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Potential Output Growth in Emerging Market Countries: The Case of Chile[1]

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Abstract

This paper estimates potential output and the sources of growth in Chile during 1970–96. Actual output is cointegrated with the quality-adjusted measures of capital and labor, and constant returns to scale cannot be rejected. The estimates of potential output show a positive output gap in the years when the Chilean economy was deemed to be overheated. In 1986–90, the quality-adjusted labor variable explains close to 60 percent of the growth rate of GDP, while during 1991–95 capital formation plays a dominant role. The contribution of TFP growth in Chile is relatively small, but, based on a comparison with European and East Asian experiences, it is expected to increase in the medium term.

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SUMMARY

Two issues related to emerging market countries have recurred in recent years. The first is whether their past high rates of growth are sustainable in the medium run, and the second is whether these rates could lead to overheating pressures. Although most of the discussion has concentrated on the rapidly growing East Asian economies, the same concerns have arisen about Chile. Using a combination of growth accounting and regression analysis, this paper studies both issues for Chile during 1970-96.

During the last decade, the indices of capital and labor quality show a steady growth pattern, as the share of equipment in total capital rose and higher-skilled jobs were created. In 1986-90, the quality-adjusted labor variable explains close to 60 percent of Chile's growth rate of GDP, while during 1991-95 capital formation plays a dominant role. The contribution of total factor productivity (TFP) growth is relatively small, is estimated to increase in the medium term and to help sustain Chile's high GDP growth rates.

Total GDP is found to cointegrate with quality-adjusted capital and labor after a break in the deterministic trend that captures technological progress is taken into consideration. This break is confirmed by the estimation of Solow residuals, which begin to trend upward around 1985. The existence of constant returns to scale could not be rejected, and the share of imported capital goods in total capital appears to be one of the factors behind TFP growth.

To estimate potential output, the cyclical component of TFP and employment was removed using the Hodrick-Prescott filter. For Chile, this procedure captures a possible increase in the natural rate of unemployment in the late 1970s—related to structural reforms—as well as a relatively large trend component in labor force participation. The estimates show a positive output gap in the years when the economy was deemed to be overheated, leading the central bank to tighten monetary policy. However, the paper did not find the positive association between output gaps and inflation typically found in industrial countries and more recently in several Asian countries.

I. INTRODUCTION

Two issues related to emerging market countries have been recurrent in recent years. The first is whether the high rates of growth achieved by these countries in the last decades are sustainable in the medium run, and the second is whether these rates could lead to overheating pressures. Although most of the discussion of these issues has concentrated on the rapidly-growing East Asian economies, the same concerns have arisen in the context of the recent Chilean experience. Using a combination of growth accounting and regression analysis this paper studies both issues for the case of Chile during 1970-96.

The macroeconomic performance of Chile in the last decade has often been cited as an example of the outcome of the consistent application of stable macroeconomic policies and appropriate structural reforms (see, for instance, the volume by Bosworth, Dornbusch and Laban, 1994). After the deep recession in the early 1980s, Chile's GDP grew at around 7 percent a year in a context of relatively low inflation and sustainable external positions. For many economists (see, for example, Marfan and Bosworth, 1994) the growth of the Chilean economy during the 1980s and early 1990s was basically the result of a recovery from the deep recession in 1982-83, fueled by a large reduction in unemployment (which fell to 4.6 percent in 1993 from 18.9 percent in 1982). The above mentioned authors also concluded that the more recent acceleration of total factor productivity (TFP) growth was largely due to cyclical factors, and based on historically low investment rates that Chile could sustain a growth rate of around 4 percent a year in the near future. Other authors, like Dornbusch and Edwards (1994) and De Gregorio (1994), attribute the recent gains in productivity to the process of structural reform and consider them to be of a more permanent nature. More recently, Chumacero and Quiroz (1995) estimated—using a purely statistical model—that Chile's "natural" growth rate of GDP would be above 8 percent a year.

An assessment of potential output growth requires first an evaluation of the economic factors underlying the recent growth experience of Chile, and abstracting them from cyclical developments. As mentioned above, the sources of growth and the estimates of potential output growth for Chile presented here are based on a production function approach. The estimation of a production function is central to most recent studies of potential output growth (Adams and Coe, 1990; Coe and Moghadam, 1993; Jadresic and Sanhueza, 1992), and it is even more important in the case of emerging market countries, where growth is generally faster than in industrialized countries and tends to dwarf short-run macroeconomic fluctuations. The estimation of a production function gives estimates of factor shares that will then be used to calculate Solow residuals or total factor productivity, as well as to test the existence of increasing returns to scale—a key ingredient of recent endogenous growth theories.

To improve the estimates of total factor productivity, the present study allows for quality change in factor inputs by using indices that reflect changes in the composition of the capital stock and the labor force, which make aggregate inputs more productive (see

Jorgenson and Grilliches, 1967; Harberger, 1990; and Young, 1995). An index of labor quality for Chile was developed by Jadresic and Sanhueza (1992), and it displays a clear upward trend, reflecting improvements in human capital and a shift to higher-skilled jobs following the deep recession of the early 1980s. In this paper, an index of the quality of capital is estimated, as a weighted average of investment in machinery and equipment, on the one hand, and structures on the other, where the weights are estimated relative rental rates. The index of capital quality shows a steady growth pattern during the last decade, as the share of machinery and equipment in the total capital stock rose to 31 percent in 1995 from 21 percent in the mid-1980s.

An aggregate production function is estimated using cointegration techniques that are particularly appropriate for uncovering long-run relationships between output and inputs. Total GDP is cointegrated with quality-adjusted capital and labor, once we allow for a break in the deterministic trend that captures technological progress. This break in TFP is confirmed by the estimation of Solow residuals, which begin to trend upwards around 1985 after two decades of persistent decline. The existence of constant returns to scale could not be rejected, and the share of imported capital goods in total capital appears to be one of the factors behind TFP growth.

The concept of potential output is central to the analysis of cyclical developments and medium-term growth prospects and plays an important role in the assessment of the stance of macroeconomic policies. To estimate potential output, the cyclical component of TFP and employment needs to be removed. The Hodrick-Prescott filter was used to smooth the TFP series, and two approaches were used to remove the cyclical component of employment. The first approach, also followed by Jadresic and Sanhueza (1992), assumes the natural rate of unemployment to be 5.5 percent, while the second one also smooths the labor input by applying the Hodrick-Prescott filter to the actual employment figures. The latter procedure permits us to capture a possible increase in the natural rate of unemployment in the late 1970s—related to the initial frictional costs of structural reforms—as well as the relatively large trend component in labor force participation found in micro studies of the Chilean labor market (see García, 1995).

Both estimates of potential output show a positive output gap in the years when the economy was deemed to be overheated (1989, 1992–93 and 1995–96), leading the Central Bank of Chile to tighten monetary policy. However, we could not find the positive association between output gaps and inflation typically found in industrialized countries, and more recently in several Asian countries (Coe and McDermott, 1996). This is consistent with the more general result that in most Latin American countries neither current nor lagged output gaps—estimated using statistically smoothing techniques on GDP data only—show any significant correlation with inflation (IMF, 1996). Indeed, the contemporaneous correlation between inflation and the output gap is negative for Chile in the sample period under study, presumably reflecting the very high levels of inflation in a large fraction of the sample, as well as the influence of two fairly long periods (1975–80 and 1985–96) of GDP growth

acceleration and gradual disinflation. This result is also consistent with the evidence found in Hoffmaister and Roldos (1997) for a large sample of Latin American countries.

Finally, the sources of growth are studied, weighing the changes in inputs by the estimated factor shares. Introducing quality change in factor inputs brings into sharper focus the relative roles of these inputs in the growth experience of Chile in the last decade. In particular, in 1986–90 the quality-adjusted labor variable explains close to 60 percent of the growth rate of GDP, as the effect of the increase in the share of skilled labor in total employment is superimposed on the fall in unemployment. In 1991-95 the accumulation of capital is the main engine of growth, explaining 55 percent of output growth owing to the increase in the investment rate as well as the rising share of machinery and equipment in total capital. With these changes, TFP growth is reduced significantly compared with the figures that do not adjust for quality change in inputs: for the period 1986–90, it falls to 0.9 percent from 2.2 percent (without adjustment), while in the period 1991–95 estimated TFP growth falls to 1.4 percent from 3.3 percent.

The fact that increases in TFP account for a small share of the growth process in developing countries is documented in Bosworth, Collins and Chen (1995). It was originally shown by A.Young (1995) for the East Asian countries and has led to a controversial debate on the sustainability of high growth rates in these countries (see Krugman, 1994; Sarel, 1995; and World Bank, 1993). This paper's results show a similar pattern for Chile. Comparing Chile's recent growth experience to that of the East Asian countries and also to the European countries in post World War II, the paper discusses the prospects for growth in Chile for the next five years.

The paper is organized as follows. The next section discusses the estimation of the indices of the quality of inputs. Section III presents estimates of an aggregate production function as well as of potential output for Chile over the period 1965–95, using annual data. Section IV examines the sources of growth in Chile, compares Chile's experience with that of other countries and discusses the projections of potential output growth for Chile over the medium term. Finally there is an appendix Table with the estimated rental prices of capital and the capital quality indices.

II. The Quantity and Quality of Inputs

The basic growth accounting framework measures the contribution of the growth of inputs and of technological progress to output growth . The analysis starts from a neoclassical production function, which defines GDP (Y) as a function of total factor productivity (A) and factor inputs (capital, K, and labor, L):

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \qquad (1)$$

Taking logs and time derivatives on both sides and assuming perfect competition, Solow (1957) shows how one can use estimates of the share of capital to weigh the contribution of the growth rates of inputs and obtain straightforward estimates of total factor productivity growth as a residual. However, the estimates of the Solow residuals are quite sensitive to adjustments to factor inputs for utilization and quality as well as to assumptions on the share of capital.

In order to improve the estimates of total factor productivity, the present study allowed for quality change in factor inputs by using indices that reflect changes in the composition of the capital stock and the labor force which make aggregate inputs more productive (see Jorgenson and Grilliches, 1967; Harberger, 1990; and Young, 1995). The production function can be redefined as:

$$Y_t = A_t (K_t z_t)^{\alpha} (L_t h_t)^{1-\alpha} \qquad (2)$$

where z and h are the indices of quality of capital and labor respectively. These indices are weighted averages of inputs of different quality (say, skilled and unskilled labor) and they provide an adjustment to the quantities of inputs similar to that obtained by translog indices.of subinputs.

The index of *quality of labor,* h, is defined as a weighted average of labor with different levels of education

$$h_t = \Phi (L_1, L_2, ..., L_n) = \sum_j \omega_j (L_j/L) \qquad (3)$$

where the weights ω_j are relative wages. This index was estimated for the case of Chile by Jadresic and Sanhueza (1992) and recently updated by the Central Bank of Chile.[2] [3]

Changes in the index of *quality of capital*, z, are computed as a weighted average of investment in machinery and equipment on the one hand, and in buildings and structures on

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[2]The author wishes to thank Eduardo Lopez for the updated series on the labor quality index. The data on the labor force and unemployment is from the National Statistics Institute of Chile, and from Jadresic and Sanhueza (1992).

[3]It is interesting to note that this type of index encompasses increases in human capital due to schooling as well as to on-the-job training or learning by doing—deemed crucial in the performance of the East Asian economies, see Lucas (1993).

the other, where the weights are relative rental rates.[4] The index z was estimated for Chile following the definition used in Christensen, Cummings and Jorgenson (1980):

$$\log z(t) - \log z(t-1) = \sum_i v_i [\log K_i(t-1) - \log K_i(t-2)] - [\log K(t-1) - \log K(t-2)] \quad (4)$$

where the weights v_i are the relative capital rental rates. While data on investment (and capital stocks) for machinery and equipment and for structures are available from the Central Bank of Chile, data on the rental rates of both types of capital are not available and estimates were produced using the arbitrage relation (see Barro and Sala-i-Martin, 1995; and Young, 1995):

$$R_i(t) = [1 + r(t)] P_i(t) - (1 - \delta_i) P_i(t+1) \quad (5)$$

where R is the rental rate, P is the price, and δ the depreciation rate for a capital good of type i, and r(t) is the economy-wide real interest rate. Estimates of the rentals and the index are presented in the Appendix Table. In order to take into account the volatility of the real exchange rate in Chile, which affects directly the relative price of both types of capital, two estimates of z are presented: one that excludes the effect of relative price changes, and the other, which includes a five-year moving average of relative price changes.[5] Index z (quality of capital) reflects the fact that assets with higher depreciation rates and declining relative prices should command comparatively higher rentals.

The estimated indices of the quality of labor (h) and capital (z) are presented in Figure 1. The index of labor quality displays a clear upward trend, reflecting improvements in human capital and a shift to higher-skilled jobs, as the economy came out of the deep recession of 1982-83. The quality of capital index shows a more uneven pattern, mainly reflecting the changes in the share of machinery and equipment in the capital stock, which dropped slightly over most of the 1970s before rising to 31 percent in 1995, from less than 20 percent in the late 1970s. It should be noted that these indices do not account for the differential productivity of capital and labor of different "vintages"—which remains to be captured in the residual TFP.

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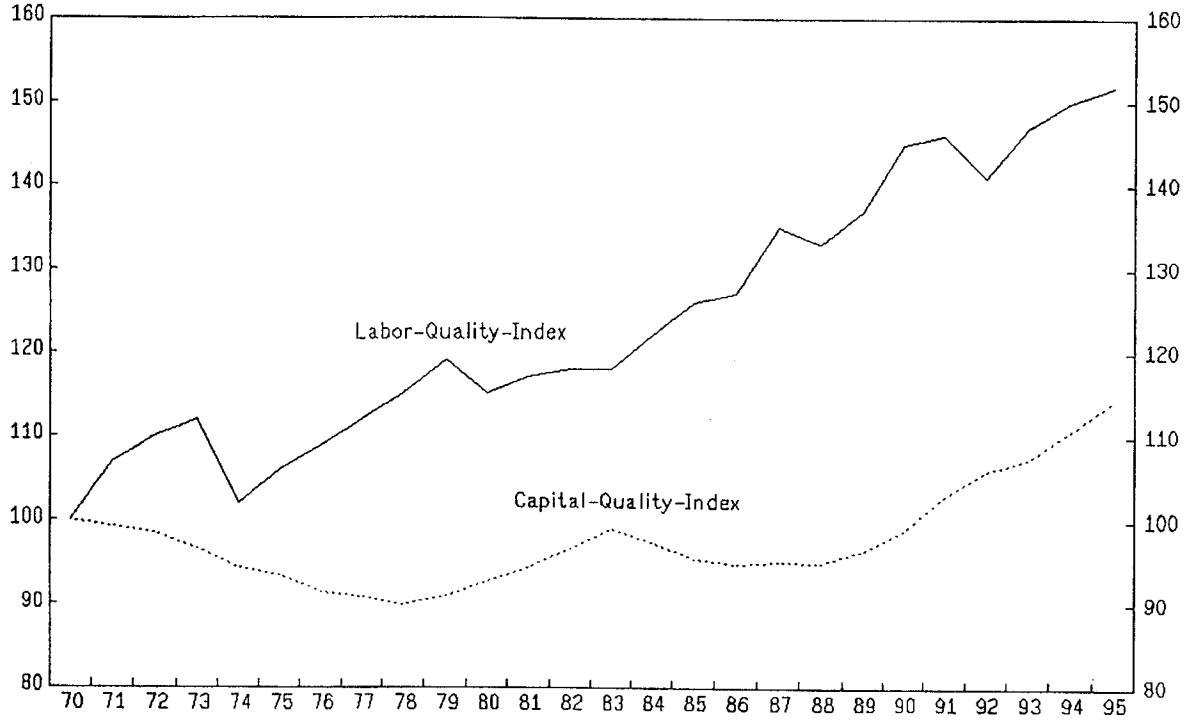
[4]The data on the capital stock, derived from investment figures at 1986 prices, is from the Central Bank of Chile.

[5]The relative price of both types of capital goods is computed as the ratio of the respective deflators relative to the GDP deflator.

Figure 1. Chile: Capital and Labor Quality Indices, 1970-96

(1970=100)



Sources: Central Bank of Chile; and Fund staff estimates.

III. Potential Output Estimates: A Production Function Approach

In this section, a production function is estimated using cointegration techniques. The estimated parameters are combined with a smoothed series for TFP and factor inputs to estimate potential output, and then relate the output gaps to inflation.

A. Production Function Estimates

The estimation of a production function is central to most recent studies of potential output growth (Adams and Coe, 1990; Coe and Moghadam, 1993; Jadresic and Sanhueza, 1992). It is even more important for the case of emerging market countries, where growth is generally faster than in industrialized countries and tends to dwarf short-run macroeconomic fluctuations. The estimation of a production function gives estimates of factor shares that will then be used to calculate Solow residuals or total factor productivity.

Some features of the recent Chilean growth experience, like the presence of large external shocks and structural reforms, makes it difficult to uncover the key parameters of a production function. The existence of stochastic trends in both the quantity and quality of inputs, as well as in GDP, requires the estimation of a cointegrating regression between output and quality-adjusted inputs (Coe and Moghadam, 1993). Moreover, the presence of two deep recessions (1973-74 and 1982-83), as well as the outstanding growth performance of the last decade suggest a potential role for dummies and/or breaks in trends. Indeed, Ben-David and Papell (1995) show that a large sample of industrialized countries exhibit a break in the level of output around World War II (and/or the Great Depression) followed by a nontrivial acceleration in the postbreak growth rate that persisted for several decades. The Chilean growth experience appears to share some of these features.

The results from the regressions, that estimate equation (2) using the annual data described in the previous section for the period 1966–95, are presented in Table 1. The first two regressions include, together with the quality-adjusted capital and labor variables, a constant (C), a deterministic trend (DT), a break in that trend beginning in 1985 (DTB) as well as a dummy variable (DU) for the recession of 1982–83. It turns out that, in line with the findings of Jadresic and Sanhueza (1992), the dummy for the 1982–83 recession is not significant. Hence, in regressions (3) and (4) of Table 1 a dummy for the boom in economic activity of 1979–81 was included, with better results.

The cointegration tests are based on the residuals of the static regressions of Table 1. Note that these tests are the most common ones, but they assume the existence of only one cointegrating vector. Campbell and Perron (1991) stress the importance of the inclusion of a constant and a deterministic trend component in these tests, as well as the fact that the asymptotic distribution of the test statistics depends on the number of integrated regressors

Table 1. Chile: Production Function-Regression Results

(Dependent Variable: Y = Log [GDP])

	Regressions				
	(1)	(2)	(3)	(4)	(5)
Variable					
Kz	0.588	0.619	0.589	0.442	0.722
	(0.22)	(0.23)	(0.16)	(0.08)	(0.10)
Lh	0.838	0.829	0.708		0.572
	(0.22)	(0.22)	(0.17)		(0.11)
C	-0.798	-1.209	0.20	3.608	-0.308
	(4.52)	(4.66)	(3.37)	(0.59)	(1.68)
DT	-0.024	-0.024	-0.023	-0.015	-0.018
	(0.01)	(0.01)	(0.01)	(0.002)	(0.005)
DTB	0.009	0.008	0.020	0.028	
	(0.01)	(0.01)	(0.01)	(0.004)	
DU		-0.024 1/	0.121	0.124	
		(0.05)	(0.03)	(0.03)	
Imk					0.135
					(0.03)
Summary statistics					
R^2 – adj.	0.965	0.967	0.980	0.817	0.983
DW stat.	1.010	0.970	1.760	1.560	1.746
S.E. of regr.	0.054	0.054	0.040	0.040	0.037
Cointegration tests 2/					
ADF	-3.46	-3.36	-4.20*	-3.75	-3.30
Phillips-Perron	-3.19	-3.12	-5.21**	-4.56**	-5.14**

Source: Author's estimates.

1/ Dummy variable for 1982–83; regressions (3) and (4) have dummy for period 1979–81. Standard errors are in parenthesis and are provided as an indication of the precision of the estimates. Note, however, that the statistic formed by the ratio of the estimate over the square of the standard error is not distributed t.

2/ The null hypothesis of co-integration is rejected at the 5 percent level (**) or at the 10 percent level (*), according to the Engle and Yoo's (1989) critical values.

and the nature of their deterministic trends. The null hypothesis of no-cointegration is rejected for the last two regressions, but could not be rejected for the first two.[6]

The factor shares estimated in regression (3), 0.59 for capital and 0.71 for labor, suggest the possibility of increasing returns to scale. However, the hypothesis of the sum of both coefficients being equal to one could not be rejected using standard tests.[7] Regression (4) imposes the assumption of constant returns to scale and yields an estimate of the share of capital equal to 0.44. It also confirms a fact noted in previous studies on the Chilean growth experience (Marfan and Bosworth, 1993; Jadresic and Sanhueza, 1992), this is the existence of a negative deterministic trend.[8] These authors have attributed the negative trend—interpreted as negative total factor productivity growth—to the large external and structural shocks that the Chilean economy faced during the 1970s and 1980s. It is interesting to note that, in contrast to these studies, a significant break in that trend is found here (see regression (4) in Table 1), which suggests that total factor productivity has been growing at approximately 1.3 percent per year since 1985, after two decades of persistent decline.

Endogenous growth theories have attempted to endogenize total factor productivity growth through a variety of channels. For the case of Chile, an economy with a high degree of openness, it seems appropriate to analyze the role that trade could have played in the recent growth experience. Grossman and Helpman (1991), Rivera-Batiz and Romer (1991), and others have shown that international trade can increase the growth rate of an economy by providing a wider range of intermediate inputs. More recently, Lee (1995) has shown that international trade, by providing relatively cheaper foreign capital goods, can increase growth through another channel—the efficiency of capital accumulation. Using cross country data for the period 1960–85, Lee shows that the ratio of imported to domestically produced capital goods has a significant positive effect on per capita income growth.

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[6]Engle and Yoo (1989) include a trend but no dummies or break in trends; critical values for the latter case are not available.

[7]Campbell and Perron (1991) mention that the asymptotic distribution of the OLS estimates of the parameters depends on the serial correlation of the errors as well as on the endogeneity of the regressors. Hence, the test of hypothesis should take those elements into account, for instance, by adding leads and lags of the first differences of the regressors. This approach was not followed here, as the small number of observations would have implied an important loss of degrees of freedom.

[8]Schmidt-Hebbel (1980) finds positive technological progress in the period 1960–1979, presumably as a result of the shorter sample that excludes the deep recession of 1982–83. The author also finds that the hypothesis of constant returns to scale—as well as unitary elasticity of substitution between capital and labor—cannot be rejected.

In order to test the effect of imported capital goods in Chile's GDP growth, the ratio of imported capital goods to total capital was included in regression (5) of Table 1 as the variable denoted as Imk.[9] Interestingly, the ratio of imported capital enters with a positive and statistically significant coefficient and renders insignificant the dummy and break-in-trend variables. More importantly, the ratio of imported capital follows an evolution quite similar to that of technological progress (as estimated in the next section), suggesting that an increase in the imported component of the capital stock in Chile could be behind the recent acceleration of TFP growth, which is consistent with the results in Coe, Helpman and Hoffmaister (1997).

B. Potential Output Estimates

The regression analysis of the previous section was based on actual GDP and factor utilization series, adjusted for quality. In order to estimate *potential* GDP, the cyclical components of total factor productivity (TFP) and labor input need to be removed. The smoothed series for TFP and the full utilization levels of labor and capital are combined according to equation (2) to produce the potential output estimates.

A series on TFP growth was estimated by subtracting a weighted sum of factor inputs from GDP growth, using as weights the factor shares estimated in regression (4) of Table 1. The series on TFP was then smoothed using the Hodrick-Prescott (HP) filter. The smoothed series displays a negative trend until 1985, when it begins trending upward (Figure 2). This confirms the results obtained by the regression trend and its break around 1985, following the consolidation of the process of stabilization and structural reforms.

Two approaches were used to remove the cyclical component of employment. The first approach, followed also by Jadresic and Sanhueza (1992), assumes the natural rate of unemployment to be 5.5 percent (the average of the actual unemployment rate in 1990–95, when the economy appeared to have attained full employment) and replaces the actual unemployment rate with that figure.[10] The second approach smooths the labor input by applying the Hodrick-Prescott filter to the actual employment figures. This technique captures a possible increase in the natural rate of unemployment in the late 1970s related to the initial frictional costs of structural reforms, in particular those derived from trade

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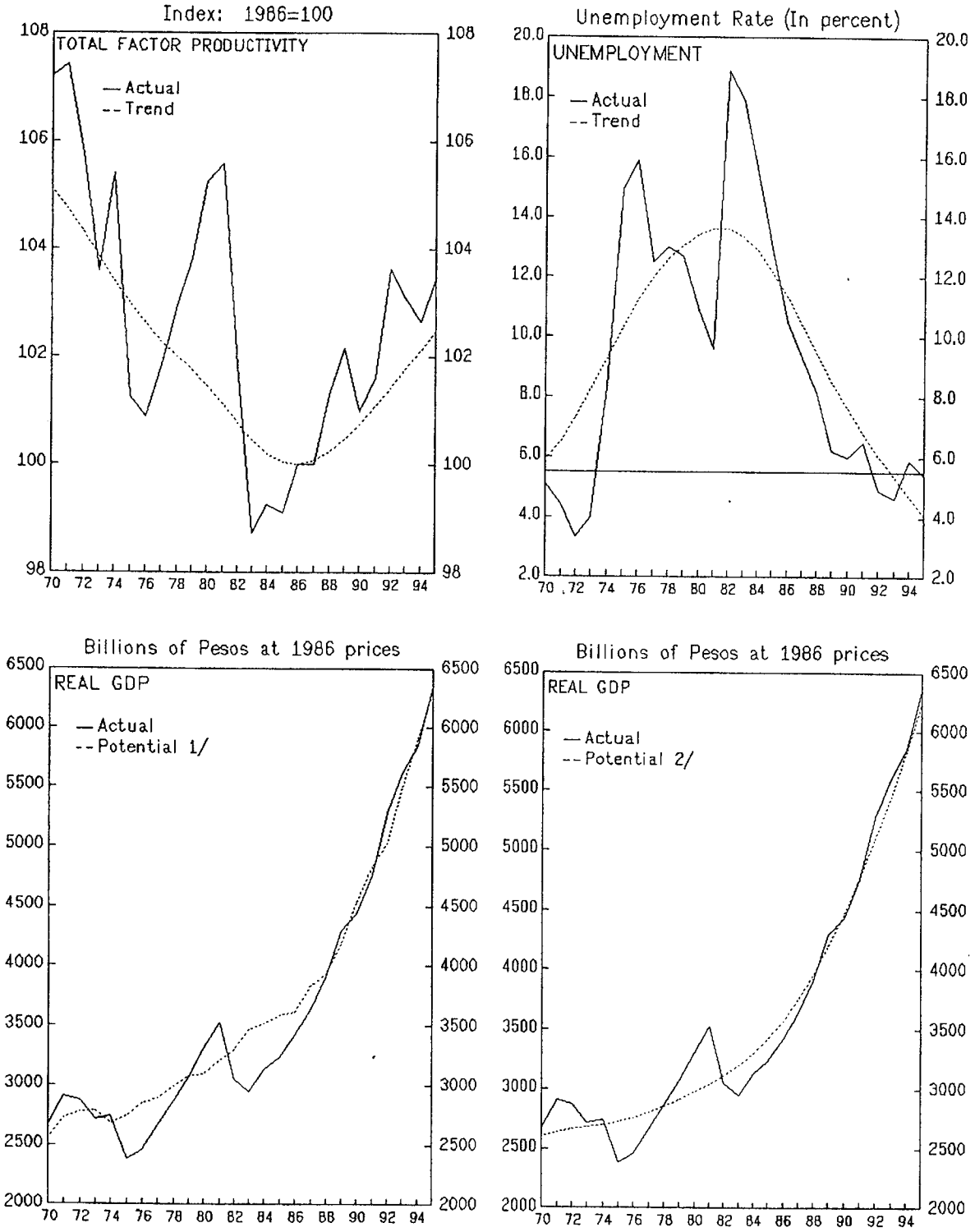
[9]In Lee's model, the ratio of imported to domestic investment is equivalent to a constant fraction of the ratio of imported investment to the total capital stock. We preferred to include the later ratio as it is more stable than the former in our sample period.

[10]The natural rate of unemployment measures that fraction of the labor force that is unemployed due to normal frictions in the process of job separations and findings (Barro, 1990). It is hence consistent with the concept of full employment of resources and potential output.

Figure 2. Chile: Potential Output, 1970-95



Sources: Central Bank of Chile; and Fund staff estimates.
1/ Assuming a natural rate of unemployment of 5.5 percent.
2/ Natural rate of unemployment estimated using a Hodrick-Prescott filter.

liberalization (see Chart 2).[11] It also captures the relatively large trend component in labor force participation found in micro-studies of the Chilean labor market (see García, 1995).

Estimates of Chile's potential output, using the labor input that results from the two above approaches to calculate the natural rate of unemployment and the smoothed TFP series, show a similar pattern (see Chart 2, bottom panels), especially for the last decade. In particular, both estimates show a positive output gap in the years when the economy was deemed to be overheated (1989 and 1992–93), leading the Central Bank of Chile to tighten monetary policy. The results also show that after a slowdown in 1994, the resumption of output growth in 1995 left the economy slightly above potential. Finally, assuming real GDP growth of 7 percent for 1996 would leave the level of output around 2 percent beyond its potential providing support for a tightening of financial policy.[12]

It is interesting to note that we could not find in the data on Chile, the positive association between output gaps and inflation typically found for industrialized countries and more recently also for several Asian countries (Coe and McDermott, 1996). This is consistent with the more general result that in most Latin American countries neither current nor lagged output gaps—estimated using statistically smoothing techniques on GDP data only—show any significant correlation with inflation (IMF, 1996). Indeed, the contemporaneous correlation between inflation and the output gap is negative, presumably reflecting the very high inflation in a large fraction of the sample, as well as the influence of two fairly long periods (1975–80 and 1985–96) of GDP growth acceleration and gradual disinflation.[13] This result is also consistent with the evidence found in Hoffmaister and Roldos (1997) for a large sample of Latin American countries.

IV. Sources of Growth: Chile Versus Other Country Experiences

Growth accounting is a useful framework for assessing alternative explanations of a country's growth experience and it provides a basis for medium-term projections (Maddison,

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[11]The average unemployment rate in 1976–80 was 13 percent despite average real GDP growth of 6.8 percent.

[12]The size of the output gap in 1996 would have been similar to that of 1989 but smaller than the 3.7 percent figure of 1992.

[13]Using quarterly data for Chile for the period 1985–95, the author was able to find a marginally significant positive influence of the output gap—lagged three quarters—on inflation. The model included three significant lags of inflation and the most important determinants of inflation appeared to be the contemporaneous rate of devaluation and the change in the terms of trade.

1987). However, as was discussed above, the measurement of the contribution of various factors of production to growth is quite sensitive, *inter alia,* to adjustments to factor inputs for utilization and quality, and to assumptions on the share of capital. In this section, two alternative measures of the sources of growth for Chile are presented to facilitate comparisons with other studies both of Chile as well as other comparable growth experiences in a sample of OECD countries and in Korea and Taiwan Republic of China. The first measure adjusts both factor inputs for the degree of utilization (using the unemployment rate, as in Solow, 1957), while the second one introduces the estimated indices of the quality of factor inputs.

A. Chile's Growth Experience

The Chilean economy grew at an average annual rate of 3.7 percent in real terms in 1971–95 (Table 2, Panel A). During that period labor and capital contributed in about equal amounts (1.3 and 1.6 percent) to the growth rate of GDP, while total factor productivity growth contributed with 0.8 percent (or about 22 percent of the total).[14] More recently, in the period 1986–90 factor inputs and TFP contributed about equally to the growth process, with an important contribution coming from labor. In contrast, during 1991–95 capital formation and TFP growth had a dominant role.

The contribution of the labor input to growth in the second half of the 1980s—a result of the reduction in unemployment to 4.6 percent in 1993 from 18.9 percent in 1982—was noted by Jadresic and Sanhueza (1992), and by Marfán and Bosworth (1994). The latter authors also concluded that the more recent acceleration of TFP growth was largely due to cyclical factors, in contrast with Dornbusch and Edwards (1994) and De Gregorio (1994) who attribute the recent gains in productivity to the process of structural reform and consider them to be of a more permanent nature.

Introducing quality change in factor inputs brings into sharper focus the relative roles of these inputs on the growth experience of the last decade (see Table 2, Panel B). In particular, in 1986–90 the quality-adjusted labor variable explains close to 60 percent of the growth rate of GDP, compared to 30 percent explained by the unadjusted labor variable, as the effect of the increase in the share of skilled labor in total employment—now captured by the labor quality index—is superimposed on the fall in unemployment. In 1991-95 the accumulation of capital is the main engine of growth, explaining 55 percent of output growth owing to the increase in the investment rate as well as the rising share of machinery and equipment in total capital. With these changes, TFP growth is reduced significantly compared

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[14]The low contribution of TFP for this period may be associated with weaknesses in the data. For example, data on hours worked are not available and the series on employment that were used may underestimate the fall in utilization of inputs in the deep recessions of 1973–75 and 1982–83.

Table 2. Chile: Sources of Growth

	Growth Rates			Contribution From		
	GDP	Capital	Labor	Capital (0.44)	Labor (0.56)	TFP
Panel A: Data Adjusted for Utilization of Inputs 1/						
1971–95	*3.7*	*3.7*	*2.4*	*1.6*	*1.3*	*0.8*
1971–75	-2.0	1.8	-0.7	0.8	-0.4	-2.4
1976–80	6.8	2.7	4.3	1.2	2.4	3.2
1981–85	-0.1	2.2	2.1	1.0	1.2	-2.3
1986–90	6.5	5.1	3.7	2.2	2.0	2.2
1991–95	7.5	6.4	2.4	2.8	1.4	3.3
Panel B: Data Adjusted for Quality of Inputs						
1971–95	*3.7*	*4.2*	*4.1*	*1.9*	*2.3*	*-0.4*
1971–75	-2.0	2.6	0.6	1.1	0.3	-3.5
1976–80	6.8	1.6	6.0	0.7	3.4	2.7
1981–85	-0.1	3.3	4.0	1.5	2.2	-3.8
1986–90	6.5	4.3	6.6	1.9	3.7	0.9
1991–95	7.5	9.4	3.4	4.1	1.9	1.4

Sources: Central Bank of Chile; National Statistics Institute; and author's estimates.

1/ Date on employment were used for the labor input. The capital stock data were adjusted using the actual unemployment rate.

with the unadjusted figures. For the period 1986–90, it falls (without adjustment) from 2.2 percent to 0.9 percent, while in the period 1991–95 estimated TFP growth falls from 3.3 percent to 1.4 percent.[15]

B. International Comparisons

Chile's sources of growth also could be assessed by examining the experience of other countries with comparable phases of growth acceleration. Table 3 summarizes the results of two studies using comparable methodologies that also adjust for quality change in factor inputs. The first study focuses on a sample of OECD countries in the postwar period up to the 1973 oil shock (Christensen, Cummings and Jorgenson, 1980), and the second one concentrates on Korea and Taiwan Republic of China (Young, 1995). The results show that the rapid growth in the East Asian countries is largely explained by the accumulation of quality-adjusted inputs, and that TFP accounted for only one fifth of the GDP growth rate. The studies also show a relatively large contribution of the labor input in East Asia, a result of an increase in participation rates. For the OECD countries, the increase in participation rates is much slower than in the East Asian countries and it is sometimes outweighed by a decline in average hours worked.

The recent Chilean experience shares some of the features of the East Asian economies. In particular, Garcia (1995) shows that the participation rate increased by more than 4 percentage points between 1986 and 1994, largely as a result of an increase in female participation. Although investment rates have not reached the levels of some Asian countries, they have increased substantially—to 27 percent in 1995 from around 20 percent of GDP in the late 1980s. Chile and the East Asian countries also share relatively low contributions of TFP compared with OECD countries. This result has recently been generalized for a larger sample of developing countries by Bosworth, Collins and Chen (1995).[16]

C. Potential Output Growth Projections

Based on the regression results and the HP-filtered variables introduced in the previous section, a baseline projection for potential output was made as an extrapolation of the trends of the last five years for each of the components in equation (2). The average growth rate of real GDP for the period 1995–2000 in this baseline projection was 6.9 percent.

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[15]Jadresic and Sanhueza (1992) predicted an acceleration of TFP growth to 1–2 percent for the period 1991–95, from the negative trend found for the 1970s and 1980s. Their residuals should be between those of Panel A and those of Panel B, as they adjust the data for utilization and the quality of labor, but do not account for the quality of capital.

[16]These authors use postulated shares of capital and measures of school attainment as proxies for human capital, but they do not adjust for the quality of capital.

Table 3. Sources of Growth: International Comparison 1/

	Growth Rates			Contribution From		
	GDP	Capital	Labor	Capital	Labor	TFP
Panel A: OECD 1947–73						
Canada						
1947-60	5.2	6.8	1.1	2.9	0.6	1.7
1960-73	5.1	4.9	2.0	2.2	1.1	1.8
France						
1950-60	4.9	4.7	0.3	1.8	0.2	2.9
1960-73	5.9	6.3	0.4	2.6	0.2	3.0
Germany						
1950-60	8.2	6.9	1.6	2.5	1.0	4.7
1960-73	5.4	7.0	-0.7	2.8	-0.4	3.0
Italy						
1952-60	6.0	3.3	1.6	1.3	1.0	3.8
1960-73	4.8	5.4	-0.7	2.1	-0.4	3.1
Japan						
1952-60	8.1	4.5	4.8	1.6	3.1	3.4
1960-73	10.9	11.5	2.7	4.8	1.6	4.5
Average	*6.5*	*6.1*	*1.3*	*2.5*	*0.8*	*3.2*
Netherlands						
1951-60	5.0	4.0	1.4	1.9	0.7	2.3
1960-73	5.6	6.6	0.3	2.8	0.2	2.6
United Kingdom						
1955-60	3.3	4.5	0.2	1.7	0.1	1.5
1960-73	3.8	4.6	0.0	1.8	0.0	2.1
United States						
1947-60	3.7	4.5	1.0	1.8	0.6	1.4
1960-73	4.3	4.0	2.2	1.7	1.3	1.3
Average	*5.6*	*5.6*	*1.1*	*2.3*	*0.7*	*2.7*
Panel B: East Asia 1966–90						
Korea						
1966-70	14.4	19.4	10.3	6.0	7.1	1.3
1970-80	9.4	14.8	5.4	4.8	3.6	1.1
1980-90	9.6	10.4	6.0	2.8	4.4	2.5
Taiwan						
1966-70	11.1	17.1	4.4	4.5	3.3	3.4
1970-80	10.3	14.4	6.8	3.8	5.0	1.5
1980-90	7.8	8.3	3.2	2.1	2.4	3.3
Average	*10.4*	*14.1*	*6.0*	*4.0*	*4.3*	*2.2*

Sources: Panel A: Christensen, Cummings, and Jorgenson (1980); Panel B: A. Young (1995).

1/ Capital and labor inputs adjusted for quality.

This baseline projection was supplemented with estimates of high and low bounds for potential output growth. These bounds were estimated using inferences from a comparison of the recent Chilean growth experience with the European and East Asian experiences briefly summarized above, as well as insights from other growth experiences. Under the assumptions on factor inputs and TFP growth described below, the projections using equation (2) yielded 6.4 percent for the average low growth rate and 7.5 percent for the average high growth rate.

Population growth was estimated at 1.7 percent a year during 1996–2000 (from the United Nation's Economic Commission for Latin America). The participation rate in Chile, which is still fairly low compared to other countries, was assumed to increase from the current level of 54.7 percent to 56.7 percent by the year 2000 in the high growth scenario, and to 56.2 percent in the low growth scenario. The unemployment rate was assumed to remain at about 5 percent in the low growth scenario and to fall to 4.2 percent by the year 2000 in the high growth scenario.

The index of quality of labor in Chile rose at an average annual rate of 1.7 percent in the period 1985–95, but slowed to 0.9 percent in the last five years. A comparable measure of labor quality for Korea and Taiwan Province of China during 1966–90 shows average growth rates of 1 percent and 0.3 percent, respectively (Young, 1995), reflecting a structural shift toward higher-skilled jobs in the composition of the labor force. Taking into account these elements and the Chilean Government's commitment to step up investment in human capital, the projections for Chile assume that the quality of labor would grow at 0.8 percent a year through 2000 in the high growth scenario, and at 0.6 percent a year in the low growth scenario.

The recent acceleration of physical capital accumulation was assumed to continue in the high growth scenario, albeit at a slower pace with gross fixed capital formation rising to 29 percent by the year 2000 from the current level of 27 percent of GDP. In the low growth scenario fixed capital formation was assumed to return gradually to 24 percent of GDP (the level prevailing at the beginning of the 1990s). The index of quality of capital was assumed to remain unchanged in the low growth scenario, and to grow by 0.5 percent a year in the high growth scenario.

Despite its recent acceleration, TFP growth in Chile has been slower than in other countries. Looking ahead, it is reasonable to expect an increase in TFP growth because of the recent investment in equipment (suggesting a larger share of more productive "vintages" of capital) and the large fraction of that equipment that is imported, which has proven to be a vehicle for knowledge spillovers (Coe, Helpman and Hoffmaister, 1997). On that basis, the low growth scenario assumes a TFP growth rate of 1.9 percent and the high growth scenario one of 2.4 percent, compared to an average rate of 1.4 percent in the last five years.

V. Concluding Remarks

A fairly disaggregated study of the sources of growth in Chile shows that the last decade of rapid growth can be divided into two different subperiods, one in which the absorption of unemployed—and underemployed—labor is the main engine of growth, followed by another one where capital accumulation—mainly in machinery and equipment—is the driving force. It also shows that the Chilean experience shares some features with the growth processes in other emerging market countries, namely, an important increase in labor force participation and low TFP growth. More importantly, a comparison with other growth experiences such as the European and East Asian suggests that Chile's potential output could continue to grow at rates around 7 percent a year in the medium run, as labor force participation and investment continue to increase and the rate of TFP growth is likely to accelerate. It is important to stress, however, that actual output growth may lag behind potential in the next years, as the economy faces adverse external shocks and inflation is brought down to international levels.

The empirical results in this study have some policy implications. In particular, they underscore the current efforts in Chile to increase the level of human capital via increases in schooling. As emphasized in Lucas (1993), on-the-job training (learning-by-doing) could be an even more important factor in sustaining high growth rates. In this respect, keeping the flexible labor market policies that have allowed Chile to achieve unemployment rates below the 5 percent level, appears also to be an important policy lesson from this study.

The results also suggest some issues for further research. First, as mentioned in Section III of the paper, total factor productivity appears to be correlated with the ratio of imported capital goods to total capital. This might be a good starting point to better understand the process of technology adoption that could sustain high rates of output growth. Second, it would be important to embed the potential output estimates in a model that specifies explicitly the price-wage dynamics triggered by positive output gaps, to better appreciate the role output gaps may have played in the more recent inflationary experience.

Appendix Table. Chile: Real Interest Rates, Rental Prices, and the Quality of Capital, 1965–95

	Real Interest Rates 1/	Rental Price of Structures (Without Price Change)	Rental Price of Mach. and Eq. (Without Price Change)	Index Quality of Capital Stock (Without Price Change 1970=100)	Rental Price of Structures (With MA Price Change)	Rental Price of Mach. and Eq. (With MA Price Change)	Index Quality Capital Stock (1970=100)
1965	9.3	0.118	0.193	104.3	0.096	0.180	104.9
1966	10.2	0.127	0.202	102.9	0.098	0.217	103.2
1967	10.0	0.125	0.200	100.8	0.116	0.209	100.9
1968	10.1	0.126	0.201	100.3	0.125	0.212	100.3
1969	10.4	0.129	0.204	99.9	0.113	0.212	99.9
1970	9.7	0.122	0.197	100.0	0.073	0.216	100.0
1971	8.3	0.108	0.183	99.5	0.053	0.207	99.3
1972	7.8	0.103	0.178	99.0	0.008	0.168	98.6
1973	11.2	0.137	0.212	97.9	0.040	0.133	96.7
1974	10.5	0.130	0.205	96.1	0.074	0.147	94.4
1975	7.1	0.096	0.171	95.2	0.071	0.149	93.4
1976	8.0	0.105	0.180	93.4	0.081	0.143	91.5
1977	9.0	0.115	0.190	92.7	0.133	0.191	90.8
1978	10.4	0.129	0.204	91.9	0.147	0.302	90.0
1979	12.2	0.147	0.222	92.7	0.149	0.296	91.0
1980	12.3	0.148	0.223	94.4	0.150	0.199	92.7
1981	14.7	0.172	0.247	96.1	0.183	0.249	94.3
1982	15.5	0.180	0.255	98.5	0.179	0.239	96.6
1983	11.1	0.136	0.211	100.9	0.112	0.169	99.0
1984	9.2	0.117	0.192	99.1	0.102	0.119	97.4
1985	9.1	0.116	0.191	96.9	0.106	0.175	95.4
1986	7.6	0.101	0.176	96.3	0.086	0.143	94.8
1987	7.2	0.097	0.172	96.6	0.076	0.151	95.2
1988	7.4	0.099	0.174	96.5	0.095	0.152	95.0
1989	8.9	0.114	0.189	97.9	0.102	0.206	96.5
1990	12.7	0.152	0.227	100.0	0.129	0.265	98.9
1991	8.3	0.108	0.183	103.2	0.075	0.216	103.0
1992	8.3	0.108	0.183	105.6	0.086	0.224	106.0
1993	9.3	0.118	0.193	106.8	0.113	0.252	107.4
1994	9.3	0.118	0.193	109.6	0.116	0.242	110.7
1995	8.5	0.110	0.185	112.7	0.112	0.217	114.2

1/ Source: For 1980-95, Indexed interest on 1-3 year loans; BCCH, Indicadores Economicos y Sociales; for 1960-80, Cuadro 14 of "Ahorro Interno y Crecimiento Economico", Mario A. Gutierrez, Cuad. de Econ., December 1970.

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