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ON THE DETERMINANTS OF CHILEAN ECONOMIC GROWTH

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On The Determinants Of Chilean Economic Growth

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Preface

This paper is part of the project “Explaining Economic Growth Performance” launched by the Global Development Network (GDN). The purpose of this project is to explain economic growth performances across seven regions - East Asia, South Asia, Latin America, Eastern Europe, Former Soviet Union, Middle East and North Africa, and Sub-Saharan Africa. Project support was provided by the GDN. Eduardo Fernández-Arias coordinated the preparation of the country papers for the Latin American region on behalf of the Latin American and Caribbean Economic Association (LACEA)

Introduction

Since the mid-1980s, Chile's economic performance has been nothing short of impressive compared to the other economies of Latin America and most countries in the world. Yet this was not always so.

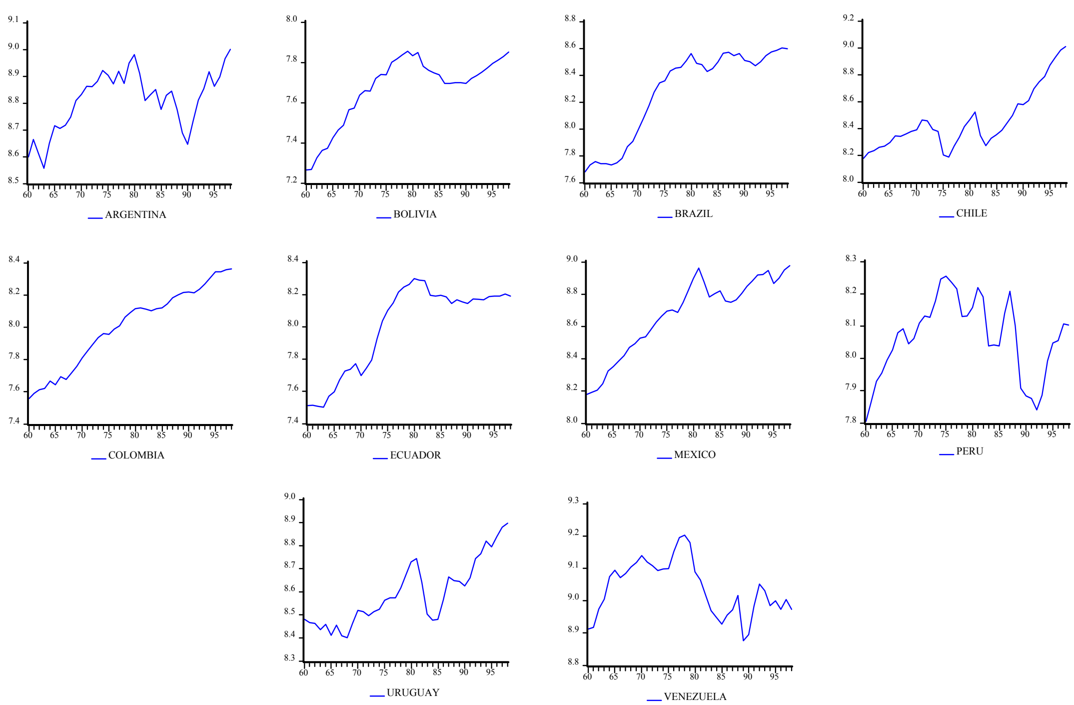
In the 1960s and 1970s Chile's performance was far from outstanding (Table 1). In fact its per capita GDP growth was far below the average of East Asia, the OECD countries, and the global economy. When compared with other Latin American countries, the Chilean economy was about average in the 1960s, below average in the 1970s, and only pulled clearly ahead in the next two decades. That positive difference in performance is even larger if we consider the period 1984–98 (Figure 1).[1]

Table 1. Average Annual Per Capita GDP Growth (1960–95)

	1960–70	1970-80	1980–90	1990–95	1960–95
Chile	2.3	0.8	1.1	5.4	1.9
Latin America (21)	2.3	2.3	–1.5	1.4	1.1
Sub-Saharan Africa (17)	2.1	1.1	–0.8	–1.9	0.5
East Asia	4.7	6.0	4.6	4.1	5.0
OECD (22)	4.3	2.5	2.1	1.1	2.7
World (81)	3.2	2.6	0.6	1.1	2.0

Source: De Gregorio and Lee (1999)

Figure 1. Evolution of (Log) Per Capita GDP in 10 Latin American Countries



[1] Figure 9.1 is obtained from the latest Penn World Table (for details see Summers and Heston, 1991).

Figures 2 and 3 show that, depending on the period, Chile experienced differences that were statistically significant compared to other Latin American countries, not only in average per capita GDP growth, but also in its volatility. The informal evidence depicted in these figures shows that the Chilean experience is “influential” in the sense that without it valuable information about the region’s economic performance would be omitted.

Figure 2: Deviations from Latin American Average Growth

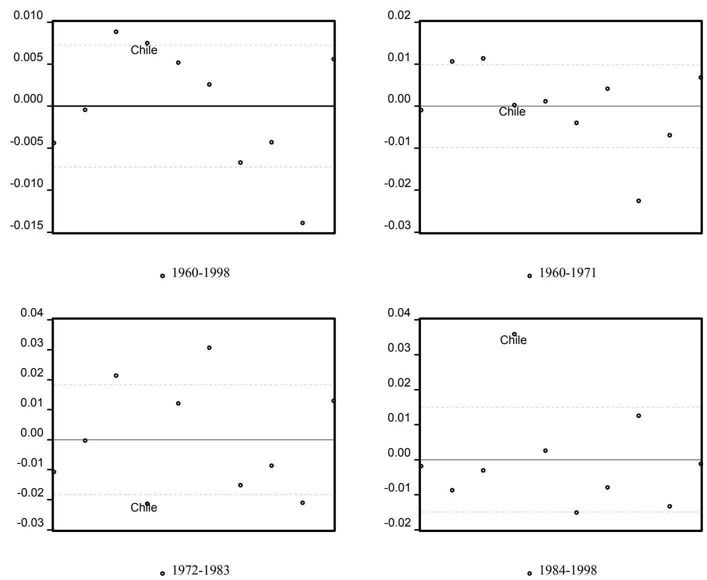
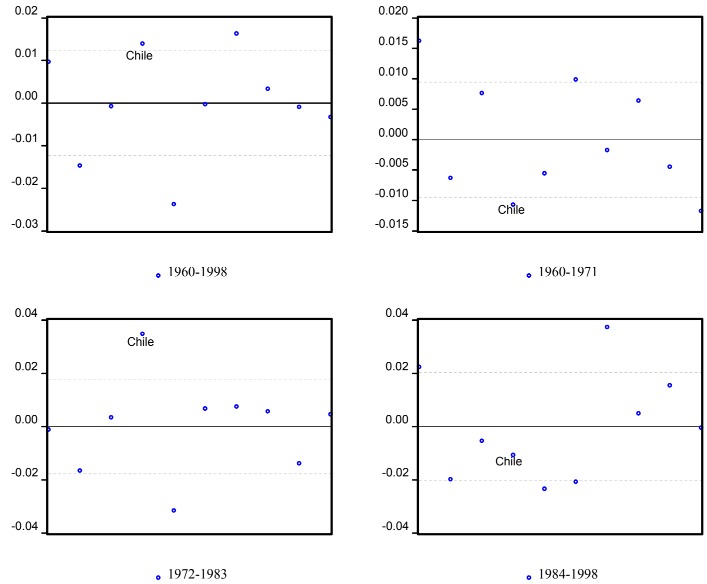


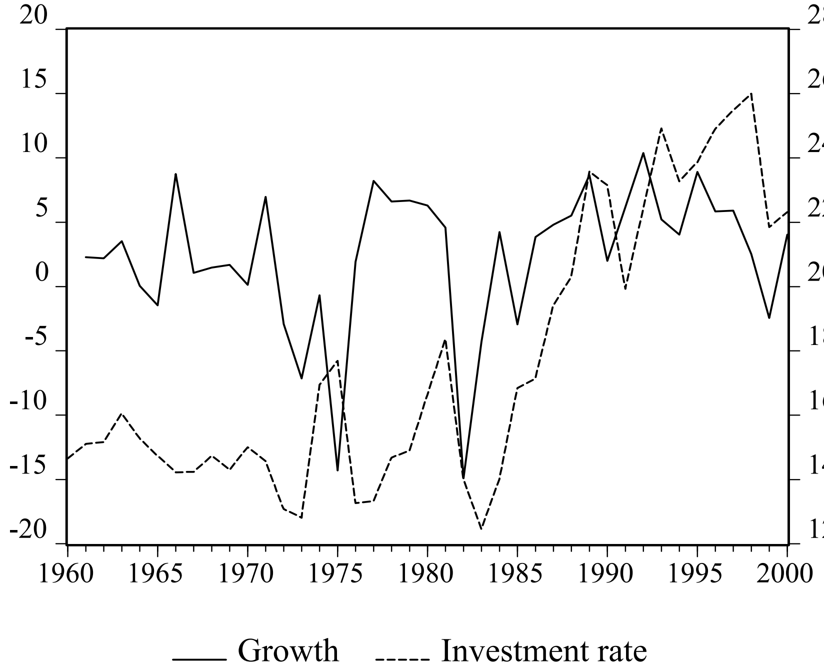
Figure 3: Deviations from Latin America's Average Growth Volatility



Chile's experience over time significantly diverged from the other countries in its cohort (at least in degree and often in kind). Before the oil crisis of the early 1970s, its economic performance (both in terms of growth rate and volatility) was close to the Latin American average. Between the oil crisis and the debt crisis, Chile displayed "atypical" vulnerability, given the low growth and high volatility exhibited during those crises (Chile's figures lie outside the 95 percent confidence intervals). However, the speed of its recovery afterwards was unmatched. Chile not only generated the region's highest growth rates, but did so while exhibiting a level of volatility that was not statistically different from the regional average.

A usual candidate for explaining the performance of an economy is its investment rate. However, the correlation between per capita GDP growth and the investment rate is, at most, 0.35. Furthermore, while the investment rate between 1960 and 1973 steadily declined, it rose from 1984 until 1998 (Figure 4). It could be argued that while the contribution of capital to growth was very important during the first period, in the second, the recovery from the deep recession of the early 1980s caused the growth rate to lead the economy to higher investment rates. Anecdotal (statistical) evidence is readily available, given that Granger causality tests suggest that both the level and first difference of per capita GDP preceded the investment rate from 1984–2000, while there is no discernible direction of statistical causation from 1960–73.

Figure 4: Per Capita GDP Growth and Investment Rate



Thus having formal measures to evaluate a range of determinants for such a heterogeneous performance during the two periods would be instructive. In particular, one would like to know which characteristics made economic performance so average through the 1960s, so sensitive to the two major international crises in the early 1970s and early 1980s, and so stimulative to growth rates and dampening to volatility from the mid-1980s onward.

Studying Chile's economic performance is interesting not only because of its remarkable differences in growth rates and volatility compared to other countries in the region, but also because it has experienced major swings in institutional arrangements and economic policies that provide a rich contextual history for evaluating the data.

This paper provides a qualitative and quantitative evaluation of the main factors behind Chilean growth. The first section looks at the history for the period under analysis.

The next section uses a growth accounting exercise to approximate Total Factor Productivity (TFP). The results from that exercise are then used to conduct a multivariate time series analysis that includes several measures of economic distortions to assess which are important determinants (or consequences) of Chile's economic performance. Features found to be relevant are then incorporated into a model that attempts to quantify the growth effects of several shocks. Finally, the last section summarizes the main analytic conclusions and draws policy implications.

Historical Overview of the Chilean Economy

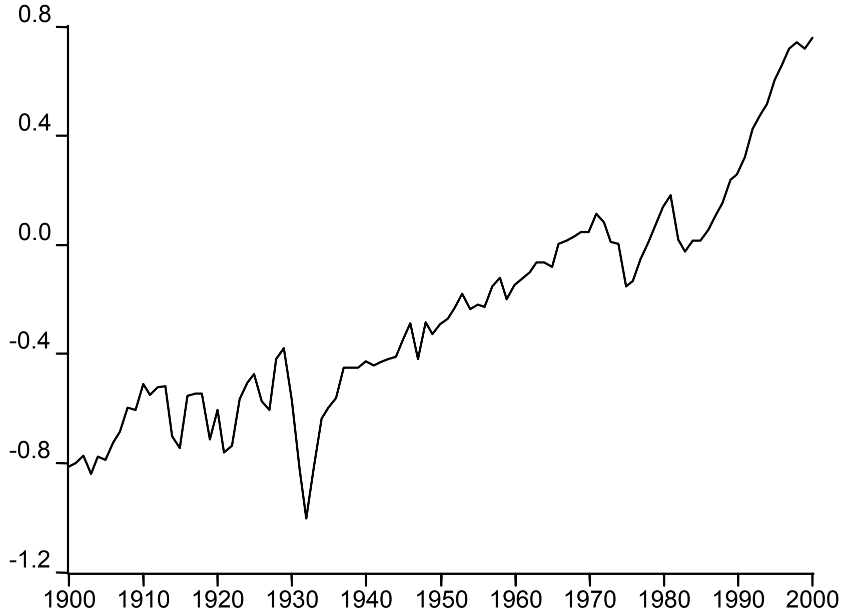
One purpose of this paper is to better understand how economic policy has impacted Chilean growth. This section presents a brief overview of the main economic policies since Chile became a nation. Much of this can be summarized from Lüders (1998), who provides a long-term analysis (1820–1995) of the Chilean economy and compares it to other developing and developed countries. The primary focus is on the last 40 years, for which more reliable information is available. Figure 5 tracks the last century's events.

Chile achieved political independence from Spain in 1810. According to Lüders, the first period of Chilean economic history can be characterized as liberal, with two distinct phases demarcated by the Pacific War. Between 1820 and 1878, Chile grew faster than the other Latin American countries (1.39 percent versus 0.1 percent), while in the second phase, 1880–1929, the growth rate was about average. Lüders highlights the positive wealth effect that the Pacific War had on the Chilean economy, but notes that the annexation of nitrate and silver mines may have induced two negative effects: a very rapid increase in government expenditures (more rent seeking activities) and a "Dutch disease" phenomenon that cut off some traditional activities. During the second phase of the liberal economy that followed the war, the political climate was unstable, marked by a civil war in 1891 and military takeovers in 1924 and 1927–32.

The Great Depression ushered in a new economic period, characterized by a strategy of import substitution, mainly in reaction to the sudden and precipitous drop in the price of nitrate, a bedrock of the previous period. As the price and sales of most Chilean export products plunged after 1929, the national economy contracted severely. According to Lüders the Chilean economy was among the hardest hit during the Great Depression (per capita GDP fell by 47 percent and exports by 79 percent).

Unable to affect the global climate, economic policy turned inward, a reaction typical of the times. Government took an active role, implementing industrial policies and creating state-owned enterprises. Manufacturing was protected with high tariffs, nontariff barriers (NTBs), and multiple exchange rates. These trends took root and expanded between 1940 and 1970, interrupted only briefly by a weak and failed attempt to reverse course between 1959 and 1961.

Figure 5. Log of Per Capita GDP (1900–2000)



Sources: Braun et al. (2000) and Díaz et al. (1999) for the period up to 1995 and the official growth rates from the Central Bank of Chile for the period 1996–2000.

In 1970, a newly elected socialist government took inward-oriented economic policy and government intervention to a new level. From that year until 1973, Chile could accurately be described as virtually a closed economy. Economic policy was characterized by strong government interventions; price, interest rate and exchange rate controls; high (tariff and nontariff) barriers to trade and to international capital flows; and a very high inflation rate. The government also expropriated a significant number of private companies.

After the military coup of 1973, movement began toward a market-oriented economy. Among the most important changes in policy were a focus on price liberalizations, an aggressive opening of the economy to trade and international capital flows, a reduction of the size of government, and privatizations. Furthermore, Chile introduced pioneering reforms to its social security system, financial markets, and health care system. One of the most profound changes was the trade reform that eliminated all the NTBs and reduced tariffs to 10 percent across the board (except for automobiles).

All these changes were implemented despite major international crises. The oil crisis hit when the economy was starting the reforms. The sum of the external shock and the reform severely impacted on GDP.

The debt crisis of the early 1980s was set off by a negative external shock (an increase in the international interest rate and a deterioration in terms of trade) coupled with internal policy mistakes. A fixed exchange rate policy, combined with a very low convergence of domestic to international inflation, induced a large real appreciation of the peso with respect to the dollar, creating a large current account deficit. Given the external situation, the foreign sector was unwilling to finance the current account deficit; while at the same time, the domestic financial system had structural problems, lacking effective regulation, supervision, and expertise.[2] As a result, the Chilean economy confronted a two-headed crisis (external and financial).

Hard on the heels of trade reform, the real exchange rate appreciation of that period constituted a second shock for the trade sector, inducing several bankruptcies and forcing firms to try to increase productivity in order to survive. In fact, the manufacturing sector experienced important reallocations of resources coupled with productivity increases (Fuentes, 1995; and Alvarez and Fuentes, 2001).[3] In 1982 the peso was devalued, and tariffs started climbing until 1985 (reaching a peak of 35 percent across the board) before declining until 1991.

Finally, after the return of democracy in 1990, the major economic reforms formulated in the 1980s were left virtually intact. In fact the newly appointed government reduced tariffs even further in 1991, from 15 to 11 percent, and negotiated free trade agreements with Mexico, Colombia, Venezuela, Canada, Mercosur, the European Union, South Korea, and the United States. These agreements reduced the average tariff paid on imported products. Recently the tariff structure has been reduced even more (from 11 to 8 percent) for countries that are nonmembers of free trade agreements.

This brief overview can be summarized by the evolution of per capita GDP in Figure 5. It uses data from Braun et al. (2000) and Díaz et al. (1999) for the period up to 1995 and the official growth rates from the Central Bank of Chile for the period 1996-2000.

Total Factor Productivity Analysis

This section derives several estimates of TFP, which are later used to uncover those factors driving the growth process.

Data

Given the available data and its degree of reliability, we analyze the period 1960–2000 using National Accounts records. Capital stock was estimated using the perpetual inventory system from 1940.[4] The data on labor corresponds to the number of employed people each year and is obtained from the National Bureau of Statistics (INE).

Figure 6 shows the evolution of GDP, capital stock, and labor for the 1960–2000 period (expressed as indexes). As can be seen, capital stock grew faster than labor and GDP over the whole sample. Five periods are clearly distinguishable: three of rapid growth and two severe recessions.[5] In the first growth period, GDP expansion was accompanied by a faster increase in capital stock and a smooth upward trend in labor. After the recession, in the middle 1970s, the economy grew very fast, with a relatively

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[2] See Fuentes and Maquieira (2000) and the references therein.

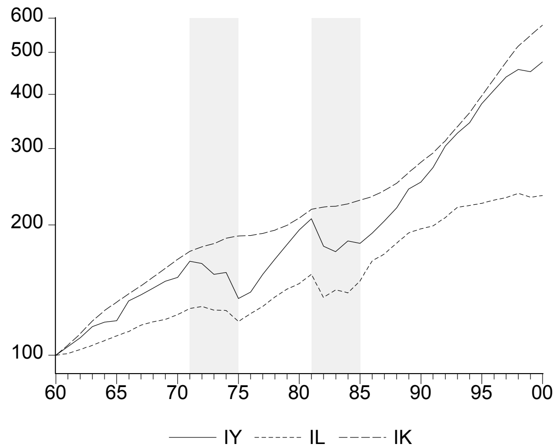
[3] Fuentes (1995) shows that during the trade and market reform period (1975–82) there were substantial increases in the productivity of different manufacturing sectors. As a pattern across sectors could not be found, this feature is consistent with the idea of a "mushroom" process.

[4] We thank Herman Bennett for providing this series.

[5] The economy entered a short recession in the last quarter of 1998, recovering in 2000. In parts of our analysis we will assume that the third expansionary period ends in 1998.

slow increase in capital and labor until the onset of the debt crisis. This profound recession caused the unemployment rate to spike. Starting in the mid-1980s the economy bounced back, with a quick recovery in employment followed by a later pick-up in the capital growth rate.

Figure 6: Evolution of GDP, Labor, and Capital (1960–2000)



Notes: Index 1960 = 100, log scaling.

Methodology

Using the databases cited earlier, one can estimate TFP growth. A key to understanding the contribution of productivity is the measurement of production factors and their change in quality over time. Two estimates of TFP growth will be provided: one using the raw capital and labor data, and the other correcting labor with a quality index.

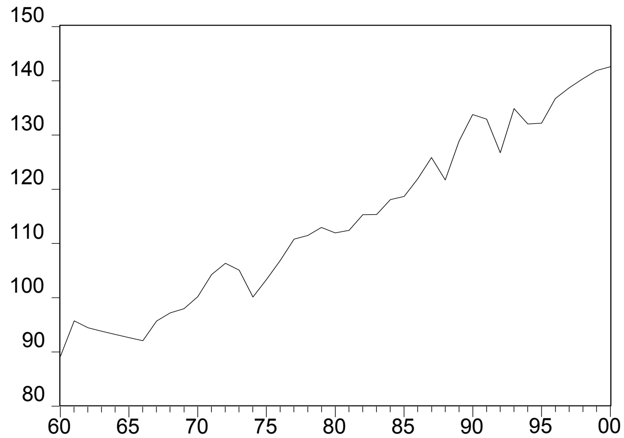
Input Quality

Better assessing the growth process in Latin America has been facilitated by improved factor quality (Elías, 1992). One usual way to adjust raw data is by using a labor and capital augmenting correction. For labor we used the estimate made by Roldós (1997), which considers that there are different types of labor (L_j), with wages (w_j), such that the quality correction becomes:

$$\sum_{j=1}^{n} \frac{w_j L_j}{wL} \quad (1)$$

Figure 7 shows the evolution of this index over time. We compare it with an estimation of human capital stock found in Braun et al. (2000), in which the authors express the educational level of the labor force in tertiary education equivalence using the relationship between market wages. The correlation between both variables is 0.98.

Figure 7. Index of Labor Quality (1960–2000)



Roldós (1997) also provides an index of quality for the capital stock. The construction of this index hinges on relative rental rates of different types of capital. As this information is unavailable, the author estimates the rate using the market price of investment goods. Figure 8 shows the evolution of this index, which contains several disturbing features. In particular it states that the quality of capital goods in 1995 was about the same as in 1960. Furthermore, the continuous decline in capital quality during the 1960s is difficult to explain. For these reasons, we chose not to use this variable.

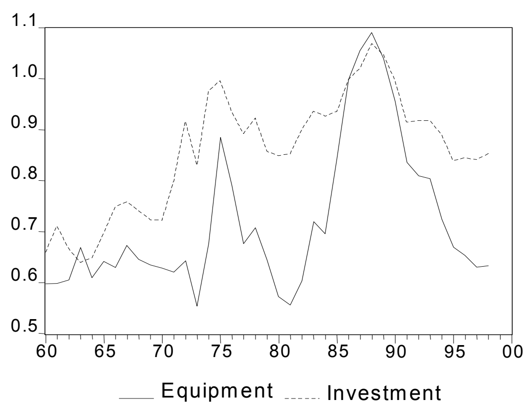
Figure 8. Index of Capital Stock Quality (1960–2000)

Greenwood and Jovanovic (2000) provide another view of improved quality in capital stock. They associate quality with the evolution of the relative price of investment in terms of consumption; when this relative price decreases, the quality of capital goods rises. There are at least two problems with this interpretation. First, at the aggregate level (even though we separated equipment from structure), there are no permanent decreases in the relative price of equipment. If we consider the case of computers, for example, we can expect a continuous decrease in their relative prices; but when one considers different types of equipment, this may not be the case. For instance, when a higher quality of equipment appears in the market, the producing firm may exploit, for a while, monopoly rents in order to pay for the R & D costs (as in the quality ladder type models cited in Grossman and Helpman, 1991), causing the equipment price to actually rise.

Second, in linear technology models of endogenous growth, a decrease in the price of an investment good will increase the capital accumulation and ultimately the rate of growth. Thus quality should rise when an economy opens to trade and starts importing capital goods at a lower price (Jones and Manuelli, 1990).

Figure 9 shows the evolution of the relative prices of equipment goods and investment goods with respect to consumption goods. Even though they seem to follow the evolution of the real exchange rate (rather than being good estimates of the quality of capital), we will assess the impact of these relative prices on TFP in the next section.

Figure 9. Prices of Equipment and Investment Goods Relative to Consumption Goods



TFP Growth Measures and Capital Share Estimates

Given the considerations discussed above, we analyze two different formulations for TFP. The first does not consider any correction for changes in quality of factors, and the second includes a correction for human capital (*TFPH*). The equations for TFP growth are:

$$T\hat{F}P = \hat{Y} - \alpha\hat{K} - (1-\alpha)\hat{L} \tag{2}$$

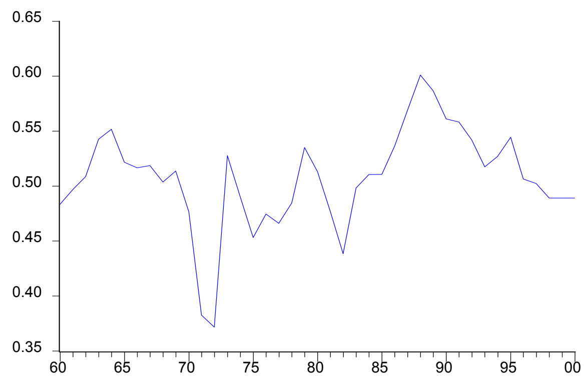
$$TF\hat{P}H = \hat{Y} - \alpha\hat{K} - (1-\alpha)\hat{L} - (1-\alpha)\hat{H} \tag{3}$$

in which H stands for the index of labor quality and $\hat{x}$ denotes the growth rate of variable x. Note that when measured in either way, TFP growth will include both improvements in the quality of capital over time and the technological shock.

The key parameters necessary to estimate TFP are the factor-output elasticities. From the pure growth accounting point of view, estimates of the elasticities are given by the capital and labor shares from the National Accounts records. These shares vary yearly, thus the calculations were made using the average capital and labor shares between two years and the average shares for the entire period (α = 0.50733). There is not much difference between these two choices. An alternative estimation used in this exercise is one-third, obtained from the capital share conventionally used in the growth literature. Correlations of the growth rates of estimates of TFP under different assumptions for α are never smaller than 0.98.

Despite the similarities of the TFP measures using a variable or a constant α, there is always a "reasonable" doubt with respect to which model best describes the data. For instance a CES function may do a better job than a Cobb-Douglas production function. Figure 10 provides informal evidence suggesting that a constant capital-output elasticity is not a bad approximation. In particular, note that the value in 2000 is about the same as in 1960 and close to the average. However a regression on a constant shows that the mean is unstable over time. This fact could be reconciled with changes in the input-output matrix from National Accounts (1977 and 1986).

Figure 10. Capital Share (1960–2000)



Estimation of TFP Growth

Table 2 shows the TFP growth rate for the entire period (1960–2000) and for two subperiods. The first subperiod corresponds to the inward-oriented phase, and the second starts with the trade reform with more than a one percentage point of difference between periods, mostly accounted for by differences in TFP growth. This feature signals that the elimination of distortions may have significantly increased the efficiency of the economy.

Table 2. Growth Accounting for Periods of Economic Orientation (Percent)

Period	GDP Growth	TFP (α = 0.507)	TFP (α = 1/3)	TFPH (α = 0.507)	TFPH (α = 1/3)
1961–2000	3.97	0.67	1.07	0.06	0.24
1961–74	3.19	0.06	0.55	–0.37	–0.04
1975–2000	4.40	1.00	1.36	0.29	0.39

Notes: H denotes the inclusion of human capital.

Table 3 shows the TFP growth rate for the entire period 1960–2000 and for the periods of rapid growth in the Chilean economy. Two of the booms coincide with the trade liberalization of the 1970s and with the tariff reduction of the late 1980s and early 1990s (after the debt crisis). The performance of TFP growth is rather poor over the whole sample (growing no more than 1.1 percent) while GDP grew an average of 4 percent annually.

Table 3. Growth Accounting for Periods of Rapid Growth (Percent)

Period	GDP Growth	TFP (α = 0.507)	TFP (α = 1/3)	TFPH (α = 0.507)	TFPH (α = 1/3)
1960–2000	3.97	0.67	1.07	0.06	0.24
1960–71	4.65	0.91	1.41	0.18	0.42
1975–81	7.32	3.97	3.65	3.27	2.69
1985–98	7.36	2.23	2.72	1.54	1.77

Note: H denotes the inclusion of human capital.

As Figure 6 made clear, we distinguished three episodes of growth. In evaluating the differences in growth rates of TFP among these periods, one can say that although the growth rate of GDP in the 1975–81 and 1985–98 episodes might be influenced by the recovery from the two deep recessions of the 1970s and the 1980s, in both cases there are significant increases in TFP, a phenomenon not evident in the 1960s.

During the trade reform period (late 1970s), the average TFP growth reached its highest value. This period is characterized by important factor reallocations, bankruptcies, and the creation of new firms. In the longest period of continuous growth (1985–98), TFP growth was somewhere between 1.5 and 2.7 percent, more than 1 percent less across the range of results than for 1975–81.

Table 4. Growth Accounting for Periods of Rapid Growth

		(α = 0.5073)		
Period	Labor	Human Capital	Capital	TFPH
1960–2000	0.27	0.15	0.57	0.01
1960–71	0.25	0.15	0.56	0.04
1975–81	0.29	0.09	0.17	0.45
1985–98	0.25	0.09	0.45	0.21
		(α = 1/3)		
Period	Labor	Human Capital	Capital	TFPH
1960–2000	0.36	0.20	0.38	0.06
1960–71	0.33	0.21	0.37	0.09
1975–81	0.39	0.13	0.11	0.37
1985–98	0.33	0.12	0.30	0.25

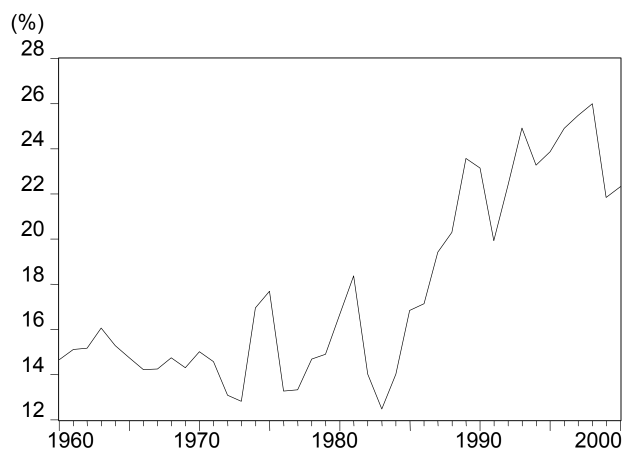
Note: Figures are expressed as ratios of GDP growth.

How important was TFP in accounting for GDP growth? This is important because TFP growth rates were higher in 1975–81 and 1985–98, but so were GDP growth rates. Table 4 shows the contribution of factor accumulation (including human capital) and TFP to growth. As expected, for the entire period the contribution of TFP was very small after including human capital. The most important contribution to growth was physical capital, which accounts for 57 percent of total GDP expansion.

The growth rate of GDP during the 1960s is characterized by capital accumulation, human capital accumulation, and the lack of total factor productivity growth. As expected, after 1975 the growth rate of TFP played a key role in accounting for growth. However, there is an important difference between the 1975–81 and 1985–98 periods in terms of capital accumulation. The successful period after the debt crisis is accounted for by capital accumulation, which was less robust than in the 1960s but still very important. Furthermore, as the growth literature predicts, trade liberalization and the movement of the Chilean economy towards a free market economy that began in the mid-1970s brought important total factor productivity growth.

However, as mentioned earlier, our TFP growth estimates are also capturing improvements in the quality of capital stock and other factors (such as changes in relative prices, resources allocations, etc.). Following the logic of Greenwood and Jovanovic (2000), the reduction in trade restrictions should have increased the average quality of the capital stock and this should lead to higher TFP growth. This feature is even more important considering that the contribution of capital accumulation was very high in the first period of Chilean economic growth (1960–71), while a lower rate of capital accumulation accompanied higher growth rates in the other two periods. This result is in line with economic theory suggesting that an opening to trade and the elimination of distortions increase the average quality of capital and help reallocate capital towards sectors with higher marginal productivity. For convenience, we reproduce the evolution of the investment rate (using current prices) where the efforts from increasing the investment rate in the last period are made evident (Figure 11).

Figure 11. Investment Rate (1960–2000)



It is important to emphasize that the trade reform and the reduction of government interventions in the economy appear to be key when evaluating the performance of the economy in the 1980s and 1990s. However, as mentioned in the historical overview, there were several other reforms that could help account for a higher marginal productivity of capital and for higher growth. For example this is the case when the banking and capital market reforms combined with a new bankruptcy law.[6] In a recent paper, Bergoeing et al. (2001) highlight these reforms as key in explaining the fast recovery of the Chilean economy after the debt crisis.

Another important difference between rapid growth in the 1960s versus that during the other two periods is in the contribution of human capital. Two caveats accompany this observation: First, since educational attainment has continuously increased over time, it can be argued that "enough" human capital had already accumulated by the 1970s to make its subsequent marginal contribution modest. Second, the human capital series was measured using relative wages, but changes in these wages may be due to factors other than human capital accumulation. At any rate, other studies show that the contribution of human capital, even when measured differently, is not that dissimilar from the result found here (Schmidt-Hebbel, 1998).

Multivariate Analysis

In the previous section and its subsections we constructed variables that can help one to better understand Chilean economic growth. Specifically the evolution of Total Factor Productivity and its importance at different stages of recent history were shown. This series can be used to evaluate their main determinants and thus the determinants for growth. Here, we conduct several econometric exercises intended to provide quantitative and qualitative guidelines for a theoretical model to understand the growth dynamics of the Chilean economy.

Factors Behind TFP

Having obtained several estimates for TFP, we now consider a set of possible associated variables. Among them are a time series for terms of trade, variables intended to capture the evolution of distortionary policies (such as tariffs and fiscal expenditure over GDP), and relative prices of equipment and investment goods with respect to consumption goods.[7]

Our econometric formulations begin with overparameterized models. After careful reductions and reparameterizations we end up with models for series of TFP (in logs) that can be expressed as:

$$f_t = a_0 + a_1 t + a_2 f_{t-1} + a_3 f_{t-2} + a_4 p_t + a_5 p_{t-2} + a_6 T_t + a_7 T_{t-1} + a_8 g_{t-1} + e_t \qquad (4)$$

in which a_i are coefficients to be determined, f is the log of each TFP series, p is the log of the relative price of equipment goods with respect to consumption goods, T is the log of terms of trade, and g is the ratio between fiscal expenditures and GDP.

[6] Fuentes and Maquieira (2000) provide an explanation of how these laws affected the recovery of the banking system after the deep banking crisis in the early 80s.

[7] The last variables are considered taking into account the derivations of Greenwood and Jovanovic (2000). Thus if either of these relative prices appears significant, we could subtract their participation from the TFP series since, in the spirit of that paper, movements of relative prices would be related to the quality of the capital stock and not directly to TFP per se. Nevertheless a case could be made for associating the evolution of these relative prices to modifications in distortionary policies, making these prices a combined effect of increased capital quality and reduced distortions.

Table 5. Results of TFP Regressions

	TFP (α = 0.507)	TFP (α = 1/3)	TFPH (α = 0.507)	TFPH (α = 1/3)
a_1	0.008 (0.001)	0.010 (0.004)	0.005 (0.001)	0.006 (0.001)
a_2	0.349 (0.135)			
a_3	–0.269 (0.116)	–0.405 (0.182)	–0.501 (0.155)	-0.377 (0.156)
a_4	–0.220 (0.038)	–0.303 (0.033)	–0.259 (0.032)	-0.283 (0.035)
a_5		–0.141 (0.068)	–0.197 (0.061)	-0.210 (0.065)
a_6	0.083 (0.026)	0.082 (0.038)	0.164 (0.033)	0.116 (0.039)
a_7		0.083 (0.030)		0.072 (0.033)
a_8	–0.571 (0.119)	–0.410 (0.139)	–0.852 (0.113)	-0.576 (0.114)
R^2	0.940	0.963	0.913	0.915
DW	2.199	1.895	2.015	1.858
Q	0.115	0.199	0.241	0.793
Q^2	0.741	0.109	0.159	0.467
JB	0.629	0.572	0.852	0.365
Ra	0.174	0.286	0.081	0.167

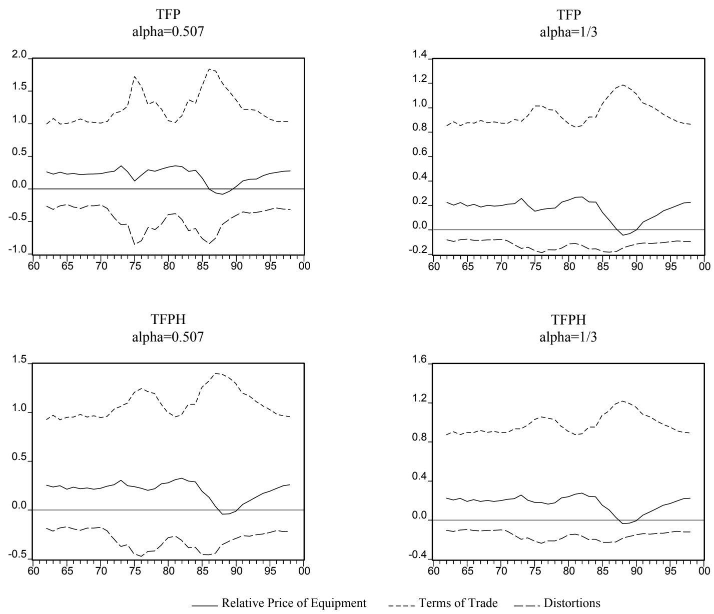
Notes: R^2 = Adjusted R^2; DW = Durbin-Watson statistic; Q = Minimum p-value of Ljung-Box test for white noise on the residuals; Q^2 = Minimum p-value of the Jarque-Bera normality test; Ra = p–value of the Ramsey test; standard errors are in parentheses; TFPH indicates the inclusion of human capital.

Table 5 shows the results of the estimations (only statistically significant variables are included). Given the close association between the measures of TFP, the characteristics and even the coefficients associated with each variable are remarkably similar, finding in all cases that reductions in the relative price of equipment goods with respect to consumption goods, improvements in terms of trade, and reductions in the contribution of government expenditures to GDP are positively associated with our measures of TFP. Furthermore, consistent with results from the previous section, we also find that TFP can be characterized as trend stationary. Thus every transitory shock on the variables included in the regressions would have only transitory effects on the levels of our TFP estimates.

This does not mean that policies are unimportant; it only means that transitory policy shocks affect the level of the series without having permanent effects. As expected, a_4 and a_5, when significant, are negative; if these variables measure the quality of capital, a reduction in the relative price of equipment with respect to consumption goods signals an improvement in the quality of capital stock. In this regard, this variable is intended to capture the exclusion of the adjustment for capital stock quality in our growth accounting exercise as well as possible reductions in distortions. Also of interest is the positive effect of terms of trade on TFP and the negative and statistically significant effect of the size of government as a fraction of GDP. It may be argued that this last variable cannot be considered as exogenous given that it may have been used to conduct countercyclical policies. We find evidence that g is weakly exogenous to the parameter of interest (in the sense used by Hendry, 1995); thus conditioning our estimates of TFP on g is a valid econometric practice.

After removing the trend and persistence component, Figure 12 presents the contribution of each variable to TFP. We find that almost all of the variation of TFP (excluding the trend component) can be accounted for by the evolution of terms of trade and that the negative effect of our measure of distortions more than offsets the improvements in the quality of the capital stock.

Figure 12. Effect on TFP



Given that all our estimates of TFP are robustly associated with these three variables, we estimate a simple model for the level of (log) GDP that associates it with them. The impulse-response functions of the innovations of these variables on GDP will be used as a metric to compare with the theoretical model developed in the next section.

While simple, our econometric formulation is able to provide well-behaved residuals and successfully passes all of our specification tests. It is given by:

$$y_t = b_0 + b_1 t + b_2 y_{t-1} + b_3 p_t + b_4 T_t + b_5 g_t + e_t \qquad (5)$$

in which b_i are coefficients to be determined, y is the log of GDP, and all the other variables are as defined in (4).

Table 6. Results of TFP Regressions

	y
b_1	0.017 (0.005)
b_2	0.615 (0.106)
b_3	–0.163 (0.064)
b_4	0.107 (0.051)
b_5	–0.634 (0.174)
R^2	0.990
DW	1.817
Q	0.262
Q^2	0.150
JB	0.099
Ra	0.257

Notes: R^2 = Adjusted R^2; DW = Durbin-Watson statistic; Q = Minimum p-value of Ljung-Box test for white noise on the residuals; Q^2 = Minimum p-value of the Jarque-Bera normality test; Ra = p – value of the Ramsey test; standard errors are in parentheses.

As Table 6 shows, the relative price of equipment with respect to consumption goods and our proxy for distortions are negatively associated with GDP, while improved terms of trade positively affect GDP. Consistent with our previous findings, we model y as a trend stationary series; thus all included regressors have only transitory effects over the scale variable. Furthermore, weak exogeneity conditions are satisfied by p, T, and g.

Next, we estimate laws of motion for p, T, and g as univariate time series models. These simple specifications provide good statistical approximations for the processes of each variable and are able to account for most of their dynamic characteristics.[8]

Back to Fundamentals

Chumacero and Fuentes (2002) calibrate a dynamic stochastic general equilibrium model that explicitly introduces the theoretical counterparts of p, T, and g. For completeness, we summarize the model and present their results.

The economy is inhabited by a representative agent who maximizes the expected value of lifetime utility as given by

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t)$$

with

$$u(c_t, l_t) = \theta \ln c_t + (1-\theta) \ln (1-l_t), \qquad 0 < \theta < 1, \tag{6}$$

[8] VAR models were also considered for obtaining the multivariate representation of these variables. Our results do not change significantly if a VAR(1) representation is considered instead of simple univariate representations.

where c_t and l_t represent period-t consumption of an importable good and labor. Two goods are produced in this economy: The first is not consumed domestically, while the second (the importable good) is produced domestically and can be obtained from abroad.

We assume that the output of the exportable good (y_1) is constant and can be sold abroad at a price (expressed in terms of the importable good) of T_t, which in our economy represents terms of trade. The production technology for the importable good is described by

$$y_{2,t} = e^{zt} k_t^{\alpha} l_t^{1-\alpha} \,, \tag{7}$$

in which α is the compensation for capital as a share of output of sector 2. As before, production in this sector is also affected by a stationary productivity shock (z_t) that follows an AR(1) process.

The resource constraint of the economy is given by

$$c_t + i_t + g_t = T_t y_1 + y_{2,t} \tag{8}$$

where investment (i) and government expenditures (g) are expressed in units of consumption of importable goods.

The capital accumulation equation is

$$k_{t+1} = (1 - \delta)\, k_t + i_t q_t \tag{9}$$

where, following Greenwood et al. (2000), q denotes the current state of technology for producing investment goods and represents investment-specific technological change. Given that i is expressed in consumption units, q determines the amount of investment in efficiency units that can be purchased for one unit of consumption. Thus a higher realization of q directly affects the stock of new capital that will be active in production in the next period. We assume that ln q follows an AR(1) process.

As discussed in Greenwood et al. (2000) the relative price for an efficiency unit of newly produced capital, using consumption of the importable good as numeraire, is the inverse of q. This 1/q is our theoretical counterpart to p (analyzed earlier).

Finally, the government of this economy levies taxes on labor and capital income at the rates τ_l and τ_k. Part of the revenue raised by the government in each period is rebated back to agents in the form of lump-sum transfer payments (F), and part of it is "lost" in government expenditures that do not provide services to the representative agent. The government's budget constraint is then

$$F_t + g_t = \tau_k r_t k_t + \tau_l w_t l_t \tag{10}$$

where r and w represent the market returns for the services provided by capital and labor. Finally, we also assume that ln g follows an AR(1) process.

The base configuration of the parameters is presented in Table 7. Note that θ is set to reproduce a steady-state participation rate of l equal to 0.35, and the depreciation rate is calibrated to match the average investment rate in steady state. The persistence and volatility of p, T, and g are made consistent with AR(1) estimates obtained with observed data of the relative price of equipment with respect to investment, terms of trade, and government expenditures (in this case we include a time trend that is absent in the model). Finally, the persistence and volatility of the technology shocks are estimated by simulation in order to match as closely as possible the results of Table 6.

Table 7. Parameters

Preference			
$\beta = 0.98$	$\theta = 0.43$		
Technology			
$\alpha = 1/3$	$\delta = 0.06$		
Shocks			
$\rho_z = 0.73$	$\sigma_z = 0.04$	$\rho_p = 0.844$	$\sigma_p = 0.1$
$\rho_T = 0.892$	$\sigma_T = 0.14$	$\rho_g = 0.895$	$\sigma_g = 0.024$

Once the values of the parameters are set, we solve the model, simulate artificial realizations from it, and compare the impulse-response functions of several shocks. According to our specification, the policy functions of the control variables cannot be obtained analytically and we have to resort to numerical methods. We use a second-order approximation to the policy function, using perturbation methods. This method has the advantage of explicitly incorporating in the decision rule the volatility of shocks and has been proven superior to traditional linear-quadratic approximations (Schmitt-Grohé and Uribe, 2001).

Figure 13. Impulse-Response Functions: Model and Reality

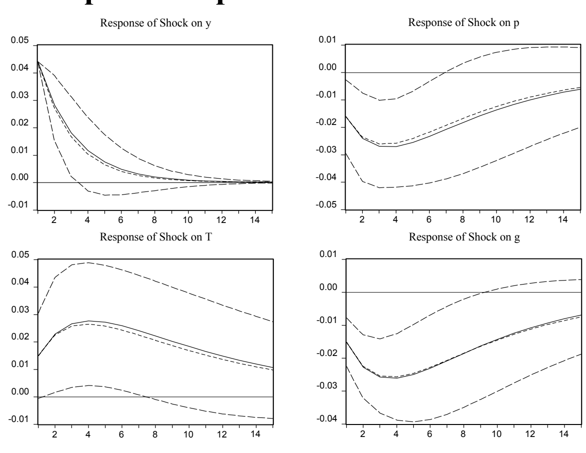


Figure 13 presents the results of comparing the impulse-response functions of shocks on the innovations of the equation that describes *y* in (5), and innovations on *p*, *T*, and *g* from their univariate representations. Along with the impulse-response functions and the 95 percent confidence intervals obtained from the data, the figure shows the impulse-response function obtained from a long simulation of the model. Our results evidence an almost perfect match between the impulse-response functions of the model and the data.

Analyzing the results of the impulse-response functions, we observe that a positive shock of 10 percent on the relative price of equipment with respect to consumption has a negative (but transitory) effect on GDP of almost 3 percent after three years. On the other hand, a positive shock of 14 percent on terms of trade has a positive effect on GDP that on average reaches its peak of almost 3 percent after three years. Finally, a transitory increase of 2.4 percent on the share of government expenditures over GDP has an exactly offsetting effect on GDP (decline of 2.4 percent) after three years.

Thus our theoretical model is not only able to capture the first moments of key variables of the Chilean economy but matches almost perfectly the impulse-response functions of the dynamic characterization of GDP, showing that a model which incorporates the relative price of equipment with respect to consumption goods, terms of trade, and distortions (measured as the share of government expenditures in GDP) predicts the same qualitative and quantitative responses of GDP to transitory shocks.

Summary Remarks

The objective of this study was to better understand the factors behind the growth dynamics in Chile. This case study is of interest because Chile has experienced deeper recessions than most Latin American countries when faced with an external shock (e.g., the Great Depression, an oil shock, and external debt), but has also experienced an impressive and stable growth during the past 16 years.

The main conclusions of this study can be summarized as follows:

- Looking at the evolution of GDP over the last four decades, we distinguish three periods of continuous growth: 1960–71, 1975–81, and 1985–98. The first period corresponds to a moderately inward-oriented economy; the second is the period of the major trade liberalization and market reforms; while the third is the period in which many of the reforms from the previous decade were consolidated. Two other characteristics are worth highlighting: The periods of growth had different lengths and the growth rates were different. While during the 1960s the economy grew at less than 5 percent, in the other two periods the growth rate was above 7 percent.

- But why is the recent growth period so different from the 1960s? We think this question can be answered by analyzing the behavior of TFP growth. As no reliable measures of the quality of capital stock are available, we used series for human capital along with different capital shares to estimate TFP.[9] Our results suggest that in the 1960s physical capital and human capital accumulation were the most important factors stimulating growth, while in the other two periods TFP played a major role (especially in 1975–81). Both capital accumulation and TFP growth account for the expansion of 1985–98.

- Following the literature of growth and distortions, we analyzed to see if distortions have anything to do with the evolution of TFP levels after controlling

[9] We extensively used two values: 0.507 (from pure growth accounting) and 1/3 (from the literature on growth).

for good luck (positive external shocks measured by terms of trade), exogenous technological progress, and a proxy for the quality of capital. The relative price of equipment with respect to consumption was used as a proxy for the latter variable (Greenwood and Jovanovic, 2000). We found that exogenous technological shocks, terms of trade, the relative price of equipment to consumption, and distortions account for a good deal of the evolution of TFP. It is important to note that terms of trade and distortions are the variables with the largest impact on the level of TFP.

- What policy implications can be drawn from the Chilean experience that can help other countries and Chile itself? Good policies matter. The most robust measure of distortions that we found in this document is captured by the share of fiscal expenditures on GDP. We find that this variable not only offsets the positive effects of improvements in the quality of capital goods, but that it also has detrimental effects on the level and volatility of the Solow residuals. External shocks are of course important, but among the variables that can be controlled by authority, distortionary policy helps explain several episodes of mediocre Chilean growth.

- The previous findings provide guidelines for the features that a theoretical model should have if it is to account for the dynamics of our TFP estimates and the dynamics of GDP itself. Building on these observations, we calibrate, solve, and simulate a small open economy model that incorporates terms of trade shocks, includes the relative price of investment to consumption goods, and distortionary taxes that help finance government expenditure. This model is able to replicate (almost exactly) the impulse-response functions of several shocks on the trajectory of GDP. We find that a 1 percent transitory increase in the share of government expenditures on GDP has a detrimental effect on GDP of the same order of magnitude (a decrease of 1 percent in GDP) by the third year. Transitory increases of 1 percent on terms of trade or decreases in the relative price of investment goods have positive and temporary effects on GDP, which however are not as important as the quantitative effects of increased distortions.

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