	4.2	4.3	17.0	40.2	20.4
2004–2007	20.8	6.4	1.2	5.2	15.6	30.8	24.7
2008–2013	23.7	9.0	1.7	7.3	16.4	37.8	30.5
2014–2017	23.0	6.2	2.5	3.8	19.3	26.7	16.0

Source: Prepared by the authors, on the basis of figures from the Central Bank of Chile; R. Ffrench-Davis, "La inversión extranjera directa en Chile", *Hacia un Chile competitivo*, O. Muñoz (ed.), Santiago, Editorial Universitaria/Latin American Faculty of Social Sciences (FLACSO)-Chile, 2003; M. T. Cofré and T. Cornejo, "Medición de la inversión extranjera directa en la balanza de pagos", *Economía Chilena*, vol. 7, No. 3, Santiago, Central Bank of Chile, 2004; Central Bank of Chile, *Balanza de pagos, posición de inversión internacional y deuda externa*, Santiago, 2018; H. Fazio, *La transnacionalización de la economía chilena. Mapa de la extrema riqueza al año 2000*, Santiago, LOM Ediciones, 2000; and C. Álvarez, "Chile: oportunidades y desafíos para diversificar la inversión extranjera", InvestChile, 2017 [online] https://investchile.gob.cl/wp-content/uploads/2017/06/investchile-britcham.pdf.

Note: The data for gross FDI come from the following sources: between 1991 and 1998, Ffrench-Davis (2003); between 1999 and 2002, from the balance of payments as reported by Cofré and Cornejo (2004, table 1); since 2003, Banco Central de Chile (2018), 2013 series. Data on mergers and acquisitions between 1991 and 1998 come from Ffrench-Davis (2003) on the basis of UNCTAD; for 1999 the figure of US$ 11 billion reported by Fazio (2000, p. 9) is used; then M&A data are obtained from InvestChile/Foreign Investment Promotion Agency; the remainder of the figures come from the central bank, using rates of variation from the 2013 series at current prices; the figures in pesos were converted into dollars at each year's average exchange rate.

Foreign direct investment is a major participant in the export and technology-intensive sectors, and undoubtedly makes an important contribution (13 of the 20 leading export firms are foreign). Nonetheless, despite its boom, FDI remains a small minority in terms of GFCF. Moreover, the transmission of its technology is not automatic or free. Accordingly, an active policy is needed to selectively attract FDI, as the Foreign Investment Promotion Agency did between 2015 and 2017 (Álvarez, 2017).

Thus far this article has discussed investment flows in current prices. The trend of productive capacity is related to the capital stock in intertemporally comparable currency, so the gross investment flows of different years can be added together. It is also necessary to consider the trend of depreciation over the period analysed. The central bank calculates the stock of capital goods and depreciation or capital consumption in constant-currency terms (see Henríquez, 2008, and successive updates by the central bank). Table 4, column (2) shows how the depreciation of available productive capital has varied over time. Initially, it declined relatively to GDP (which is a flow) owing to rapid GDP growth of 7% per year in the 1990s, while depreciation increased more slowly because it depends on the stock of capital goods. Since the late 1990s, the rate has increased, driven by the shortening of the useful life of productive assets, owing mainly to technological innovation, the deteriorating quality of natural resources and the global spread of financial volatility, which increases the obsolescence of productive assets.

Table 4
Chile: gross fixed capital formation and depreciation, 1974–2017
(Percentages of GDP and rates of GDP growth at constant prices)

Periods	GFCF (1)	Depreciation (2)	GFCF minus depreciation (3) = (1)-(2)	GDP (4)
1974–1989	14.6	9.9	4.7	2.9
1990–1998	21.8	7.8	14.0	7.1
1999–2007	21.2	9.0	12.2	4.0
2008–2013	23.0	12.3[a] (10.8)	10.7	3.8
2014–2017	22.3	12.8	9.5	1.7

Source: Prepared by the authors, on the basis of estimations from the Central Bank of Chile; and Budget Office (DIPRES), "Acta. Resultados del Comité Consultivo del PIB Tendencial", Santiago, 31 August 2018 [online] http://www.dipres.gob.cl/597/articles-178468_c_acta_pib_tendencial.pdf.

Note: Based on central bank estimates of investment and the capital stock at constant 2013 prices; for 2016 and 2017 the rate of change of the chain-linked 2013 series is used for GFCF with depreciation of 13.1% and 13.4% of GDP, respectively, based on DIPRES (2018); since there is no GDP series at constant 2013 prices, column (4) uses the same series as table 1, column (4).

[a] Includes the destruction caused by the earthquake of February 27, 2010.

In recent years there has been an upward trend in depreciation as a proportion of the capital stock and GDP, rising from 8% to 13% of GDP, which represent a very large proportion of gross investment. Gross fixed capital formation is the measure that is usually published and commented on.

According to this depreciation data, net investment averaged about 10% of GDP in the 1960s before falling steeply in 1974–1989 to average just 4.7% (column (3)). This reveals a fundamental cause of the mediocre annual GDP growth of 2.9%, compared that recorded in the 1960s (4.6% between the peaks of 1962 and 1971). In 1990–1998, with democracy now restored, the net investment ratio rose to 14% and supported GDP growth of 7.1%. This accentuated the positive correlation between the stock of productive capital and GDP growth. Subsequently, net investment fell moderately, while GDP growth declined sharply, from 7.1% in 1990–1998 to 3.9% in 1999–2013.

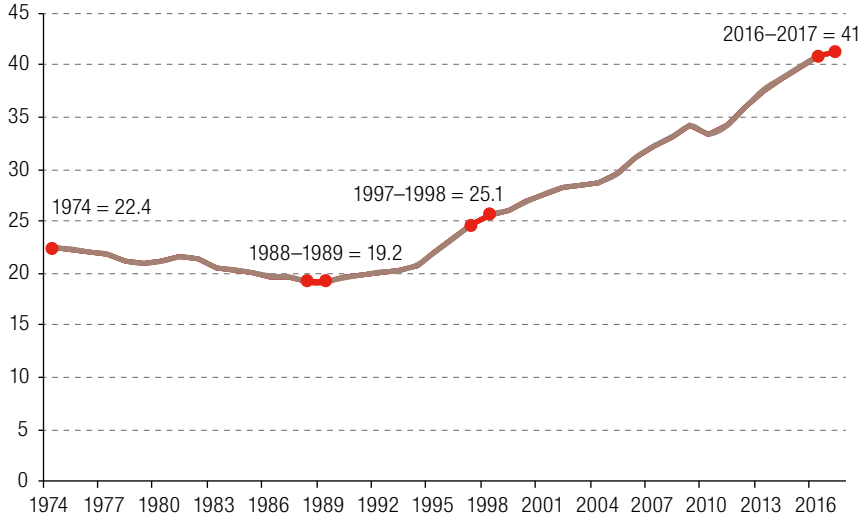
This changing relationship between GFCF, minus depreciation of the capital stock and growth requires three complementary explanations. The first concerns changes in relative prices. The national accounts record a diverging trend between the implicit deflator of GDP and that of machinery and equipment. While the machinery and equipment deflator fell by 3% between 1996 and 2015, that of GDP more than doubled in the same period (see Ffrench-Davis and Vivanco, 2016).[10] This implies a sharp drop in the relative prices of capital goods with respect to the other components of GDP and causes a sharp divergence between constant and current figures.

The second explanation relates to mining investments that account for a large share of GFCF. As discussed above and illustrated in table 2, mining investment has increased significantly, but has not yet fully matured. Moreover, part of it merely replaces the dwindling capacity of old deposits, which is why it is not reflected in an equivalent increase in potential GDP. A third explanation relates to the deterioration in the macroeconomic environment, particularly since 1999, which has kept actual GDP persistently below potential (output or recessionary gap).

Before concluding this subsection, the estimation of the stock of productive capital made by the central bank in constant 2013 prices is reviewed, to examine how it has evolved in relation to the labour force. Figure 3 shows that the coefficient deteriorated during the dictatorship, owing to the mediocre investment ratio and a sharp increase in the labour force. In the 1990s, a persistent increase began which supported substantial wage hikes in that decade, with a continuous growth in the ratio between the capital stock and the labour force in the ensuing years, albeit accompanied by smaller wage increases.

[10] The trend continued in the 2016-2017 biennium, with a fall of around 2% and a rise of 9%, respectively.

Figure 3
Chile: capital stock per member of the labour force, 1974–2017
(Millions of pesos at 2013 prices)



Source: Prepared by the authors, on the basis of estimates from the Central Bank of Chile; and Budget Office (DIPRES), "Acta. Resultados del Comité Consultivo del PIB Tendencial", Santiago, 31 August 2018 [online] http://www.dipres.gob.cl/597/articles-178468_c_acta_pib_tendencial.pdf.
Note: Net capital stock at constant 2013 prices and labour force as reported in the minutes of the Consultative Committee on Trend GDP (DIPRES, 2018).

2. Macroeconomic environment and investment ratio

The investment rate has fluctuated widely, responding sharply to imbalances in the macroeconomic environment —particularly the aforementioned recessionary gap and external-account imbalances resulting from procyclical exchange-rate appreciation. These are imbalances in the real macroeconomy, instead of nominal or inflationary ones. The rate of utilization of potential GDP has a major influence on the level of capital formation through four channels: (i) actual productivity (a recessionary gap implies a difference between actual productivity and potential or structural productivity); (ii) actual profits for self-financing through reinvestment; (iii) access to capital markets; (iv) business investment expectations, because if the existing productive capacity is underutilized and it is expected to remain that way for a while, then further expansion by potential investors in the same activities makes no sense. Investment in new product lines and the entry of new entrepreneurs is discouraged by a depressed environment caused by recurrent imbalances in the real macroeconomy.

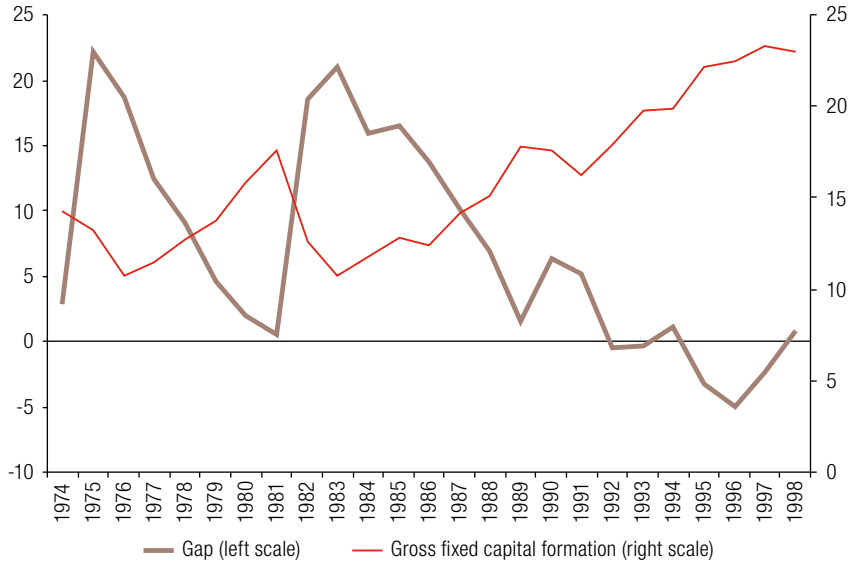
That is why the domestic and external macroeconomic environment in which specific productive development policies are implemented has a decisive influence on the volume of investment, the resource utilization rate, and the mentality and attitudes that permeate economic agents. Macroeconomic policy approaches that over-prioritize a given instrument, either exclusively or at the expense of the rest —for example, by prioritizing an inflation-targeting approach over growth, employment and investment targets— may generate high average rates of underutilization of the capital stock and thus discourage new capital formation.

Relatively greater real macroeconomic stability —in the sense of keeping aggregate demand consistent with potential GDP, along with sustainable external and fiscal balances— tends to provide an incentive for capital formation. This is worth reiterating, given its importance and the frequency with which more fashionable macroeconomic approaches are imposed, which prove to be procyclical,

with many imbalances in the real macroeconomy which ignore a number of fundamental facts: real macroeconomic stability provides an environment that fosters productivity improvements more than for speculative operations; there is a greater emphasis on capacity increases than the expansion of business groups through mergers and acquisitions; and there is greater effective productivity thanks to a higher rate of capacity utilization of existing physical capital and the labour force (ECLAC, 2010; Ffrench-Davis, 2010). Similarly, efforts to innovate (which often require long periods to mature) depend heavily on the existence of real macroeconomic "tranquillity" and expectations of sustainability.

Figure 4, which spans 1974–1998, shows the negative association between the recessionary gap and the investment ratio. It appears as a dominant force in 1974–1989 given the size of that gap (more than 20% of GDP in 1975 and again in 1982–1983). In 1990–1998, the gap was very small or non-existent and contributed to the continued expansion of investment until 1998. Since then, the sign of the relation has persisted: changes in the recessionary gap are followed by changes of opposite sign in GFCF; but the relation is weakened by the presence of the three variables discussed in the previous subsection which change the relationship between the size of the recessionary gap and the investment ratio.

Figure 4
Chile: output gap and gross fixed capital formation, 1974–1998
(Percentages of GDP)



Source: Prepared by the authors, on the basis of R. Ffrench-Davis, *Reformas económicas en Chile, 1973–2017*, Santiago, Taurus, 2018.

Note: The output or recessionary gap is estimated as the average of the two potential GDP estimates reported in Annex I of Ffrench-Davis (2018); GFCF and GDP series at constant prices from 2003 to 2005; since 2006 (inclusive), the percentage changes of both variables are used according to the mobile-based chain-linked series referenced to 2013.

The exchange rate has played a very important role in allocating productive resources between tradable and non-tradable goods; and it has had a significant impact on the composition of domestic demand. From the outset of each economic recovery process —given the procyclical behaviour of exchange-rate policy (Ffrench-Davis, 2018, chapter VIII and annex 2)— the real rate started to appreciate sharply and to unbalance the external accounts, except in 1990–1995. Thus, as investors noted that the exchange rate appreciated as the economy approached the production frontier. In general, currency appreciation not only discourages the production of tradable goods (exports and importing-competing goods), but also erodes their value-added. In turn, cyclical volatility impairs investment quality by inducing

investments in tradables in periods of excessive depreciation and by encouraging investments in non-tradable goods at times of excessive appreciation. In other words, cyclical volatility leads to inefficient resource-allocation decisions with consequences that tend to be irreversible.

In all cases —except when a countercyclical macroeconomic policy predominated, as in 1990–1995— exchange rate appreciation has persisted for prolonged periods, generating a growing current account deficit. This clearly means that economic agents —consumers and producers— have naturally adjusted their behaviour to the macroeconomic environment they perceive, which is abruptly reversed at the end of each cycle through sharp depreciations. This represents a clear failure of macroeconomic policy since 1999.

The continuity of recovery processes and the sustainability of the domestic and external balances that are achieved after eliminating a recessionary gap (see ECLAC, 2010, Titelman and Pérez Caldentey, 2015) are crucial for growth and inclusion. A more prolonged economic recovery gives more time and generates greater confidence among productive investors to develop their projects. In this context, the investment ratio rises gradually, facilitating the development of small and medium-sized enterprises (SMEs) and new entrepreneurs. In short, the dynamic effect will be more significant if economic actors gain solid expectations that public policies will keep effective demand close to the production frontier, and that the trend of the exchange rate is consistent with external-account sustainability. This set of conditions only tended to prevail in most of the period 1991–1998, when the investment ratio rose steadily until 1998.

In contrast, if greater activity is achieved at the expense of an imbalance in another variable (such as the external sector, for example because of volatility imposed by a free-floating exchange-rate policy), the positive effect will be diluted as soon as a major devaluation of the free exchange rate (and the likely need to reallocate resources between tradable and non-tradable goods) reopens the recessionary gap. This outcome was common with interventionist policies, but even more so under the neoliberal macroeconomic approach.

3. The globalization of financial volatility and real macroeconomic imbalances in Chile[11]

The instability of international financial capital flows has been a factor driving fluctuations in domestic demand and macro-prices, and has affected the level of capital formation and its quality. Financial flows have spearheaded the economic globalization process in the last three decades and have been strongly procyclical. Paradoxically, the composition of these flows has diversified towards volatility, intensively pursuing economic rents or capital gains, rather than productivity in generating GDP.

Financial creditors display traits that explain their procyclical behaviour. The leading lenders tend to specialize in liquid investments and operate with short horizons, so they are highly sensitive to changes in the variables that affect short-term gains. A second characteristic is the gradual dissemination of information among the various operators about the investment opportunities in the geographical destinations that are being targeted by the current operators and by a succession of latecomers during the boom process. This explains why the supply of capital flows has been a succession of increasing processes, each of which has lasted for several years. These processes have frequently received feedback from the existence of a significant recessive gap and a depreciated exchange rate at the outset (in the case of Chile, in 1976, 1990, 2004 and 2010). Moreover, in recent times, financial flows to Chile have been correlated with the price of copper, thereby accentuating procyclicality.

[11] The subject is discussed more extensively in Ffrench-Davis (2010).

All of this is self-reinforcing: some variables, such as stock prices, the exchange rate, the evaluations made by risk rating agencies, and bond and real estate prices, can move in a certain direction, first recovering and then overshooting in the adjustment of aggregate demand or the exchange rate. They thus diverge from sustainable equilibria for long periods; and in the adjustment process they stimulate financial flows that pursue capital gains (rent-seeking), fuelling a growing expansion of domestic demand, external imbalance and exchange-rate appreciation, and generating vulnerabilities, which then give way to a sudden reversal and a recessionary adjustment.

Unlike investment in fixed capital, which tends mainly to be irreversible, these financial capital flows can be fully reversed; but, in the process, their macroeconomic effects have led to irreversible and inefficient allocations of productive resources.

The key variables for financial operators are not related to the long-term fundamentals of the national economy, but rather to their short-term profitability. This explains why their opinion of a given country can change drastically and suddenly, even though the country's economic fundamentals are broadly similar before and after the abrupt flow reversal.

In short, financial flows have been procyclically highly volatile and, as a result, have made little direct contribution to the financing of GFCF. They have also exerted a strong adverse impact indirectly by generating macroeconomic instability in domestic demand and in the exchange rate. What usually happens is that these flows are used for consumption and the purchase of existing assets, thereby generating bubbles and crowding-out domestic savings. In fact, they have frequently destabilized domestic demand and the exchange rate, without making any significant contribution to the formation of productive capital (Ostry, Loungani and Furceri, 2016; Rodrik, 2015). The fact that Chile has been an active participant in this trend since 1999 implies the predominance of a "financialist" attitude over a "productivist" approach".

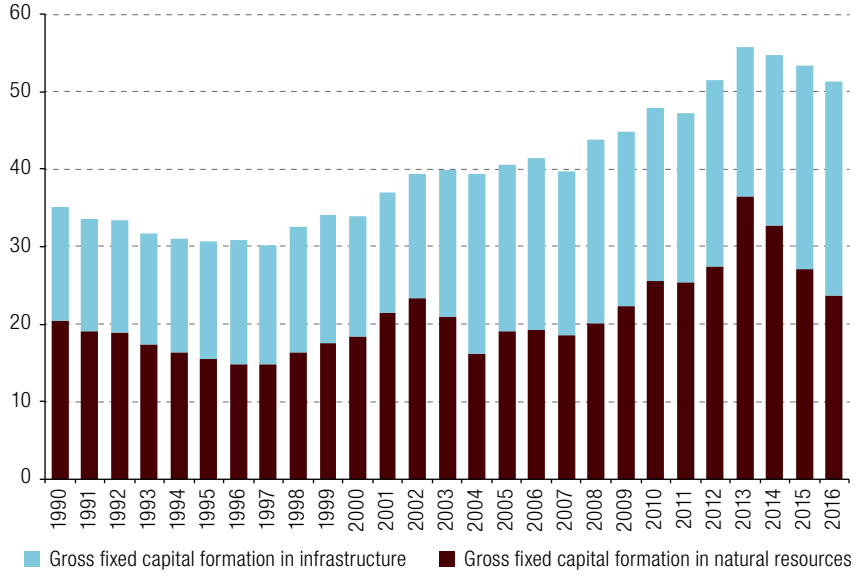
III. Sectoral trends of capital formation and growth

Gross fixed capital formation in the various sectors of the Chilean economy is determined by variables common to any investment decision, such as the gap between actual and potential GDP, effective external and domestic demand, the density of linkages with other sectors (Hirschman, 1958), the trend of the exchange rate, the quality of the long-term capital market and financial flows. However, the strategies pursued by business groups and firms that are constantly evaluating the allocation of resources towards productive or financial investments, whether in Chile or abroad, are also key factors. There are also institutional determinants such as macroeconomic policy, development policies, regulations governing public utility services, environmental regulations and taxation. In some sectors, such as transport infrastructure, public investments and the dynamism of the concession system, which in Chile was consolidated in the mid-1990s, also have an influence.

Disaggregated long series of GFCF by sector are available at chain-linked prices for reference year 2008. By splicing these with the data available for 2015 and 2016, a 1990–2016 series was constructed as shown in figure 5.[12]

[12] The Central Bank of Chile has not yet published disaggregated GFCF series at chain-linked prices referenced to 2013, except in respect of mining and housing services for 2008-2016. The methodological changes and the effects of taking base years 2008 and 2013 generate considerable differences in mining GFCF.

Figure 5
Chile: gross fixed capital formation in natural resources and infrastructure, 1990–2016
(Percentages of total GFCF at chain-linked prices referenced to 2008)



Source: Central Bank of Chile, *Cuentas nacionales de Chile*, Santiago, various years.
Note: Percentage changes for 2015 and 2016 were added to the series produced by Claudio Aravena on the basis of the Chilean national accounts, chain-linked series referenced to 2013.

This information makes it possible to highlight two sectors which accounted for an average of 34.0% of total GFCF in 1990–2003 and of 48.3% in 2004–2016.

One sector, the exploitation and processing of natural resources, represented on average 18.2% of GFCF for 1990–2003, rising to 25.3% in 2004–2016, led by the expansion of mining investment. The other sector, aggregate investment in physical infrastructure, transportation, health, gas, fuel, electricity and telecommunications, accounted for 15.8% of GFCF in 1990–2003 and had grown its share to 23.0% in 2004–2016. The trends in these two sectors contrast with the behaviour of industrial GFCF, which in 1990–2003 represented 8.8% of total GFCF, before declining to 6.9% in 2004–2016.

This article makes two claims. The first is that, since the early years of the 2000 decade, Chile has been facing a scenario of diminishing returns in the production and exportation of natural-resource-based goods and services. This is explained mainly by the diversion of business funds and energies towards the internationalization of large firms, a deterioration in the quality of natural resources and a reduction in nature's capacity to provide environmental services (without market prices) to restore ecosystems (such as H_2O), for the absorption of emissions (such as CO_2, ozone, particulate matter (PM)) and industrial liquid and solid waste. In addition, environmental conflict is raising the costs and lengthening the gestation periods of investments in mining, the forestry sector, aquaculture production and fishing; and this is further compounded by major exchange-rate instability caused by the policy adopted since 1999. The only sectors that have successfully implemented dynamic growth strategies are fruit growing and wine production.

The second claim is that public investment policy has lost momentum in the last decade compared to the period 1990–2005, particularly in terms of its ability to attract new investments in transport infrastructure, energy and telecommunications. Although investment in the electric power sector has recovered recently, it has not been possible to launch a wave of investments in the transport infrastructure or telecommunications sectors, particularly broadband infrastructure. This is very worrying,

since the positive externalities of infrastructure investment far outweigh those of investments in natural resources, particularly by opening up opportunities for new sectors to emerge in regions and in new technology-intensive subsectors.

1. Decreasing returns in the production of natural resources

Since the early years of the 2000 decade, a cycle of diminishing returns has been observed in the production of goods based on renewable and non-renewable natural resources. This is explained by two factors: first, the loss of density per unit volume or area (for example, kilograms of metallic and non-metallic products per metric ton of rock, as in the case of the declining purity of the copper deposits mentioned above, the metric tonnage of fish catches, and aquaculture production per km^2 of maritime or aquatic surface, cubic meters of wood per hectare, and so forth). It is also due to nature's reduced capacity to provide environmental services to replenish ecosystems, to supply water for agricultural production and the processing of raw materials, as well as to absorb liquid, solid waste and emissions.

In the past, Chile endured other cycles of growing shortage of raw materials that were overcome through the discovery of new reserves, the development of new products with global market demand and technological progress. Nonetheless, with the exception of horticultural and wine production, the country now faces hitherto unknown constraints. During the last decade, the growth of forest plantations has virtually stalled. Also, since the mid-1990s the marine biomass available for fishing has deteriorated and Chile no longer has new oceanic spaces with high fish density. Similarly, the recovery of the growth of aquaculture production cannot be based on the old production regime that went into crisis in 2007. No less important, it will be hard to repeat the extraordinary cycle in which nearly 30 new mineral deposits were opened, which was a global phenomenon.

Overcoming the cycle of diminishing returns from natural resources not only requires the incorporation of advanced process technologies, but also depends on complementary investments in water desalination, minimizing liquid and solid industrial waste and emissions, as well as socioenvironmental investments to overcome the growing conflict between firms and communities that live in the neighbourhood of natural-resource extraction sites. A document published by the National Council on Innovation for Development (CNID, 2017) notes that Chile is ranked fifth worldwide in terms of environmental conflicts per 100,000 inhabitants. Overcoming this problem requires a more advanced institutional framework than currently exists in Chile, both to promote science and innovation, and to combine competitive markets with institutional mechanisms that facilitate agreements between the public, private and civil-society sectors.

Having considered the case of mining, the following paragraphs analyse the forestry, fishing, salmon, fruit and wine subsectors in greater detail. Although the Central Bank of Chile does not publish a GFCF series disaggregated to this extent, changes in the rates of growth of physical production offer indirect evidence of investment dynamics, while qualitative data make it possible to construct an overview of the process that natural-resource-based sectors are experiencing.

In the forestry sector, the annual rate of growth of forest plantations dropped from 6.2% in 1978–1989 to 2.8% in 1990–2003, and then to 1.3% in 2004–2016 (see figure 6). The main causes of this decline are the depletion of the forest frontier in Chilean territory, the restriction of water resources, relative energy costs compared to other Latin American countries, the growing environmental demands of the population and social conflicts in southern Chile. The strategic response from the business groups involved was to internationalize their activities through investments in northern Argentina, Uruguay and southern Brazil using the technological package and business model developed in Chile, but also taking advantage of tax incentives in those countries.[13] In this connection, South America's Atlantic

[13] A report from the Directorate General of International Economic Relations (DIRECON) (2014) states that the foreign investments undertaken by firms resident in Chile total US$ 100 billion, equivalent to 50% of total FDI in Chile.

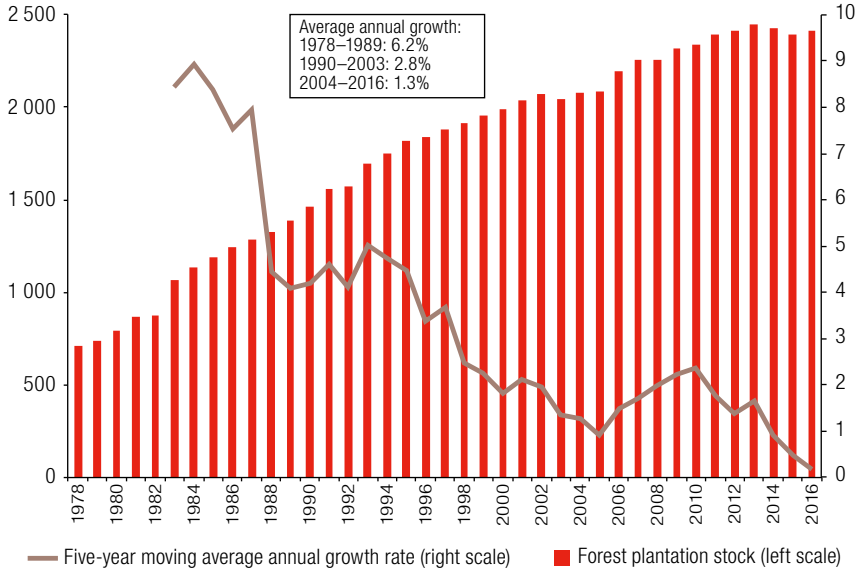
coast has ports that are at a relatively similar distance as Chile's are from the large Asian markets; but forest production in those countries entails lower energy costs and generates significant Ricardian rents relative to the situation in Chile. For example, in Brazil the eucalyptus forest species reaches maturity twice as quickly as in Chile.

As a result, the growth of forest plantations and the production of forest by-products has tended to decline significantly in Chile. The rate of forest plantation has virtually stagnated at around 100,000 hectares per year, nearly all of it reforestation. This has been accompanied by a significant reduction in the annual growth rate of the production of certain forest by-products. Comparing 1990–2003 with 2004–2016, the rate of growth of the physical production of wood pulp slowed from 9.9% to 3.7% per year, that of paper from 6.9% to 0.4%, while that of panels and veneers decreased from 13.1% to 4.3% (see figure 6). This is explained not only by the stagnation of forest plantations, but also by the evolution of the exchange rate and the internationalization of forestry investments.

Figure 6

Chile: stock of forest plantations and five-year moving average growth rate per year, 1978–2016

(Thousands of hectares and percentages)

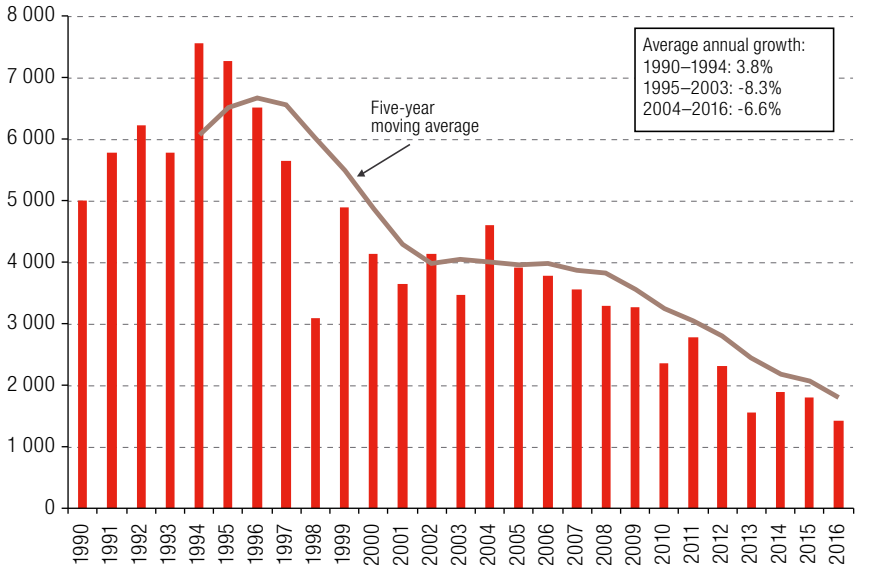


Source: Forestry Institute (INFOR), *Chilean Statistical Yearbook of Forestry 2018*, Santiago, 2018.

In the fishery sector, Chile's industrial fish catches have been trending down since the mid-1990s; and by 2016 they had dropped back to their 1978–1979 level. Although global demand is growing steadily, the collapse of marine biomass has drastically curtailed the great momentum displayed by this activity between 1965 and 1985, when it grew at an average annual rate of 10.2%. Since 1995 it has been declining, with average falls of 8.3% in 1995–2003 and 6.6% in 2004–2016 (see figure 7). This has led to the destruction and conversion of the capital stock: the number of industrial fishing vessels in the north has decreased, while in the south there has been a shift towards aquaculture activity and the production of crustaceans and molluscs. This mainly involves increasing the stock of artisanal fishing boats, many of which have been converted from industrial fishing vessels to comply with the legal regulations that allow a maximum length of 18m. As a result, the artisanal sector's share of total catches (including fish, molluscs and crustaceans) grew from 8.2% to 62.6% between 1990 and 2017. This represented a structural transformation of the extractive fishing sector in Chile.[14]

[14] See the reports on industrial and artisanal fishing [online] at www.sernapesca.cl. Between 1990 and 2003, artisanal fishery landings grew by 8.7% per year, while those of industrial fishing decreased by 6.0%. Between 2004 and 2017, artisanal fishery landings declined by 1.3% per year, while those of industrial fishing continued to decrease by 9.6% annually.

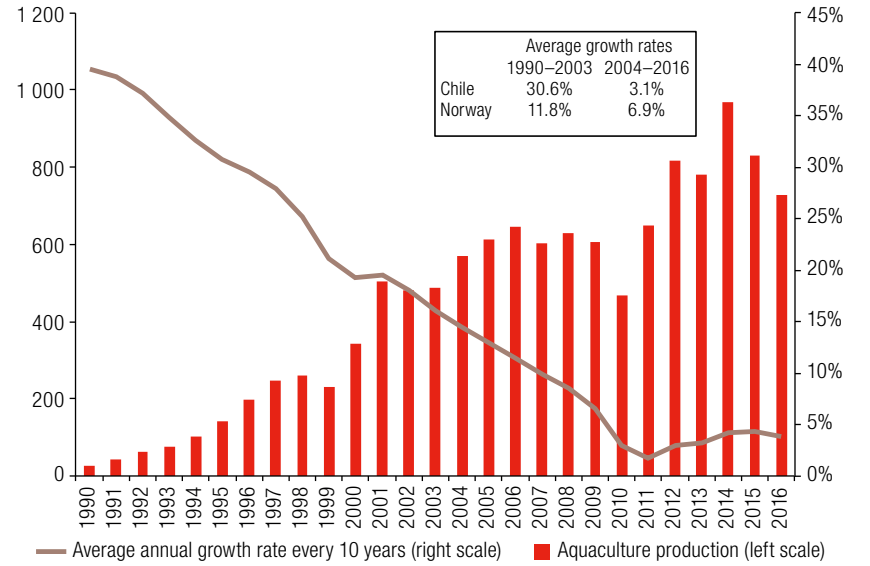
Figure 7
Chile: fish catches, 1990–2016
(Thousands of metric tons)



Source: Food and Agriculture Organization of the United Nations (FAO), "Global Capture Production, 1950–2016" [online] http://www.fao.org/fishery/statistics/global-capture-production/query/es

In the aquaculture sector, the crisis caused by the infectious salmon anaemia virus in 2007 resulted in the collapse and then structural stagnation of this activity, since the production model had overburdened the waters of lakes and marine channels (see figure 8). Whereas the annual growth rate of aquaculture production was 30.6% in 1990–2003, it slumped to 3.1% in 2004–2016, that is less than half of Norway's average annual growth in the same period.

Figure 8
Chile: aquaculture production: salmon, trout and other species, 1990–2016
(Thousands of metric tons and percentages)

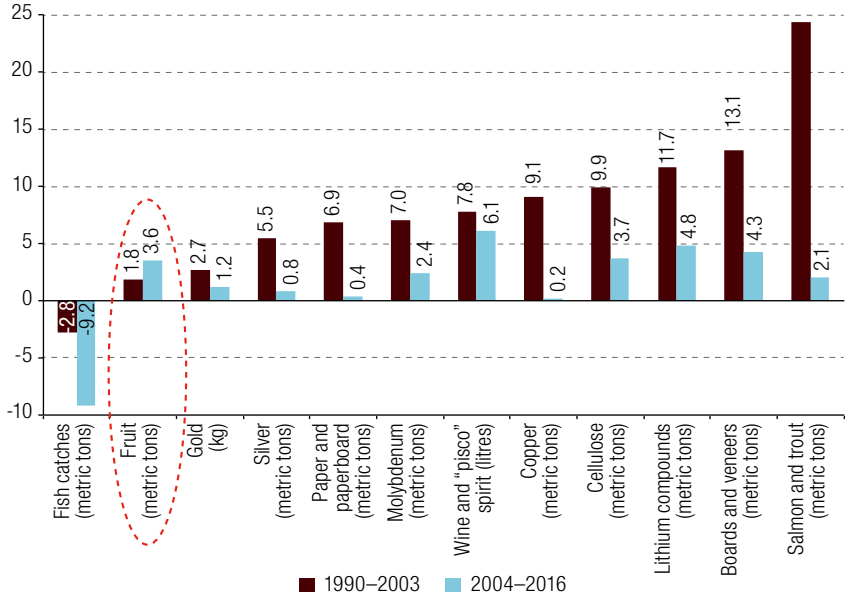


Source: Food and Agriculture Organization of the United Nations (FAO), "Global Aquaculture Production" [online] http://www.fao.org/fishery/statistics/global-aquaculture-production/en.

The salmon industry currently makes massive use of antibiotics, to the extent that these represent up to 19% of the industry's sales value. This has tarnished the prestige of Chilean exports, and resulted in price penalties and market exclusions since 2014. As a result, health regulations have become increasingly stringent and will require more capital-intensive investments, greater contracting of technological services and firms operating on larger production scales. The simple extensive model of salmon production is in full retreat, and the industry is undergoing a restructuring process that will drastically reduce the number of firms (Hosono, Iizuka and Katz, 2016). The salmon harvest is projected at nearly 700,000 metric tons by 2020, compared to 1 million metric tons in 2014.

Figure 9, which illustrates physical production growth rates in various natural-resource-producing sectors, reveals a worrying overall situation. A comparison of long periods shows that almost all sectors producing raw-materials based on natural resources saw their growth rates slowing between 1990–2003 and 2004–2016. The only exception is the horticultural sector, which is booming in the south of Chile and which adapts to the trends of global demand. This sector is growing strongly, thanks to the buoyancy of investments in fruit tree plantations and constant incorporation of technology. The other high-growth sector in recent times has been wine production. According to OECD R&D statistics, these two activities have the highest R&D growth rates in Chile, approaching the average of OECD countries.

Figure 9
Chile: physical production of commodities, 1990–2016
(Percentages, average annual growth rates)



Source: Chilean Copper Commission (COCHILCO), Food and Agriculture Organization of the United Nations (FAO) and Agrarian Research and Policy Office.

Chile certainly has the potential to overcome this cycle of diminishing returns, by intensifying research and scientific-technological development to diversify the natural-resource production matrix, increase productivity and reduce adverse environmental impacts. While this potential exists, however, major obstacles need to be overcome.

Lithium is a prominent example, since it has the potential for greater value added, with deposits mostly in State hands (Production Development Corporation – CORFO). Although its physical production growth rate slowed from 11.7% in 1990–2003 to 5.0% in 2004–2016, it is likely to increase between 2018 and 2030 thanks to CORFO's new agreements with the firms Sociedad Química y Minera de Chile

(SQM) and Albemarle. This will involve not only increasing production, but also reducing the extraction of water and brine, which means more efficient and sustainable management of salt flats. It remains to be seen whether these firms fulfil their contracts; and there is a strong current of public opinion that believes the best option for Chile is to set up a state enterprise to produce lithium.[15]

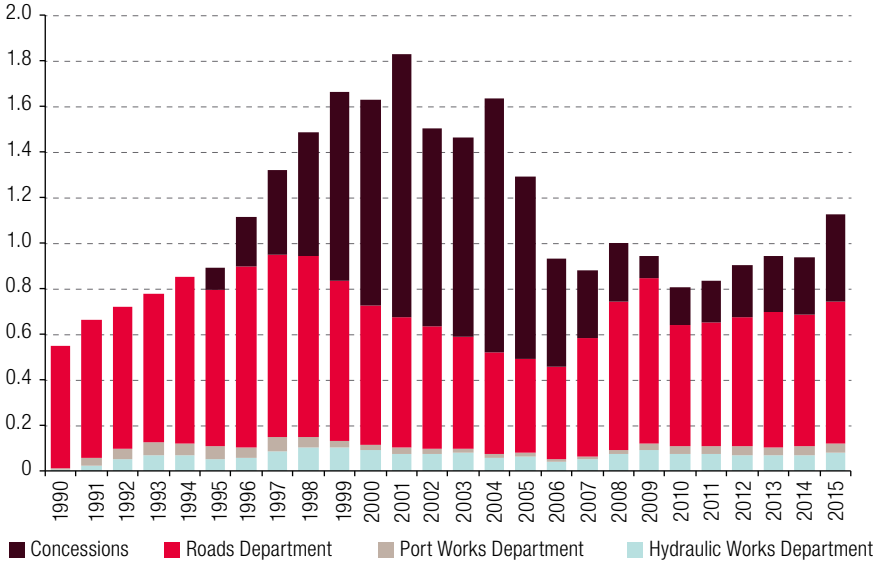
2. Loss of momentum in infrastructure investments

Investment in infrastructure is crucial for the country's growth; and it is vital for diversification of the production matrix, both in territorial terms and in facilitating the emergence of new technology- and knowledge-intensive sectors. Its dynamics are mainly codetermined by public-policy decisions and the expansion strategies being pursued by domestic and foreign business groups. In the case of public investments, financing constraints or government decisions influence transport infrastructure, health and education; and, in this regard, the Infrastructure Fund approved by Congress and then promulgated in 2018 could be a powerful tool. In the second case, business groups' rate-of-return expectations are important in the context of the rules of the game for construction and concession tenders.

In 1990–2016, infrastructure investment represented around 11% of total GFCF, which includes concessions that began in 1995 and peaked in 2005. The importance of infrastructure policy is measured not only by its GFCF share, but by the externalities it generates, which elicit new investments from the private sector. It is, therefore, worrying that its share has declined in the last decade.

Figure 10 shows that Chile experienced a cycle of increased investment in road, sanitation and port infrastructure based on the Public Concessions Law (1992–1996); the partial privatization of health infrastructures and the improvement of its regulatory framework (1997); and the Law of the Port Company of Chile (EMPORCHI), which calls for the expansion of State ports through private concessions; and the Law on Shared Urban Financing (2001). The only sector that has failed to set up an effective concession system is the railways.

Figure 10
Chile: road investments and concessions by the Ministry of Public Works
(Percentages of GDP at current prices)



Source: Ministry of Public Works.

[15] Chile also has the potential to produce "rare earths", including cobalt, which it stopped producing in 1944. Ongoing studies prove Chile's potential in this field, although mining exploration needs to confirm that the reserves in question can be profitably exploited with the technologies available (Townley, Díaz and Luca, 2017).

The result was an increase in investments in physical infrastructure which, in conjunction with MOP road concessions and public investments, represented an average of 1.5% of GDP in 1998–2005. The innovation was certainly the successful concession system. The institutional and macroeconomic context that attracted foreign investors into the country contributed to this, although domestic investors were crowded out. Nonetheless, the momentum of the 1998–2005 period slackened later. In relative terms, MOP investment and road infrastructure concessions stabilized around 0.9% of GDP, before partially recovering in the 2016–2017 biennium. The State also faces problems in the design and management of large-scale projects that are sufficiently attractive for private-sector tenders, while the concessions system encountered difficulties especially in the area of cost overruns, obtaining environmental authorizations, and regulation and inspection. Extending concessions to other areas, such as hospitals, has met with resistance in Chilean society. All this occurs in the context of a conservative fiscal policy that has made it difficult to relaunch public investments since 2017.

There are three large sectors that have been left behind in terms of infrastructure investment. The first is the cabotage system, owing to the persistence of legislation that has fostered a monopoly in cargo and passenger transport, which undermines its capacity to compete with road alternatives.

The second laggard sector is telecommunications, in which the deficit should be visualized in terms of future demands for digital services. Currently, broadband in Chile is concentrated in large cities and has an average speed of nearly 8 Mbps, which is insufficient for current and future requirements (see table 5). The development potential of advanced manufacturing, new technologies applied to education and training, telemedicine and other technologies applied to health, radar and air control systems, new mining, new digital requirements in terms of logistics, astronomy and interactive video, all require speeds above 70 Mbps (Yanyan and others, 2013). Until Chile develops a new-generation broadband infrastructure, the potential for diversifying its production matrix will not be realized. Nonetheless, as a CNID study conducted in 2017 in conjunction with the Chilean Telecommunications Department (SUBTEL) and CORFO warns, implementing this new type of infrastructure will probably require regulatory change and progress towards a system of concessions for the large fibre-optic backbones (see CNID, 2018).

Table 5
Japan, OECD and Chile: digital infrastructure, 2016–2017

Countries	Firms with high-speed connections *(> 30 Mbps)*[a]	Households with high-speed connections *(> 30 Mbps)*	Fibre optics as a percentage of fixed accesses	PPP dollar price of plan at > 30 Mbps	Download speed *(real, Mbps)*	Backbone resilience	Undersea cables	Average nominal investment in telecommunications *(US$/ inhabitant)*[b]
Japan	95%	54%	75%	28	20.2	National	18	180
OECD	50%–60%	25%	22%	37	16.2	All cities	12	152
Chile	12%	5%	7%	46	9.3	Santiago -Valparaíso	3[c]	120

Source: Department of Telecommunications; Chilean Economic Development Agency, "Programa Estratégico de Industrias Inteligentes", 2016 [online] http://seguimiento.agendadigital.gob.cl/download?filename=1507037460_20150122%20PENII%20Resumen%20Ejecutivo%20vF.pdf; Organization for Economic Cooperation and Development (OECD); International Telecommunication Union (ITU); and Akamai, *The State of the Internet*, 2017 [online] https://www.akamai.com/fr/fr/multimedia/documents/state-of-the-internet/q1-2017-state-of-the-internet-connectivity-report.pdf.

[a] Does not include microenterprises.
[b] In the case of Japan, 2013 data.
[c] Includes the Austral Fibre Optics project.

The third key sector embraces electric power generation, transmission and distribution; gas production, transmission and distribution; and sewerage networks. All are regulated public utilities, in which investments are determined by the relationship between installed capacity and the expected growth in demand for the services in question, plus supply factors such as available technologies, regulations and availability of resources. This sector has gained importance over the last 25 years, especially because the investment structure is becoming more complex and diversified. A comparison

of the averages of the 1990–2003 and 2004–2016 periods shows that its share of GFCF rises from 11% to 14% (at current prices). Overall, a recovery from the investment shortfall from which this sector had been suffering since the middle of the last decade now seems to have begun.

The rest of GFCF depends significantly on the degree to which domestic demand is aligned with potential GDP. A recessionary gap (Ffrench-Davis, 2010) between actual and potential GDP in these sectors acts as a significant discouragement to capital formation. In the case of sectors that produce tradable goods, such as the manufacturing industry and SMEs that compete with imports, exchange-rate instability and the reversal of countercyclical policies have stalled economic growth since 1999, thus reducing the capacity to reduce inequality given their depressive impact on the level and quality of employment.

IV. Capital formation, innovation and growth

As noted above, GFCF plays a decisive role in economic growth. In addition to its direct growth effects, it is a vehicle for incorporating technological innovations, improving productivity and creating jobs.

Although innovation and gross capital formation are complementary, one is not sufficient to lead to the other. Innovation is not enough to generate new investments: effective demand and adequate macroeconomic and institutional conditions are also necessary. Moreover, if investments do not incorporate technological progress in the machinery and constructions in question, and if they are not accompanied by innovations in the way they combine with each other and with labour, they end up lagging behind the global technological frontier. As a result, lesser or greater complementarity between investment and innovation depends crucially on the presence of productive development policies and adequate and inclusive regulatory frameworks with SMEs, in an environment of sustainable real macroeconomic equilibria.

As noted above, the evidence shows that rapid and sustained economic growth cannot be achieved with a low investment ratio. In aggregate terms, the volume of GFCF is more decisive for growth than TFP, as shown by the high intensity of the capital stock per member of the United States or European labour force, compared to those of Chile or elsewhere in Latin America (see figure 1).

Nonetheless, this does not detract from the importance of innovation as a component of a growth and development strategy. Chile has historical experiences in which investment and innovation complemented each other significantly, such as the railway in the nineteenth century and import substitution industrialization in the mid-twentieth century, which enabled new industries to emerge with new products and new production processes.

In the historical cycle defined by the open economy and natural resource exports, the innovation process was dominated by the production of new sources of food and raw materials that were already known in Chile in the first half of the twentieth century, but only came to be exploited on a massive scale as from the 1980s. The generation of new products and processes attracted new technologies, new investments and, therefore, new credit flows. All of this was founded on the strengthening of private property rights, in the context of an economic policy that favoured large firms rather than SMEs, through privatizations, regulations and financing. This was accompanied by incentives for the extensive exploitation of natural resources without regard to negative externalities. In short, it was a relatively simple model: imports of machinery and equipment with their embedded knowledge, and exports of raw materials, based on an unsustainable model of natural resource exploitation that caused a persistent deterioration of environmental resources.

This does not mean that no technological learning resulted from the introduction of new products, processes and forms of organization. Nonetheless, the foregoing discussion shows that the natural-resource economy is facing a cycle of diminishing returns that will only be overcome as investment regains momentum, together with systems of innovation and inclusive learning for entrepreneurs and SMEs. These firms usually harbour larger productivity gaps in terms of best practices and technologies than in large firms. Consequently, they offer the greatest opportunities to raise average TFP.

In the coming decades, Chile will continue to depend on natural resource exploitation (Codelco has 70 years' reserves for continued copper production); but it is becoming increasingly clear that it will no longer be able to exploit natural resources as it has done thus far. A set of institutional, natural and economic constraints will force a move from an unsustainable exploitation model with low technological content to a more knowledge- and innovation-intensive accumulation model.

This is currently becoming essential, when the accumulation process is being profoundly influenced by several waves of new technologies (biotechnology, nanotechnology, Internet of Things, big data, among others) which, unlike their predecessors in the nineteenth and twentieth centuries, tend to be incorporated quickly in Chile. As they evolve, however, they become more and more complex, so they require the creation of complementary capabilities that are not limited to firms, but extend to public-private networks and partnerships.

The historical problem currently facing Chile is that these investment opportunities no longer depend on guaranteed property rights alone, but on an adequate regulatory institutional framework. They also require an increasingly advanced digital infrastructure, trained human resources, as well as scientific and technological services. All this requires the State to venture into areas in which private companies cannot act alone, either because they involve very uncertain or high-risk investments; or because they are investments with high externalities which are not appropriable. In this effort, the State must overcome its own interagency coordination failures, and also provide support to overcome coordination failures between private entities.

The growth and diversification of the production matrix requires an active state rather than a passive one; and this means shedding the paradigm of the subsidiary state and adopting a new state paradigm based on innovation and development; or, as Mazzucatto (2015) would say, an "entrepreneurial state".

In short, gross capital formation will be more efficient and sustainable insofar as it is based on innovation, which is being facilitated by the technological revolutions currently under way. Nonetheless, new public policies, institutions and regulations are needed that generate incentives to ensure that new waves of investment are accompanied by technological and institutional innovations. This path offers more possibilities than a strategy that encourages investment by replicating what was done in the past and assumes that markets alone will encourage innovation and overcome the problems of environmental sustainability and economic-social inclusion.

Bibliography

Álvarez, C. (2017), "Chile: oportunidades y desafíos para diversificar la inversión extranjera", InvestChile [online] https://investchile.gob.cl/wp-content/uploads/2017/06/investchile-britcham.pdf.

Beltrán, F. (2017), "Productividad total de factores: una estimación estructural y sus determinantes en Chile: 1960–2015", thesis, Santiago, University of Chile.

Calvo, G., A. Izquierdo and E. Talvi (2006), "Phoenix miracles in emerging markets: recovering without credit from systemic financial crises", *NBER Working Pape*r, No. 12101, Cambridge, Massachusetts, National Bureau of Economic Research.

Central Bank of Chile (various years), *Cuentas nacionales de Chile*, Santiago.

CNID (National Council of Innovation for Development) (2018), "Propuesta estratégica del Consejo Nacional de Innovación para el Desarrollo: banda ancha de Visviri a Cabo de Hornos", January [online] http://www.cnid.cl/wp-content/uploads/2018/02/BandaAncha-CNID.pdf.

___(2017), *Ciencias, tecnologías e innovación para un nuevo pacto de desarrollo sostenible e inclusivo*, Santiago [online] http://www.cnid.cl/wp-content/uploads/2017/05/CTI-para-un-nuevo-pacto-de-desarrollo-CNID-2a-edicion.pdf.

CNP (National Productivity Commission) (2017), *Productividad en la gran minería del cobre*, Santiago.

___(2016), *La productividad en Chile: una mirada de largo plazo. Informe anual 201*6, Santiago.

Cofré, M. T. and T. Cornejo (2004), "Medición de la inversión extranjera directa en la balanza de pagos", *Economía Chilena*, vol. 7, No. 3, Santiago, Central Bank of Chile.

Coremberg, A. and F. Pérez García (2010), *Fuentes del crecimiento y productividad en Europa y América Latina*, Bilbao, BBVA Foundation.

DIPRES (Budget Office) (2018), "Acta. Resultados del Comité Consultivo del PIB Tendencial", Santiago, 31 August [online] http://www.dipres.gob.cl/597/articles-178468_c_acta_pib_tendencial.pdf.

DIRECON (General Directorate for International Economic Affairs) (2014), "Presencia de inversiones directas de capitales chilenos en el mundo", Santiago [online] https://www.direcon.gob.cl/inversion-exterior/presencia-de-inversiones-directas-de-capitales-chilenos-en-el-mundo-1990-diciembre-2017/.

Doggett, M. and R. Leveille (2010), "Assessing the returns to copper exploration, 1989–2008", *Exploration and Mining Geology*, vol. 19, No. 1–2, Westmount, Canadian Institute of Mining, Metallurgy and Petroleum.

ECLAC (Economic Commission for Latin America and the Caribbean) (2010), *Time for equality: closing gaps, opening trails* (LC/G.2432(SES.33/3)), Santiago.

Fazio, H. (2000), *La transnacionalización de la economía chilena. Mapa de la extrema riqueza al año 2000*, Santiago, LOM Ediciones.

Ffrench-Davis, R. (2018), *Reformas económicas en Chile, 1973–2017*, Santiago, Taurus.

___(2010), "Macroeconomics for development: from 'financierism' to 'productivism'", *CEPAL Review*, No. 102 (LC/G.2468-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

___(2003), "La inversión extranjera directa en Chile", *Hacia un Chile competitivo*, O. Muñoz (ed.), Santiago, Editorial Universitaria/Latin American Faculty of Social Sciences (FLACSO)-Chile.

Ffrench-Davis, R. and D. Vivanco (2016), *Depreciación del capital físico, inversión neta y producto interno neto*, Santiago, Corporation for Latin American Studies/University of Talca, Santiago, November.

Henríquez, C. (2008), "Stock de capital en Chile (1985–2005): metodología y resultados", *Estudios Económicos Estadísticos*, vol. 63, and annexes, "Series de stock capital consumo capital fijo. Periodo 1985–2015, referencia 2008", Santiago, Central Bank of Chile [online] https://www.bcentral.cl/-/stock-de-capital-en-chile-1985-2005-metodologia-y-resultad-1.

Hirschman, A. O. (1958), *The Strategy of Economic Development*, New Haven, Yale University Press.

Hosono, A., M. Iizuka and J. Katz (eds.) (2016), *Chile's Salmon Industry: Policy Challenges in Managing Public Goods*, Springer.

Iizuka, M. and J. Katz (2011), "Natural resources industries: 'tragedy of the commons' and the case of the Chilean salmon farming", *International Journal of Institutions and Economies*, vol. 3, No. 2, July.

Jorgenson, D. and K. Vu (2001), "Accounting for growth in the information age", Cambridge, Massachusetts, Department of Economics, Harvard University.

Marcel, M. and P. Meller (1986), "Empalme de las cuentas nacionales de Chile, 1960–1985. Métodos alternativos y resultados", *Colección Estudios CIEPLAN*, No. 20, Santiago, Corporation for Latin American Studies, December.

Mazzucato, M. (2015), *The Entrepeneurial State: Debunking Public vs. Private Sector Myths*, London, Anthem Press.

Ostry, J., P. Loungani and D. Furceri (2016), "Neoliberalism: oversold?", *Finance & Development*, vol. 53, No. 2, Washington, D.C., International Monetary Fund (IMF), June.

Rodrik, D. (2015), *Economics Rules: The Rights and Wrongs of the Dismal Science*, New York, W. W. Norton & Company.

Solow, R. (1956), "A contribution to the theory of economic growth", *The Quarterly Journal of Economics*, vol. 70, No. 1, Oxford University Press.

Sotelsek, D. and L. Laborda (2010), "Latin America: incorporating environmental factors into the measurement of production efficiency and technical change", *CEPAL Review*, No. 101 (LC/G.2455-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

Titelman, D. and E. Pérez Caldentey (2015), "Macroeconomics for development in Latin America and the Caribbean", *Neostructuralism and Heterodox Thinking in Latin America and the Caribbean in the Early Twenty-First Century*, A. Bárcena and A. Prado (eds.), ECLAC Books, No. 132 (LC/G.2633-P/Rev.1), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

Townley, B., A. Díaz and R. Luca (2017), "Recursos minerales por cobalto en Chile: potencial de exploración y explotación minera", Chilean Economic Development Agency/Non Metallic Mining Committee/National Geology and Mining Service [online] https://www.corfo.cl/sites/Satellite?blobcol=urldata&blobkey=id&blobtable=MungoBlobs&blobwhere=1475166619428&ssbinary=true.

Yanyan, Z. and others (2013), "Future Internet bandwidth trends: an investigation on current and disruptive technologies", *Technical Report*, No. TR-CSE-2013-04, New York, New York University [online] https://ssl.engineering.nyu.edu/papers/tr-cse-2013-04.pdf.