PSL Quarterly Review

vol. 77 n. 310 (September 2024)

Special issue on structural change, social inclusion, and environmental sustainability

The Solow residual, a distributional approach: The case of Chile, 1985-2019

FERNANDO VILLANUEVA MELO

Abstract:
The primary goal of this paper is to present a distributive proposal for reinterpreting Solow's residual and apply it within the Chilean context. We argue that Solow's residual can only indirectly capture technological phenomena. This critique draws upon the contribution of Felipe and McCombie (2020), who contend that production functions merely reflect an identity account. Hence, the so-called Total Factor Productivity (TFP) mirrors the dynamic of real wages and the rate of profit.
We adopt a descriptive approach to estimate and decompose the Solow residual growth for the Chilean economy, to discern the origins of distributional changes between 1985 and 2019. A key patterns is that throughout almost the entire period, the dynamic of the Solow residual is closely intertwined with fluctuations in the profit rate. Additionally, we decompose the profit rate to highlight that the decline in the Chilean economy's profit rate stems from both distributional and technological factors.

National Statistics Institute of Chile (INE),
email: fvillanuev@fen.uchile.cl

How to cite this article:
Villanueva Melo F. (2024), "The Solow residual, a distributional approach: The case of Chile, 1985-2019" *PSL Quarterly Review*, 77 (310), pp. 409-436.

DOI: https://doi.org/10.13133/2037-3643/18663

JEL codes:
D33, E01, E24, O47, O54

Keywords:
Solow residual, total factor productivity, functional income distribution, wages, productivity, rate of profit, Chile, growth accounting

Journal homepage:
http: //www.pslquarterlyreview.info

Mainstream approaches to economic growth postulate a binary viewpoint, wherein output growth can or cannot be attributed to the accumulation of factors of production. According to this tradition, and in line with Solow's (1957) seminal contribution, the long-run growth of capitalist economies relies on "unobservable" factors rather than on the accumulation of labor or capital (p. 316). These unobservable factors, empirically labeled as the "Solow residual", would reflect the evolution of Total Factor Productivity (TFP) or the contribution of technological progress to economic growth. Nonetheless, this argument hinges on a particular economic theory that claims that aggregate production can be represented by a function with specific properties.

We contend that both this approach and the mainstream prescriptions aimed at observing and enhancing productivity are misleading. TFP is merely a theoretical construct, and the so-called Solow residual primarily reflects distributional dynamics within the economy rather than technological change. Henceforth, we put forth an alternative proposal based on the work of Felipe and McCombie (2020). They argued that output, employment, and capital stock are already related through an account identity. Henceforth, empirical research based on production functions merely reflects this identity rather than actual production patterns. As Anwar Shaikh stressed: “this is a law of algebra, not a law of production” (Shaikh, 1974, p. 118). The implications of this argument are profound. Economic analysis and policy formulation rely on economy theory. If the underlying economic theory is flawed, it can lead to misleading analyses and, worse still, could result in adverse effects when applied to economic policy. This argument holds particular relevance in the current debate in Chile, as the country has experienced a lackluster macroeconomic performance since 1998. Moreover, there is a widespread agreement that productivity lies at the root of this issue, and conventional measures of it often rely on TFP.

In section 1, we will present the argument of Felipe and McCombie (2020), demonstrating that the production functions reflect an account identity and that the Solow residual is just an indicator of distributional dynamics. Additionally, we stress that this argument is not a novel, as it has been articulated by various thinkers since 1950. In section 2, we conduct a comparative analysis of various growth accounting exercises applied in the Chilean economy and discuss the implications of observing productivity through TFP and its role in informing economic analysis and policies. In section 3, we estimate the Solow residual for Chile during 1985-2019, aiming to uncover its underlying components. Notably, in the case of Chile, the evolution of the Solow residual mirrors the dynamics of the profit rate, particularly evident post-2000. In section 4 we delve into the analysis of the underlying forces driving the dynamics of the profit rate in Chile. In section 5, we undertake a brief productivity analysis of the Chilean economy, seeking to comprehend its relationship with the fall in the profit rate over the last decade, and in section 6 we draw conclusions based on our findings.

1. Growth accounting and income account identities

The neoclassical approach to economic growth is grounded on the assumption that the economy’s total production can be effectively represented by a production function with specific properties. Typically, the production function is structured as follows:

$$Y = f(A, K, L)$$

where Y represents the real level of output (GDP), A denotes the TFP level, K is the monetary value of the capital stock of the economy, and L stands for labor, which can be measured by the number of workers employed or the total hours worked. This approach argues that economic growth can only occur if, and only if, one or more of the components of the production function grows. Growth accounting exercises are essentially aimed at decomposing GDP growth into the contributions of these variables.

If we assume that: (1) the production function is differentiable with respect to every input (K and L), (2) there exist positive and diminishing marginal productivities of capital and labor, (3) there are constant returns to scale, and (4) the overall economy operates under perfect competition, we can decompose GDP growth using the following equation:

$$g_y = g_A + s_k \cdot g_K + (1 - s_k) g_L \tag{1}$$

where g_y represents the growth in real GDP, g_A denotes TFP growth, s_k represents the share of capital income in total income, g_K indicates the growth in capital stock, and g_L stands for the growth in labor inputs’. However, as g_A is empirically not observable, it is estimated as the difference between GDP growth and the weighted growth of capital and labor. Consequently, in growth accounting exercises, there is a component explained by the accumulation of capital and labor and a non-observable component g_A. Thus, g_A is practically estimated as a residual:

$$\widehat{g_A} = g_y - s_k \cdot g_K - (1 - s_k) g_L \tag{2}$$

According to this theory, the growth of the residual captures the expansion of TFP or the contribution of technological change to economic growth. Furthermore, empirical studies rooted in this economic framework argue that GDP growth is predominantly attributable to unexplained factors and conclude that it is due to improvements in the technology implemented in the production process that enhances long-term economic growth (Solow, 1957; Barro and Sala-i-Martin, 2004; Acemoglu, 2008). Economists have introduced refinements to this approach, correcting labor inputs by education, highlighting the role of human capital in economic growth, and correcting capital by intensity use. Nonetheless, the theoretical foundation remains unchanged.

However, using the approach of Felipe and McCombie (2020), we can derive the exact expression of equation (1) without relying on any theory of production or competition but based solely on accounting identities. Thus, this approach is theory-free in the sense that we rely just on the boundaries of production and income defined by the System of National Accounts (SNA).[1] Nonetheless, the primary distinction is that this expression reflects an income identity and not the contribution of each factor of production to achieve a specific output level.

In the current SNA, primary income is defined as the "income that accrues to institutional units as a consequence of their involvement in processes of production or ownership of assets that may be needed for purposes of production." (UNSC, 2008, p. 131) Consequently, the gross value generated in the production process is distributed to various economic agents. This is known as the functional distribution of income. As per the SNA, primary income encompasses wage-workers' labor income for their participation in the production process, property income, and net taxes on production and imports.

$$\begin{matrix} Primary \\ Income \end{matrix} \equiv \begin{matrix} Compensation \\ of\ employees \end{matrix} + \begin{matrix} Property \\ Income \end{matrix} + \begin{matrix} Net\ taxes\ on \\ production\ and\ imports \end{matrix} \tag{3}$$

This accounting principle is applicable to specific firms, industries, or the whole economy. Thus, this approach's conclusion can be used at every economic level. Subtracting net taxes on primary income yields the market value of GDP at factor cost ($\mathrm{GDP_{FC}}$). According to the SNA, GDP at factor cost is "essentially a measure of income and not output. It represents the amount remaining for distribution out of gross value added." (UNSC, 2008, p. 104) Thus, GDP at factor cost is divided between wages and property income, labeled as gross operating surplus (GOS) since it is the flow of all income other than compensation of employees.[2] Consequently, GDP at factor cost can be decomposed into overall labor income ($\sum_{i=1}^{n} w_i$) and GOS. The real value of these variables can be obtained by deflating them using the same price index, and, if we divide the overall wage bill and GOS by the total number of workers (L) and assets used in the production process (K),

---

[1] These boundaries are based on a series of assumptions and definitions aimed at delineating accountable relationships to observe and describe them. However, these assumptions do not explain economic relationships or behavior at the micro or macro level. In this regard, the SNA is considered "theory free".

[2] It is relevant to stress that we overestimate property income under this approach, since gross value added includes capital consumption (depreciation), mixed income, rents, direct taxes, interest, and dividend payments.

respectively, we will derive the average real wage (w) and the average rate of profit (r). Thus, the following expression is derived:

$$GDP_{FC} \equiv \sum_{i=1}^{n} w_i + GOS = wL + rK \quad (3.1)$$

Neoclassical theory refers to this identity as Euler's theorem, premised on the assumption that the aggregate production function exhibits constant returns to scale. However, the aforementioned account does not depend on any theory of production or competition; rather, it relies solely on the boundaries of income and production defined by the SNA.

By differentiating the previous expression with respect to time (the variables with the dot at the top stand for the first difference) and dividing it by the initial level of GDP, we derive the growth in real GDP at factor cost and its components:

$$g_y \equiv \frac{\dot{w}}{w}\left[\frac{Lw}{Y}\right] + \frac{\dot{L}}{L}\left[\frac{Lw}{Y}\right] + \frac{\dot{r}}{r}\left[\frac{Kr}{Y}\right] + \frac{\dot{K}}{K}\left[\frac{Kr}{Y}\right] \quad (4)$$

If we define the GOS share in GDP at factor cost as s_k, we obtain the following expression:

$$g_y \equiv g_w(1 - s_k) + g_r s_k + g_L(1 - s_k) + g_K s_k \quad (4.1)$$

where g_w represents the growth rate of real wages and g_r denotes the growth of the profit rate.

Therefore, following the SNA, we can decompose the growth of GDP at factor cost in the weighted growth of labor, productive assets, and a distributional component that captures the weighted growth of real wages and the rate of profit. This latter component is identified by mainstream economists as the increase in production that is not attributed to the accumulation of factors of production. We can observe that identity (4.1) is the same expression as equation (1). Hence, what economists typically label as TFP growth is essentially the weighted growth of wages and the rate of profit. Specifically:

$$g_A = g_w(1 - s_k) + g_r s_k = g_w + s_k(g_r - g_w) \quad (5)$$

Economists often refer to TFP as the "measure of our ignorance" (Abramovitz, 1956), since they label whatever is not captured in the accumulation of capital and labor as technological change (Solow, 1957, p. 312). Nevertheless, with a clearer understanding of the SNA, we recognize that this unobservable element of neoclassical theory can indeed offer insights into distribution and profitability dynamics (Shaikh, 2016, p. 658). Furthermore, empirical estimations of TFP consistently reveal its procyclical nature (Fuentes et al., 2006; Field, 2010; Schmöller and Spitzer, 2020). This forms the base for real business cycles theory, which seeks to explain economic fluctuations based on exogenous shocks in TFP. However, the procyclical nature of TFP can be attributed to the stronger (weaker) growth of both real wages and the profit rate during the upswing (downswing) phase of the business cycle. This is because real wage growth is partly determined by labor demand, which is linked to firms' expectations of sales/production, and the intensity of sales determines firms' profitability, influencing decisions to expand output and capital.

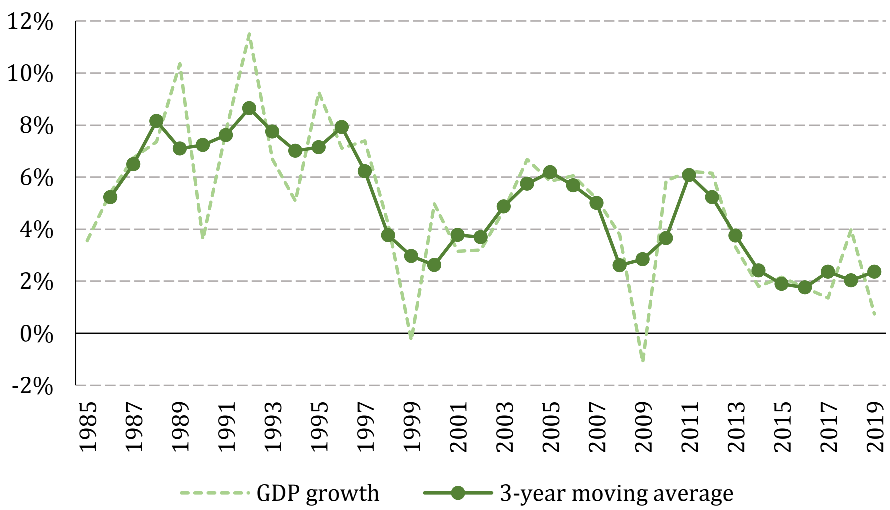
It is pertinent to emphasize that this critique is not a novelty. In 1957, the same year Solow published his seminal contribution, Brown critiqued Cobb and Douglas's work, arguing that production function estimations are predetermined by an accounting identity (Brown, 1957).

Decades later, the same argument was reiterated by Simon and Levy (1963) and Shaikh (1974). However, despite these critiques, neoclassical growth theory remained largely unaffected.

2. Growth accounting exercise in the Chilean economy

The assertion that production functions reflect an accounting identity implies that analysis utilizing this approach can never be rejected on an empirical or econometrical ground. Consequently, production functions seem to function well empirically, fitting data effectively. However, they do not provide any support for neoclassical theory since its results are predetermined (Brown, 1957; Shaikh, 2016, p. 659). Therefore, we will summarize growth accounting exercises conducted for the Chilean economy, bearing in mind that the TFP estimations reflect the distributional dynamics expressed in equation (5).

Figure 1 – *GDP growth rate in Chile, 1985-2019 (3-year moving average)*



Source: Own elaboration based on SNA data provided by the Central Bank of Chile (https://si3.bcentral.cl/Siete/ES/Siete/Cuadro/CAP_CCNN/MN_CCNN76/CCNN_HIST18_ENC/).

Since the end of the 1980s, the Chilean economy experienced a period of historically high GDP growth until 1998. This era, often referred to as the 'golden age' of the Chilean economy,[3] provided the backdrop for numerous growth accounting exercises aimed at understanding the economic boom from 1986 to 1998 and the subsequent decline in growth rates after the Asian crisis. Figure 1 illustrates the relatively high GDP growth rates achieved during the 1990s, juxtaposed with the inability of the Chilean economy to sustain these levels post-1998. Indeed, the graph also reveals a downward trajectory in GDP growth over the last few decades. The average GDP growth rate

[3] During those years, GDP growth in Chile was among the fourth highest in the world (Gallegos and Loayza, 2002).

stood at 7% during 1990-1998; it declined to 4.4% during 1999-2007 and further decreased to 3% during 2008-2019.

The growth accounting exercises conducted to analyze the ‘golden age’ primarily concentrated on offering insights into the dynamics of TFP growth and its role in achieving high GDP growth rates. Before the world financial crisis, there was a complacent viewpoint in which several economists argued that this period was the product of the institutional framework set by the economic reforms of the dictatorship rather than of the current economic policies implemented by democratic governments. However, these explanations became more complex afterward, as the same institutional framework exhibited a trend toward economic stagnation. We argue that insights aimed at describing and explaining productivity growth and technological change based solely on TFP are misleading, as the Solow residual primarily reflects the dynamics of the rate of profit and wages rather than providing a complete picture of technological progress.

Before the world financial crisis, growth accounting exercises aimed at explaining the sources of the exceptional GDP growth during the 1990s. These exercises primarily originated from the academic sphere, with estimations made irregularly over time and for specific periods (CNP, 2016, p. 20). Most of the methodologies did not correct for human capital and capital utilization. We have selected in Table 1 some growth accounting exercises conducted by prominent Chilean macroeconomists who hold significance in both the academic and the economic policy realms. The purpose of selecting these exercises is to highlight their arguments and to gain insight into the narrative construction of the Chilean economy’s performance.

Table 1 – *First generation of growth accounting exercises*

Author	**Study period**	**Adjustment in K and/or L**	α **or** s_K	**Sub-periods**	**TFP growth**	**GDP growth**
De Gregorio (1997)	1975-1997	No	40%	1985-1989	2.0%	6.6%
				1990-1997	2.6%	6.7%
Beyer and Vergara (2002)	1976-2001	No	40%	1986-1990	2.3%	6.8%
				1991-1995	3.7%	8.7%
				1996-2000	0.1%	4.1%
				1998-2001	–0.6%	2.4%
De Gregorio (2004)	1970-2004	No	40%	1985-1989	1.8%	6.4%
				1990-1999	2.0%	6.3%
				2000-2004	0.8%	3.7%
Vergara (2005)	1960-2004	No	55%	1986-1990	2.1%	6.7%
				1991-1995	4.9%	8.7%
				1996-2000	0.9%	4.2%
				2001-2004	1.0%	3.8%
Fuentes, Larraín and Schmidt-Hebbel (2006)	1960-2005	No	40%	1990-1997	3.9%	7.1%
				1998-2005	1.0%	3.1%

According to De Gregorio (1997), the high growth at the end of the 1980s was primarily attributed to the employment recovery that followed the debt crisis of 1982, during which the unemployment rate exceeded 20% of the labor force. In contrast, in the 1990s, the growth was led by a capital accumulation and TFP growth. In this paper, De Gregorio explores the underlying determinants of growth. He highlights the primordial role of increased coverage in secondary education, the reduction in inflation, and the contraction in government expenditure as factors that fostered economic growth (De Gregorio, 1997, p. 32).

In a more recent analysis, De Gregorio (2004) highlights the decline in GDP and TFP growth following the 1998 Asian crisis and delves into the areas he considers crucial for explaining economic growth in Chile during the 'golden age'. Among these factors are low inflation, sound fiscal policy (including low fiscal deficits and public debt), a strong financial sector, and openness to trade. In a broader exploration of the fundamental causes of economic growth, he concludes that certain property rights and an appropriate structure of rewards are the main determinants for encouraging economic growth (De Gregorio, 2004, p. 47). This perspective aligns with the prevailing view in mainstream macroeconomics and international financial institutions during the 1990s, which emphasized that macroeconomic fundamentals, such as low inflation and fiscal balances, were the most relevant variables for enhancing economic development. Despite several Latin American economies achieving these targets during the 1990s, their macroeconomic performance has been disappointing (Ffrench-Davis, 2005).

Beyer and Vergara (2002) argue that the growth of the golden age resulted from the reforms that "transformed Chile from a very closed and overregulated economy to an open and competitive one" (p. 328). The argument goes further: "If the Country is able to maintain and improve these policies and institutions, it will ensure an additional period of high growth" (p. 337). Paradoxically, they also highlight the slowdown in economic growth and the negative contribution of TFP to growth after 1998. The authors argue that the country needed a "new shock" to initiate a new period of high economic growth. These shocks involved extending previous reforms, such as the extensive privatization of the health system, increasing the labor market's flexibility, and reducing social program coverage (pp. 317-319). A similar argument can be found in Vergara (2005), which claims that the golden age is explained by the delayed fruits of the reform of the dictatorship. Furthermore, this author also stresses that TFP in Chile is volatile and highly procyclical, with a correlation index of 0.91 between GDP and TFP growth (Vergara, 2005).

Fuentes et al. (2006) also highlight the significant drop in the contribution of TFP growth after 1999. These authors emphasize the pro-cyclical nature of TFP in the Chilean economy and attempt to explain its evolutions through a regression analysis. They use as independent variables the terms of trade, the real exchange rate undervaluation index, the civil liberty and macroeconomic instability index, and variables that try to capture structural reforms. The authors conclude that cyclical factors, particularly the terms of trade, dominate over structural factors to explain the growth of TFP in recent years in Chile. Using the SNA approach, it becomes evident that the terms of trade would account for the variation of the Solow residual. This linkage arises from the evolution of the price of copper, which constitutes the primary component of Chilean exports. Consequently, fluctuations in copper prices impact the profit rate of the mining sector, thereby affecting aggregate profitability and the Solow residual. Furthermore, the terms of trade play a crucial role in relaxing the external constraint, allowing a minor recessionary gap (the ratio between effective and potential GDP), which also enhances profitability.

There is a second group of growth accounting exercises elaborated after the world financial crisis by public institutions such as DIPRES (budget office of the government), CORFO (Chilean economic development agency), and the CNP (national commission of productivity). These represent a stage in which economic growth never recovered its 1990s levels and exhibited a continued trend of economic stagnation, especially after 2014. These second-generation growth accounting exercises are conducted regularly over time. Furthermore, the involvement of public institutions in these exercises indicates a recognition that addressing the productivity slowdown post-1998 has become a priority in economic policy. TFP serves as a crucial metric for assessing productivity in this regard. For instance, DIPRES annually gathers a team of macroeconomists to estimate potential GDP, estimating several TFPs, to inform the government's fiscal policy decisions. DIPRES's long-term growth accounting exercise spanning 1960 to 2019 underscores the volatile and procyclical nature of TFP.

Additionally, according to these institutions that performed systematically growth accounting ecersies, Chile's average TFP growth has been negative (-0.8%) since the world financial crisis (2009-2019).

Table 2 – *Second generation of growth accounting exercises*

Author	Study period	Adjustment in K and/or L	α or s_K	Sub-periods	TFP growth	GDP growth
UAI and CORFO (2014)	1993-2014	K and L	53%	1993-1998	2.4%	6.5%
				2000-2008	0.8%	4.7%
				2010-2014	0.4%	4.6%
CNP (2018)	1990-2018	No	48%	1991-1998	3.2%	7.2%
				1999-2008	0.8%	4.0%
				2009-2018	–0.02%	3.0%
DIPRES (2020)	1960-2019	K and L	48%	1990-1998	2.2%	6.8%
				1999-2008	0.7%	4.3%
				2009-2019	–0.8%	2.9%
CLAPES UC (2020)	1970-2018	No	48.5%	1990-1998	2.8%	n.a.
				1999-2008	0.8%	n.a.
				2009-2018	–0.6%	n.a.

Since 2012, CORFO, in collaboration with Universidad Adolfo Ibañez (UAI), has conducted growth accounting exercises based on a Cobb-Douglas production function. These exercises include corrections for human capital and capital utilization. They have identified the onset of stagnation in the Chilean economy in 2014 and a decline in TFP growth following the golden age. A key distinction from previous approaches is their estimation of TFP growth for different economic sectors. They emphasize the heterogeneity among economic sectors and pinpoint the systematic fall in the wage of the manufacturing and retail sectors, even though they attributed this to a fall in the labor force quality (UAI and CORFO, 2014). Furthermore, they point out that TFP growth for the Chilean economy appears higher when excluding the mining and electricity, water, and gas supply sectors.

In 2015, the National Productivity Commission (CNP) was established as a research center tasked with providing recommendations to enhance national productivity. Since 2016, the CNP has conducted an annual estimation of TFP for the overall economy and by economic sector. Its methodology involves assuming a Cobb-Douglas production function corrected by capital utilization and quality of hours worked. The CNP has emphasized that the decline in TFP growth after 2000 may be attributed to the exhaustion of the boost of the dictatorship reforms, as well as the structure of Chilean exports, which are heavily concentrated in natural resources (CNP, 2016, p. 40). Furthermore, it has underscored that productivity stagnation cuts across all economic sectors and cannot be attributed solely to a decrease in the grade of copper ore. Table 2 illustrates a consistent pattern observed by all entities, depicting a decline in GDP growth following the golden age and negative TFP growth since the world financial crisis.

The assumption that the Solow residual reflects technological change allows for the creation of ad hoc arguments to explain its dynamics, as it is essentially viewed as a "measure of our ignorance". However, the insights provided to explain the golden age in Chile, based on macroeconomic fundamentals, seem unsatisfactory, since the same framework would create periods of output expansion and stagnation. However, when utilizing the SNA, it becomes evident that the Solow residual offers valuable insights into the economy, particularly regarding the evolution of the rate of profit. This is crucial for understanding long-term economic growth as it reflects the profitability of investment and production, serving as a fundamental variable in macroeconomic analysis.

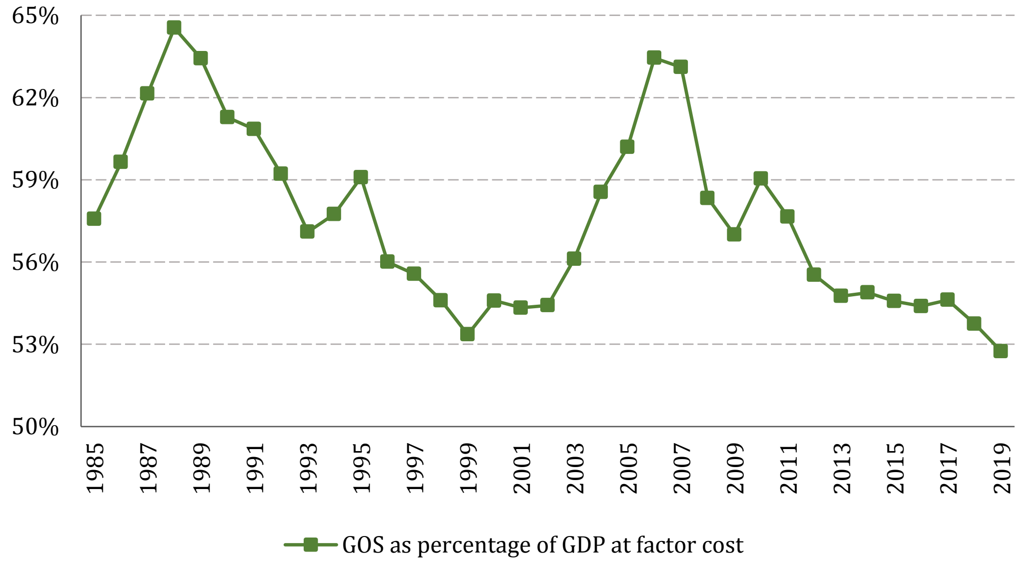
3. Estimation strategy and results

We aim to estimate the growth rate of the Solow residual for the 1985-2019 period. Our primary objective is to utilize this estimation to deconstruct its distributional components and gain insights into the economic stagnation experienced by the Chilean economy over the past decade. It's crucial to note that while the Solow residual indirectly captures technological factors, such as labor productivity and capital per worker, we must not overlook its distributional components. To accomplish this, we must first obtain the functional income distribution in Chile, calculate the Solow residual, analyze its components and empirically validate that the account identity holds true.

Utilizing the data of the SNA provided by the Central Bank of Chile we can calculate the share of GOS in GDP at factor cost. It is important to note that while this measure of income distribution provides valuable insights, it is not a perfect indicator of the actual income distribution within the economy. This is because both GDP at factor cost and GOS includes capital consumption (depreciation) incurred during the production process.

Additionally, it's worth mentioning that there is not a compiled database of income components of GDP spanning the entire period from 1985-2019. The longest database covers the period 1985-1998. We will use the growth rate of aggregate income's component from posteriors databases to estimate the levels of nominal GOS, wage bill, net indirect taxes, and GDP from the original database (1985-1998). While this method deviates from the accounting identity expressed in equation 3, the discrepancy observed is minimal, typically not exceeding 1% of GDP at factor cost (see table A1 in the appendix). Consequently, the impact on the participation of GOS in GDP at factor cost is marginal. The results of this method are presented in Figure 2.

Figure 2 – *Gross operating surplus (GOS) as percentage of GDP at factor cost, 1985-2019*



Source: Own elaboration based on SNA data provided by the Central Bank of Chile (https://si3.bcentral.cl/estadisticas/Principal1/enlaces/Informes/AnuariosCCNN/CCNN-anuarios.html).

Throughout the past 35 years in Chile, we can spot fluctuations in the participation of GOS, with an overall mean value of 58%. This indicates that a significant portion, nearly 60%, of the economy's gross value added has taken the form of gross surplus. Notably, the composition of GOS in Chile has been influenced by copper rents, particularly following the commodity boom of 2003. This stands in contrast to traditional growth accounting practices in Chile, which often assume a fixed labor income share of either 52% or 60%. Our approach to estimating the Solow residual diverges from these traditional assumptions by considering the actual functional income distribution. Consequently, we anticipate a more variable residual.

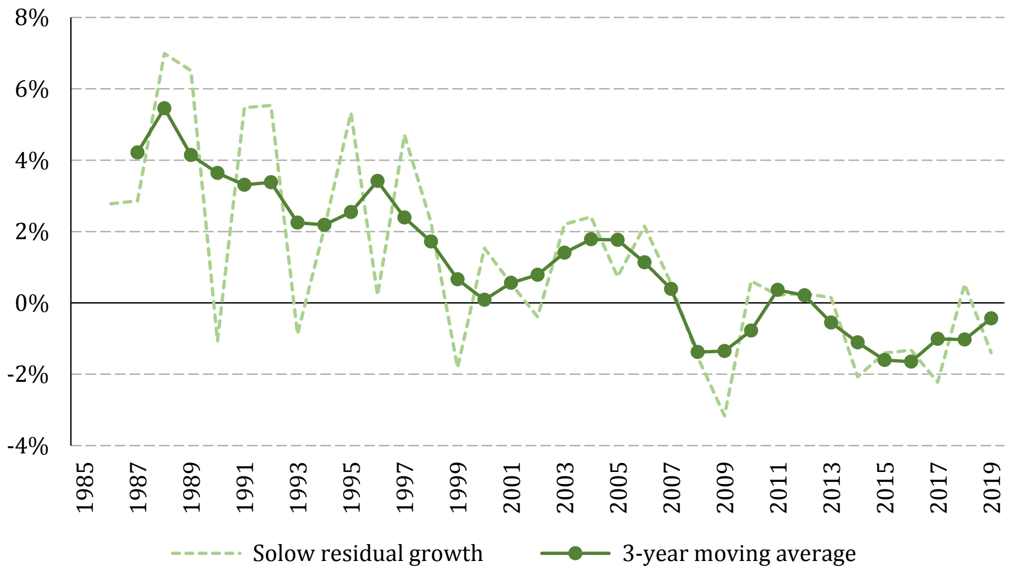
Examining functional income distribution in Chile since 1985 reveals four distinct patterns. Initially, there was a notable surge in the relevance of operating surplus in value added, peaking at its historical maximum of 65% in 1988. The second period, coinciding with the prosperous 1990s, witnessed a significant decline in surplus participation. This period is particularly noteworthy, as it corresponds to both robust economic growth and peak growth in the Solow residual. The juxtaposition of declining GOS participation in domestic product and positive growth in the Solow residual raises theoretical questions, suggesting specific conditions that are necessary for such a scenario.

In 1999, the participation of operating surplus reached its lowest value and remained stagnant until 2003. The third period saw a resurgence in surplus participation, attributed primarily to favorable terms of trade, notably the substantial increase in copper prices, which bolstered the mining sector's surplus. The final period marked a decline in GOS participation since the global financial crisis, reaching historical lows. Indeed, by 2019, GOS participation had dwindled to just 53%.

Utilizing our series of functional income distribution, we estimate the growth in the Solow residual based on equation (2) and employing the growth rates of the following variables: GDP at factor cost, gross capital stock, and total employment. Notably, we utilize the gross capital stock instead of the net capital stock, aligning with standard growth accounting practices, as our aim is to capture an accounting identity that encompasses depreciation (see equation 3). Furthermore, GDP is deflated to 2013 prices, while the gross capital stock is measured in constant 2013 prices. Additionally, we measure employment as total employment, as there is a negligible difference when using total hours worked. The results of this exercise are depicted in figure 3 and the details can be found in table A2 in the appendix.

The evolution of the Solow residual exhibits significant volatility and procyclicality. Remarkably, the coefficient of correlation between the growth of the Solow residual and GDP growth stands at 0.96. This procyclical dynamic can primarily be attributed to the nature of the growth rates of wages and the profit rate, which expands and contracts in accordance with the phase of the business cycle. Furthermore, we observe a declining trend in the growth of the Solow residual over the entire period. Following the global crisis, its growth turned negative, plummeting from an average of 2.3% per year during 1986-2007 to –0.9 during 2008-2019. These estimations align with previous empirical findings (see section 2). Moreover, the high volatility in the growth of the residual during the 1990s can be associated with fluctuations in GDP, particularly in years such as 1990, 1993, and 1996, when the reported GDP growth rate at factor cost deviated notably from the average of 6.9% achieved between 1985 and 1998.

Figure 3 – *Solow residual growth in Chile, 1986-2019*



Source: Own elaboration based on SNA data provided by the Central Bank of Chile and DIPRES (https://www.dipres.gob.cl/598/articles-202679_doc_xls.xlsx).

To stablish the connection between functional income distribution and the dynamic of the Solow residual, a theoretical clarification is necessary. As per equation (5), the growth of the Solow residual mirrors the weighted growth of wages and the profit rate, determined by the shares of labor and capital income. Thus:

$$g_A = s_L \cdot g_w + s_k \cdot g_r = g_w + s_k(g_r - g_w)$$

The first derivative, under the assumption that the growth of the profit rate and of real wages is independent of the functional income distribution,[4] is:

$$\frac{\partial g_A}{\partial s_k} = g_r - g_w$$

As a result, changes in functional income distribution would directly influence the growth of the Solow residual, contingent upon the disparity between the growth rates of the profit rate and real wages. Consequently, various combinations of distributional dynamics and residual growth can be attained, as depicted in table 3.

Table 3 – *Different cases of Solow residual growth and distributive dynamics*

	$\frac{\partial g_A}{\partial s_k} > 0$	$\frac{\partial g_A}{\partial s_k} < 0$
Increasing s_k	$g_r > g_w$	$\lvert g_r \rvert < \lvert g_w \rvert$
Decreasing s_k	$g_r < g_w$	$\lvert g_r \rvert > \lvert g_w \rvert$

Based on our estimations of the dynamic of the functional income distribution and the growth in the Solow residual in Chile, we can theoretically argue that four distinct distributional periods occurred within the analysis period:

- From 1985-1989, it is likely that the growth in the profit rate exceeded the growth of real wages. This phenomenon could be attributed to the impact of increased capacity utilization on profitability after the 1982 crisis, coupled with the increase in the price level, which was a consequence of the macroeconomic policies implemented to address the crisis (Matus and Reyes, 2021). As a consequence, the average growth of real wages, deflated by the GDP deflator, between 1986-1989 was a mere 0.1% per year.
- During the period from 1990 to 1998, it is probable that the growth in real wages surpassed the growth of the profit rate. This period characterized the golden age of growth in Chile, marked by positive growth in the Solow residual and a declining participation of the gross operating surplus in product. According to Matus and Reyes, this era was shaped by the convergence of two favorable macroeconomic trends: a substantial increase in GDP, which

[4] This assumption is made for algebraic simplification and clarity. It is evident that changes in functional income distribution affect both the growth of wages and the rate of profit, but the conclusions remain unaffected by it. Indeed, if we apply the full derivative, it is easy to obtain that: $\frac{\partial g_A}{\partial s_k} = 2(g_r - g_w)$.

elevated labor demand relative to labor supply, resulting in historically low unemployment rates of 7%, and a continual reduction in inflation.

- Between 2004 and 2007, it is likely that the growth in the profit rate outpaced the growth of real wages. This trend could be attributed to the beneficial impact of favorable terms of trade, particularly the significant increase in copper prices, on the average profit rate.
- Following the global financial crisis, we observed a decrease in both the Solow residual and GOS participation. Consequently, it is anticipated that, during the stagnation period, the profit rate experienced a more pronounced decline, in absolute terms, than the decline in real wages Given the stagnation of the GDP post-financial crisis, particularly after 2014, a fall in the profit rate is expected.

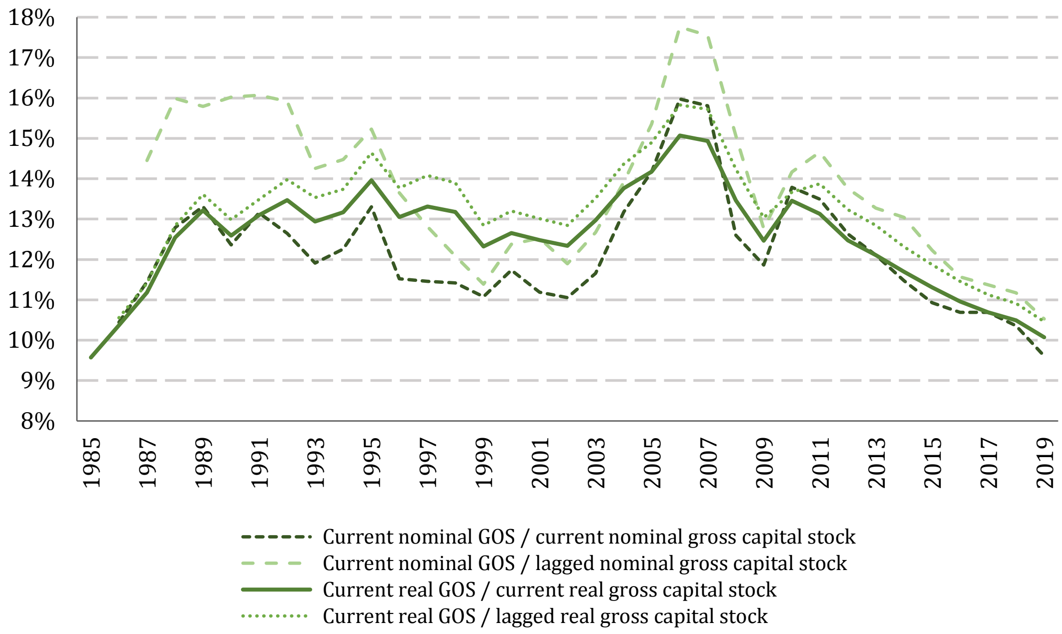
Under this framework, the golden age represented a historical anomaly in Chile's modern growth trajectory. It stands as the sole period during which real wages grew faster than the profit rate, aligning with a period of high economic growth. Conversely, in all other periods, regardless of whether the Solow residual exhibited positive or negative growth, the profit rate consistently grew more rapidly, in absolute value, than real wages. Consequently, it can be inferred that the dynamic of the Solow residual was predominantly driven by the behavior of the profit rate post golden age.

Having computed the Solow residual, the next step is to further decompose it into its components, as expressed in equation (5), to unveil its distributional components. To accomplish this, we must estimate the rate of profit in Chile over the analysis period. This involves dividing the GOS for a particular year by the stock of gross capital of the current and the previous year for comparative purposes. The utilization of lagged capital stock aims to capture the notion that the capital stock at the beginning of a year "earned" the profit income for that year (Basu and Vasudevan, 2013).

In figure 4, we present four estimations of the profit rate, all of which exhibit relatively similar levels and dynamics. It is important to note that these indicators represent the broader measure of profitability, as the GOS encompasses various types of income, including depreciation of the capital stock, taxes on capital income, copper rents, mixed income, interest, and dividend payments. In essence, it is crucial to understand and analyze the gross profit rate as the ceiling of profitability. A more nuanced analysis would delve into the composition of the surplus and the dynamic of its components to distinguish between net and gross profit rates.

The average rate of profit for the Chilean economy stood at 13% during the period spanning 1985-2019. The dynamic of the rate of profit can be delineated into five discernible trends: (1) a sharp increase from the mid-1980s until the early 1990s, (2) a relatively stable profit rate until approximately 1995-96, (3) a decline and stagnation of profitability between the Asian crisis and the commodity boom, (4) a significant surge in the rate of profit since 2003, peaking before the global financial crisis, and (5) a downward trajectory in the Chilean rate of profit since 2010-2011. Furthermore, it is evident that the profit rate is procyclical, albeit to a lesser extent than the growth of the Solow residual. Notably, the variable exhibiting a high degree of procyclicality is the growth in the profit rate, with a correlation index of 0.76 with GDP growth.

Figure 4 – *Rate of profit in Chile, 1985-2019 (ratio of GOS and gross capital stock)*



Source: Own elaboration based on SNA data provided by the Central Bank of Chile (https://si3.bcentral.cl/estadisticas/Principal1/enlaces/Informes/AnuariosCCNN/CCNN-anuarios.html https://si3.bcentral.cl/Siete/ES/Siete/Cuadro/CAP_IND_SEC/MN_IND_SEC20/CCNN2013_S1_P1_DUPLICADO/CCN N2013_S1_P1_DUPLICADO).

The analysis of the dynamic of the profit rate holds significant importance for growth analysis and economic policy, as several schools of economic thought argue that the rate of profit establishes the upper limit for sustainable accumulation and, thus, economic growth. This perspective is upheld by classical political economy, Marxian economics, and certain branches of post-Keynesian theory (Pasinetti, 1962). Indeed, one approach involves examining the ratio of actual economic growth to the "normal" profit rate to discern the "growth utilization rate". This indicator provides insights into the extent to which the growth potential of the economy is being realized (Shaikh, 2016, p. 659). Consequently, analyzing economic growth through the lens of the evolution of the profit rate and the gap between potential and effective growth offers valuable insights for policymaking and economic analysis.

After computing the rate of profit for the entire economy, we obtain the predicted growth of real wages. From equation (5), it is easy to observe that the predicted growth of real wages is:

$$g_w = \frac{g_A - s_k g_r}{1 - s_k} \tag{5.1}$$

We will utilize the growth rate of the rate of profit, measured as the ratio of real GOS and the real stock of capital. With the growth rate of real wages and the rate of profit, we can then decompose the growth of the Solow residual in Chile to describe and identify which type of income leads the dynamic of this variable. Table 4 presents the growth of the rate of profit, predicted real wages using equation (5.1), and the weighted growth by the functional income distribution. To delineate the overall 1985-2019, period, we will follow the full economic cycles of the Chilean economy, as outlined by Ffrench-Davis (2018). It is important to stress that the predicted real wage represents the real product wage, which is the nominal wage deflated by the GDP deflator, not by the consumer price index (CPI).

Table 4 – *Distributional decomposition of the Solow residual in Chile (the mean of each variable under specific periods)*

Period	g_r	g_w *(predicted)*	$s_k \cdot g_r$	$(1 - s_k) \cdot g_w$ *(predicted)*	g_A
1986-1989	8.43%	–1.17%	5.28%	–0.49%	4.79%
1990-1998	0.05%	6.12%	0.05%	2.58%	2.63%
1999-2007	1.49%	–0.25%	0.93%	–0.05%	0.88%
2008-2013	–3.28%	2.88%	–1.85%	1.27%	–0.57%
2014-2019	–3.01%	0.67%	–1.63%	0.31%	–1.32%

Source: Own elaboration based on SNA data provided by the Central Bank of Chile (https://si3.bcentral.cl/estadisticas/Principal1/enlaces/Informes/AnuariosCCNN/CCNN-anuarios.html).

Table 4 reveals that either real wages or the profit rate's dynamic leads the growth of the Solow residual in Chile over the analyzed period. Additionally, there exists a negative relationship between the growth rate of the profit rate and of real wages in the economy. During periods of rapid profit rate growth, wages tend to decline, and vice versa. The correlation index between both variables is –0.53.

One of the most notable patterns is the strong correlation between the growth of the Solow residual in Chile and the growth of the profit rate. Indeed, the correlation index between these two variables is 0.78, whereas the correlation index of the growth of the Solow residual and of real wages is just 0.11. Consequently, in Chile the dynamic of the Solow residual mirrors the dynamic of the rate of profit. Furthermore, the growth rate of the profit rate, in absolute terms, exceeded that of wages in every period except during the golden age, as argued previously.

The analysis underscores the exceptional nature of the golden age in Chilean economic growth, where real wage growth played a leading role in shaping the dynamic of the Solow residual. Unlike other periods, where the profit rate predominantly influenced its trajectory, during the golden age, wage growth outpaced average labor productivity growth, leading to a decline in the share of GOS and an increase in the labor income share.[5] This change in functional income distribution and a stable profit rate relies on continuous increases in capital productivity.

Following the world financial crisis, the stagnation and subsequent decline of the Solow residual can be attributed to the decrease in the rate of profit. This trend was further exacerbated by a stagnation in real wages post-2014. Overall, this analysis sheds light on the intricate interplay

[5] Based on equation (3.1), we know that $GDP_{FC} \equiv \sum_{i=1}^{n} w_i + GOS = wL + rK$. Therefore, the labor income share is: $1 - s_K = wL/GDP_{FC} = w/AP_L$, the ratio of real wages and real average labor productivity (AP_L). Hence, the dynamic of the labor income share depends on the growth discrepancy of these two variables.

between wage dynamics, profit rates, and productivity growth in shaping the trajectory of the Solow residual in Chilean economic growth.

Furthermore, we can validate the account identity by comparing the predicted value of wage growth with the actual evolution of real wages. To compute the effective growth rate in real wages, we subtract inflation, measured as the annual change in the GDP deflator (2013 prices), from the growth in the general index of nominal remunerations from the National Statistics Institute of Chile. Figure 5 illustrates that, while the predicted and the effective growth in wages are not identical, they exhibit remarkably similar levels and dynamic. Specifically, the predicted growth rate of real wages for the 1985-2019 period stands at 2% per year, whereas the effective growth rate of wages is slightly higher, at 2.1%. This finding bolsters the argument that the Solow residual functions not only as a productivity measure but also as an indicator of how income is distributed among factors of production.

Figure 5 – *Predicted and actual growth of real wages in Chile, 1985-2019*

Source: Own elaboration based on data provided by the Central Bank of Chile (https://si3.bcentral.cl/estadisticas/Principal1/enlaces/Informes/AnuariosCCNN/CCNN-anuarios.html https://si3.bcentral.cl/Siete/ES/Siete/Cuadro/CAP_EMP_REM_DEM/MN_EMP_REM_DEM13/REM_HIST/REM_HIST).

4. Analysis of the Chilean rate of profit

Having established that the Solow residual's trajectory is largely dictated by the profit rate's growth over the analyzed period, we can proceed to investigate the factors underlying the decline of the profit rate in Chile. This entails examining the pivotal drivers of profitability, which are income distribution and technology, encapsulated within the average productivity of capital. To facilitate a thorough analysis, we propose decomposing the profit rate as follows:

$$\begin{matrix} rate\ of \\ profit \end{matrix} = \left[\frac{Gross\ Operating\ Surplus}{GDP\ at\ factor\ cost}\right] \cdot \left[\frac{GDP\ at\ factor\ cost}{Gross\ capital\ Stock}\right] = s_k \cdot AP_K \tag{6}$$

Equation 6 reveals two fundamental factors driving the profit rate's dynamics. Firstly, there is a distributional aspect, reflected in the share of GOS in GDP at factor cost. Secondly, there is a technological component, represented by the inverse of the capital-output ratio or the average productivity of capital. Consequently, all else being equal, an uptick in the capital income share will bolster the profit rate, thus amplifying the growth of the Solow residual. Similarly, an enhancement in average capital productivity could elevate the profit rate, consequently fueling the growth of the residual. We posit that the extraordinary performance during the golden age was underpinned by a surge in capital productivity. This surge sustained the profit rate despite a substantial increase in real wages, which would typically depress profitability.

While it's possible to further decompose the rate of profit to account for the influence of capacity utilization on profitability (Weisskopf, 1979; Bhaduri and Marglin, 1990), we opt not to pursue this avenue in our analysis. This decisions stems from the necessity of estimating full or normal capacity GDP, which is inherently challenging due to its non-observability. It is essential to recognize that fluctuations in aggregate demand can indeed impact both the capital income share and capital productivity (Basu and Vasudevan, 2013).

The dynamic nature of the rate of profit reflects not only distributional elements but also the interplay between aggregate supply and demand dynamics. However, it's important to note that our study does not directly focus on the relationship between functional income distribution and capacity utilization, nor does it aim to determine whether the latter is wage- or profit-led[6] (Bhaduri and Marglin, 1990; Lavoie and Stockhammer, 2013). Given the timeframe of our research, we assume that capacity utilization hovers around normal levels, and we can afford to overlook realization conditions (Shaikh, 2016).

Figure 6 illustrates a notable increase in GOS share and capital productivity from 1985 to 1989. Consequently, the upsurge in the profit rate during that period can be attributed to enhancements in both distributional and technological factors. During the golden age, we observe a decline in the surplus's share in GDP, which is counteracted by the positive trajectory of capital productivity. Thus, the sustained profit rate during the golden age is a result of the offsetting effects of the distributional component and technological factors. However, it's crucial to acknowledge that this trend is not solely driven by supply-side or technological factors but is also influenced by demand-side components. The substantial reduction in the recessionary gap between effective and potential GDP during this period underscores the importance of demand dynamics in shaping the observed trends, since it is captured in capital productivity[7] (Ffrench-Davis, 2018).

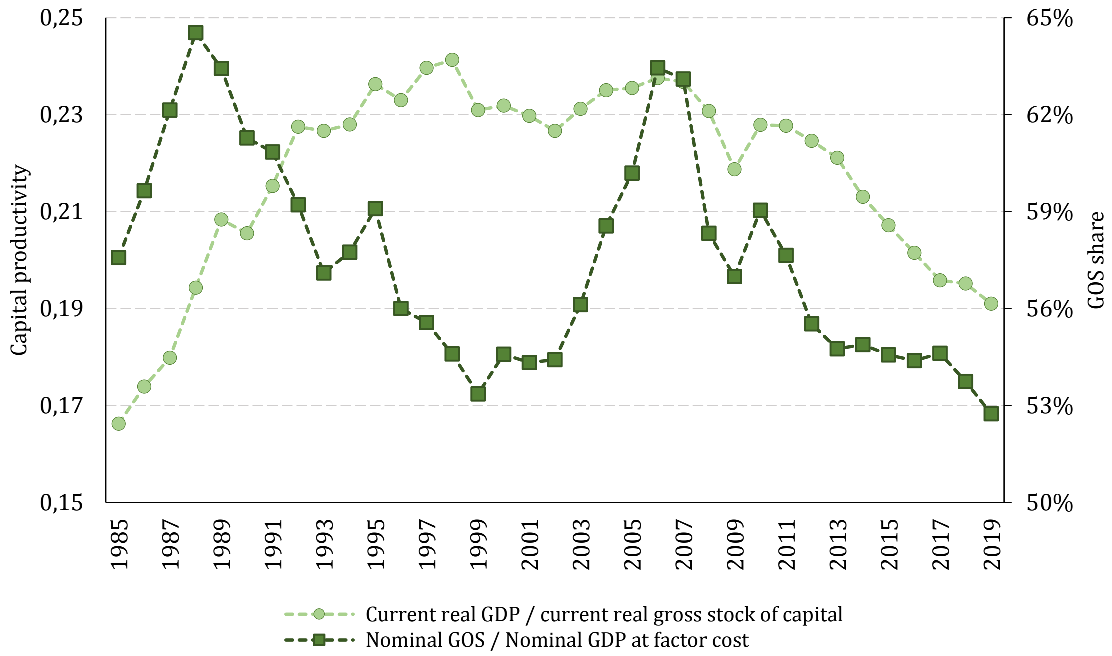
[6] To consult an empirical study of the nature of aggregate demand in Chile, see https://repositorio.uchile.cl/handle/2250/175669?show=full

[7] We can express average capital productivity as:

$$AP_K = \left[\frac{GDP\ at\ factor\ cost}{Gross\ capital\ Stock}\right] = \left[\frac{GDP_{fc}}{Normal\ or\ full\ capacity\ GDP_{fc}}\right]\left[\frac{GNormal\ or\ full\ capacity\ GDP_{fc}}{Gross\ capital\ Stock}\right]$$

Therefore, an increase in capacity utilization, measured as the ratio of effective to normal/full capacity GDP, would foster capital productivity.

Figure 6 – *GOS share and average capital productivity in Chile, 1985-2019*



Source: Own elaboration based on SNA data provided by the Central Bank of Chile (https://si3.bcentral.cl/estadisticas/Principal1/enlaces/Informes/AnuariosCCNN/CCNN-anuarios.html).

In 1998, the Chilean economy reached its pinnacle in terms of capital productivity. Subsequently, both variables stagnated and, following the global financial crisis, there was a decline in capital productivity levels, reverting to pre-1990 levels. This trend serves as a critical indicator, suggesting that macroeconomic policies aimed at mitigating recessionary gaps through aggregate demand management and industrial policies aimed at enhancing capital productivity have failed to sustain a stable profit rate.

From 1999 to 2007, there was a notable convergence of positive growth in both the distributional and the supply components of the profit rate. Specifically, the share of capital income (GOS) in GDP at factor cost reached 63%, marking its second-highest peak after 1988. This trend can be attributed to a significant surge in the price of copper, resulting in substantial growth in the surplus generated by the mining sector. Furthermore, this period witnessed a contraction in the recessionary gap due to the external positive shock.

Following the global financial crisis, the decline in the profit rate in the Chilean economy was driven by reductions in both distributive and technological variables until 2019. This macroeconomic phenomenon is noteworthy, as a simultaneous decline in both variables is typically observed only during specific years of economic crisis, such as 1998-1999 and 2008-2009.

The recent trend poses a significant challenge for both the Chilean economy and economic analysis. While the economy may experience shifts that exacerbate income inequality against workers, the profit rate could simultaneously experience an upsurge. Mainstream economists might interpret this as an increase in the Solow residual attributed to technological advancements. This was evident in the aftermath of the COVID-19 crisis, where the CNP reported positive growth in the Solow residual during 2020 and 2021 (CNP, 2022, p. 17), linking it to the widespread adoption of information technology for remote working.[8]

However, this apparent boost in the profit rate, which could bolster the Solow residual, may be sustainable only if capacity utilization returns to normal levels and income distribution continues to favor surplus owners. Furthermore, this sustainability hinges on reversing the downward trajectory in capital productivity, which is currently being overshadowed by increasing inequality in functional income distribution. Indeed, according to the Central Bank of Chile, the GOS participation of GDP at factor cost evolved from 54% in 2019 to 56% in 2020, to reach 58% of GDP at factor cost in 2021. Hence, we are observing a strident deterioration of functional income distribution rather than technological improvements when we observe the evolution of the Solow residual after 2020.

The current social and political transformations in Chile make it increasingly improbable to sustain long-term economic growth based on an outdated productive system and escalating inequality. The sluggish growth in labor productivity since 2014 constrains the potential for real wage growth that does not alter functional income distribution.[9] This paints a bleak picture for workers in Chile, especially considering the inflationary pressures post-2020, leading to a decline in real wages. Furthermore, tighter monetary policies aimed at combating inflation could exacerbate the recessionary gap and unemployment.

In such a scenario, capital owners and their political allies are likely to resist any social or economic policies aimed at altering functional income distribution to avoid a further decline in the profit rate. However, there exists a socio-political threshold beyond which the economy's income distribution cannot become more regressive (Minsky, 2013, p. 28). This poses a constraint on the potential boost in the profit rate and presents a significant challenge for medium-term economic growth in Chile.

For instance, to achieve a profit rate of 12% within five years, given the current trends in labor and capital productivity, it would be necessary an increase the surplus share to almost 70% of GDP at factor cost. Achieving such a surplus share would entail an average annual reduction in real wages of approximately 5%, or a cumulative loss of 30% in purchasing power over the entire period, all else being equal. This underscores the magnitude of the challenge and the socioeconomic implications of pursuing such a path.

5. Productivity trends in Chile

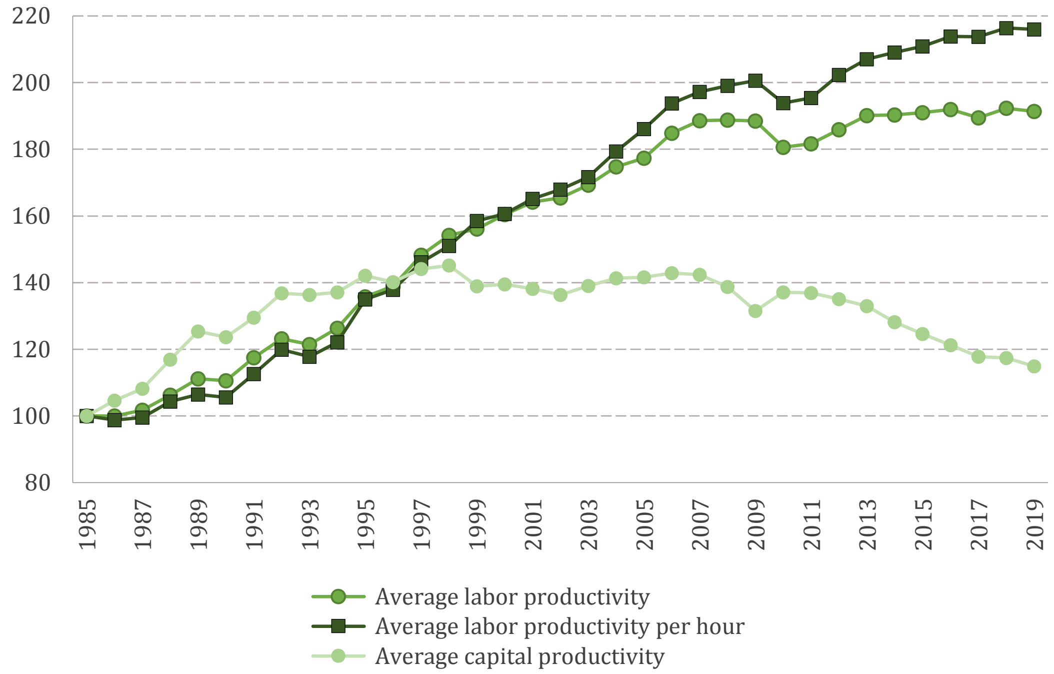
Given our contention that TFP may not accurately reflect technological change in the economy, we provide three widely recognized indicators of productivity for the entire period. These include output per worker and output per hour worked, both of which are related to labor productivity, along with the evolution of capital productivity, which was previously examined. Furthermore, we aim to dissect the evolution of capital productivity to gain insights into the underlying drivers behind its declining trend over the past decade. This comprehensive analysis will offer a nuanced

[8] Nonetheless, they stress that cyclical components influence these growth rates, and, indeed, the massive economic policies to address the socio-economic effects of the pandemic led to movements in the recessionary gap, which also fostered the rate of profit.

[9] The dynamic of the labor income share depends on the evolution of real wages relative to labor productivity, as we have stressed previously.

understanding of the productivity dynamics in the Chilean economy and shed light on the factors shaping its trajectory.

Figure 7 – *Evolution of productivity indicators in Chile, 1985-2019 (100=1985)*



Source: Own elaboration based on data provided by the Central Bank of Chile and DIPRES (https://si3.bcentral.cl/Siete/ES/Siete/Cuadro/CAP_IND_SEC/MN_IND_SEC20/CCNN2013_S1_P1_DUPLICADO/CCNN2013_S1_P1_DUPLICADO
https://www.dipres.gob.cl/598/articles-202678_doc_pdf.pdf)

To comprehend the decline in the profit rate, it's crucial to examine how the trajectory of technological change in Chile has influenced the adoption of different factor-saving technologies. Figure 7 illustrates the evolution of the index of output per worker, output per hour worked, and average capital productivity.

We observe that technological advancements have predominantly been labor-saving until the onset of the world financial crisis, as evidenced by the steady increase in labor productivity using both output per worker and output per hour worked indicators throughout the entire period. However, a closer inspection reveals a stagnation in labor productivity, particularly when measured by output per worker, since 2007. While the stagnation trend is subtler when productivity is measured by output per hour worked, it still indicates a slowdown in productivity growth. As for capital productivity, its evolution has been detailed in the preceding section. Notably, there was an increase in capital productivity until 1998, followed by a period of stagnation until the world financial crisis, and a subsequent downward trend from 2010-2011.

This analysis provides valuable insights into the shifting landscape of technological change in Chile and its implications for factor productivity, thereby contributing to a better understanding of the factors driving the decline in the profit rate.

Decomposing capital productivity into the ratio of output per worker and capital per worker allows us to unravel its dynamics. The growth in capital productivity can be attributed to the difference between the growth rate in output per worker and the growth rate in capital per worker. Increases (or decreases) in labor productivity correspond to higher (or lower) capital productivity, all else being equal. However, a higher (or lower) capital intensity, as measured by capital per worker, will depress (or boost) capital productivity, all else being equal, as illustrated in equation (6.1). Indeed, a high growth rate of labor productivity can positively influence the rate of profit through this channel, assuming it is not counteracted by alterations in the ratio of capital per worker.

$$\begin{matrix} rate\ of \\ profit \end{matrix} = \left[\frac{Gross\ Operating\ Surplus}{GDP\ at\ factor\ cost}\right] \cdot \left[\frac{GDP\ at\ factor\ cost}{Employment}\right] \cdot \left[\frac{Employment}{Gross\ capital\ Stock}\right] = s_k \cdot \frac{AP_L}{k} \qquad (6.1)$$

Figure 8 illustrates the average growth rates of output per worker, capital per worker, and capital productivity in Chile since 1986. This visualization helps elucidate the factors driving the evolution of capital productivity over the specified period.

Figure 8 – *Growth decomposition of capital productivity in Chile, 1985-2019* (average annual growth rate)*

* For the 1999-2010 period; the year 2009 was omitted.
Source: Own elaboration based on data provided by the Central Bank of Chile and DIPRES (https://si3.bcentral.cl/Siete/ES/Siete/Cuadro/CAP_IND_SEC/MN_IND_SEC20/CCNN2013_S1_P1_DUPLICADO/CCNN2013_S1_P1_DUPLICADO https://www.dipres.gob.cl/598/articles-202678_doc_pdf.pdf).

For the period spanning 1985 to 1998, both capital and labor productivity experienced positive growth. Specifically, capital productivity increased at an average rate of 3% per year, while labor productivity grew at a slightly higher rate of 3.4% annually. This growth was facilitated by a modest increase in capital intensity, averaging just 0.5% per year. Consequently, the technological advancements during this period were characterized by both labor- and capital-saving innovations, without significant increases in capital per worker. This dynamic was highly conducive to profitability and supported a more equitable functional income distribution.

In contrast, the period from 1999 to 2010 witnessed a stagnation in capital productivity. This stagnation can be attributed to the offsetting effects of increased labor productivity and capital intensity. There was a notable decline in labor productivity, by almost 2 percentage points compared to the previous period, coupled with a substantial increase in capital intensity by nearly 1.5 percentage points. Consequently, the technological advancements during this period leaned towards labor-saving technologies and significant increases in the capital-to-labor ratio in the economy.

Finally, in the most recent period, spanning 2011 to 2019, capital productivity experienced a decline of 2% per year. This decline can be attributed to a halving of the growth rate in output per worker and an increase in the economy's capital intensity. Thus, the technological changes implemented during this period were characterized by a deepening of capital intensity in the production process and a weakening of labor-saving technologies, resulting in a reduced increase in labor productivity.

According to Palma (2019), the slowdown in labor productivity in Chile can be attributed to the lack of dynamism in both the export sector, primarily reliant on extractive activities, and the non-tradable sector, which is dominated by labor-intensive and low-productivity activities. This interpretation aligns with the analysis put forth by the CNP, which suggests that Chile's natural-resource export strategy has reached its limits.

However, it's noteworthy that the extractive nature of the Chilean economy played a role in boosting labor productivity during the golden age. For instance, the agricultural sector experienced a significant increase in labor productivity from the mid-1980s onwards (Palma, 2019). This was the counterpart of the robust growth rates in export goods and non-copper exports, averaging 8.8% and 13%, respectively, during 1986-1989, and 9.6% and 9.8%, respectively, during 1990-1998 (Ffrench-Davis, 2018). Following the global financial crisis, however, export growth in Chile stagnated. Consequently, the lack of economic diversification, coupled with the reluctance of the capitalist class and government to revitalize existing economic sectors or to transition to sectors with greater potential for productivity growth, are key factors contributing to the stagnation of labor productivity in Chile.

Indeed, the dynamics of labor productivity also have distributional implications, as they establish the upper limit on which real wages can increase without altering functional income distribution. By considering that the share of capital income (GOS) in output is complementary to the share of labor income, and that this variable represents the difference between the average real wage and the average labor productivity of the economy, we can express the profit rate as follows:

$$\begin{matrix} rate\ of \\ profit \end{matrix} = s_k \cdot \frac{AP_L}{k} = [1 - s_L] \cdot \frac{AP_L}{k} = \left[1 - \frac{w}{AP_L}\right] \cdot \frac{AP_L}{k} = \frac{1}{k}[AP_L - w] \tag{6.1}$$

Indeed, the profit rate can experience a boost as long as labor productivity increases, as this would raise the share of capital income (GOS) in total income, assuming capital productivity remains constant. Consequently, the dynamics of labor productivity have both distributional and supply-side impacts.

Conversely, two factors depress the rate of profit: the evolution of real wages and the ratio of capital per worker. The increasing capital intensity of the production process, and the stagnation in the growth of real wages relative to labor productivity, are key elements to track the dynamic of the decline in the profit rate in the Chilean economy over the last decade.

6. Conclusion

This paper adopts the argument put forth by Felipe and McCombie (2020), asserting that the neoclassical production function reflects an aggregate identity account. Building upon this framework, we analyze the evolution of the Chilean economy over the past 35 years. We contend that what is conventionally labeled as Total Factor Productivity (TFP) in neoclassical theory, or the Solow residual, actually reflects the weighted growth of the profit rate and real wages.

We agree with the mainstream consensus in asserting that the stagnation of productivity is a pivotal factor in explaining Chile's lackluster economic performance, notably since 2014. However, we contest the reliability of TFP as an indicator of productivity. Relying on TFP to gauge technological change across the entire economy may yield misleading analyses and unsuitable policy recommendations.

The Solow residual is not merely a "measurement of our ignorance"; it holds valuable insights into relevant macroeconomic variables. Our estimation of the growth of the Solow residual for the Chilean economy spanning 1985-2019 revealed its strong pro-cyclical nature, mirroring the pro-cyclicality of wages and profitability growth. Additionally, we observed a downward trend in the growth of the Solow residual over this period. However, we argue that this trend is not directly attributable to productivity shocks but rather to a decline in the aggregate rate of profit.

Our analysis emphasizes that the dynamic of the profit rate is the primary driver of the Solow residual's evolution throughout the entire period, with the exception of the golden age of economic growth in Chile. During this last period, real wage growth emerged as the leading variable, marking the golden age as a historical exception in modern Chilean economic growth.

We conducted a comprehensive description and decomposition of the rate of profit into its distributional and technological components, revealing that the stable rate of profit during the golden age was achieved through a combination of higher labor income participation in GDP and increased capital productivity. However, since 1999, the Chilean economy has grappled with stagnant capital productivity, which further declined to pre-1990 levels following the world financial crisis.

Furthermore, we underscored that the confluence of distributional dynamics, stagnant labor productivity, and an escalating ratio of capital per worker elucidates the downward trajectory of the Chilean rate of profit. This configuration presents a pessimistic outlook for workers and medium-term economic growth prospects in Chile, as restoring profitability based solely on distributional components would necessitate continual cuts in real wages.

Consequently, the most viable path to revitalizing profitability hinges on enhancing its technological components, requiring sustained and targeted efforts in industrial policy over the medium term. Lastly, we argue at the economic policy level that the traditional use of TFP as an indicator of productivity is flawed and can lead to misguided economic analyses and policy recommendations. Instead, we advocate for macroeconomic theories grounded in and respectful of aggregate accounting identities.

Appendix

A1. GDP income components

Given the unavailability of a historical series for GDP income components beyond 1998 and the incomparability of subsequent databases, we will derive the GDP income components for the period 1998-2019 using growth rates from seven databases covering different time frames: 1996-2004, 2003-2008, 2008-2011, 2011-2014, 2014-2016, 2016-2018, and 2018-2020.

We prioritize utilizing growth rates to depict the movement of the Solow residual rather than its absolute level. To ensure the preservation of the accounting identity, where the sum of income components equals overall GDP, we will estimate Gross Operating Surplus (GOS) as the difference between estimated GDP and the estimated sum of net taxes and the wage bill. Our analysis confirms minimal discrepancies between this derived GOS series and the GOS estimated directly through the growth rates of posterior databases. Furthermore, the impact of this approach on functional income distribution is negligible.

Notably, as capital consumption data is no longer published in the System of National Accounts (SNA) of the Central Bank of Chile and is not essential for our research purposes, it will not be reported or imputed.

Table A1 – *Estimation of GDP income components (levels in nominal millions of Chilean pesos)*

Year	Levels			Growth rates			Estimated	Database
	GDP	Net taxes	Wage bill	GDP	Net taxes	Wage bill	GOS	Database
1985	2,651,937	423,959	945,224				1,282,754	1985-1998
1986	3,419,209	538,369	1,162,533				1,718,307	1985-1998
1987	4,540,556	712,408	1,449,286				2,378,862	1985-1998
1988	5,917,879	765,187	1,827,207				3,325,485	1985-1998
1989	7,353,729	879,525	2,367,731				4,106,473	1985-1998
1990	9,245,504	1,179,611	3,123,435				4,942,458	1985-1998
1991	12,100,475	1,540,221	4,135,233				6,425,021	1985-1998
1992	15,185,438	2,053,179	5,356,002				7,776,257	1985-1998
1993	17,974,917	2,631,131	6,582,086				8,761,700	1985-1998
1994	21,395,185	2,955,061	7,791,601				10,648,523	1985-1998
1995	25,875,727	3,488,234	9,159,037				13,228,456	1985-1998
1996	28,268,364	4,025,258	10,666,243				13,576,863	1985-1998
1997	31,567,287	4,398,918	12,072,662				15,095,707	1985-1998
1998	33,630,367	4,469,612	13,239,136				15,921,619	1985-1998

From this period, the levels of GDP, net taxes, and the wage bill are estimated from the growth rates.

1999	34,186,045	4,426,274	13,880,758	1.7%	−1.0%	4.8%	15,879,013	1996-2004
2000	37,349,599	4,850,351	14,758,884	9.3%	9.6%	6.3%	17,740,364	1996-2004
2001	40,075,600	5,207,336	15,924,476	7.3%	7.4%	7.9%	18,943,788	1996-2004
2002	42,657,673	5,634,728	16,874,673	6.4%	8.2%	6.0%	20,148,272	1996-2004
2003	46,903,540	5,753,070	18,057,437	10.0%	2.1%	7.0%	23,093,033	1996-2004
2004	53,456,189	6,374,220	19,513,332	14.0%	10.8%	8.1%	27,568,637	2003-2008
2005	60,689,692	7,322,041	21,243,389	13.5%	14.9%	8.9%	32,124,262	2003-2008
2006	71,360,152	7,949,535	23,179,590	17.6%	8.6%	9.1%	40,231,027	2003-2008
2007	78,712,675	8,659,716	25,846,498	10.3%	8.9%	11.5%	44,206,461	2003-2008
2008	81,789,412	9,590,113	30,083,092	3.9%	10.7%	16.4%	42,116,206	2003-2008
2009	84,051,703	9,179,920	32,198,248	2.8%	−4.3%	7.0%	42,673,535	2008-2011
2010	96,744,484	10,411,494	35,363,704	15.1%	13.4%	9.8%	50,969,286	2008-2011
2011	105,882,102	11,865,635	39,816,518	9.4%	14.0%	12.6%	54,199,948	2008-2011
2012	112,609,372	13,111,458	44,252,357	6.4%	10.5%	11.1%	55,245,558	2011-2014
2013	119,767,724	13,811,819	47,934,996	6.4%	5.3%	8.3%	58,020,910	2011-2014
2014	128,790,725	14,894,294	51,384,311	7.5%	7.8%	7.2%	62,512,120	2011-2014
2015	138,307,222	16,241,363	55,451,712	7.4%	9.0%	7.9%	66,614,147	2014-2016
2016	146,676,400	16,988,199	59,153,381	6.1%	4.6%	6.7%	70,534,821	2014-2016
2017	155,517,456	18,141,116	62,344,275	6.0%	6.8%	5.4%	75,032,065	2016-2018
2018	165,475,432	19,655,232	67,446,840	6.4%	8.3%	8.2%	78,373,360	2016-2018
2019	171,049,369	19,972,150	71,397,070	3.4%	1.6%	5.9%	79,680,150	2018-2020

A2. Estimation of the Solow residual and the profit rate

Based on the previous estimation, we obtain the growth in the Solow residual using the following variables:

- The GDP deflator base 2013 (p_Y) from the Central Bank of Chile is used to deflate nominal variables.
- Total employment (L), measured in thousands of people, is found in the historical databases used by the Budget Office (DIPRES) of Chile to project potential GDP.
- The aggregate gross capital stock measured in constant prices of 2013 (K), measured in billions of pesos, is obtained from the series estimated by the Central Bank of Chile. This series is constructed by the Central bank using the perpetual inventory method (PIM) and linear functions of depreciation. For further information, check the methodological document of the Central Bank of Chile (Henríquez, 2008).

In table A2, we report the surplus share (s_k), GDP at factor cost (Y), computed as total GDP minus net taxes, the real gross operating surplus computed using the GDP deflator at 2013 prices, and the profit rate, which is the ratio of the real gross operating surplus to the gross capital stock of the economy at constant prices of 2013.

Table A2 – *Estimation of the Solow residual and the profit rate (GDP and GOS in millions of pesos of 2013 and capital stock in billions of pesos of 2013)*

Year	s_k	p_Y	Y	L	K	g_Y	$(1-s_k)g_L$	$s_k g_K$	g_A	Real GOS	Profit rate
1985	57.6%	9	24,610,620	3,551	148,027					14,169,516	9.6%
1986	59.6%	11	26,200,873	3,781	150,674	6.5%	2.6%	1.1%	2.8%	15,627,783	10.4%
1987	62.1%	14	27,665,440	3,925	153,793	5.6%	1.4%	1.3%	2.9%	17,191,672	11.2%
1988	64.5%	17	30,593,464	4,154	157,429	10.6%	2.1%	1.5%	7.0%	19,744,651	12.5%
1989	63.4%	19	33,791,418	4,385	162,155	10.5%	2.0%	1.9%	6.5%	21,433,298	13.2%
1990	61.3%	23	34,374,743	4,484	167,256	1.7%	0.9%	1.9%	–1.1%	21,063,473	12.6%
1991	60.8%	28	37,074,469	4,552	172,180	7.9%	0.6%	1.8%	5.5%	22,556,677	13.1%
1992	59.2%	32	40,633,149	4,759	178,617	9.6%	1.9%	2.2%	5.5%	24,060,888	13.5%
1993	57.1%	36	42,327,095	5,030	186,752	4.2%	2.4%	2.6%	–0.9%	24,169,869	12.9%
1994	57.7%	41	44,440,701	5,074	194,915	5.0%	0.4%	2.5%	2.1%	25,662,942	13.2%
1995	59.1%	46	48,310,811	5,134	204,461	8.7%	0.5%	2.9%	5.3%	28,546,182	14.0%
1996	56.0%	48	50,264,432	5,221	215,725	4.0%	0.7%	3.1%	0.2%	28,149,582	13.0%
1997	55.6%	50	54,656,154	5,321	228,070	8.7%	0.9%	3.2%	4.7%	30,368,893	13.3%
1998	54.6%	50	58,059,063	5,434	240,624	6.2%	1.0%	3.0%	2.3%	31,699,943	13.2%
1999	53.4%	51	57,931,195	5,355	250,870	-0.2%	–0.7%	2.3%	–1.8%	30,910,526	12.3%
2000	54.6%	54	60,672,122	5,455	261,665	4.7%	0.8%	2.3%	1.5%	33,119,090	12.7%
2001	54.3%	56	62,674,967	5,509	272,773	3.3%	0.5%	2.3%	0.5%	34,051,059	12.5%
2002	54.4%	58	64,364,663	5,612	283,966	2.7%	0.9%	2.2%	–0.4%	35,027,919	12.3%
2003	56.1%	60	68,408,088	5,832	295,881	6.3%	1.7%	2.4%	2.2%	38,389,604	13.0%
2004	58.6%	65	72,572,018	5,991	308,768	6.1%	1.1%	2.6%	2.4%	42,494,221	13.8%
2005	60.2%	70	76,420,052	6,217	324,513	5.3%	1.5%	3.1%	0.7%	46,000,484	14.2%
2006	63.4%	78	80,955,186	6,319	340,825	5.9%	0.6%	3.2%	2.1%	51,362,223	15.1%
2007	63.1%	83	84,903,195	6,497	358,645	4.9%	1.0%	3.3%	0.5%	53,577,606	14.9%
2008	58.3%	82	87,551,315	6,692	379,446	3.1%	1.3%	3.4%	–1.5%	51,071,538	13.5%
2009	57.0%	86	86,753,871	6,642	396,588	-0.9%	–0.3%	2.6%	–3.2%	49,445,788	12.5%
2010	59.0%	94	91,806,035	7,335	402,856	5.8%	4.3%	0.9%	0.6%	54,200,464	13.5%
2011	57.6%	97	96,958,378	7,699	425,843	5.6%	2.1%	3.3%	0.2%	55,895,943	13.1%
2012	55.5%	98	101,464,635	7,873	451,759	4.6%	1.0%	3.4%	0.3%	56,337,566	12.5%
2013	54.8%	100	105,955,906	8,039	479,217	4.4%	1.0%	3.3%	0.1%	58,020,910	12.1%
2014	54.9%	106	107,544,479	8,154	504,763	1.5%	0.6%	2.9%	–2.1%	59,025,848	11.7%
2015	54.6%	111	109,818,404	8,295	530,016	2.1%	0.8%	2.7%	–1.4%	59,930,429	11.3%
2016	54.4%	116	111,683,786	8,394	554,168	1.7%	0.5%	2.5%	–1.3%	60,742,579	11.0%
2017	54.6%	122	112,905,130	8,598	576,636	1.1%	1.1%	2.2%	–2.2%	61,666,405	10.7%
2018	53.7%	125	117,081,067	8,785	599,874	3.7%	1.0%	2.2%	0.5%	62,927,061	10.5%
2019	52.7%	127	118,981,997	8,972	622,831	1.6%	1.0%	2.0%	–1.4%	62,752,700	10.1%

References

Abramovitz M. (1956), "Resource and output trends in the United States since 1870", in *Resource and output trends in the United States since 1870* (pp. 1-23). Cambridge (MA): National Bureau of Economic Research.
Acemoglu D. (2008), *Introduction to modern economic growth*, Princeton University Press.
Barro R. and Sala-i-Martin X. (2004), *Economic growth*, second edition, Cambridge (MA): The MIT Press.
Basu D. and Vasudevan R. (2013), "Technology, distribution and the rate of profit in the US economy: understanding the current crisis", *Cambridge Journal of Economics*, 37(1), pp. 57-89.
Beyer H. and Vergara R. (2002), "Productivity and economic growth: the case of Chile", in Loayza N. and Soto R. (eds), *Economic Growth: Sources, Trends and Cycles*. Santiago (Chile): Central Bank.
Bhaduri A. and Marglin S. (1990), "Unemployment and the real wage: the economic basis for contesting political ideologies", *Cambridge Journal of Economics*, 14(4), pp. 375-393.
Brown E.P. (1957), "The meaning of the fitted Cobb-Douglas function", *The Quarterly Journal of Economics*, 71(4), pp. 546-560.
CLAPES UC (2020), *Informe Cuarto trimestre de 2019 y anual 2019: Índice de Productividad Clapes UC*, Centro Latinoamericano de Políticas Económicas y Sociales (CLAPES).
CNP – Comisión Nacional de Productividad (2016), *La productividad en Chile: Una mirada de largo plazo. Informe Anual 2016*, Comisión Nacional de Productividad.
CNP – Comisión Nacional de Productividad (2018), *Informe anual 2018*, Comisión Nacional de Productividad.
CNP – Comisión Nacional de Productividad (2022), *Informe anual 2021*. Comisión Nacional de Productividad.
De Gregorio J. (1997), "Crecimiento potencial en Chile: una síntesis", in Morandé F. and Vergara. (eds), *Análisis Empírico del Crecimiento en Chile* (pp. 39-66), Santiago (Chile): CEP/ILADES.
De Gregorio J. (2004), "Economic growth in Chile: evidence, sources and prospects", *Documentos de Trabajo (Banco Central de Chile)*, no. 298, Santiago (Chile): Banco Central de Chile.
DIPRES. (2020). Resultados comité PIB tendencial: Acta Comité Consultivo PIB tendencial 2020. https://www.dipres.gob.cl/598/articles-202678_doc_pdf.pdf
Felipe J. and McCombie J. (2020), "The illusions of calculating total factor productivity and testing growth models: from Cobb-Douglas to Solow and Romer", *Journal of Post Keynesian Economics*, 43(3), pp. 470-513.
Ffrench-Davis, R. (2005). Reformas para América Latina después del fundamentalismo neoliberal. CEPAL.
Ffrench-Davis R. (2018), *Reformas económicas en Chile 1973-2017*, Santiago (Chile): Taurus.
Field A.J. (2010), "The Procyclical Behavior of Total Factor Productivity in the United States, 1890-2004", *Journal of Economic History*, 70(2), pp. 326–350.
Fuentes R., Larraín M. and Schmidt-Hebbel K. (2006), "Sources of Growth and Behavior of TFP in Chile", *Cuadernos de economía*, 43(127), pp. 113-142. Available online.
Gallego F. and Loayza N. (2002), "La época dorada del crecimiento en Chile: explicaciones y proyecciones", *Revista Economía Chilena*, 5(1), pp. 37-67.
Henríquez, C. (2008). Stock de capital en Chile (1985-2005): metodología y resultados (No. 63). Central Bank of Chile.
Lavoie M. and Stockhammer E. (2013), "Wage-led growth: Concept, theories and policies", in *Wage-led growth: An equitable strategy for economic recovery* (pp. 13-39), London: Palgrave Macmillan UK.
Matus and Reyes. (2021), "Precios y Salarios en Chile, 1886-2009", in Llorca-Jaña M. and Miller R. (2021), *Historia económica de Chile desde la Independencia* (pp. 677-723), Santiago (Chile): RIL Editores.
Minsky H.P. (2013), *Ending poverty: Jobs, not welfare*, Annandale-on-Hudson (NY): Levy Economics Institute.
Palma J.G. (2019), "The Chilean economy since the return to democracy in 1990. On how to get an emerging economy growing, and then sink slowly into the quicksand of a 'middle-income trap'", *Cambridge Working Papers in Economics*, no. CWPE1991, Cambridge: University of Cambridge.
Pasinetti L.L. (1962), "Rate of profit and income distribution in relation to the rate of economic growth", *The Review of Economic Studies*, 29(4), pp. 267-279.
Schmöller M. and Spitzer M. (2020), "Endogenous TFP, business cycle persistence and the productivity slowdown in the euro area", ECB Working Paper, no. 2401, Frankfurt: European Central Bank.
Shaikh A. (1974), "Laws of production and laws of algebra: the humbug production function", *The Review of Economics and Statistics*, 56 (1), pp. 115-120.
Shaikh A. (2016), *Capitalism: Competition, conflict, crises*, Oxford University Press.
Simon H.A and Levy F.K. (1963), "A note on the Cobb-Douglas function", *The Review of Economic Studies*, 30(2), pp. 93-94.
Solow R.M. (1957), "Technical change and the aggregate production function", *The Review of Economics and Statistics*, 39 (3), pp. 312-320.

UAI and CORFO (2014), “Evolución de la Productividad Total de Factores (PTF) en Chile”, *Boletín*, no. 8, Santiago (Chile): Universidad Adolfo Ibáñez/Corporación de Fomento de la producción.

UNSC – United Nations Statistical Commission (2009), *System of national Accounts 2008*, New York: European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations and World Bank. Available online.

Vergara R. (2005), “Productividad en Chile: determinantes y desempeño”, *Estudios públicos*, 99, p. 23-66. Available online.

Weisskopf T.E. (1979), “Marxian crisis theory and the rate of profit in the postwar US economy”, *Cambridge Journal of Economics*, 3(4), pp. 341-378.