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CHILE'S ECONOMIC GROWTH*

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Chile's average per capita GDP growth of 4.1% during 1991-2005 was significantly higher than average world growth during the same period and was a strong break from its own past. How much of Chile's recent growth is trend growth and how much is cyclical, influenced largely by external conditions? Which are the main determinants of Chile's long-term growth and cyclical fluctuations, according to the recent empirical literature? Which are the country's main growth strengths and weaknesses, and, based on the latter, which are the policy reforms advocated by recent technical studies and campaign proposals? This review article addresses the latter questions, starting with the facts about Chile's average growth and growth volatility at the aggregate, regional, and economic-sector level. Then the paper surveys trend growth studies for Chile that range from decomposition by sources of growth to econometric and simulation studies of deep growth determinants, based on international panel-data and national time-series evidence, and on research focused on individual reforms. Studies on short-term output fluctuations and cyclical recoveries in Chile, also comprising cross-country and national time-series evidence, are presented next. This issue of Cuadernos publishes six new, relevant research papers on Chile's growth, which are briefly introduced. Then the paper reviews selectively growth-enhancing policy proposals that have been put forward by academic authors, international organizations, and presidential candidates in their 2005 campaign programs. An epilogue with brief thoughts about Chile's growth potential and policy reform challenges closes the paper.

JEL: O40, O47, O54

Keywords: Economic Growth, Productivity, Chile, Growth Policies, Structural Reform.

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1. INTRODUCTION

*“Once one starts to think about them (growth issues),
it is hard to think about anything else”
(Lucas, 1988)*

*(Chile’s) “... overarching policy challenge
is to lift the economy’s growth potential”
(OECD, 2005)*

Chile grew at an average per capita GDP rate of 4.1% during 1991-2005, breaking with its past mediocre growth performance of barely 1.5% recorded from its independence (1810) to 1990. The country’s high growth during the last 15 years also exceeds significantly the world’s average per capita growth during the same period (at 1.4%) and that of most individual countries and regions. How much of Chile’s recent growth is trend growth and how much is cyclical, influenced largely by external conditions? Which are the main determinants of Chile’s long-term growth and cyclical fluctuations, according to the recent empirical literature? Which are the country’s main growth strengths and weaknesses, and, based on the latter, which are the policy reforms advocated by recent technical studies and campaign proposals?

This article addresses the latter questions, motivated by Lucas’ intellectual obsession with growth and the OECD’s key policy prescription for Chile that I have quoted above. In section 2, I revise the facts about Chile’s average growth and growth volatility at the aggregate level (contrasting the recent past to Chile’s history and to international experience) and describe the country’s growth performance at regional and economic-sector levels. Then I review the literature on trend growth in Chile, ranging from decomposition by sources of growth to econometric and simulation studies of deep growth determinants, based on international panel-data and national time-series evidence, and on research focused on individual reforms. In section 4, I review research that has analyzed short-term output fluctuations and cyclical recoveries in Chile, also comprising cross-country and national time-series evidence. This issue of *Cuadernos de Economía* publishes six new and relevant research papers on Chile’s growth, introduced in section 5, that focus on trend growth determinants, regional growth convergence, aggregate TFP determinants, economic sector-level TFP dynamics, and the behavior of manufacturing-sector TFP using plant-level and sub-sector data. Section 6 is devoted to a selective review of growth-enhancing policy proposals made by academic authors, international organizations, and presidential candidates in their 2005 campaign programs. I close the paper with brief thoughts about Chile’s growth potential and major policy reform challenges.

2. GROWTH FACTS

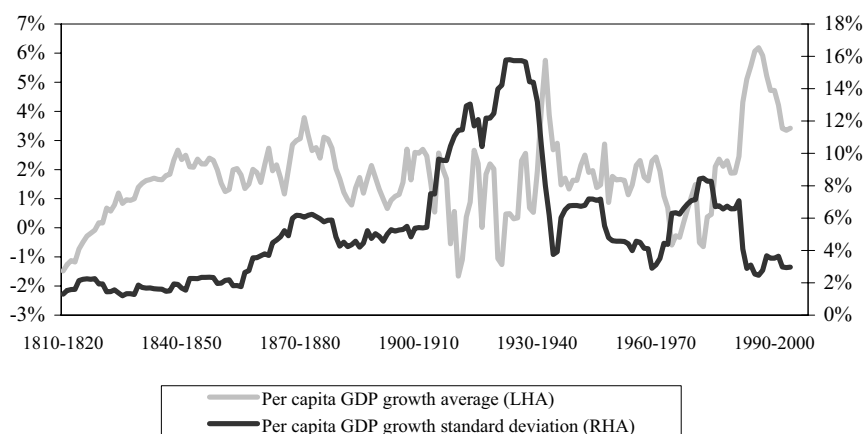
2.1 Long-term Growth and Volatility (1810-2005)

Chile has recorded an impressive economic expansion during the last two decades, reflected in 4.8% average annual growth of per capita GDP from 1986 to 2005. The period after 1985 was also exceptional regarding booms and busts, featuring only one recession of moderate magnitude in 1999. Chile's relative output stability during 1986-2005 is reflected in a moderately low standard deviation of per capita GDP growth, at 3.1%.

This favorable combination of a high first moment and a low second moment of growth is exceptional in Chilean economic history. Chile's average per capita GDP growth has been only 1.7% in the period spanned from 1810 through 2005 – the country's full history as an independent nation. And Chile's long-term growth volatility –at a 6.3% standard deviation of per capita growth from 1810 to 2005– doubles the above mentioned figure recorded during the last 20 years.

A more detailed account of growth rates and growth volatility for all of Chile's independent history is summarized in Figure 1 and Table 1. After low growth in the first three decades that followed independence, Chile attained per capita growth that averaged 2.3% between 1840 and 1910. Growth instability rose almost monotonically throughout the 19th century, peaking at 6.2% during

FIGURE 1
PER CAPITA GDP AVERAGE GROWTH AND GROWTH VOLATILITY
IN CHILE, 1810-2005
(10-year windows)



Source: Díaz *et al.* (1998) and Central Bank of Chile.

TABLE I
 PER CAPITA GDP AVERAGE GROWTH RATE AND GROWTH
 VOLATILITY IN CHILE, 1810-2005
 (by decades)

	Per capita GDP growth average	Per capita GDP growth standard deviation
1810-1820	-1.5%	1.3%
1820-1830	0.2%	1.9%
1830-1840	1.4%	1.9%
1840-1850	2.7%	1.9%
1850-1860	2.0%	2.0%
1860-1870	1.9%	3.5%
1870-1880	3.0%	6.2%
1880-1890	2.0%	4.8%
1890-1900	1.7%	5.0%
1900-1910	2.6%	5.4%
1910-1920	0.6%	11.1%
1920-1930	2.0%	12.5%
1930-1940	0.5%	14.4%
1940-1950	1.6%	6.8%
1950-1960	1.8%	4.6%
1960-1970	2.3%	2.9%
1970-1980	1.1%	7.1%
1980-1990	1.9%	6.6%
1990-2000	4.7%	3.5%
1995-2005	3.4%	3.0%

Source: Díaz *et al.* (1998) and Central Bank of Chile.

the 1870s. Average growth fell massively and growth volatility rose dramatically between 1910 and 1940 –the worst three decades in Chile’s growth history. The Chilean economy, highly open to the world economy and lacking stable domestic institutions and policies, suffered from external and domestic shocks and rising domestic economic and political instability between the World War I and the early 1930s. Deteriorating external conditions –associated to World War I, the declining world demand for Chilean nitrate, and the subsequent Great Depression– led to the deepest recorded GDP loss in the world –Chile’s– between 1930 and 1932. Adverse foreign shocks, combined with domestic institutional instability, resulted in misguided and unstable economic policies that led to financial crises and government coups during the 1920s and early 1930s, exacerbating economic uncertainty and output instability.

As a response to the Great Depression and in tandem with a closing world economy, Chile adopted an import-substitution strategy based on government-

led industrialization.¹ Starting in the mid-1930s and increasingly until the mid-1970s, successive governments strengthened their role in resource allocation and property, broadened market interventions, expanded social policies and government transfers, and engaged in largely destabilizing macroeconomic policies. After a short period of high growth that characterized the post-Depression recovery, average per capita growth attained just 1.4% between 1938 and 1973, with a standard deviation of 5.1%.

The government-led development strategy peaked during the 1970-1973 period of “Chile’s road to socialism”, when government intervention, economic mismanagement, and socio-political conflict were reflected in large uncertainty and stagnating growth. The ensuing coup and military dictatorship led to a U-turn in development strategy, with the adoption of market-based institutions and policies, gradual macroeconomic stabilization, large-scale privatization and market deregulation, and integration into the world economy. However, as a result of severe domestic policy mistakes and two major international recessions, average growth was modest between 1974 and the mid-1980s, while growth volatility was very high.

Yet the structural reforms of the 1970s and 1980s paved the way for the high growth recorded during the last two decades. Macroeconomic stabilization and structural reforms were deepened by the successive governments that have ruled Chile since the return to democracy in 1990. Therefore it is hard to dispel the notion that Chile’s recent growth record –exceptional by its own historical standards– is related to the broad policy framework that has been adopted since the mid-1970s. However, before jumping to easily to the latter conclusion, let’s review Chile’s growth record in international comparison – an exercise that is particularly relevant when considering that Chile’s small economy is highly dependent on world economic conditions.

1.2 International Comparison (1820-2005)

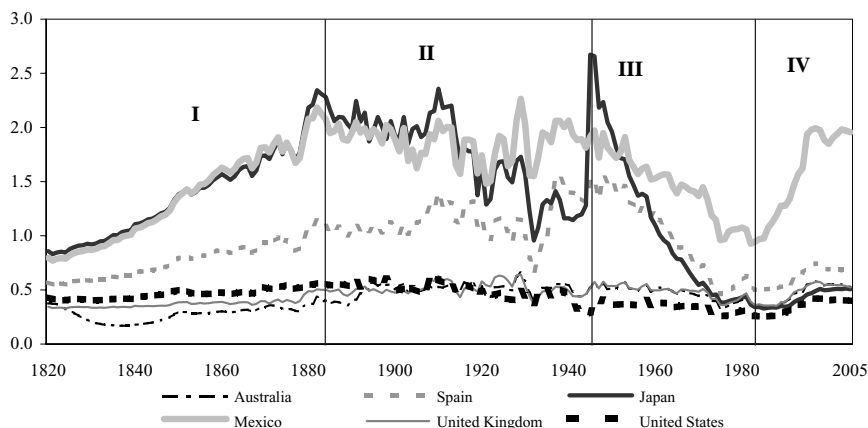
Chile’s uneven growth history is confirmed in international comparison. Figure 2 depicts Chile’s per capita GDP level relative to per capita GDP levels of six representative economies during the last 185 years.² While Chile’s relative performance is somewhat dependent on each individual country,³ a common

¹Phelps (1935) reviews Latin American policies implemented after the Great Depression, arguing that the rise in trade tariffs in developed countries was a critical factor for their implementation in the region. Ellsworth (1945) analyzes domestic policies following the Great Depression (abandoning the Gold Standard, introduction of exchange-rate controls, and increase of import duties, among others), presenting a favorable view of the industrialization strategy. Mamalakis (1976) provides a historical analysis of Chilean economic growth between independence and the early 1970s. Hurtado (1988) reviews Chile’s growth performance from 1930 to the 1980s. Lüders (1998) assesses Chile’s comparative economic performance from 1810 through 1995.

²Country choice was determined by data availability and relevance for Chile.

³For example, Chile’s performance improves *vis-à-vis* Spain between 1880 and 1940 but deteriorates *vis-à-vis* Japan during the same time span.

FIGURE 2
RATIO OF CHILE'S PER CAPITA GDP AND SELECTED COUNTRIES'
PER CAPITA GDP, 1820-2005
(Annual data)



Source: Díaz *et al.* (1998), IMF and Central Bank of Chile.

Note: Based on per capita GDP levels expressed at PPP-based exchange rates.

average pattern regarding Chile's relative growth performance is apparent. Considering the full 1820-2005 period, Chile's relative GDP ended up in 2005 at a similar or slightly lower level than in 1820, in comparison to the five currently industrialized countries (Australia, Japan, Spain, the US, and the UK), improving only relative to Mexico. This may be representative of Chile's general historic growth record –growing more than most developing economies but somewhat less than industrial countries.

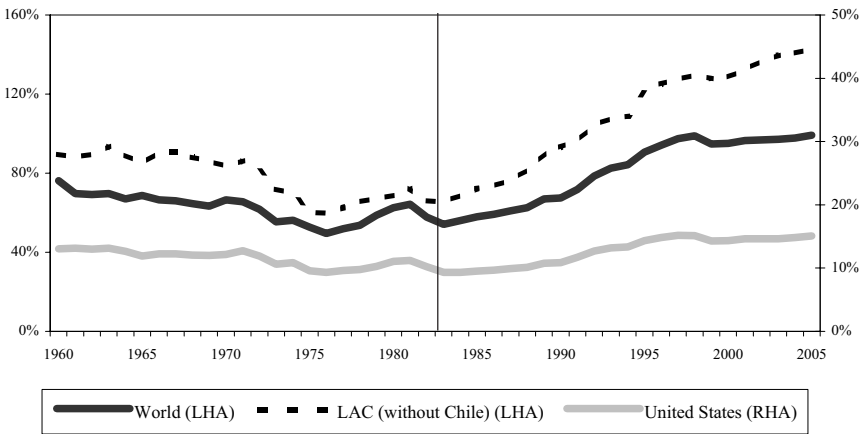
Chile's almost two centuries of independent economic performance can be roughly divided into four periods of growth convergence and divergence. The country was on a path of income convergence during much of the 19th century, from 1820 until ca. 1880. During the second phase, from the 1880s until 1930, Chile's relative output performance stagnated on average *vis-à-vis* the rest of the world, particularly in comparison to Australia, the US, and the UK. The Great Depression started the third growth phase that lasted until the mid-1980s, a long period during which the Chilean economy featured unambiguous growth divergence, losing relative weight in the world economy.⁴ Chile's relative GDP fell from 1930 to 1983 *vis-à-vis* all countries, a decline that ranges from 0.54 to 0.36 in comparison to the UK and from 1.57 to 0.34 compared to Japan.

⁴Lüders (1998) argues that the break between convergence and divergence occurred towards the end of the 19th century and the beginning of the 20th century, and not as a result of the Great Depression.

The past 20 years of exceptional growth are confirmed in international comparison. During this fourth growth phase Chile records a vigorous relative GDP improvement in comparison to all six countries. However, Chile's relative improvement is not monotonic. After major convergence during the "golden years" of high growth 1986-1997, the 1997-1998 Asian crisis and its aftermath affects Chile's growth performance more negatively than that of comparator countries. Only more recently –since 2004– Chile's relative GDP position starts to improve again. Yet considering the full 1985-2005 period, Chile's relative GDP rise ranges from 0.25 to 0.4 compared to the US and from 0.97 to 1.96 relative to Mexico.

The ratios between Chile's per capita GDP level relative to those of the world, Latin America and the Caribbean (LAC), and the US are depicted for 1960-2005 in Figure 3.⁵ Table 2 (upper half) reports per capita GDP growth rate averages for Chile, LAC, the East Asia and Pacific (EAP) region, Japan, the US, and the world, during 1961-2004 and sub-periods. The pattern discussed above is confirmed here. Chile's economy diverged by growing less than most countries and regions from the 1960s through the mid-1980s, and subsequently converged by growing more from the mid-1980s to 2005. Relative to world (LAC) per capita GDP, Chile's per capita GDP fell from 76% (90%) in 1960 to 55% (65%) in 1983, subsequently recovering to attain 99% (143%) in 2005. The exception to the previous pattern is Chile's performance compared to EAP, where per capita growth has been systematically higher than in Chile, including the last 20 years.

FIGURE 3
RATIO OF CHILE'S PER CAPITA GDP TO PER CAPITA GDP IN
THE WORLD, LATIN AMERICAN AND CARIBBEAN REGION,
AND THE UNITED STATES, 1960-2005



Source: World Bank (2005) and IMF.

Note: per capita GDP levels in US\$ at year 2000 market exchange rates.

⁵Due to lack of available data, the GDP series relative to the world and LAC start only in 1960.

TABLE 2
PER CAPITA GDP AVERAGE GROWTH RATE AND PER CAPITA
GROWTH VOLATILITY IN CHILE AND SELECTED COUNTRIES AND
REGIONS, 1961-2004

	1961-1970	1971-1980	1981-1990	1991-2004	1961-2004
Average GDP per capita growth					
Chile	1.9%	1.4%	2.3%	4.2%	2.6%
LAC (without Chile)	2.6%	3.2%	-0.9%	1.2%	1.5%
East Asia & Pacific	2.5%	4.5%	5.8%	6.7%	5.0%
Japan	9.3%	3.3%	3.4%	1.2%	4.0%
US	2.5%	2.2%	2.3%	1.9%	2.2%
World	3.3%	2.0%	1.3%	1.4%	1.9%
Volatility of GDP per capita growth (standard deviation)					
Chile	2.5%	6.8%	6.1%	3.3%	4.9%
LAC (without Chile)	1.9%	1.4%	2.1%	2.2%	2.4%
East Asia & Pacific	7.0%	2.1%	1.6%	2.3%	4.0%
Japan	2.2%	2.9%	1.7%	1.5%	3.7%
US	1.8%	2.6%	2.3%	1.5%	2.0%
World	5.2%	4.7%	1.3%	0.9%	3.4%

Source: Bank (2005).

Similar results are obtained when comparing Chile's growth volatility to the growth volatility recorded in major regions (Table 2, lower half).⁶ Chile's increasing stability is reflected by a large decline in the standard deviation of per capita GDP growth in 1991-2004, in comparison to the growth volatility observed in the 1970s and 1980s. This evolution of Chile's second moment of growth is favorable compared to LAC's and EAP's, where growth volatility rose in 1991-2004, but is similar to the increased stability observed in industrial countries (the US and Japan) and the world at large, during the same time span.

The correlation between Chile's and the world's per capita GDP growth declined (statistically) to zero during 1990-2004, in comparison to the positive significant correlations –close to 0.5– observed in 1961-1974 and 1975-1989 (Table 3). The change in correlations between Chile's per capita GDP growth and that of individual industrial countries and the Eurozone is even stronger, reflecting significant delinking between Chile and industrial economies since 1990. However, the opposite pattern is observed in Chile's growth correlation with LAC, which shifts from negative and significant in 1961-1974 to positive and significant during the past three decades.

⁶The size of Chile's standard deviation of growth is typically larger than the standard deviations of growth of any region because country-specific shocks are smoothed out in large regions.

TABLE 3
CORRELATION BETWEEN CHILE'S PER CAPITA GDP AND PER CAPITA
GDP IN SELECTED COUNTRIES AND REGIONS, 1961-2004

	1961-2004	1961-1974	1975-1989	1990-2004
World	0.32	0.48	0.55	-0.08
LAC (without Chile)	0.14	-0.57	0.46	0.43
US	0.24	-0.15	0.59	-0.10
European Monetary Union	0.07	-0.10	0.70	-0.18
Japan	-0.02	0.04	0.61	0.20
United Kingdom	-0.09	-0.54	0.19	-0.21

Source: Author's calculations based on World Bank (2005) data.

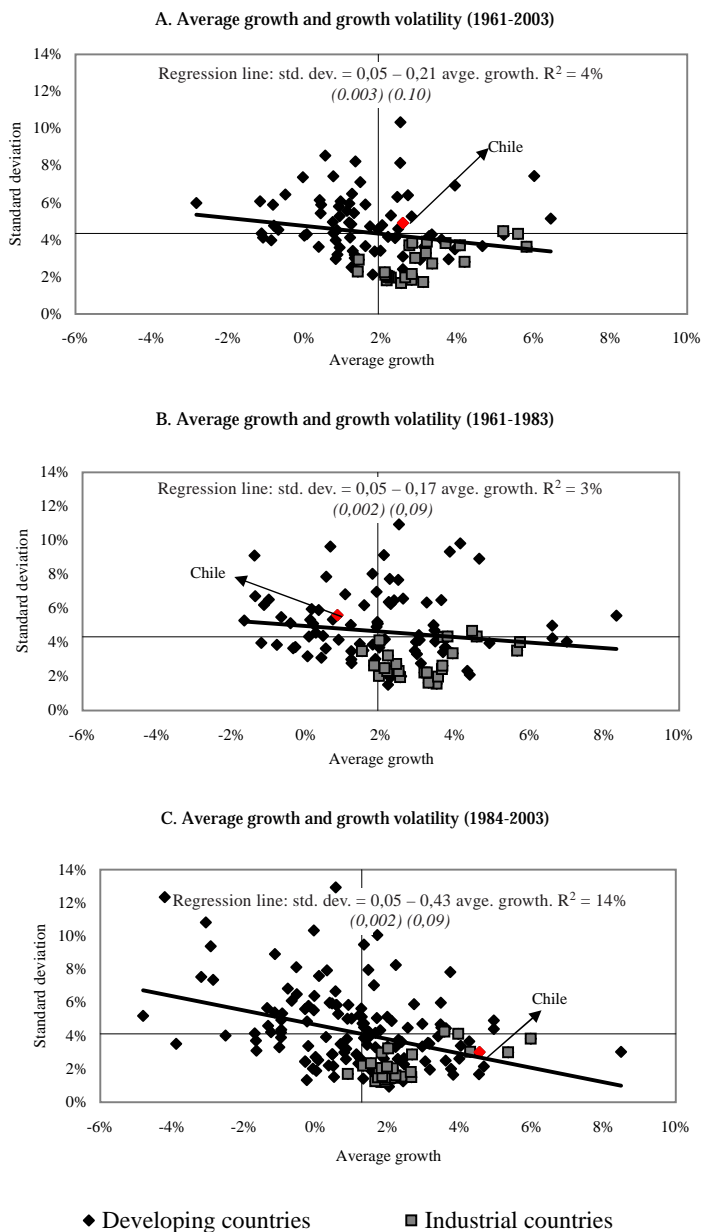
Note: In bold correlation coefficients that are statistically different from zero.

A well-known stylized fact about growth in the world is the negative correlation observed between the first and second moment of growth in large cross-country samples (Ramey and Ramey, 1995, Calderón *et al.*, 2006). Using the most recent cross-country data available, I report the relation and corresponding regression between average per capita GDP growth and the standard deviation of per capita GDP growth across 150 countries in 1961-2003 and two sub-periods (Figure 4). The negative correlation between average growth and growth volatility is confirmed for the full sample period and also separately for its two halves, with significant slope coefficient estimates. In fact, the negative correlation between growth and volatility has increased in magnitude since 1984.

Chile's average per capita growth rate (at 2.6%) and per capita growth volatility (at 4.9%) were above average world growth (1.9%) and world growth volatility (4.6%) during the full 1961-2003 period (Figure 4).⁷ However this overall pattern hides very different performances during the first and second halves of the above mentioned period. Average growth was lower and growth volatility was higher than the corresponding world figures during 1961-1973. The opposite pattern is observed in 1984-2003, when Chile recorded more growth and less growth volatility than the world on average. During the first period, Chile's growth-volatility combination was close to that of a representative developing country but much worse than that of an average industrial country. The opposite is observed in the second period, when Chile's growth-volatility mix is somewhat better than that of a representative industrial economy and dominates by far the combination observed in an average developing nation.

⁷However, Chile was not an outlier from the estimated cross-country relation in any of the three considered periods.

FIGURE 4
RELATION BETWEEN AVERAGE GROWTH AND GROWTH VOLATILITY IN
150 COUNTRIES, 1960-2003 AND SUB-PERIODS



Source: Author's estimations based on World Bank (2005).

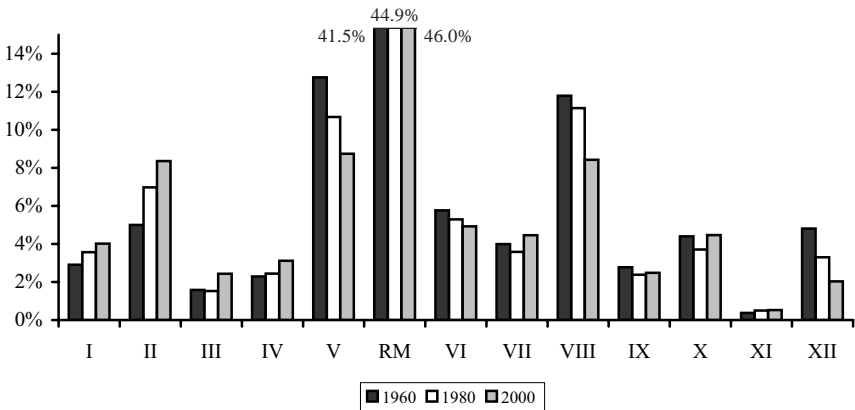
Note: standard errors of estimated coefficients are reported in parenthesis.

2.3 Regional and Sector growth (1960-2005)

Economic concentration in Chile's Santiago Metropolitan region (*Región Metropolitana*, RM) is reflected by its growing share of Chile's GDP, rising from 41.5% in 1960 to 46.0% in 2000 (Figure 5). Hence centralization has implied that Chile's 12 regions other than RM have, on average, lost economic weight for the past 50 years –and probably since the start of independence– mainly as a result of migration to and industrialization in Santiago. However, major changes in relative economic weight have taken place among the 12 regions during the past half century. Since the start of trade opening in the mid-1970s and the opening up of mining to foreign investment in the early 1980s, the regions endowed with significant natural resources (mining, fisheries, and suitable land for forestry and agriculture) saw large private investments and grew significantly through exports. This was the case of the four Northern regions and, to a lesser extent, regions VII and X since 1980. In contrast, regions V, VIII, and XII had relative large shares of import-substituting manufacturing in the 1960s and early 1970s, suffering from subsequent trade opening, reflected in their declining GDP shares.

However, the latter regional trends in economic size are not correlated with changes in productivity, measured by the ratio of regional to national per capita income (Figure 6). Surprisingly, Santiago RM's relative income, among the highest in 1987, declines until 2000. Excepting region III, relative income rises significantly in the Northern regions from initially low or average levels. No clear correlation between exporting regions and relative income levels are

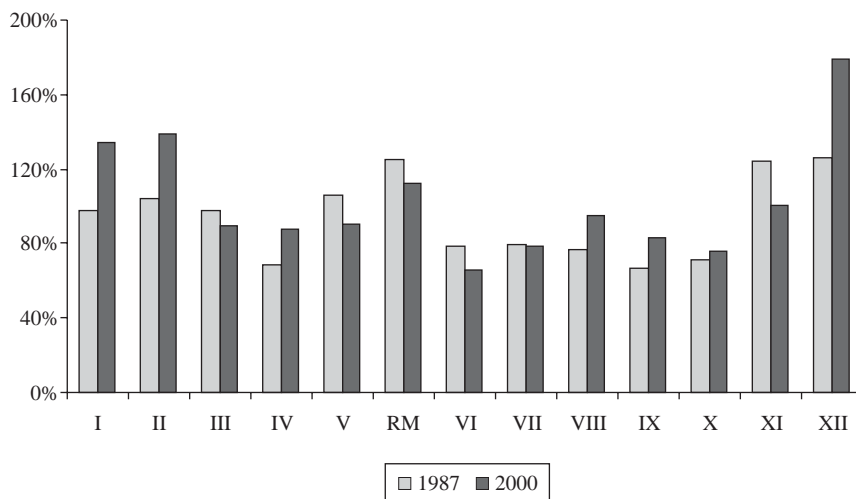
FIGURE 5
RATIO OF CHILEAN REGIONS' GDP TO CHILE'S GDP, 1960, 1980, AND 2000 (percentage)



Source: Central Bank of Chile.

Note: Chile's 12 regions are named by roman numerals, in addition to the Metropolitan Santiago Region (RM).

FIGURE 6
RATIO OF CHILEAN REGION'S PER CAPITA INCOME TO NATIONAL PER
CAPITA INCOME, 1987 AND 2000



Source: Duncan and Fuentes (2006, in this volume)

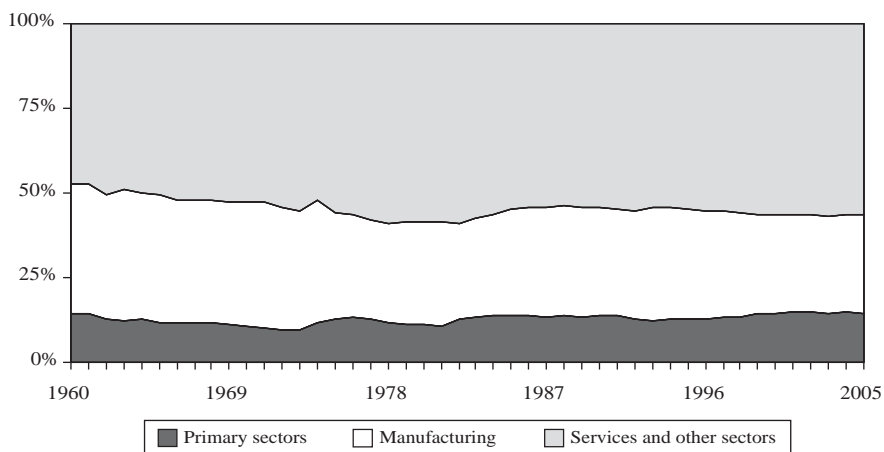
Note: Chile's 12 regions are named by roman numerals, in addition to the Metropolitan Santiago Region (RM).

observed among all Southern regions. However, regions that were relatively poor in 1987—regions IV, VIII, IX, and X—exhibit gains in relative income levels until 2000. The latter facts suggest that regional growth dynamics exhibit income convergence in Chile. In fact, convergence is confirmed by most regional growth studies for Chile.⁸

Now let's turn to the economic-sector composition of Chile's growth during the last half century. At a very aggregate level—distinguishing between primary, secondary, and tertiary sectors—growth has been relatively balanced (Figure 7). The relative share of the primary sector (agriculture and livestock, fishing, and mining and quarrying) has risen from 12.3% of GDP in 1960 to 14.5% in 2005, the secondary sector (manufacturing) has declined from 20.1% in 1960 to 17.1% in 2005, while the tertiary sector (services and others) has increased slightly during the same time span, from 67.6% to 68.4% of GDP (Table 4). This evolution is quite different from the standard international development experience, particularly that of high-growth countries, where the relative size of the primary sector shrinks quickly, manufacturing's share may rise and then decline, and the

⁸See Soto and Torche (2004), Díaz and Meller (2004), Anríquez and Fuentes (2001), Araya and Oyarzún (2001), Aroca and Bosch (2000), Díaz and Herrera (1999), Morandé *et al.* (1997), and Fuentes (1997). For an earlier analysis of regional growth see Tagle (1968).

FIGURE 7
SHARES OF MAIN SECTOR GDP TO AGGREGATE GDP
IN CHILE, 1960-2005



Source: Central Bank of Chile.

TABLE 4
SECTOR GDP SHARES IN CHILE, 1960, 1980, AND 2005
(percent of GDP)

	1960	1980	2005
Public administration	9.7%	8.1%	3.6%
Banking	3.8%	12.4%	13.7%
Transport and communications	3.7%	5.2%	8.8%
Wholesale and retail trade	9.5%	10.7%	11.9%
Construction	11.2%	8.2%	8.8%
Gas, electricity and water	1.9%	2.8%	3.2%
Manufacturing	20.1%	20.3%	17.1%
Mining and quarrying	6.8%	6.6%	8.1%
Fishing	0.3%	0.5%	1.5%
Agriculture and livestock	5.2%	4.1%	4.9%

Source: Central Bank of Chile.

tertiary sector share grows continuously. Again, the explanation for Chile's different development pattern lies in its adoption of an outward-oriented growth strategy since the mid-1970s, based on developing natural-resource intensive activities in the primary sector and in resource-processing manufacturing sub-sectors. Therefore the share of mining (largely copper) in GDP has risen from

6.8% in 1960 to 8.1% in 2005, the share of fisheries has increased its share by five during the same period, attaining 1.5% of GDP, while agriculture and livestock has declined only between 1960 and 2005, achieving 4.9%.

Digging deeper within the tertiary sector, large changes in the relative size of individual service and other sectors are evident since 1960. Substantial government downsizing since the mid-1970s and through the 1990s explains the massive shrinkage of public administration, from 9.7% of GDP in 1960 to 3.6% in 2005. Large-scale privatization of public enterprises in transport, communications, and public utilities and the subsequent growth of private enterprises, complemented by auctions of infrastructure investment to the private sector since the 1990s, is behind the explosive growth of transport and communications (more than doubling its size, from 3.7% in 1960 to 8.8% in 2005) and of gas, electricity, and water (rising from 1.9% of GDP in 1960 to 3.2% in 2005). Privatization of public financial institutions and financial liberalization since the mid-1970s also led to explosive growth in banking, more than tripling its GDP share from 3.8% in 1960 to 13.7% in 2005. Privatization and foreign trade opening contributed also to the rise in the share of wholesale and retail trade. Hence the sector structure of Chile's economy has changed drastically during the last three decades, as a result of deep structural reforms applied since the mid-1970s and through the present.

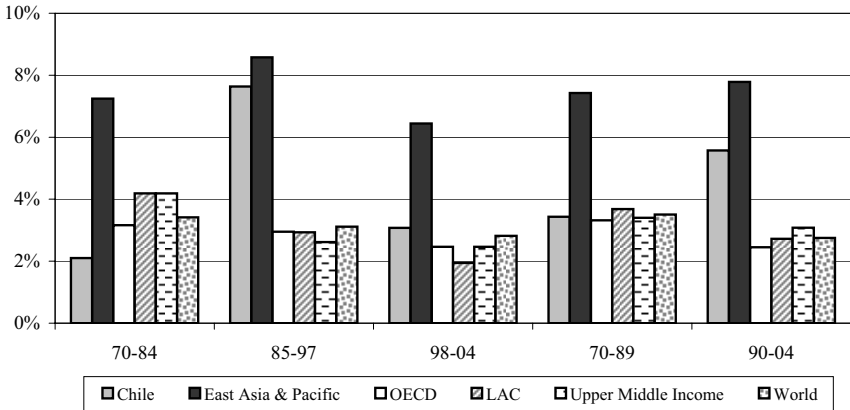
2.4 The "Golden Period of Growth" and thereafter

Chile's economic growth performance from 1985 to 1997 was remarkable indeed. After an average annual GDP growth of 1.5% (0.5% in per capita terms) during the 15 years spanned between 1970 and 1984, the country grew at an average 7.6% (5.9% in per capita terms) between 1985 and 1997. This so-called "golden period of growth" in Chile has been the subject of several studies that conclude that high growth in this period was a successful result of market-oriented structural reforms (e.g. Gallego and Loayza, 2002). The subsequent performance was less outstanding, as average annual GDP growth declined to 3.5% (or 2.2% in per capita terms) between 1998 and 2005.

The changes in Chile's growth performance during the last 35 years are confirmed in international comparison (Figure 8). Chile displayed dismal growth during 1970-1984, growing by half the LAC average and by significantly less than the world average.⁹ In contrast, Chile's 7.6% annual growth during the "golden period" was close to EAP's, and more than doubled average growth in any other major world region. Although Chile's GDP growth fell significantly, to

⁹Adverse foreign conditions and domestic mismanagement are certainly behind Chile's bad performance during 1970-1984. Another negative factor could be temporary up-front costs of structural reforms adopted since the mid-1970s, like trade reform. For example, Rauch (1997), based on a model where trade reform raises long-run growth but reduces short-term growth due to adjustment costs, argues that trade reforms explains Chile's low growth between 1973 and 1984.

FIGURE 8
GDP GROWTH IN CHILE AND SELECTED REGIONS, 1970-2004



Source: World Bank (2005).

3.1%, in 1998-2004, it still outperformed most of the major world regions, except EAP that grew at more than twice the latter figure.

The most recent years, since 1998, span a period that coincides with a full business cycle. The 1997-1998 Asian crisis triggered a sharp cyclical contraction in 1998-1999 in Chile (with average GDP growth of 1.2%) that was followed by a slow cyclical recovery in 2000-2003 (with growth at 3.3%), and a strong recovery toward full employment in 2004-2006 (with average growth projected at 6%). This description leads straight into distinguishing between trend growth and growth cycles –and their determinants–, the subject of the following two sections. The latter distinction is important because it filters out the cyclical component of growth in any given period. For example, the 7.6% figure of average GDP growth during the “golden period” reflects in part cyclical recovery, starting in 1984 (when actual output fell very short of potential output, and labor unemployment was very high) and ending in 1998 (when output was close to potential and labor unemployment was close to its natural level).

3. TREND GROWTH

3.1 Sources of Growth

Empirical growth studies tend to start with an application of the Solow (1957) method of growth decomposition based on the three main contributing factors or sources of growth: physical capital, labor, and total factor productivity (TFP).¹⁰

¹⁰See Barro and Sala-i-Martin (1995) for a cross-country growth decomposition.

This traditional method consists in determining first the contribution of labor and capital to GDP growth, based on their output shares and growth rates, and then to estimate residually the contribution of TFP growth. There are several ways to implement this method, ranging from the choice of production function, the measurement of factor shares and factor growth, possible adjustment for factor utilization and quality, and possible inclusion of other factors of production like human capital and natural resources.

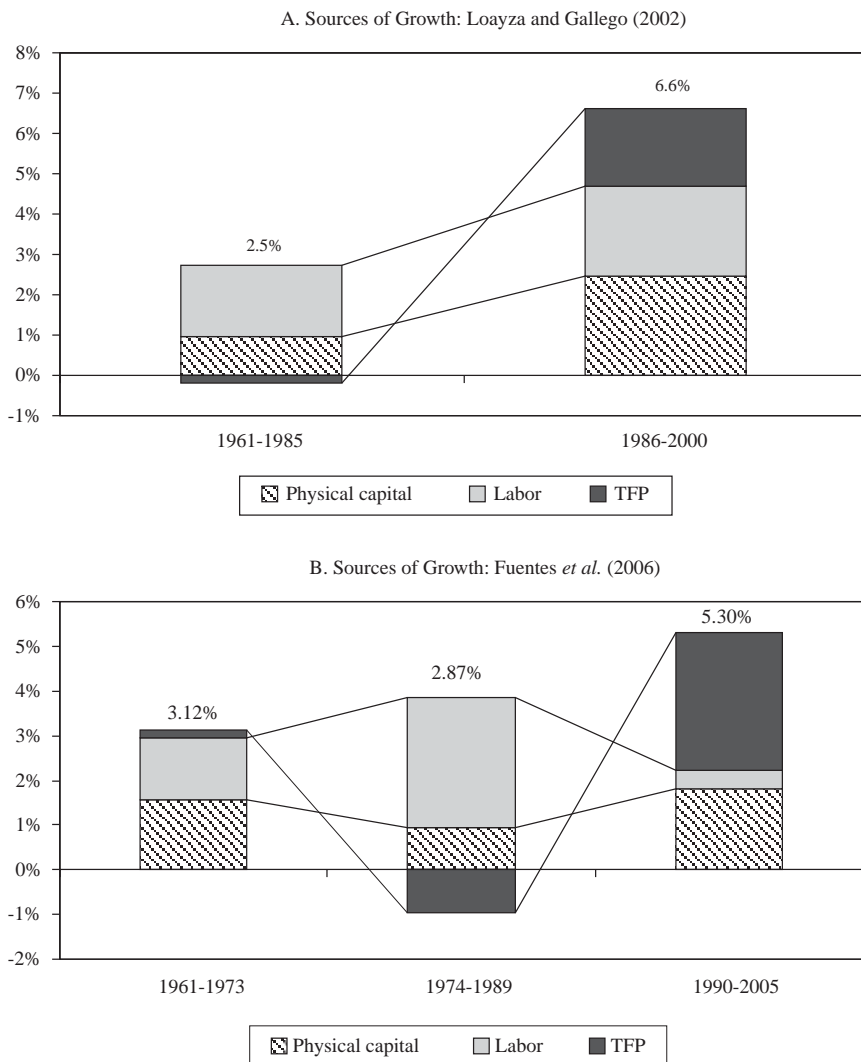
Many authors have applied the Solow decomposition to measure the proximate determinants of Chile's growth.¹¹ For example, Gallego and Loayza (2002) document a significant change in the relative contribution of the "perspiration" component of growth (accumulation of capital and labor) and the "inspiration" component (the productivity gains reflected in TFP growth) during the last four decades (Figure 9A). Adjusting factor growth for input utilization and human capital, they find that Chile's low GDP growth of 2.5% per year recorded during the quarter century between 1961 and 1985 was largely a result of labor accumulation and, to a lesser degree of physical capital growth. Residual TFP growth was close to nil during the same time span. This performance stands in marked contrast to the subsequent high-growth period of 1986-2000, when average GDP growth –at 6.6%– is explained by factor accumulation and significant efficiency gains.

Fuentes *et al.* (2006, this issue) extend the previous measures both in time and by separating sub-periods by those years in which they estimate that actual GDP was close to its potential level, in order to avoid measurement bias of trend-growth sources stemming from cyclical components. Dating those (close to) full-employment years as 1973 and 1989, the authors report results for three sub-periods of similar length, similar cyclical features, and broadly coinciding with distinct periods of political and economic regimes: 1960-1973, 1974-1989, and 1990-2005 (Figure 9B).

"Perspiration" explained almost all the mediocre 1961-1973 growth rate (3.1%), hence "inspiration" was close to nil. Even worse, the level of TFP declined during the 1974-1989 period of low growth (2.9%), when labor accumulation contributes the most. During the last 16 years from 1990 to 2005, growth was relatively high, at 5.3%, and more than half of it (3.1%) is due to productivity gains. Capital investment also contributes substantially while labor growth contributes the least. These results confirm the previous findings that Chile's higher growth since the mid-1980s is largely due to larger TFP growth, followed by the contribution of capital accumulation deepening. However, one should be careful in identifying shorter sub-periods within the last two decades, during which TFP growth exhibits a significant pro-cyclical behavior (Fuentes *et al.*, this issue).

¹¹ Among the sources-of-growth studies conducted for Chile during the last 40 years are Chumacero and Fuentes (2005), Vergara and Rivero (2005), Vergara (2005), Loayza *et al.* (2004), De Gregorio (2005), Beyer and Vergara (2002), Gallego and Loayza (2002), Corbo and Tessada (2002), Contreras and García (2002), Bergoing and Morandé (2002), Coeymans (1999), Roldós (1997), Rojas *et al.* (1997), Edwards (1983), Schmidt-Hebbel (1981), Elias (1978), Selowsky (1969), Bruton (1967), and Harberger and Selowsky (1966).

FIGURE 9
SOURCES OF GDP GROWTH IN CHILE, 1961-2005



Sources: Gallego and Loayza (2002) and Fuentes *et al.* (2006, this volume)

Note: Gallego and Loayza (2002) adjust capital by labor employment and labor by hours worked and educational attainment. Fuentes *et al.* (2006) adjust labor by hours worked and a wage-based quality index.

3.2 Deep Growth Determinants

Growth analysis based on sources of growth sheds some indirect light on the policies that should be pursued to raise growth. For example, considering that many international studies conclude that TFP is the main source of growth (e.g. Easterly and Levine, 2003) –a relevant hypothesis for Chile’s experience since the mid-1980s, as discussed above– one may conclude that policies and institutions aimed at increasing productivity and innovation should be preferred over policies designed to raise, say, saving rates. However, the links between deep determinants, such as policies and institutions, on the one side, and sources of growth, on the other, are complex. Multi-causal links are observed between deep determinants, sources of growth, and GDP growth itself. Potential interactions among deep growth determinants, and between them and the sources of growth, may trigger trend growth jumps. Positive interactions between structural change, factor accumulation, and efficiency gains, with ultimate positive feedback from output growth and higher income levels back to good policies and institutions, may start a prolonged period of high growth. And the converse –a low-growth trap– is perpetuated when a critical mass of high-quality policies and institutions cannot be attained.

Hence much of the empirical cross-country growth research (following the pioneering work by Barro 1991), as well as research at country levels –aims at identifying statistically significant and economically relevant deep determinants of growth, including domestic policies, the quality of institutions, international factors, geography, and even good luck.¹² Following this line of research, several studies have investigated the determinants of Chile’s growth performance. Some of them have followed a time-series approach (Chumacero and Fuentes 2005, Fuentes *et al.* 2006, Rivera and Toledo 2004, and Corbo and Schmidt-Hebbel 2003 among others), and other have used cross-country samples to derive specific inferences for the Chilean case (Corbo *et al.* 2005, Calderón and Fuentes 2005a, Gallego and Loayza 2002, Beyer and Vergara 2002, Barro 1999, and Lefort 1997). The first approach allows for more flexibility by using richer Chilean data, including variables idiosyncratic to Chile’s experience. The strength of the second approach lies in including variables that exhibit little change over time but large cross-country variance, like quality of institutions or initial conditions. Finally, a third line of research describes Chile’s relative strength in areas identified as major growth determinants in international studies, but without a formal quantitative framework.¹³

¹²See Sachs (2003) for the role of geographic factors, Sachs and Warner (1999) for natural resources, and Easterly *et al.* (1993) for luck.

¹³See Fuentes and Mies (2005), Vergara (2005), and De Gregorio (2005), for a general analysis of growth in Chile, and Hernández and Parro (2005), Albagli (2005), Benavente (2005), and Tokman (2005), as well as the chapters in Beyer and Vergara (2001), Larraín and Vergara (2000), and Cortázar and Vial (1998), for more detailed analysis in specific areas with implications for Chile’s aggregate growth.

The quality of institutions, defined in a broad sense, has been identified as a main determinant of economic growth. The large changes in institutional design and quality implemented in Chile during the last three decades is therefore a serious candidate in explaining the rise in growth.

Corbo *et al.* (2005) find that the quality of institutions –voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption– explains one half of the difference in development between Chile and LAC during 1960-2000. Calderón and Fuentes (2005a) estimate that more than 20% in the growth increase between 1981-1985 and 1996-2000 was caused by better institutions. Moreover, the latter estimations could under-estimate the effects of institutions, as the latter have also a positive effect on policy determinants, particularly financial liberalization (and subsequent financial deepening) and macroeconomic stabilization (and subsequent fiscal sustainability and low inflation).

Several policies or policy variables have been identified as candidates to explain the Chilean growth success. Traditionally, they have been classified into stabilization and structural policies. Inflation levels, public deficits, and real exchange rate misalignments (or black-market exchange rate premiums) have been used as proxies for macroeconomic stability (or the lack thereof). Chile has achieved a major and possibly persistent success in gradually conquering macroeconomic stability during the last three decades, after a century-old history of rampant macroeconomic instability. Under the inflation-targeting regime adopted by Chile's strongly independent Central Bank since 1991, inflation has been reduced to levels observed in industrial countries, after registering double (and triple) digit inflation for many decades. Successive governments have achieved fiscal surpluses during the last decades, a policy institutionalized by a 1%-of-GDP structural public sector surplus adopted since 2001. Full elimination of foreign exchange controls and adoption of a floating exchange-rate regime since the late 1990s precludes existence of black market exchange premiums and avoids real exchange rate misalignments that arise from exchange-rate management.

Empirical studies confirm the positive effects of macroeconomic stabilization on Chile's growth. An early example is Fischer (1991), who shows, based on cross-country regressions as well as a case study for Chile, that macroeconomic policy outcomes (low inflation and budget deficits), have a significant and persistent impact on economic growth. Calderón and Fuentes (2005a) estimate that the contribution of stabilization policies to the acceleration of growth in Chile was close to 20% of growth, while Loayza *et al.* (2004) estimate that this contribution was closer to 40%.¹⁴

Structural policies and policy reforms have played a crucial role in Chile's growth acceleration.¹⁵ As mentioned above, Chile implemented a large array of

¹⁴Another early study, Solimano (1989), presents evidence suggesting that macroeconomic stability was an essential component for the recovery of investment in the 1980s.

¹⁵For a review of macroeconomic reforms and its effects see Corbo and Fischer (1994), Dornbusch and Edwards (1994), Edwards (1994, 1995), Fontaine (1989), Hachette (1992), Mujica (1992) and Wisecarver (1992).

deep structural reforms in many areas since the mid-1970s. Among the latter are domestic financial liberalization and capital-market development, trade and financial integration into the world economy, public sector restructuring and state-owned enterprise privatization, sector deregulation and opening-up to private investment, and adoption of social policies aimed at reducing poverty and improving equal opportunity. Progress in these and other areas was neither uniform nor monotonic, but the general trend over the course of the last three decades has been toward adoption of structural policies better suited to attain higher growth and better social opportunities.

In a pioneering early study, Harberger (1959) estimated that eliminating all distortions that characterized Chile's pre-reform situation of the 1950s would result in static output gains reflected in higher growth (by 1-2% per year), for a limited period of time.¹⁶ In more recent work, Schmidt-Hebbel (1998) and Corbo and Schmidt-Hebbel (2003) find statistically significant effects of an aggregate index of structural reforms on TFP growth between 1960 and the late 1990s. In international panel studies, Calderón and Fuentes (2005a) and Loayza *et al.* (2004) estimate that more than half of Chile's growth acceleration since the mid-1980s is explained by structural policy improvements.

Several studies relate specific policy improvements to Chile's aggregate growth –I refer to them subsequently. On trade liberalization,¹⁷ Rojas *et al.* (1997) estimate that 1.5% of Chile's annual growth between 1986 and 1996 was due to the increase in international trade. Herzer (2004) finds that export diversification has played an important role in increasing growth. Pardo and Meller (2002) analyze the effect of exports on regional growth, reporting that export-oriented regions converge to steady-state per capita GDP levels. Several studies investigate the effects of free trade agreements (FTAs) signed by Chile in recent years. Their results, which depend critically on the levels of multilateral tariffs, range from long-term GDP level gains of 0.3% to 10.0% of GDP for Chile's FTA with the U.S.¹⁸ Chumacero *et al.* (2004) consider both FTAs adopted with the European Union and the U.S., reporting an estimated steady-state gain of 1% for the level of GDP.

Bergoing *et al.* (2002a and 2002b) compare Chile and Mexico's growth performance after both countries experienced deep crises at the start of the 1980s. Crisis recoveries were very different, with Chile attaining growth earlier and faster than Mexico –Figure 2 shows that Chile almost doubled Mexico's per

¹⁶Mamalakis and Reynolds (1965) analyzed the effects of the import-substituting strategy and the distortionary policies on Chile's economy and Harberger (1970) presented a more general view of development problems affecting Chile and Latin America in the 1960s.

¹⁷Among the earlier studies are the following. Behrman (1976) analyzes the effects of exchange rate regimes and liberalization episodes on growth during the Post-War period in Chile. Coeymans (1978) and Schmidt-Hebbel (1981) estimate the effects of the 1970's tariff liberalization on welfare and economic growth. Figueroa and Letelier (1994) measure the contribution of trade openness to GDP growth.

¹⁸See Hinojosa-Ojeda *et al.* (1997), Harrison *et al.* (1997), Brown *et al.* (1998), and Coeymans and Larraín (1994).

capita GDP during the last two decades. The authors argue that this difference was due to the different timing of structural reforms in both countries— in particular reforms of banking and bankruptcy law –which had a significant effect on TFP growth in Chile. Bergoeing *et al.* (2005), using Chilean plant level data on manufacturing firms, conclude that their adoption of better technologies and production processes during the 1990s were fostered by broader foreign exposure and superior access to external finance.

Lagos and Díaz (1992) find a negative effect of financial repression on growth for the 1965-1974 period. Hernandez and Parro (2005), using the cross-country results by Levine *et al.* (2000) and Beck *et al.* (2000), estimate that Chile's financial liberalization and development contributed by 1.5% to annual growth between 1961 and 2001, and by 0.4% to annual growth between 1986 and 2001.

Corbo and Schmidt-Hebbel (2003), based on models that identify three channels of transmission from structural pension reform to growth, estimate the overall contribution of the 1981 pension reform to Chile's growth at 0.5% per year between 1981 and 2001.¹⁹

Chumacero and Fuentes (2005a) find a negative effect of total government expenditure on TFP growth and GDP growth for 1960-2000. Ramírez (2000) reports a positive effect of public investment on labor productivity, but public expenditures have a negative effect on labor productivity. Rivera and Toledo (2004) also find a positive and significant effect of public investment on GDP growth.²⁰

There is scarce evidence that provides quantitative links between education and growth, and research and development and growth. In early work, Selowsky (1969) estimated that education in Chile contributed by 0.7-1.1% to annual growth during 1950-1964, and by 1-1.2% during 1960-1964. Fuentes and Vatter (1991) and Benavente (2005) provide a qualitative analysis on the contribution of research and development to growth in Chile.

Policy interactions have been identified as an important contributing factor to the acceleration of economic growth –worldwide and in Chile. The argument is based on the notion that growth benefits of comprehensive structural reforms, that attain a critical mass of reform progress in many or most policy areas, could extend well beyond the sum of partial effects of individual reforms, as a result of positive and significant reform interaction effects. For example, trade and financial integration into the world economy will matter little to potential exporting firms if their property rights are not protected, if they face inadequate bankruptcy laws or lack access to domestic bank and capital-market financing, or if they are hampered by overly restrictive labor-market laws and regulations.

Corbo and Schmidt-Hebbel (2003) argue that complementary policy changes, in particular fiscal and financial reforms, and privatization, were critical

¹⁹Davis (1964) provides an early estimation of the effects of a parametric (i.e., non-structural) reform of Chile's state pay-as-you-go pension system on national income, by reducing labor market distortions.

²⁰Fontaine (1997) analyzes development of an information system for decision-making on public investment projects and government capital budgeting.

for the positive and significant contribution of pension reform to growth in Chile. Gallego and Loayza (2002) explore empirically policy interactions for the case of Chile, using international panel data. The authors explain only 45% of Chile's after-1985 growth acceleration when restricting their specification to conventional variables included in growth regressions.²¹ In order to reduce the growth residual for Chile, one of the highest in their cross-country sample, the authors expand the set of explanatory variables, including governance, public services and infrastructure, and policy complementarity. For capturing the latter, they use a dummy variable that takes a value of 1 when all measures of policy indicators for any country are above the sample median. This strategy allows the authors to raise the share of Chile's growth acceleration explained by their regression to 73% and identify the contribution of policy interactions as the most influential growth determinant.

Calderón and Fuentes (2005a), also using international panel data, investigate the complementarily effects between quality of institutions and financial as well as trade openness. In both cases they find that low quality of institutions implies a negative contribution of openness to growth. As institutional quality develops, the effect of financial openness becomes positive, reaching its largest contribution close to the 60th percentile of the world institutional quality distribution, just where Chile is ranked. In the case of trade openness, where the relation is linear, the complementarity effect is also positive for Chile. Taking these effects into account, the authors are able to explain almost 90% of the growth acceleration in Chile observed between 1981-1985 and 1996-2000. Nearly 30% is explained by openness, in particular financial openness, and including interaction effects. Finally, Schmidt-Hebbel (1998) finds a statistically significant interaction between structural policies and macroeconomic stability in explaining Chile's growth. Fuentes *et al.* (2006, this issue) also include an index of structural policies as an explanatory variable for TFP growth.

4. CYCLICAL GROWTH

I confirmed above the negative correlation observed between growth levels and growth volatility, both across countries and over time in Chile. Fatás (2003) presents econometric evidence about the effects of business-cycle volatility on long-term growth in the world. In the case of developing countries, more vulnerable to external shocks, the recessions associated to adverse foreign shocks and the nature of subsequent cyclical recoveries have profound effects on average growth during longer horizons. Therefore when analyzing Chile's long-term growth prospects it is relevant to refer to the country's vulnerability to external

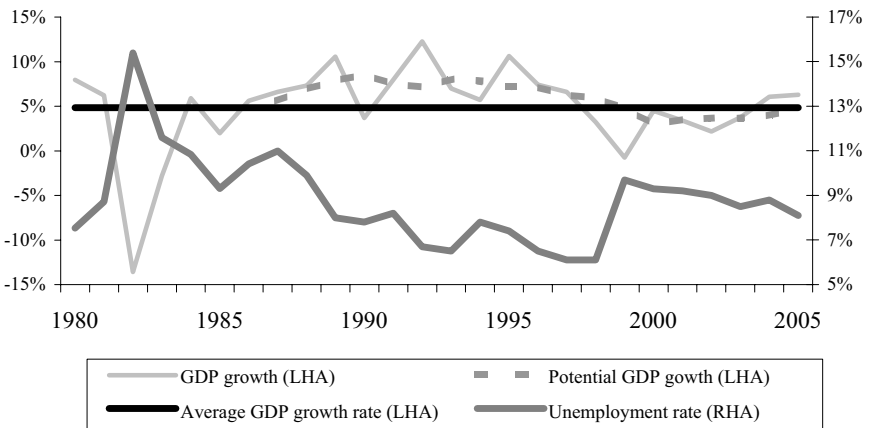
²¹Their basic specification includes initial per capita GDP, initial average years of schooling, life expectancy, domestic credit to the private sector, government consumption, black market premium, openness, and terms-of-trade shocks. Their sample extends from 1970 to 1998.

shocks and its capacity to recover from recessions quickly and on a sustained basis. It is particularly relevant to identify the role of international and domestic factors in shaping recessions and recoveries.

Chile suffered three recessions during the past quarter century. The deepest recession occurred in 1982, as part of LAC's debt crisis. In Chile –as in other Latin American economies– this recession was associated to a profound and generalized financial crisis.²² The second recession, in 1990, was mild and so short that it was reflected only in quarterly, not annual, data. Finally, the 1999 recession, triggered by the Asian Crisis, was of moderate intensity and did not imply a financial crisis, but was followed by a relatively slow cyclical recovery. Only after vigorous growth in 2004-2005, it is estimated that GDP will attain its potential level and labor unemployment will converge back to its natural rate during 2006 (Figure 10). Estimates for potential GDP growth show a pro-cyclical behavior, returning to 5% and slightly higher in 2005-2006. Note that the latter figure is very close to the 5.3% average annual GDP growth recorded in 1990-2005 (Figure 9) –a full-cycle period that reflects well Chile's recent potential growth over the business cycle.

Based on defining a recession as two quarters of negative growth and applying a metric based on initial (pre-recession) GDP levels and quarterly data, Calderón and Fuentes (2005b) compare Chile's three recessions to recessions

FIGURE 10
ACTUAL GDP GROWTH, POTENTIAL GDP GROWTH, AND UNEMPLOYMENT RATE IN CHILE, 1980-2005
(percentage)



Source: Central Bank of Chile.

²²See Edwards and Cox Edwards (1988), and Condon *et al.* (1985) for a detailed analysis of the factors that triggered the crisis of 1982 in Chile.

registered in 23 countries between 1990 and 2004 (Table 5). In terms of total duration (21 quarters), largest GDP decline (23.3% of quarterly initial GDP), and total GDP loss (204% of quarterly initial GDP), Chile's 1982 recession was by far the largest and longest recession included in the full international sample. Interestingly, Chile's 1999 recession was shorter, shallower, and less costly than the recessions in Mexico (1995 and 1999), Korea (1998), and average recessions in Latin America and Emerging Asia in general. However, Chile's 1999 recession was significantly deeper and more costly than the average recession in an OECD country.

TABLE 5
ECONOMIC CYCLES IN CHILE AND THE WORLD, 1990-2004
(quarterly data)

	Complete cycle duration (quarters until GDP reach initial GDP)	Maximum reduction in GDP (% of quarterly initial GDP)	Total cost (% of quarterly initial GDP)
Chile 1982	21.0	23.3	204.1
Chile 1990	4.0	2.8	4.5
Chile 1999	6.0	4.3	13.5
Mexico 1995 and 2001	8.0	6.4	23.8
Korea 1998	8.0	9.3	37.1
Latin America	9.6	6.4	46.8
Emerging Asia	7.8	10.6	46.1
OECD countries	7.0	1.6	6.4

Source: Calderón and Fuentes (2005).

Using a different metric based on annual data and potential GDP levels, Céspedes and De Gregorio (2005) compare Chile's 1982 and 1999 recessions to those in a sample of emerging economies during 1990-2004 (Table 6). In terms of duration, Chile's 1999 recession was similar to the average LAC recession of 1982 and longer than the recessions registered in the rest of the world. However, the first-year GDP loss was smaller than in any other individual recession as well as in the world average. Finally, the total output cost was similar to that observed in Asian 1997-1998 and in Mexico (1995), but smaller than the output loss in the world (sample) average. The authors also compare the evolution of relevant variables before and after 1999 in Chile and selected recessions in other countries. They observe that the rise in unemployment in Chile 1999 was more persistent than in other country experiences. This could be the result of real wage rigidity in Chile, reflected in real wage growth during the 1999 recession at the same rate observed before the recession, precluding quicker absorption of unemployed labor during the recovery. Finally, the real exchange rate also exhibits

TABLE 6
RECESSIONS AND RECOVERIES IN CHILE AND THE WORLD, 1990-2004
(annual data)

	Complete cycle duration (years)	First year reduction in GDP (% of last year GDP)	Total cost (% of potential GDP)
Chile 1982	7.0	13.6	34.5
Chile 1999	6.0	0.8	10.7
Mexico 1995	3.0	6.2	10.7
Korea 1998	2.0	6.7	11.1
Indonesia 1998	6.0	13.1	22.6
Colombia 1999	5.0	4.2	9.9
Ecuador 1999	3.0	6.3	9.6
Latin America 1981-82	6.6	4.2	24.6
East Asia 1997-98	3.3	6.2	9.4
Average (full sample)	4.6	2.1	13.6

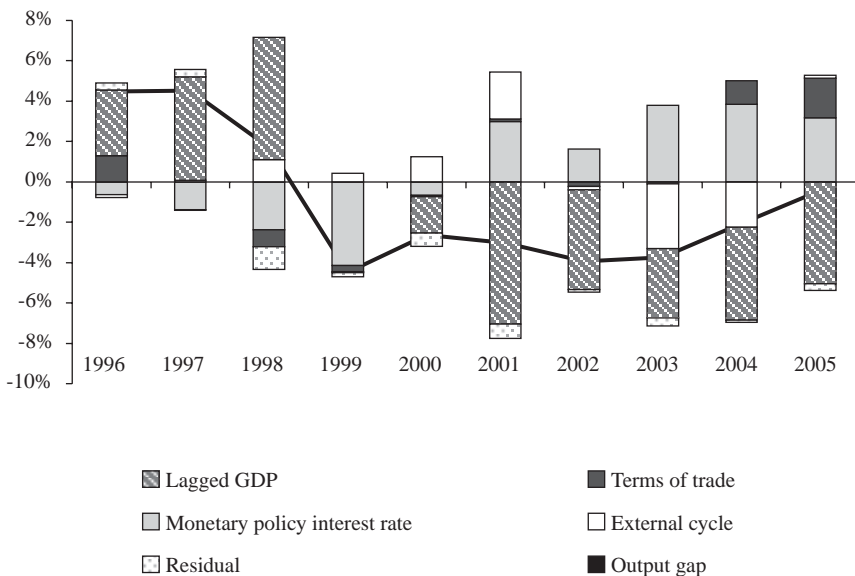
Source: Céspedes and De Gregorio (2005).

only moderate adjustment during and after 1999, slowing down resource reallocation required for a faster recovery.

Gallego *et al.* (2006) use a micro-founded dynamic general equilibrium model, calibrated to Chile, to decompose the output loss from trend observed in the 1998-1999 recession, according to the influence of international and domestic determinants. Their simulations suggest that the deterioration in foreign conditions, the contractionary monetary policy, and the cyclical fiscal policy (first expansionary, than contractionary) caused the recession.

Finally, Central Bank of Chile (2006) reports an analysis that was carried out to identify external and domestic conditions in Chile's cyclical evolution during 1996-2005, including the 1999 recession and its aftermath. Borrowing an equation from the Central Bank's projection model (*Modelo Estructural de Proyección*), the output gap was decomposed according to the influence of international factors –terms of trade and GDP growth of trading partners– and domestic conditions –the monetary policy interest rate–, controlling for lagged effects of the latter variables and the output gap itself (Figure 11). This exercise shows that both international and domestic external conditions have played a fundamental role in the 1999 recession and its recovery. The terms of trade contributed significantly to the recovery in 2004-2005 and foreign growth contributed moderately until 2001. The effect of the monetary policy rate was exceptionally negative in 1998-1999 but contributed strongly to the recovery in 2001-2005.

FIGURE 11
OUTPUT GAP DECOMPOSITION IN CHILE, 1996-2005



Source: Central Bank of Chile (2006).

5. THIS ISSUE OF *CUADERNOS DE ECONOMÍA*

The research on Chile’s growth carried out to date, revised in the preceding sections, has shed light on growth regularities and determinants. However, several questions remain unaddressed or require a deeper understanding. This issue of *Cuadernos de Economía* includes six articles that contribute substantially to the empirical research on Chile’s past growth performance and future prospects. The articles focus on four areas: policy and institutional determinants of Chile’s aggregate growth in international comparison, output and income convergence among Chile’s regions, measurement of TFP growth and estimation of its behavior at the aggregate (national) and economic-sector level, and measurement of manufacturing-sector TFP and estimation of its behavior using plant-level and sub-sector level data.

Calderón and Fuentes (2006, this issue) start by providing new evidence on world growth determinants, based on dynamic panel-data estimations for 78 countries during the last three decades. Their growth specification allows for a role of complementarities between institutional quality and financial openness and/or trade openness, in addition to considering the linear effects of each individual variable. This permits identifying possible non-linear and non-monotonic effects that will depend on the extent of complementarities. The results

show that high-quality institutions lead to a larger contribution of financial and trade openness to GDP growth. The growth impact of financial liberalization is positive only in countries with strong institutions, i.e. countries above the 20th percentile in the world distribution of institutional quality. However, the relation is non-monotonic, as the effects of financial openness on GDP growth are reduced as institutional quality rises. The results show that the largest effects are observed in countries at a level of institutional quality similar to Chile's. A positive complementarity between institutions and trade openness is also estimated, but in this case the marginal effect of openness is positive at all levels of institutional quality.

Then the authors use the world panel evidence to identify the main contributing determinants of Chile's growth: the quality of its institutions, financial openness, and macroeconomic stability. They infer that if Chile were to deepen reforms during 2006-2010 at their historical pace, its annual growth would rise by 0.27 percentage points above its 1996-2000 rate. Furthermore, a larger growth gain –by 0.8 percentage points– would be attained by extending reforms in education, financial market development, and trade openness.

Duncan and Fuentes (2006, this issue) investigate per capita GDP and per capita income convergence among Chile's regions during 1960-2000, both in levels and in dispersion. Conventional convergence studies assume that under the null hypothesis of divergence the corresponding statistics have either asymptotic distributions or critical standard values. However, this is not the case in the presence of a unit root in the series, introducing serious inference problems. This paper applies unit-root tests recently developed for panel data that avoid the aforementioned problem. Other contributions to the preceding literature on regional convergence in Chile lie in using a revised database for GDP and income series and applying a non-parametric multimodality test to evaluate the presence of regional asymmetries.

The results tend to support the presence of convergence in regional per capita GDP and per capita income levels. Compared to international evidence, regional convergence is relatively slow; the gap between poor and rich regions is closed in more than 80 years. However, convergence speed is higher when the authors control for the share of the mining sector in each region, which leads to regional differences in steady-state levels of per capita GDP and income. The evidence reported by the authors on convergence in dispersion is weaker, but their multimodality tests reject the existence of bimodalities or convergence clubs.

Fuentes, Larraín, and Schmidt-Hebbel (2006, this issue) contribute to Chile's aggregate growth literature in two dimensions. First, the authors provide new estimates for the sources of Chilean growth and new measures for factor inputs and TFP levels during 1960-2005. Capital series are adjusted by utilization and labor employment series by hours worked and labor quality measures. Using a Cobb-Douglas function, the paper presents eight series for TFP based on alternative combinations of input measures.

Then the authors provide econometric evidence on the determinants of TFP for the last half-century. The results suggest that, in addition to cyclical

factors (approximated by the terms of trade and real exchange-rate undervaluation), TFP growth reflects efficiency gains from macroeconomic stabilization (measured by lower inflation) and microeconomic reforms (reflected by an index of structural reform progress). There is also evidence on significant interaction effects between macroeconomic and microeconomic factors in the dynamic behavior of TFP. The impact of microeconomic reforms on TFP is weaker (stronger) under conditions of high (low) macroeconomic instability. The converse is also true: macroeconomic stabilization yields larger gains in economic efficiency when the quality of microeconomic policies is higher. Macroeconomic stability has been largely attained in Chile, and hence it can be ruled out as a significant future growth factor. Therefore achieving high future TFP and GDP trend growth will be conditional on significant efforts in implementing further microeconomic and sector reforms in support of additional efficiency gains and major improvements in labor quality.

Vergara and Rivero (2006, this issue) contribute to the understanding of sector-level TFP dynamics. This is the first study of sources of growth at economic-sector level in Chile, which is made possible by constructing new series for sector capital stocks (based on the perpetual inventory model), extending available series for 1986-2001. These new series are also a valuable contribution of the paper for the conduct of subsequent sector studies. The authors adjust factor series by capital utilization and labor quality, and then decompose the sources of growth for six sectors: manufacturing; electricity, gas and water; construction; retail trade, restaurants and hotels; transport and communications; and financial services.

The results for the last years are consistent with the growth reduction observed during 1999-2003, with most sectors exhibiting negative TFP growth. For the full 1986-2001 period the authors show that the sector comprised by retail trade, restaurants, and hotels exhibited the highest productivity growth (2.7%), followed by financial services (1.4%) and transport and communications (1.2%). Manufacturing exhibited the lowest productivity growth, at a negative rate (-0.5%). The results of this paper support the findings of the international literature that IT-intensive sectors –in particular, retail trade– are the ones with the largest productivity expansion.

Bergoeing and Repetto (2006, this issue) decompose the sources of growth for the manufacturing sector, using plant-level data from a large sample compiled by the National Survey of Manufacturing (ENIA) for 1980-2001. Once the authors have obtained TFP series, they analyze productivity dynamics identifying the effects of production reallocation (derived from substitution of production by efficient firms for production of inefficient firms) and within-plant efficiency changes (due to adoption of superior production methods and technologies). Working with plant-level –as opposed to aggregate data– allows identifying the two latter dimensions of productivity gains.

The empirical results evidence large differences in TFP behavior, even among narrowly defined sectors. This reflects the study's key result that reallocation has accounted for most of the efficiency gains in manufacturing during 1980-2001. This leads the authors to conclude that barriers to efficient

reallocation reduce aggregate efficiency and growth. Among the latter could be policy barriers like financial restrictions, international trade barriers, firm entry costs, inefficient bankruptcy procedures, bureaucratic red tape, an excessive tax burden, labor regulations, and lack of human capital for technology adoption. The latter policy distortions have static as well as dynamic effects, pushing the economy inside its production possibility frontier (the static efficiency loss) and delaying the adoption of new and better long-run technologies (the dynamic efficiency loss reflected in a slower extension of the frontier).

Finally, in a study that complement the preceding paper, Navarro and Soto (2006, this issue) analyze the sources of shocks and determinants of labor productivity in the manufacturing sector in the 1979-2001 period, using data for 80 sectors from ENIA. They focus on the correlation between labor productivity and economic activity, an indicator of the nature of shocks affecting firms, and provide an analytical explanation to a long-standing puzzle: at the firm level there is significant and robust evidence of pro-cyclical correlation while at the aggregate level there is no correlation whatsoever. Pro-cyclical correlation indicates the predominance of supply-driven shocks (largely due to technology changes) as opposed to demand-driven shocks. The explanation highlights the role of aggregation biases that arise when using aggregate productivity series and distort the cross-industry correlation; sector heterogeneity in productivity levels is one cause for such biases. More important in biasing the results is the role of cross-industry productivity correlations that tend to offset the positive correlations observed at the industry level.

Based on an econometric model, the authors provide evidence on the determinants of productivity changes. The results indicate that technology shocks account for most of productivity cycles in the 1979-2001 period (around 50%), thus supporting the supply shocks hypothesis as the main source of business cycles in Chile. The remaining productivity changes are explained by important reallocation effects between sectors of different productivity in the 1979-1985 period and the presence of increasing returns and market power in the 1986-2001 period. Variations in the utilization rates of capital and labor appear to be insignificant.

6. POLICY PROPOSALS TO FOSTER GROWTH

Chile does not suffer from any shortage of reports on growth impediments and policy proposals to put the country on a faster development path. There is no lack of meetings and conferences on development issues put together by business associations, academic institutions, think tanks, the Central Bank or the government, complemented by a stream of studies, papers, and books on the subject. Scarcely a month goes by without a mission from an international institution eager to meet key players and specialists to obtain data and their views on the country's development limitations in order to write the corresponding institution's regular Chile report.

Not all this activity is relevant to improve our understanding of Chile's growth prospects. I may add, at the peril danger of incurring in a colossal understatement, that considering the large quantity and wide dispersion of the studies and proposals that are put forward, not all are relevant for fostering Chile's growth prospects. Hence next I refer briefly to a selective sub-set of studies that are relevant and/or representative of current views on growth. In fact, I restrict the subsequent survey to a few academic studies with policy proposals on growth and to parts that are relevant to growth in the reports issued by international organizations and the campaign proposals put forward by the candidates in Chile's 2005-2006 presidential election. Finally, it is important to realize that the latter reports and proposals cover a wide range of development and growth impediments and therefore propose a correspondingly broad set of policy reforms and extensions. But they offer little guidance on the relative ranking and development impact of their proposals. The only way to assess the proposals' growth effectiveness –will they lift growth? By how much and for how long?– is in the light of economic theory and empirical studies, i.e., against the findings of the systematic studies reviewed in the three previous sections. I leave this evaluation to the reader.

6.1 Proposals by International Institutions

Among the reports issued by international institutions, the Economic Survey of Chile by the Organisation for Economic Co-operation and Development (OECD, 2005) is the one that focuses directly on Chile's long-term growth challenges, which is the subject of its first chapter. The report identifies four key areas of reform with significant impact for the growth potential of the economy. The largest long-term growth gains would be achieved by raising human capital, Chile's weakest growth determinant. This should be attained by raising the currently low educational standards to the level of the top performers among industrial countries and by raising the quality of labor training programs. The second proposal is to foster pro-competition policies in network industries (electricity, telecoms, and infrastructure). Boosting innovation should be an additional policy priority, based on cost-effective use of additional government funding that will come from the new mining tax, allocating it in a contestable, transparent manner; diffusing state-of-the-art general-purpose technologies; emphasizing support of applied research; and overcoming institutional fragmentation of government bodies and policies that support innovation. Finally, the OECD proposes to make labor markets more efficient by lifting restrictions on part-time work and sub-contracting; and subsidizing availability of affordable childcare and pre-school education to raise low female labor participation.

The International Monetary Fund (IMF, 2005) also recognizes the importance of increasing human capital for achieving higher long-term growth rates. Progress should be achieved in raising pre-school coverage; increasing the quality of primary and secondary education; improving access of low-income

students to tertiary education; and providing teachers with the right incentives by allowing larger pay differentiation according to their performance. Policy reforms are also proposed to raise innovation policies and labor-market flexibility. Health-care reform and streamlining and standardization of business procedures are identified by the IMF as additional policy challenges for boosting long-run growth.

In an earlier report, the World Bank (World Bank, 2002) argues that policies should encourage a shift from growth currently based on factor accumulation to growth increasingly based on productivity gains. In order to achieve this, the World Bank proposes to focus more on policies aimed at raising the quality of human resources and knowledge, including adult education, labor training and skill development, and encouraging labor mobility. Improving the investment climate and strengthening government modernization is also advised.

Finally, a previous report by Inter-American Development Bank (IADB, 2001) claims that development of new areas of competitiveness is key for improving potential growth in Chile. This should be the focus of policies aiming at adoption of clean technologies, international trade integration, infrastructure improvement, and human capital development.

6.2 Other recent Proposals

The Central Bank of Chile conducted during 2004 a research project on Chile's growth, comprised by empirical and policy research on Chile's growth prospects and challenges. The project summary in Fuentes and Schmidt-Hebbel (2004) identifies four areas of policy proposals, based on individual studies cited subsequently. Tokman (2005) focuses on education to raise human capital, proposing to revise of government subsidies to public and privately-provided primary and secondary education; improve curricula of teacher's university education; strengthen performance evaluation of teachers; and raise government subsidies to pre-school education. Benavente (2005) assesses ways to foster innovation and technological development, proposing streamlining and centralizing dispersed government programs in support of innovation with participation of private-sector R&D leaders; and developing government support of higher private-sector participation in R&D expenditure and development. Albagli (2005) identifies labor-market imperfections, proposing substitution of higher contributions to unemployment insurance for current labor dismissal payments based on years of service; lifting restrictions on part-time work and working-hour distribution; and subsidizing child care for working mothers. Finally, Aguirre *et al.* (2004) propose policy measures to improve public and private-sector efficiency by adopting government service management practices and performance evaluation similar to those prevalent in the private sector; privatizing public enterprises; revising the bankruptcy law; extending reform of the judicial system; and improving health reform.

De Gregorio (2005) conducts an extensive review of Chile's growth determinants and prospects. The study identifies four areas of structural weakness

where policy improvements could contribute to higher: low aggregate R&D expenditure and its low share devoted to private-sector applied R&D spending; high income inequality; low quality of education; and low intra-regional (LAC) trade. Finally, the author argues for further progress in microeconomic and regulatory reforms, by improving competition policies and raising accountability of regulatory agencies and public enterprises.

6.3 Presidential Programs of the 2005 Campaign

By targeting the largest possible number of voters, presidential programs are far broader in scope and shallower in analysis –and certainly more populist– than the narrower academic and policy studies and proposals that I have summarized above. Yet they are relevant for this article because they include policy proposals and changes aimed at fostering development and growth, reflecting the views and aspirations of Chile’s main parties and players. In the case of Chile, most presidential programs exhibit significant common ground in their assessment of growth impediments and their policy proposals. This consensus –in stark contrast to many Latin American nations– reflects Chile’s political cohesion and the influence of largely mainstream economists in shaping most election programs.²³

The latter was particularly true in the recent 2005–2006 presidential elections, where the programs representing three of four first-round candidates –those that commanded more than 90% of the popular vote– proposed similar policies for strengthening growth. In the following, I will refer briefly to the three latter programs. I will leave out the fourth program, as there is very little common ground between the latter and the other three programs,²⁴ as well as between the fourth program and the studies on Chile’s growth that I have reviewed in this article.

The program of Michelle Bachelet (Bachelet, 2005), Chile’s President since March 2006, includes a significant body of policy proposals and reforms with potential growth impact.²⁵ On education, Bachelet proposes to raise coverage

²³The large influence of economists holding advanced degrees from abroad in shaping elections and policies in Chile is also reflected in their prominent role among presidential candidates and their advisors, cabinet ministers, senators, Central Bank board members and staff, and public-sector managers and staff.

²⁴One example of the stark contrast between the fourth presidential program and the other three programs can be found in the assessment of free trade. Bachelet’s program –representative of the three majority programs – asserts that (we) “... will continue consolidating our relationship with the United States. For this purpose we will use the Summit of the Americas– based on shared democratic values –and the project of creation of a Free Trade Area for the Americas” (Bachelet, 2005, p. 100, author’s translation). In contrast, the fourth program starts with the following opening paragraph: “In Chile ... a small percentage of population has systematically appropriated political power, economic strength and technology. This demolishing process of national sovereignty and independence attains its highest expression in the Free Trade Agreements or specifically in the intention of imposing a Free Trade Agreement of the Americas” (Juntos Podemos, 2005, p. 2, author’s translation).

²⁵This program, as well as the two others summarized below, includes a wide range of proposals on social and productive sectors that may have some aggregate growth impact. However, in my review I omit references to the latter, focusing only on policy proposals with potential impact on aggregate factor accumulation or aggregate efficiency gains.

of pre-school coverage and university education, establish education subsidies for low-income families, and improve the quality of education (by extending the school day, revising school curricula, reducing class size, subsidizing rural school transport, improving public school management and accountability, and upgrading teachers' skills and knowledge). On employment and labor markets, the program endorses more labor market flexibility (widening options for part-time and flex-time contracts) but also calls for more employment protection and legal protection against anti-union practices. Higher female labor participation is to be achieved by the aforementioned subsidies to pre-school education, complemented by subsidies to training programs targeted at labor market reinsertion of mothers; higher youth employment is targeted by raising subsidies for training and hiring young workers, introducing more flexible part-time contracts for students, and subsidizing pension contributions of youngsters. Further labor-market measures include extending coverage of unemployment insurance, adopting a counter-cyclical employment program, and extending training programs.

To strengthen macroeconomic stability (and in this way also to raise long-term growth), Bachelet proposes to reinforce the counter-cyclical nature of current policies by maintaining the structural fiscal surplus rule, adopting the aforementioned counter-cyclical employment program, issuing international liabilities denominated in local currency, and investing in public international assets that provide hedging against adverse shocks. On innovation and technology, the program proposes development of a national innovation system focused on raising expenditure on R&D and lifting its effectiveness, based on private-public partnerships, stronger evaluation of government subsidies to R&D, and more effective attraction of multi-national firms to invest in Chile. Another growth-oriented area in the Bachelet program is geared at competition policies and entrepreneurship, proposing stronger government competition (anti-trust) institutions and a review of M&A policies. For micro enterprises and SMEs, the program pledges more general support, subsidies for developing entrepreneurial capabilities, support of R&D, better access to financing, and tax return simplification. Bachelet proposes to continue the development of capital markets by improving corporate governance and takeovers among private firms, extending best corporate-governance practice to public enterprises, consolidating supervision in one government supervisory authority, revising competition barriers in financial-service industries, and support internationalization of Chile's financial system and capital markets. Finally, the program includes proposals for reforming government that include improving the quality and accountability of government services, up-grading qualification and evaluation of government staff, implementing policies to prevent corruption, and extending transparency of government decisions.

The presidential program of Sebastián Piñera (Piñera, 2005) also includes a significant number of policy proposals with potential growth effects. This program also starts with the shortcomings of education, proposing to raise pre-school coverage; raise the quality of education (by increasing student subsidies and up-grading school curricula); improve training, incentives, and evaluation of

school teachers; revise government evaluation and management of public primary and secondary education; and raise access to higher education and improve its quality control. On employment and labor markets, Piñera proposes to introduce more labor market flexibility (by reforming labor dismissal payments and allowing more flexible contracts on the distribution of working hours over time) and to establish an independent National Employment Council for regulation and supervision of employment conditions.

On government reform, the program proposes restructuring and mergers of ministries and government services to attain government objectives more effectively; adoption of private-sector management practices by government services; devolution of government functions to the private initiatives and institutions; up-grading of professional capabilities of government staff; raise SOE accountability and transparency and separate their dependence from ministries; SOE privatization (by selling shares to pension funds) with sales revenue invested in a government fund for financing anti-poverty programs; raise accountability and transparency of government services, government decisions, government resource allocation; and strengthen budgetary autonomy and decision-making at the municipal level, while raising transparency of municipal management to reduce opportunities for corruption at the local level. The program proposes maintaining the counter-cyclical structural fiscal budget rule, but gradually reducing the current 1%-of-GDP surplus to zero. On competition policies and support of entrepreneurship, Piñera proposes stronger and more autonomous government competition (anti-trust) institutions; elimination of excessive regulation and bureaucratic requirements for starting new enterprises; and provision of more financial, managerial, and technical support to micro and SMEs. The program targets R&D support by raising aggregate R&D expenditure; promoting applied R&D by private firms; and easing patent registration.

Finally, the presidential program of Joaquín Lavín (Talleres Bicentenario, 2005) also considers a significant body of policy proposals with significant potential growth consequences. For further capital market development, the program proposes intensifying international financial integration through bilateral agreements; extending access to credit and banking services; lowering taxes on financial transactions; and revising excessive financial regulation. On R&D the Lavín program is geared at restructuring government R&D spending and institutions; making Chile more attractive for establishing foreign R&D centers; promoting joint initiatives between universities and firms; extending significantly the number of graduate scholarships and locally trained PhDs; reducing barriers to technology and software imports; and supporting patent registration. The program establishes support of entrepreneurship, market competition, and SOE development by lowering (eliminating) corporate income taxes on reinvested profits of all firms (SOEs); reducing excessive market regulation; minimizing government arbitrariness in setting public-service tariffs and issuing government permits; providing competition (anti-trust) institutions with more independence and financial resources; strengthening M&A legislation; supporting SMEs by eliminating initial bureaucratic requirements for start-ups and subsidizing their access to credit.

On government reform, Lavín proposes modernizing government management, including competitive hiring of government managers based on performance-based contracts; providing management autonomy to public services; introducing transparency and accountability in government procurement and government service management; adopting modern corporate government practices in government service; putting SOE minority share packages on sale; reintroduce rigorous social project evaluation of government expenditure programs; and impose profitability requirements on SOEs. To strengthen macroeconomic stability, the program proposes to recapitalize the Central Bank and raise its managerial transparency; and maintain the structural public sector balance rule introducing changes in its calculation method. On employment and labor markets, Lavín proposes to make employment contract and workplace conditions subject to collective bargaining instead of government regulation; establish more effective control and enforcement of regulations on labor contracts and workplace conditions; support of female employment by subsidizing pre-school education and adopting more flexible labor contracts; support of youth employment by adopting more flexible contracts and exemption from payroll contributions. The program's proposals for education comprise devolution of education system and management decisions to school boards and principals; increase in pre-school education by providing subsidies to individual students; improve design of primary and secondary education subsidies; improve quality of technical education; and restructuring higher education, its quality control, and its coverage.

7. EPILOGUE ON CHILE'S POTENTIAL GROWTH AND RELATED POLICY CHALLENGES

On the basis of exceptional high growth observed during Chile's "golden period of growth" (the average annual 7.6% GDP growth rate recorded during 1985-1997), it is often stated – not only by the press and politicians – that Chile's growth potential is or should be in the range of 6-7% per year. But the latter inference is incorrect because it is based on a period that starts at a very weak and ends at a very strong cyclical position, as I have discussed above.

Current estimates for potential GDP trend growth – an unobserved stochastic variable – are closer to 5%. De Gregorio (2005) summarizes medium-term GDP growth projections from ten different studies provided for varying periods that span from one to ten years, roughly within the 2000-2010 decade, which average 5% with a moderately low dispersion. Estimates of the independent panel of experts consulted by the Ministry of Finance for the 2006 budget for the structural budget surplus rule and current Central Bank estimates confirm medium-term GDP growth projections that are close to 5%. Moreover, as stated above, Chile's actual long-term GDP growth, reflected in its most recent cyclically balanced period, from 1990 to 2005, has been 5.3%, equivalent to 4.1% per capita GDP growth.

Per capita growth of 4% per year, sustained over a long time period, represents a fundamental break with Chile's past. Recall that average per capita GDP has been only 1.7% during Chile's full history as an independent nation (from 1810 to 2005), implying an average per capita GDP growth of 1.5% during 1810-1990. Likewise, Chile's 4% per capita growth figure exceeds significantly per capita growth recorded by the world at large and most developing and industrial economies and regions, excepting East Asia and the Pacific's performance.

Will Chile be able to sustain high annual per capita growth—say, at 4%—for a sustained period into the future? This “million-dollar” question lacks an unconditional answer. However, the research studies and policy proposals reviewed in this article offer some guidance. First, Chile's current combination of structural, policy, and institutional strengths and weaknesses will carry its economy on its current growth path for some years to come, barring major shocks and abstracting from cyclical deviations from trend growth.

Second, Chile's exceptional strengths in macroeconomic policy and stability, and in the quality and development of its institutions, are confirmed in international country rankings, time and again. Correlating six indicators of institutional development with per capita GDP levels in a world sample, I confirm that Chile is an outlier from the cross-country regression, exhibiting levels of institutional development that are (often significantly) higher than those associated to its per capita GDP level (Figure 12). This evidence substantiates a positive outlook for future growth.

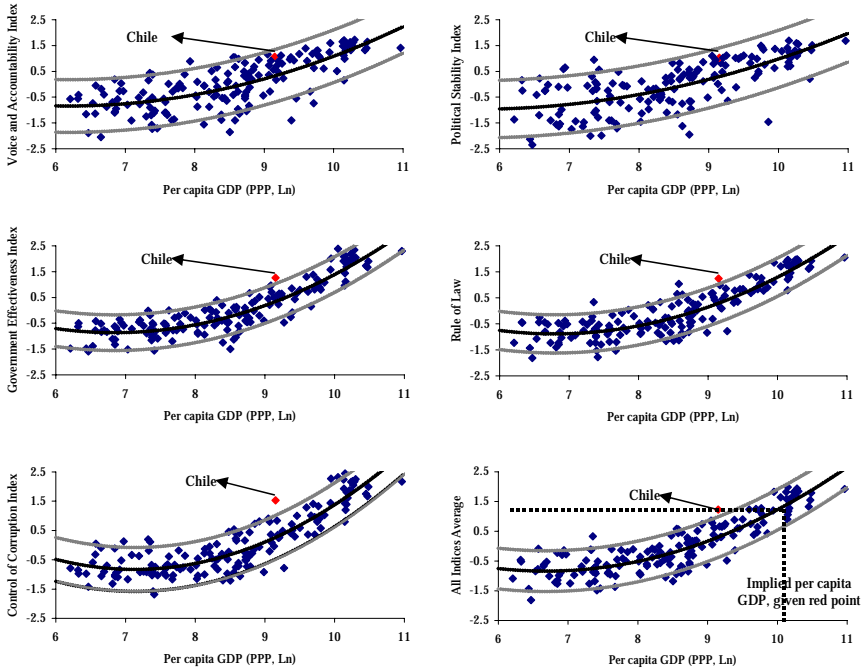
Third, Chile's weaknesses are entrenched but generally acknowledged, giving rise to the policy reform proposals reviewed in section 4 and substantiated by the research summarized in sections 1-3 and 5. Therefore I will end this article by referring briefly to the five major reform areas that, in my view, offer the largest payoffs in high future growth. Not surprisingly, this view is correlated—but not perfectly so—with the main proposals that I have reviewed above. This will excuse me for not restating the details on the abovementioned proposals.

The first area where substantial reform is required is education. The current shortcomings of Chile's education system are widely recognized and transparently reflected in the very unsatisfactory performance of students and the general population in several internationally applied tests of educational and general skills. The proposals for reform are spelled out in many studies and government programs and aim at a quantum shift in education coverage and quality over the next decade.

A second Achilles heel in Chile's development strategy is the low aggregate level and the low return of the country's R&D expenditure. Several reforms of government institutions and programs have been advocated to raise aggregate R&D expenditure levels and make them more effective through better design and implementation of government support, geared at stronger public-private partnership and reorientation toward applied R&D conducted by the private sector.

On factor markets, reform consensus is thinner than in the preceding areas. On labor markets, reform proposals for more labor-market flexibility depend on their perceived tradeoff with employment protection. Yet Chile's high average or

FIGURE 12
RELATION BETWEEN PER CAPITA GDP AND INSTITUTIONAL
DEVELOPMENT INDICES IN 161 COUNTRIES, 2002



Source: Author's estimations based data from World Development Indicators (2005) and Kaufmann *et al.* (2005).

Note: Author's regression line is in black and lines for confidence intervals at 90% are in grey.

natural unemployment rate, close to 8%, suggests that there should be room for raising labor-market flexibility to bring natural employment down and make human-capital investment more profitable. On financial intermediation and capital markets, reform proposals are geared at attaining more market competition, wider population access to banking services, and better risk diversification both within Chile and internationally.

Government reform represents a major challenge—because of its political-economy and implementation difficulties. However, a quantum leap in efficiency, transparency, and accountability of government management and service delivery is a necessary condition for sustained development. Government reform, complemented by radical privatization of all remaining SOEs and market-friendly improvements in government regulation and competition policies applied to goods and asset markets, would make a major contribution to private sector-led growth.

As fifth major requirement for achieving sustained high growth, I list the defeat of poverty. Lifting the ca. 20% share of poor Chileans out of poverty does

have a major impact on their welfare. Beyond the latter, it will raise growth by contributing to more trust, security, and social peace in Chile, hence raising the returns to investments in physical capital, human capital, innovation, and technology.

Two final observations are in order. More than in other fields of human action, the devil is in the details of good policy design and implementation. The world is plagued by well-intended policy actions with unintended but disastrous consequences (Easterly, 2001). Hence significant efforts and resources should be devoted to develop the blueprints and implementation of policy reforms.

Last but certainly not least, the growth payoff from synergies and complementarities of well-designed and implemented policy reforms can be very large, as documented by Gallego and Loayza (2002) and Fuentes *et al.* (2006) for Chile. Take the case of major and joint reform progress in the areas of education, labor markets, and poverty reduction, combined with progress in law enforcement. As a result of the latter, a growing share of better educated people with larger employment opportunities will be lifted out of poverty and will live a more productive life with a reduced alternative cost of working – crime. This outcome will have positive social externalities, reflected in more social cohesion and trust, less crime, and more security, raising investment and growth even further.

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COMPLEMENTARITIES BETWEEN INSTITUTIONS AND
OPENNESS IN ECONOMIC DEVELOPMENT: EVIDENCE
FOR A PANEL OF COUNTRIES*

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The main goal of the paper is to evaluate the sources of growth in Chile and the world in the last three decades, but stressing the role of complementarities in economic policies. Therefore, we evaluate the growth determinants for a sample of seventy-eight countries with information over the 1970-2000 period. In contrast to Gallego and Loayza (2002), we test directly the existence of complementarities between trade and financial liberalization policies with: a) the initial conditions of the economy, b) human capital policies, and c) the quality of institutions.

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1. INTRODUCTION

The empirical literature on economic growth offers a wide variety of studies that analyze the effects of economic policies and institutions on economic growth. In the case of Chile, a large part of the sustained economic growth over the so-called golden period (1986-97) could be attributed to good policies and structural reforms implemented in the country. However, other countries have implemented similar policies and they have been unable to achieve analogous results. In this respect, Rodrik (2005) argues that there is not a unique mapping from economic

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principles to policy packages. Successful countries have followed different strategies to implement reforms with a wide range of results.

We argue that the key element behind different development outcomes across countries lies in the notion of policy complementarities, which are crucial to determine whether a specific policy package help to enhance economic growth. The notion of policy complementarities is closely associated with the challenges of globalization in the world economy. In this respect, policy complementarities play an important role as economies develop closer links to each other through increasing trade and capital flows as well as technological transfers (Aziz and Wescott, 1997). Therefore policy complementarity has become a cornerstone to start up economic growth. Pro-growth policies are mutually reinforcing –for instance, financial openness will have positive and substantial growth effects in countries with solid institutions. However, policy complementarities can also impose severe restrictions in the design of the optimal growth strategy, especially among countries with unfavorable initial conditions or resistance to reform.

The goal of this paper is twofold. First, we assess the contribution of structural reforms and good policies to economic growth for Chile and compare a result to a large group of economies, using data for the last three decades. To accomplish this, we conduct a regression analysis for a sample of seventy-eight countries with data for the 1970-2000 period. Second, we proceed to test the conjecture that Chile's good performance relative to other economies is due to policy complementarities.

The issue of policy complementarities as a source of economic growth was first addressed by Gallego and Loayza (2002). They evaluate the role of economic policy complementarities on growth by including in their regression analysis a dummy variable that takes the value of one if all measures of a set of policy indicators have higher values than the corresponding world median, and zero otherwise.¹ These authors find that policy complementarities are important not only for Chile but also for other high-performing countries like Ireland, Korea, the Netherlands, and Thailand. One of the shortcomings of this indicator is that, although it accounts of the presents of policy complementarities, it does not quantify their extent or intensity.

In contrast to Gallego and Loayza (2002) we will directly test policy complementarities using interaction among specific policy dimensions. We acknowledge that it is practically impossible to specify all the potential policy complementarities in a regression equation due to lack of degrees of freedom. Here we are specifically interested in testing the complementarities of both trade and financial openness with the quality of institutions. We argue that international

¹ The policy indicators that comprise the Gallego-Loayza index of policy complementarities are related to openness, the black market premium, government consumption, financial development, life expectancy, and education. In their last period of estimation, 1986-1998, the countries with a value of 1 in the policy complementarities dummy variable are Belgium, Chile, Ireland, Korea, the Netherlands, the Philippines, and Thailand.

trade and international financial integration would lead to higher growth in countries with high-quality institutions.

The paper is divided in six sections. Section 1 is the Introduction. In section 2 we discuss the empirical strategy, while section 3 presents the main determinants of growth and the economic implications for Chile. We compare the performance of Chile in the 1980s and 1990s and establish the determinants of the economy's improvement. Section 4 discusses the policy complementarities as a determinant of economic growth. Section 5 presents different scenarios of policy improvement to show how much growth would increase. Section 6 concludes.

2. EMPIRICAL METHODOLOGY

The present section begins with a brief description of the estimation method used to obtain our parameters of interest. Specifically, we use the GMM-IV system estimator for dynamic panel data (Arellano and Bover, 1995; Blundell and Bond, 1998), which is suitable for our regression analysis by dealing with unobserved effects and endogenous regressors.² We then present a succinct discussion on the data used to proxy the determinants of growth.

2.1 Econometric Methodology

Our growth analysis is based on a pooled data set of cross-country and time-series observations (5-year period observations for 78 countries over the 1970-2000 period). We use the generalized method of moments (GMM) estimator for dynamic panel data models (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998), which accounts for unobserved country- and time-specific effects and likely endogenous regressors.

Our main goal is to estimate the following variation of the standard growth regression (see Loayza, Fajnzylber, and Calderón, 2005):

$$(1) \quad y_{i,t} - y_{i,t-1} = \alpha y_{i,t-1} + \beta' X_{i,t} + \eta_t + \mu_i + \varepsilon_{i,t},$$

where η_t is a period-specific effect that controls for global shocks that affect the growth performance of countries in the sample, and μ_i represents unobserved country-specific effects and thus accounts for growth determinants that are idiosyncratic to the country and potentially correlated with the explanatory variables.

The GMM estimator deals with unobserved time effects by including period-specific intercepts; it handles country effects by differencing and

²This section draws heavily from Loayza, Fajnzylber, and Calderón (2005) and Calderón, Loayza, and Schmidt-Hebbel (2004).

instrumentation given the dynamic specification of the model. The method also accounts for joint endogeneity by assuming that the explanatory variables are weakly exogenous. In sum, we identify our estimated parameters by assuming that future realizations of the error term do not affect current values of the explanatory variables, that the error term, ε , is serially uncorrelated, and that changes in the explanatory variables are uncorrelated with the unobserved country-specific effect.

This set of assumptions allows us to build moment conditions that set up our optimization problem and then to estimate the vector of parameters. Previous values of both levels and differences of the explanatory and dependent variables are used as instruments of these moment conditions. Since we are usually dealing with overidentified models, this method allows for specification testing through a Sargan-type test. Appendix A contains a detailed description of the methodology.

2.2 Data Sources

We estimate growth regressions on pooled cross-country and time-series data covering seventy-eight countries over the period 1970-2000. The data are organized in nonoverlapping five-year periods and each country has at most six observations (see appendix B for the list of countries). In what follows, we describe the definition and sources of the variables used in our growth regression analysis. Table B1 in appendix B contains the full description of the variables used in the paper; tables B2 and B3 provide descriptive statistics and correlation analysis between growth and its determinants.

We define our dependent variable as the growth rate of real per capita gross domestic product (GDP), measured as the five-year average of the log differences of per capita output. In turn, per capita output is measured as GDP divided by the total population (in 1985 PPP-adjusted US dollars) as in Loayza *et al.* (2005), and it is constructed using Summers and Heston (1991) and World Bank (2003). Our set of growth determinants can be classified into four groups, following Loayza *et al.* (2005): transitional convergence, structural policies and institutions, stabilization policies, and external conditions. Within the group of structural policies and institutions, we devote special attention to openness to international goods and capital markets.

Regarding the first group, transitional convergence, we use the initial value of GDP per capita (in logs) for the five-year period as our proxy for conditional convergence. We test whether the initial position of the economy is important for its subsequent growth, all things equal.

The second group, structural policies and institutions, is represented both theoretically and empirically by a wide array of economic policy determinants of growth. In the present paper, we consider the areas of education and human capital (Lucas, 1988), financial development (Levine, 1997), the government burden (Fischer, 1993; Engen and Skinner, 1996), governance (Knack and Keefer, 1995; Kaufmann, Kraay and Zoido-Lobaton, 1999), trade openness (Edwards, 1998; Wacziarg and Welch, 2003), and financial openness (Quinn, 1997; Bekaert,

Harvey, and Lundblad, 2001, 2005; Calderón, Loayza, and Schmidt-Hebbel 2004). Of these, education is approximated by the gross rate of enrollment in secondary school, which is the ratio of the number of students enrolled in secondary school to the number of persons of the corresponding age.³ Barro and Lee (2001) –our source of information– suggest that this flow measure reflects current policies on human capital investment more than stock measures associated with education attainment of the adult population or life expectancy. Financial depth is proxied by the ratio of private domestic credit supplied by private financial institutions to GDP. Here we focus on credit from and to the private sector because their incentives to perform efficiently are clearer than the public sector’s incentives. Our measure of financial depth is taken from Beck, Demirgüç-Kunt, and Levine (2000). We measure government burden as the ratio of general government consumption to GDP, using data from the World Bank (2003).⁴ We use consumption expenditure by the government as a proxy for two reasons: first, data on government expenditure categories are inconsistent, and, second, public wages arguably explain most of government consumption expenditure. In the case of governance, we use the first principal component of the following indicators: prevalence of law and order, quality of the bureaucracy, absence of corruption, and accountability of public officials. All these variables are taken from the *International Country Risk Guide* (ICRG) published by the Political Risk Services Group and constructed by Loayza *et al.* (2005).

The last two structural policies that we include are associated with the outward orientation of the economy. Here we consider the openness of the economy to international markets of goods and capital. First, we measure trade openness by the volume of trade (real exports and imports) over GDP, adjusted for the size of the country (proxied by its area and population), geography (whether the country is landlocked), and natural resources (whether it is an oil exporter). All these data are from the World Bank (2003) and the Global Development Network (2002). The rationale for using this measure is that fluctuations in the variable measured are attributed to trade policy instead of to structural features of the country.⁵ Second, we measure of financial openness by the ratio of equity-based foreign liabilities to GDP (Lane and Milesi-Ferretti, 2003):

$$EQIFI_{i,t} = \frac{PEQL_{i,t} + FDIL_{i,t}}{GDP_{i,t}} .$$

³Note that by construction, this rate could be greater than 100, as a result of repeating and late enrollment.

⁴This variable is used as a proxy for government burden in Barro (1991), Barro and Sala-i-Martin (1995), Easterly, Loayza, and Montiel (1997), and Bekaert, Harvey, and Lundblad (2001).

⁵For instance, it has been argued that (a) small countries depend more on international trade than large countries, (b) oil-exporting countries can have large trade volumes and, simultaneously, impose high tariff barriers, and (c) landlocked countries face larger transaction costs and thus trade less than coastal countries (Loayza *et al.*, 2005).

Our equity-based measure of financial integration, $EQIFI_{it}$, is the sum of the stocks of portfolio-equity and foreign direct investment liabilities, PEQL and FDIL respectively. We update the figures from Lane and Milesi-Ferretti (2001) for our sample of countries using data from the *Balance of Payments Statistics* published by the International Monetary Fund (IMF).

With regard to our third group of growth determinants, we have evidence that stabilization policies have an impact not only on growth in the short term, but also on the long-run performance of the economy (Fischer, 1993). Our first proxy of macroeconomic stabilization is the consumer price index (CPI) inflation rate, with high inflation being associated with other bad macroeconomic policies such as excessive fiscal deficits and a high black market premium (see Loayza *et al.* 2005). Our source of information is the World Bank's *World Development Indicators*. A second variable –an index of real exchange rate overvaluation– proxies the degree of external imbalances in the economy. This variable may capture the effects of monetary and exchange rate policy on the misallocation of resources between traded and nontraded sectors. See Table A2 for the construction of this variable and our data sources.

Finally, our fourth set of variables proxies the role of external conditions on the growth performance across countries. The regressions include terms-of-trade shocks, to capture shifts in the international demand for a country's exports and its input costs, and period-specific dummies, which capture the impact of other global shocks to growth across countries.

3. BASELINE RESULTS

The previous section outlined the different determinants of economic growth that we use in our regression analysis, as well as the estimation method used. We now describe the main result of our baseline growth regression. Here we use our sample of seventy-eight countries over the 1970-2000 period, organized in non-overlapping five-year periods, to estimate our growth regression equation using the GMM-system estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). This estimator accounts for econometric problems not corrected by conventional methods, such as unobserved country- and time-specific effects and the likely endogeneity of some growth determinants.

The first column of Table 1 presents our estimated baseline regression. In rest of this section, we describe our main findings, with the results organized according to the classification of the growth determinants specified in section 3. First, we find a negative and significant coefficient for the log of initial output per capita in all specifications. This implies that there is evidence of conditional convergence –that is, poorer countries may exhibit higher growth rates than richer countries as a result of decreasing returns to accumulative factors. Thus other

TABLE 1
DETERMINANTS OF ECONOMIC GROWTH:
REGRESSION ANALYSIS^a

Variable	Baseline regression (1)	Nonlinearities in financial openness (2)	Nonlinearities in trade openness (3)
Constant	18.041** (0.36)	30.674** (5.60)	11.777** (1.69)
Transitional convergence			
Initial GDP per capita (in logs)	-0.085** (0.01)	-0.418* (0.23)	-0.273** (0.08)
Structural policies			
Human capital	1.553** (0.02)	0.698** (0.14)	1.450** (0.08)
Financial depth	0.113** (0.02)	0.468** (0.14)	0.855** (0.10)
Institutions	0.259** (0.01)	0.442** (0.09)	0.194** (0.03)
Government consumption (% of GDP)	-3.105** (0.09)	-3.085** (0.19)	-2.721** (0.09)
Stabilization policies			
Inflation rate	-2.351** (0.06)	-4.328** (0.78)	-1.401** (0.33)
Real exchange rate overvaluation	-0.013** (0.00)	-0.004 (0.00)	-0.011** (0.00)
Openness:			
Trade openness	1.338** (0.03)	0.767** (0.15)	0.697** (0.13)
Financial openness	0.851** (0.09)	0.699* (0.42)	0.003 (0.14)
Interaction between openness and institutions			
Openness * Institutions	...	0.817** (0.25)	0.854** (0.07)
Openness * (Institutions**2)	... (0.10)	-0.253**	...
External conditions:			
Terms-of-trade shocks	0.032** (0.00)	0.026** (0.01)	0.044** (0.00)
Period shifts			
1976-80:	-0.463**	-0.066	-0.474**
1981-85:	-2.362**	-1.960**	-2.550**
1986-90:	-1.565**	-1.433**	-1.820**
1991-95:	-2.309**	-1.708**	-2.473**
1996-2000:	-2.410**	-2.123**	-2.383**
<i>Summary statistics</i>			
No. countries	78	78	78
No. observations	371	371	371
Specification tests (p values)			
Sargan test of overidentification	(0.46)	(0.54)	(0.49)
Second-order autocorrelation	(0.62)	(0.91)	(0.91)

* Statistically significant at the 10% level.

** Statistically significant at the 5% level.

Source: Authors' calculations.

a. The regressions are estimated using the GMM system estimator (Arellano and Bover, 1995; Blundell and Bond, 1998), based on a panel data sample of eighty-three countries over the period 1970-2000 (in non-overlapping five-year-average observations). Robust standard errors are in parentheses below the estimated coefficients.

independent variables will affect the long run level of output, but the growth rate will be affected only in the transition to the new steady state.⁶

Second, the literature focuses on both the direct and indirect roles of education in explaining long-run growth. Education, as a factor of production, leads to higher growth; it complements physical capital (Acemoglu and Zilibotti, 2001) and natural resources (De Gregorio and Bravo-Ortega, 2005); and it improves the ability of countries to either innovate or adapt technologies (Coe and Helpman, 1995; Keller, 2004). Our estimates indicate that countries with high education levels display a higher growth rate than countries with low education levels. If the enrollment rate of secondary schooling in Chile increased from 70 percent (the average in the period 1996-2000) to 100 percent (the level observed in Switzerland over the same period), the growth rate would increase 0.60 percentage points per year. This surge in education would take about eleven years given the historic growth rate of secondary schooling in Chile.

Third, the literature provides ample evidence that financial depth promotes growth.⁷ Financial systems may help allocate resources and diversify risks, among other things. Our measure of financial depth –namely, the ratio of domestic credit to the private sector relative to GDP– shows a positive and significant relation with economic growth. This result is consistent with the findings of De Gregorio (1999) and Levine, Loayza, and Beck (2000). That is, the growth rate will be higher in countries with well developed financial systems. According to our estimates, a surge in domestic credit to the private sector in Chile from the average level displayed in 1996-2000 (65.4 percent of GDP) to the levels displayed by Canada and Ireland (approximately 83 percent of GDP, which represents the seventy-fifth percentile of the world distribution in financial development) would raise Chile's growth rate by 0.03 percentage points. An abrupt reform of the financial system in Chile that increased its financial depth to the levels exhibited by the United Kingdom (121 percent of GDP, at the ninetieth percentile) or Korea (144 percent of GDP, at the ninety-fifth percentile) would increase its growth rate by 0.07 and 0.10 percentage points a year, respectively.

Fourth, we find that government consumption (relative to GDP) has a negative and significant influence on the growth rate of the economy. This shows that the government's participation in economic activity imposes a heavy burden through high taxes and an inefficient allocation of its revenues. Average government spending in Latin America was around 13 percent of GDP in 1996-2000 (excluding Chile). If this were reduced to the levels observed in Chile during the same period (10.8 percent of GDP), the region's growth rate would increase by 0.30 percentage points. The growth benefits would be even larger for countries with a higher level of government consumption, such as Brazil and Colombia with around 18-20 percent of GDP.

⁶In the rest of the paper, when we talk about the growth rate we mean the average growth rate during the transitional dynamic period.

⁷See Levine (1997) for a thorough survey of the theoretical and empirical literature on the subject.

Fifth, the quality of institutions proves to be a significant determinant of economic growth across countries. Consistent with earlier evidence (Mauro, 1995; Knack and Keefer, 1995), we find that the growth rate should be higher in countries with better institutions (that is, lack of corruption, prevalence of law and order, high democratic accountability, and high quality bureaucrats). Our aggregate index of institutions (that is, the principal components of several dimensions of governance) fluctuates between -3.26 and 3.47 , with higher values corresponding to countries with better institutions. In 1996-2000, the level of institutional quality in Chile was 1.4; this is the highest value observed among Latin American countries, and it ranks in the sixty-eighth percentile of the world distribution. Our estimates suggest that raising institutional quality in Chile to the seventy-fifth percentile (on par with Japan) would lead to an increase in the economy's growth rate of 0.20 percentage points a year. The gains in growth would be even higher—around 0.40 and 0.50 percentage points, respectively— if the level of institutional quality in Chile were to reach the levels of the ninetieth percentile (Austria, Norway, and Switzerland) or the ninety-fifth percentile (Canada, Denmark, the Netherlands, and Sweden). While Chile outperforms countries with similar levels of income per capita, its institutional quality still lags significantly behind that of advanced economies.

Sixth, we analyze the impact of openness to international trade of goods and assets on economic growth. We focus first on the impact of trade openness on economic performance. The literature attributes the positive growth effect of trade openness to an expansion of the potential market, increased specialization, and improvements in technological diffusion and managerial skills stemming from stronger interaction with foreign firms. In our regression analysis, we find a positive and significant relation between trade openness and economic growth; that is, a more outward orientation in the trade of goods may lead to higher growth. If the adjusted coefficient of trade openness in Chile were to increase to the levels observed in South Korea (that is, if it doubled), the economic growth rate of the country would increase by 0.34 percentage points. Moreover, if this “policy component” of trade openness in Chile increased to the levels of the ninetieth percentile (Ireland and the Philippines) or the ninety-fifth percentile (Canada and Thailand), the country's growth rate would rise by 0.70 and 0.90 percentage points per year.

A recent wave of empirical research on the relation between financial openness and growth reports mixed results so far. Theoretically, the impact of financial openness on growth is also inconclusive. Some researchers argue that greater openness to world capital markets may allow a higher degree of risk sharing and, hence, promote higher growth through production specialization and a more efficient allocation of capital (Acemoglu and Zilibotti, 1997). In addition, financial openness may facilitate capital flows to scarce countries and enhance domestic financial systems through greater competition and the import of financial services (Klein and Olivei, 1999; Levine, 2001). Other analysts, however, argue that financial openness can hurt growth in the presence of distortions (Eichengreen, 2001) or in countries with weak institutions and policies

(Boyd and Smith, 1992). We include the ratio of equity-based foreign liabilities to GDP in our regressions as a proxy of financial openness and we find that its coefficient is positive and significant. This implies that the growth rate will be higher in countries with a higher degree of international financial integration. According to our estimates, if the ratio of foreign liabilities to GDP in Chile (which averaged 53 percent of GDP in 1996–2000) rose to the levels of Austria or the United Kingdom (73 percent of GDP, in the ninetieth percentile of the world distribution), then its growth rate would increase by 0.20 percentage points.

Turning now to the category of stabilization policies, we begin our evaluation with the relation between price instability and growth. The inflation rate is our proxy of price instability, as it is a reliable outcome measure of good or bad macroeconomic policies, and it has become an indicator of macroeconomic instability in empirical research (see Fischer, 1993; Easterly, Loayza, and Montiel, 1997). Our estimated coefficients suggest that inflation may harm economic growth. The growth benefits that Chile can reap are small given that the country has stabilized its inflation at low levels. However, the growth gains from reducing inflation are greater for other Latin American countries. For instance, if Ecuador were to reduce its inflation rate from an average 40 percent in 1996–2000 to the levels observed in Chile during the same period (around 4.7 percent per year), its growth rate would increase by 0.70 percentage points per year. The growth rates in Colombia and Venezuela could increase by 0.20 and 0.50 percentage points, respectively, if they were to reach the inflation rate of Chile.

Our second proxy in this category is the index of real exchange rate overvaluation. This variable captures the distortions introduced by macroeconomic policies in the allocation of resources between traded and nontraded sectors. Empirically, we find that an overvaluation of the real exchange rate hinders economic growth. According to the overvaluation index computed in Loayza *et al.* (2005), the Chilean peso was slightly overvalued relative to the U.S. dollar in the 1996–2000 period.⁸ If Chile were to eliminate this misalignment (reaching an index of 100), its growth would increase by 0.07 percentage points a year. Growth gains would be even larger in countries with higher degrees of overvaluation. For instance, if Australia reduced its real exchange rate overvaluation to the levels displayed by Chile—that is, from an index of 127.1 in 1996–2000 to 105.7—its growth rate would rise by 0.30 percentage points.

Finally, we find that external conditions can also affect economic growth across countries. This category is proxied by terms-of-trade shocks and period-specific shifts. First, we find that growth is enhanced by favorable terms-of-trade shocks. This evidence is consistent with the positive impact of an increase in the terms of trade on our demand for exports. Second, the negative coefficient estimates of our period-specific dummies is consistent with the growth slowdown experienced by the world economy after 1973.

⁸Loayza *et al.* (2005) follow the methodology proposed by Dollar (1992) to construct the index. The average value of the real exchange rate overvaluation index for Chile in 1996–2000 was 105.6, which represents a 5.6 percent overvaluation.

4. POLICY COMPLEMENTARITIES AND ECONOMIC GROWTH

One of the puzzles in the analysis of economic reforms is why they have triggered higher growth in some economies but not in others. Gallego and Loayza (2002) credit policy complementarities for Chile's high economic growth and for the profitability of the country's reforms. In other words, it is not just good policies, but good combinations of policies, that could help stimulate growth. The effect of some variables on economic growth depends on the level of other variables.

Gallego and Loayza (2002) use a dummy variable to measure policy complementarities; it takes the value of one if the levels of certain structural variables are above the world median and zero otherwise.⁹ This variable would measure the existence of policy complementarities, that provides information on whether a country has surpassed certain threshold in the policy areas of education, financial development, openness to trade and stabilization. However, it does not provide information on the magnitude of the interaction among these individual policies. For instance, from their work we cannot infer whether the impact of trade policies on growth is higher when interacted with education, more liquid domestic financial sector or better quality of institutions. This information may prove useful for economic authorities in order to prioritize critical policy areas. Closing gaps in those areas may enhance the benefits of trade openness and may lead to significant growth improvements.

A number of papers in the literature attempt to determine the effects of policy complementarities on economic growth. Given that policies are inter-related in complex ways, there is a wide variety of interactions that could be evaluated. For that reason, the empirical and theoretical literature focuses on specific complementarities among policy areas. For instance, Levin and Raut (1997) show the existence of policy complementarities between human capital and the exportable sector for a sample of semi-industrial countries. Ok (2004) shows that the success of outward-orientation policies in South Korea may be attributed to active investment and industrial policies. Bolaky and Freund (2004) find that the impact of openness to trade on growth is negligible in economic environments with excessive regulation. Other works, however, find that the growth effects of high foreign direct investment depend directly on the level of human capital in the economy (Borensztein *et al.*, 1998; De Gregorio, 1999) and the degree of domestic financial development (Alfaro *et al.*, 2004). In addition, Edison *et al.* (2002) and Klein (2003) assess the importance of initial conditions, human capital, and domestic financial depth on the relation between the growth rate and openness to international financial markets.¹⁰

⁹Specifically, the constructed dummy variable takes the value of one if human capital (years of education and life expectancy), financial depth (ratio of private credit to the domestic sector), trade openness, and stabilization policies are above the world median. In the case of stabilization policies, government consumption and the black market premium should be below the median.

¹⁰Calderón and Fuentes (2006) are undertaking a comprehensive analysis of the complementarities between outward-orientation policies (both in the international market for goods and assets) and several structural and stabilization policies. Early evidence from this work in progress shows that openness to trade and the access to world capital markets are highly complementarily with a policy index.

Again, the purpose of this paper is to illustrate the impact on growth of some important policy complementarities. To analyze all the possible interactions among policies is almost impossible (due to problems with degrees of freedom and unavailability of data) and is beyond the scope of the present paper. Specifically, this section will concentrate on the interactions between the quality of institutions and policies that promote trade and financial openness.

The regressions presented in the first column of Table 1 –like most of the growth regression in the empirical literature– assume that the effect of trade openness or financial openness on economic growth is the same for Chile, Australia, Pakistan, and Malawi, that is, the coefficients are constant for each country. In all likelihood, however, this effect will be influenced by the quality of institutions in each country.

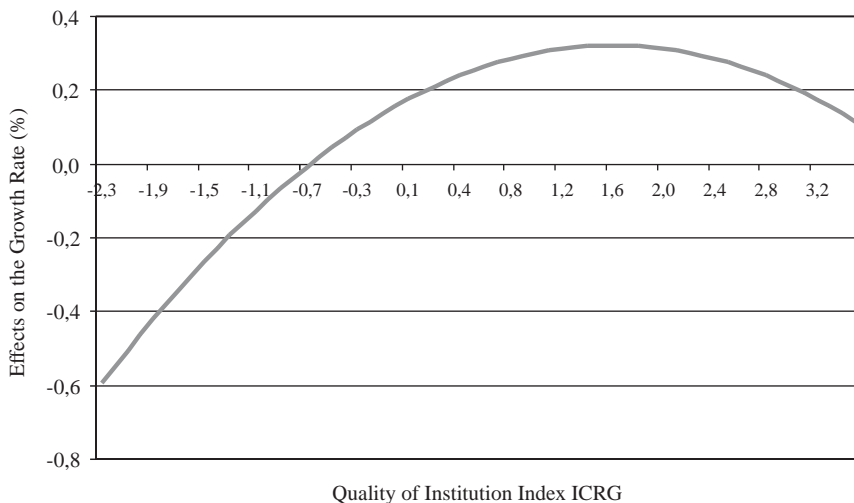
4.1 Financial Openness and Institution Quality

As indicated above, the idea that financial openness enhances growth has not been empirically demonstrated. The current state of the art establishes that under certain conditions, capital account openness has a positive impact on economic growth. Column 2 of Table 1 presents the effect of the interaction between financial openness and institutional quality on economic growth. This exercise complements the evidence on how institutional quality affects the impact of financial openness on growth (Klein, 2003) and the financial aid flows on growth (Burnside and Dollar, 2000).

Our estimations show that capital account openness enhances economic growth in countries with high quality institutions, which is consistent with Klein's (2003) findings. Figure 1 exhibits the impact of a one-standard-deviation increase of financial openness (that is, an increase of 24 percent of the coefficient external liabilities over GDP) on growth for countries with different levels of institutions. The figure shows that financial openness has a negative impact on economic growth in countries with weak institutions (identified as countries whose institutional quality lies in the lowest quintile of the distribution). Thus, the growth response to an increase of one standard deviation in financial openness fluctuates between -0.01 and -0.60 percentage points per year for countries with weak institutions. Countries with an average annual loss in growth between 0.01 and 0.20 percentage points, we found Peru (0.02 percentage points), Honduras (0.04 percentage points), Paraguay (0.07 percentage points), Indonesia (0.09 percentage points), and Colombia (0.14 percentage points). Countries with even weaker institutions, such as Togo, Nigeria, Haiti, and Niger, present average annual growth losses above 0.40 percentage points.

The impact of increased financial openness becomes positive for higher levels of institutional quality. In our sample, this is the case for countries above the twentieth percentile in the world distribution of institutional quality. The impact coefficient of financial openness on growth increases for countries with stronger institutions, reaching a maximum of 0.32 percentage points higher growth when the degree of financial openness rises by one standard deviation (24 percent

FIGURE 1
GROWTH EFFECTS OF HIGHER FINANCIAL OPENNESS
AS A FUNCTION OF THE LEVEL OF INSTITUTIONAL QUALITY



of GDP). According to our results, the highest impact occurs for Italy, Singapore, Chile, and South Korea, whose institutional quality lies in the seventieth percentile of the world distribution.

The nonlinear effect of financial openness on growth is consistent with the idea that financial openness tends to benefit middle income economies the most. More developed countries do not receive further benefits from opening their capital account, since they already have a well developed and internationally integrated financial market.

4.2 Trade Openness and Institution Quality

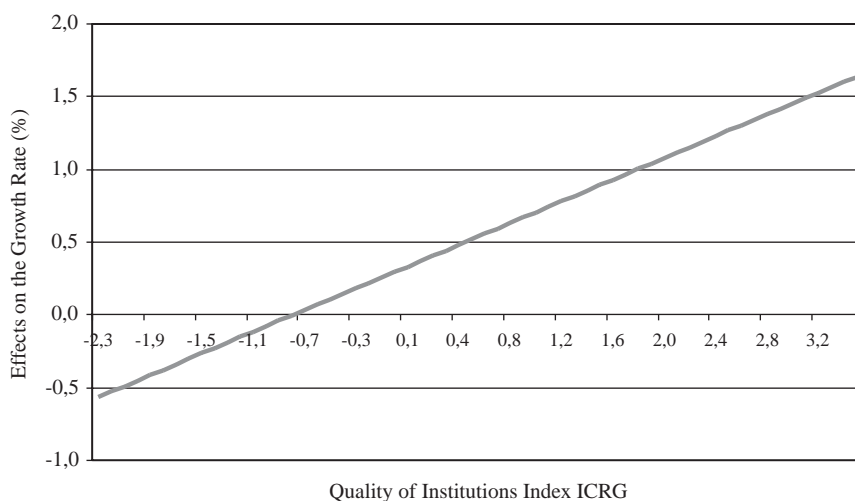
A large number of papers evaluate the relation between the degree of trade openness and economic growth.¹¹ Rodríguez and Rodrik (2000), who use different measures of openness and trade policy, claim that those works do not find a robust relation between trade openness and economic growth. However, Wacziarg and Welch (2003) study episodes of trade liberalization to get a better picture of the effect of trade openness on growth. Their results suggest that the impact of trade openness on growth depends on the speed of capital accumulation (both physical and human), political stability, and the depth of the economic reforms.

Column 3 of Table 1 reports the estimated coefficients including the coefficient of the interaction between trade openness coefficient and institutional

¹¹See, for example, Dollar (1992); Sachs and Warner (1995); Edwards (1998).

quality. According to these results, trade openness has a larger impact on growth when institutional quality is higher, and this relationship is monotonic. Figure 2 similarly illustrates that trade openness has a negative impact on growth in countries with weak institutions (in the bottom 15 percent of the world distribution). This is the case for countries like Ghana, Haiti, Paraguay, Niger, Nigeria, Togo, and Zimbabwe. A one-standard-deviation increase in the degree of trade openness (0.45) induces an average rise of 0.18 for a country in the twenty-fifth percentile (Brazil) and a 0.45 for the median country (Mexico).

FIGURE 2
GROWTH EFFECTS OF HIGHER TRADE OPENNESS
AS A FUNCTION OF THE LEVEL OF INSTITUTIONAL QUALITY



For the case of Chile, the growth rate would increase by 0.85 percentage points if the degree of openness (adjusted for scale factors and geography) rose by one standard deviation relative to the level observed in 1996–2000 (1.40). Finally for countries with a higher institutional quality than Korea (above the seventy-second percentile of the world distribution), the impact on growth of a one-standard-deviation increase in the degree of openness is larger than 1.0 percentage point per year.

5. WHAT EXPLAINS GROWTH? THE ROLE OF ECONOMIC POLICY

An important question that arises from the previous analysis is what factors explain Chilean economic growth. Was the rapid growth of the 1990s due to the

convergence force, (that is, to the fact that Chile was relatively poor and thus tended to grow faster than richer countries), or did good policies play a central role? The answers to these questions can be derived from Table 2, which presents a comparison between the effective and projected growth rates for Chile and other regions in 1996-2000 and 1981-85. We obtained this projection using our baseline regression (column 1 of Table 1) and the regression that includes the complementarity between financial openness and institutions (column 2 of Table 1). Given the statistical significance of the interaction coefficients, we base our discussion of the results on the model with complementarities.

Our first conclusion after comparing the actual and projected rates is that the model is a good fit for forecasting the growth rate of Chile and the different regions presented in Table 2, with the exception of the East Asia. Chile grew 3.57 percent more in the second period than in the first, which is very closed to the 3.30 percent projected by the model. Here, the higher Chilean growth is due to structural policies, stabilization policies, and openness. Structural policies account for 1.90 percent of the explained variation of Chilean growth in that period, while openness policies (both trade and financial) explain 1.00 percentage point of the higher growth.

In 1981-85, the Chilean economy was in the middle of a reform process and a deep financial crisis. The economy began to experience the benefits of the reforms (namely, structural policies and openness) in the late 1980s and 1990s; this process, jointly with achievements in macroeconomic stability, could explain the rapid growth of that period. One might argue that this is an unfair comparison since the first period was characterized by a large international crisis, but we control for this effect in the regression through the external shock variables. Moreover, external shocks were also present in the second period.

Latin America also experienced a higher growth rate in the second period compared to the first one. As in the Chilean case the same group of variables (openness, structural policies and macroeconomic stabilization) explains the higher Latin American growth in the later period *vis-à-vis* the earlier one, whereas openness is the key variable explaining growth for East Asia and industrial countries in the late nineties. Some structural variables and real exchange rate overvaluation explain why the growth rate was not particularly high in the second period for the latter two groups of countries.

In summary Chile shows the highest increase in its growth rate (1996-2000 respect to 1981-1985) among the group of countries considered. Different group of policies that contribute to growth explains this result. This piece of evidence enhances the conclusion on the importance of policy complementarities. Another important issue is what this empirical model predicts for the future growth rate. For this exercise, we need to predict the right-hand-side variables of the regressions for each country. To do that we will consider different scenarios.

TABLE 2
EXPLAINING CHANGES IN GROWTH BETWEEN PERIODS: 1996-2000 VERSUS 1981-85

Variable	Using regression 1 of table 1					Using regression 2 of Table 1				
	Chile	Latin America	East Asia	Industrial countries	All countries	Chile	Latin America	East Asia	Industrial countries	All countries
Economic Growth										
Actual change	3.57	2.94	-0.21	1.37	1.73	3.57	2.94	-0.21	1.37	1.73
Projected change	3.45	2.30	1.90	1.08	1.78	3.30	2.52	1.49	1.07	1.52
Transitional convergence	-0.05	0.00	-0.05	-0.02	-0.01	-0.23	0.00	-0.24	-0.11	-0.06
Initial GDP per capita	-0.05	0.00	-0.05	-0.02	-0.01	-0.23	0.00	-0.24	-0.11	-0.06
Structural policies	1.75	1.00	0.97	0.47	0.93	1.91	1.03	1.03	0.33	0.78
Human capital	0.43	0.37	0.43	0.39	0.53	0.19	0.16	0.19	0.17	0.24
Financial depth	0.03	0.02	0.06	0.03	0.02	0.11	0.08	0.24	0.10	0.07
Institutions	0.46	0.24	0.16	0.01	0.12	0.79	0.42	0.27	0.01	0.20
Government consumption	0.83	0.37	0.33	0.05	0.27	0.82	0.37	0.33	0.05	0.27
Stabilization policies	0.68	0.46	0.00	-0.36	0.22	0.66	0.87	0.05	0.13	0.41
Inflation rate	0.29	0.47	0.03	0.16	0.22	0.54	0.87	0.06	0.29	0.41
Real ex. rate overvaluation	0.39	-0.01	-0.03	-0.52	-0.01	0.12	0.00	-0.01	-0.16	0.00
Openness	1.01	0.80	1.01	1.03	0.64	1.04	0.72	0.80	0.86	0.52
Trade openness	0.65	0.60	0.72	0.59	0.41	0.37	0.34	0.41	0.34	0.23
Financial openness	0.36	0.21	0.29	0.44	0.23	0.67	0.37	0.38	0.52	0.28
External conditions	0.05	0.03	-0.03	-0.04	0.00	-0.09	-0.10	-0.15	-0.16	-0.12
Terms-of-trade shocks	0.10	0.08	0.02	0.01	0.05	0.08	0.06	0.01	0.01	0.04
Period shifts	-0.05	-0.05	-0.05	-0.05	-0.05	-0.16	-0.16	-0.16	-0.16	-0.16

Authors' calculations.

5.1 Continuous Trend Scenario

A first exercise is done under the assumption of a continuous trend for the explanatory variables, following the methodology of Loayza *et al.* (2005). This scenario forecast values for the right-hand-side variables that are in line with the historical trend. In the case of the reforms, this means that the economies will deepen their reform processes. The projection models could include deterministic trends (linear and quadratic), convergence terms, and moving average (MA) coefficients, among others. Table B4 in appendix B provides a more detailed explanation for each variable.

The results obtained under this scenario depend, in some cases, on strong assumptions. This is especially true for Chile, a country that has experienced one of the most accelerated reform processes in the world in the last thirty years. No better assumption is available, however, so we use this scenario for our baseline estimation.

The forecasted values for the variables related to structural reforms show that deepening economic policy at the previous trend would imply several things: (a) an increase in the secondary enrollment rate from 7 percent in 1996–2000 to almost 85 percent in 2006–10; (b) a rise in domestic credit to private sector from 42 percent of GDP in 1996–2000 to 52 percent of GDP in 2006–10; (c) an increase in the adjusted coefficient of openness of 5 percentage points of GDP; and (d) an increase in the external liabilities related to foreign investment and equity from 53 percent of GDP in 1996–2000 to 66 percent in 2006–10. On the other hand, the stabilization policy variables in this scenario would hold the inflation rate around 3 percent in 2006–10 (compared to an average inflation rate of 8 percent in 1996–2000), and it would keep the real exchange rate in line with the equilibrium path.

Thus, if and only if the variables followed the pattern described by the continuous trend scenario, Chile's growth rate would be 0.27 percentage points higher in the five-year period 2006–10 than in 1996–2000 (see Table 3). This is below the higher growth rate for East Asia in that period (0.47 percentage points) and barely better than Latin America (0.24 percentage points). Chile has historically introduced reforms at a faster pace than the rest of Latin America. Therefore, for the rest of the continent, the continuous trend scenario means a deepening of the reform process.

Of this 0.27 percentage point of higher growth rate for 2006–10, structural policies contribute 0.28 percentage point, while the macroeconomic stabilization efforts contribute only 0.10 percentage point. This low contribution from stabilization policies is due to the fact that the base for comparison is the 1990s, when the inflation rate was above 3 percent, whereas inflation is now stable at around 3 percent. These effects are partially cancelled by the convergence effect, since Chile has a higher initial per capita GDP than the rest of the region.

TABLE 3
GROWTH FORECASTS UNDER A CONTINUOUS TREND SCENARIO:
2006-10 VERSUS 1996-2000^a

Variable	Chile	Latin America	East Asia	Industrial countries	All countries
Estimated growth rate, 1996-2000 (%)	2.70	1.05	1.80	2.62	1.64
Projected change in growth (%)	0.27	0.24	0.47	0.14	0.21
Expected growth rate, 2006-10 (%)	2.97	1.29	2.27	2.76	1.85
Transitional convergence	-0.13	-0.05	-0.18	-0.11	-0.11
Initial GDP per capita	-0.13	-0.05	-0.18	-0.11	-0.11
Structural policies	0.28	0.14	0.53	0.20	0.28
Human capital	0.15	0.11	0.11	0.14	0.13
Financial depth	0.07	0.06	0.06	0.06	0.07
Institutions	0.03	0.08	0.05	0.02	0.04
Government consumption	-0.27	-0.28	-0.01	-0.28	-0.19
Trade openness	0.12	0.05	0.09	0.09	0.09
Financial openness	0.18	0.11	0.23	0.18	0.13
Stabilization policies	0.09	0.21	0.12	0.05	0.05
Inflation rate	0.07	0.21	0.12	0.00	0.04
Real exch. rate overvaluation	0.02	0.00	0.00	0.05	0.01
External conditions	0.03	-0.06	0.00	0.00	-0.01
Terms-of-trade shocks	0.03	-0.06	0.00	0.00	-0.01

Authors' calculations.

a. The growth forecasts are computed using regression 2 of Table 1.

5.2 Sharp Progress Scenarios

A second exercise makes projections under different scenarios of sharp progress in economic reforms. For those scenarios, the policy variables are assumed to take values above those found in the continuous trend scenario.

These scenarios assume a deepening of structural reforms in the following areas: education (an increase in the secondary enrollment), financial development (an increase in the ratio of private credit to GDP), trade openness, and financial openness. For the other variables (namely, inflation, real exchange rate overvaluation, institutions, and government consumption), we assume that the future value is the same as under the continuous trend scenario. We use four different sets of values to make our projections, which are presented as four different scenarios below. These four scenarios are useful for illustrating the growth rate that Chile could achieve if it accelerated the next stage of reforms. However, the speed of the reform process varies with the type of policy involved.

Some of the scenarios simulated here could be reached relatively quickly, while others could take a number of years.

Table 4 presents our results under all four scenarios. The first scenario (which we call EME-90th percentile) projects how far Chile needs to progress in the areas of education, financial development, and trade and financial openness to reach the ninetieth percentile of the distribution of the group of emerging market economies, based on the values registered by those economies in 1996–2000. This scenario implies the following changes: (a) an increase in the rate of secondary enrollment from 70 to 85 percent (the level registered by Philippines in 1996-2000), which could be attainable for Chile at the beginning of the 2006-2010 period, given the trend in education data; (b) a doubling of the ratio of domestic credit to GDP, from 65 percent to the levels shown by Malaysia; (c) a rise in the level of openness (adjusted for size and geographical factors) to the levels shown by China and Mexico; and (d) essentially no change in the financial openness coefficient, given that Chile is already in the ninetieth percentile of the emerging market economies' distribution.

TABLE 4
GROWTH FORECASTS UNDER SHARP PROGRESS SCENARIOS:
2006-2010 VERSUS 1996-2000^a

Variable	Scenarios of sharp progress in economic reforms				
	Continuous trend scenario	Emerging market economies 90th percentile	Leader	Average	Industrial economies 75th percentile
Estimated growth rate, 1996-2000 (%)	2.7	2.7	2.7	2.7	2.7
Projected change in growth (%)	0.3	0.8	1.3	0.4	0.8
Expected growth rate, 2006-10 (%)	3.0	3.5	4.0	3.1	3.5
Transitional Convergence	-0.13	-0.13	-0.13	-0.13	-0.13
Structural Policies	0.28	0.78	1.34	0.44	0.84
Human Capital	0.15	0.13	0.26	0.30	0.36
Financial Development	0.07	0.37	0.37	0.18	0.27
Trade Openness	0.12	0.52	0.81	0.03	0.19
Financial Openness	0.18	0.01	0.14	0.18	0.27
Stabilization Policies	0.09	0.09	0.09	0.09	0.09
External Conditions	0.03	0.03	0.03	0.03	0.03

Authors' calculations.

a. The growth forecasts are computed using regression 2 of Table 1.

The second scenario (EME–Maximum) contemplates an abrupt reform that would move Chile to the level of the emerging market leaders in the different policy areas considered. For education and domestic financial market

development, Chile would need to achieve the levels of Korea (which has 100 percent secondary enrollment) and Thailand (where private credit to GDP is 140 percent). Based on the historical growth rates of those variables, we estimate that the reforms in education and the domestic financial market could be implemented at the beginning of the 2016-2020 and 2031-2035 periods, respectively. In the area of international trade, the goal would be to reach the level of Korea, which had a coefficient of openness equal to 85 percent of GDP in 2003. Finally, in the area of financial integration, this scenario calls for an increase in the ratio of external liability to GDP from 52 percent in 1996-2000 to 62 percent, which is the level of Malaysia in that period.

The third scenario (IND-average) requires accelerating the reforms in education, financial sector development, and trade and financial openness to reach the representative outcome of industrial economies. With regard to educational level, this scenario considers an increase of the secondary enrollment rate to the level of Canada (that is, above 100 percent), which could be reached by the 2016-2020 period if Chile follows its current trend in education.¹² Deepening financial development implies raising private credit to 95 percent of GDP, which is the ratio for Portugal in 1996-2000. Chile's adjusted coefficient of trade openness is already similar to the average of industrial economies. In the case of financial integration, the level of external liabilities needs to reach 65 percent of GDP, which is the level for Austria and Finland in 1996-2000.

Our final scenario (IND-75th Percentile) projects what it would take for Chile to reach the level of the seventy-fifth percentile of the distribution of industrial economies. This is equivalent to obtaining the secondary enrollment rate observed in New Zealand, which was above 110 percent in 1960-2000; Chile could achieve this rate in the 2021-2025 period, given the observed trend in the data. In the area of financial development, Chile would need to increase private credit over GDP from 65 to 115 percent (the level of Sweden in 1996-2000). Considering the trend in the data, Chile could reach that level in the 2026-2030 period. Under this scenario, the adjusted trade openness coefficient would have to rise from 0.33 to 0.58 (Germany in 1996-2000), and financial integration should increase to 75 percent of GDP (Australia in 1996-2000)

Looking at this final exercise, our results tell us that Chile can grow between 0.3 to 1.3 percentage point faster per annum on the second half of this decade compared to the 1996-2000 period. However the efforts in terms of improving policies in several dimension is too big to be feasible in such a short period of time.

¹²The human capital variable was constructed using the secondary enrollment rate. The United Nations estimates this rate as the coefficient of the number of students enrolled in the secondary level divided by the age group that corresponds to that educational level. Given this definition, that rate of education could be higher than 100 percent, because of students who failed and are repeating the grade and because of the enrollment of student who are older or younger than the age group defined by the United Nations.

6. CONCLUDING REMARKS

Based on estimations using a sample of seventy-eight countries for the 1970-2000 period, we found that policy complementarities are important for understanding the heterogeneous response of growth to both trade openness and financial openness. Thus, the variety of experiences across countries in terms of trade and capital account liberalization could be attributed to the different interactions in play between these outward-orientation policies and the quality of institutions (as well as other structural policies) in the country.

We can summarize our findings in three key points. First, the impact of financial liberalization on economic growth is negative for nations with weak institutions. Countries with strong institutions receive the largest benefit of trade and financial openness. The peak benefit, however, is obtained at different level of openness for each variable. This result is consistent with Calderón, Loayza, and Schmidt-Hebbel (2004), who find that trade and financial openness have a nonlinear effect on growth. Specifically, they find that financial openness most strongly favors middle income countries. The industrial nations gain little additional benefit because they are already integrated to financial markets.

Second, Chile has enjoyed a relatively high level of growth mainly as a result of a range of good policies. The most important are institution quality, financial openness, and macroeconomic stability. If Chile continues to deepen the reforms at the same pace observed in the data (in terms of both direction and intensity), the average annual growth rate for the five-year period 2006-2010 would be 0.27 percentage point higher than in the second five-year period of the previous decade.

Finally, deepening economic policies and reforms in areas like education, financial market development, and trade openness will provide the momentum for the economy to increase the growth rate in the transition a higher steady state. Specifically, deepening these policies will increase the average growth rate by 0.8 percentage point per annum for 2006-2010 compared to 1996-2000.¹³

¹³Note that an annual growth rate of 2.7 percent (as experienced by Chile) in 1996-2000 would lead to a cumulative growth rate of approximately 14 percent over this 5-year period. However, an increase in the growth rate of 80 basis points (to 3.5 percent predicted for 2006-10 under the scenario of 90th percentile for EMEs) would generate a cumulative growth of 19 percent over this 5-year period.

APPENDIX A
ESTIMATION METHODOLOGY: THE GMM-IV
SYSTEM ESTIMATOR¹⁴

To estimate our growth regression equation, we have to deal with two problems. The first is the presence of unobserved country- and time-specific effects. The time effects are accounted for by the inclusion of period-specific dummy variables. In the case of country-specific effects, however, we cannot use common methods such as within-group estimators given the dynamic nature of our regression equation. The second problem we may face is the possibility of endogenous regressors in a dynamic panel data environment, and we need to control for possible inconsistent estimates resulting from simultaneity. To overcome these problems, we use the generalized method of moments (GMM) estimators developed for dynamic panel data models by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). The GMM estimator for dynamic panel data controls for unobserved country-effects by expressing the regression equation in differences and/or instrumenting for these unobserved effects, and by using internal instruments (namely, lagged observations of the regressors) to control for endogeneity.

Once we accounted for time-specific effects, we can express our growth regression equation as follows:

$$(A1) \quad y_{i,t} = \alpha y_{i,t-1} + \beta' X_{i,t} + \eta_i + \varepsilon_{i,t}$$

To account for country-specific effects, we express equation A1 in first differences:

$$(A2) \quad y_{i,t} - y_{i,t-1} = \alpha (y_{i,t-1} - y_{i,t-2}) + \beta' (X_{i,t} - X_{i,t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1})$$

As we said before, our set of instruments consists of previous observations of the explanatory and lagged dependent variables.¹⁵ The method thus only allows current and future values of the explanatory variables to be affected by the error term. In sum, this IV method assumes weak exogeneity (that is, our set of variables is not fully endogenous).

The GMM dynamic panel estimator assumes that (a) the error term, ε , is not serially correlated, and (b) the explanatory variables, X , are weakly exogenous (that is, the explanatory variables are assumed to be uncorrelated with future realizations of the error term). Hence, it establishes the following moment conditions:

¹⁴This appendix draws heavily from Loayza, Fajnzylber, and Calderón (2005).

¹⁵The use of instruments should account for (a) the likely endogeneity of the explanatory variables and (b) the problem that, by construction, the new error term, $\varepsilon_{i,t} - \varepsilon_{i,t-1}$, is correlated with the lagged dependent variable, $y_{i,t-1} - y_{i,t-2}$.

$$(A3) \quad E\left[y_{i,t-s} \cdot (\varepsilon_{i,t} - \varepsilon_{i,t-1})\right] = 0 \quad \text{for } s \geq 2; t = 3, \dots, T; \text{ and}$$

$$(A4) \quad E\left[X_{i,t-s} \cdot (\varepsilon_{i,t} - \varepsilon_{i,t-1})\right] = 0 \quad \text{for } s \geq 2; t = 3, \dots, T.$$

The estimator –based on conditions A3 and A4– is the GMM difference estimator (Arellano and Bond, 1991). Although it outperforms other simpler panel data estimators, the GMM difference estimator has some significant statistical problems. It has been shown that previous levels of explanatory variables are weak instruments for equation A2 if these regressors are persistent over time (Blundell and Bond, 1998; Alonso-Borrego and Arellano, 1999). Specifically, the problem of weak instruments generates inefficient estimates (that is, the variance of the coefficients rises), and according to Monte Carlo experiments, it can yield inconsistent coefficients in small samples.¹⁶

To overcome the problems posed by the GMM difference estimator, we use an estimator that combines the regressions in differences and in levels in a system, as developed by Arellano and Bover (1995) and Blundell and Bond (1998). The instruments for the regression in differences are similar to the ones specified above, whereas the instruments for the regression in levels are the lagged differences of the corresponding variables. These instruments are appropriate if we assume that there is no correlation between the differences of the explanatory variables and the country-specific effect –although the correlation between the levels of the right-hand-side variables and the country-specific effect in equation A1 may be different from zero. This assumption results from the following stationarity property:

$$(A5) \quad E\left[y_{i,t+p} \cdot \eta_i\right] = E\left[y_{i,t+q} \cdot \eta_i\right] \text{ and}$$

$$E\left[X_{i,t+p} \cdot \eta_i\right] = E\left[X_{i,t+q} \cdot \eta_i\right] \text{ for all } p \text{ and } q.$$

This implies that for the second part of the system –that is, the regression in levels– we have the following additional moment condition^S:¹⁷

$$(A6) \quad E\left[(y_{i,t-1} - y_{i,t-2}) \cdot (\eta_i + \varepsilon_{i,t})\right] = 0 \text{ and}$$

$$(A7) \quad E\left[(X_{i,t-1} - X_{i,t-2}) \cdot (\eta_i + \varepsilon_{i,t})\right] = 0,$$

¹⁶An additional problem with the simple difference estimator relates to measurement error: differencing may exacerbate the bias stemming from errors in the variables by decreasing the signal-to-noise ratio (see Griliches and Hausman, 1986).

¹⁷Given that lagged levels are used as instruments in the difference specification, only the most recent difference is used as an instrument in the levels specification. Using other lagged differences would result in redundant moment conditions (see Arellano and Bover, 1995).

where we use the moment conditions in equations A3, A4, A6, and A7 and employ a GMM procedure to generate consistent and efficient parameter estimates. The coefficient estimates and their asymptotic variance-covariance matrix is given by the following formulas:

$$(A8) \quad \hat{\theta} = (\bar{X}' Z \hat{\Omega}^{-1} Z' \bar{X})^{-1} \bar{X}' Z \hat{\Omega}^{-1} Z' \bar{y} \text{ and}$$

$$(A9) \quad AVAR(\hat{\theta}) = (\bar{X}' Z \hat{\Omega}^{-1} Z' \bar{X})^{-1},$$

where our vector of parameters of interest is $\theta = (\alpha, \beta)$, \bar{y} is the dependent variable stacked first in differences and then in levels, \bar{X} is the explanatory-variable matrix including the lagged dependent variable (y_{t-1} , X) stacked first in differences. For the regression in levels, Z is the matrix of instruments derived from the moment conditions. Finally, $\hat{\Omega}$ is a consistent estimate of the variance-covariance matrix of the moment conditions.¹⁸

To prove the consistency of our GMM estimators –that is, to test whether the lagged values of the explanatory variables are valid instruments– we consider two specification tests (Arellano and Bond, 1991; Arellano and Bover, 1995). First, the Sargan test of overidentifying restrictions tests the joint validity of our instruments by analyzing the sample analog of the moment conditions used in the estimation process. The model is supported empirically if we fail to reject the null hypothesis. Second, we test whether the error term $\varepsilon_{i,t}$ is serially correlated. Here, our specification is valid if we fail to reject the null hypothesis of no higher-order serial correlation.¹⁹

¹⁸In practice, Arellano and Bond (1991) suggest a two-step procedure to obtain consistent and efficient GMM estimates. First, assume that the residuals, $\varepsilon_{i,t}$, are independent and homoskedastic both across countries and over time. This assumption corresponds to a specific weighting matrix used to get first-step coefficient estimates. Second, construct a consistent estimate of the variance-covariance matrix of the moment conditions with the residuals obtained in the first step, and use this matrix to reestimate the parameters of interest (that is, second-step estimates). Asymptotically, the second-step estimates are superior to the first-step ones insofar as efficiency is concerned.

¹⁹First-order serial correlation of the differenced error term is expected even if the original error term (in levels) is uncorrelated, unless the latter follows a random walk. Second-order serial correlation of the differenced residual indicates that the original error term is serially correlated and follows a moving average process at least of order one. This would reject the appropriateness of the proposed instruments (and would call for higher-order lags to be used as instruments).

APPENDIX B
SAMPLE OF COUNTRIES AND SOURCES OF DATA

This appendix describes the data used in our analysis. We start with a list of the countries included in the sample. Table B1 contains the full description of the variables used in the paper. Tables B2 and B3 then provide descriptive statistics and correlation analysis between growth and its determinants. Finally, Table B4 describes the procedures used to forecast the variables for the continuous trend scenario.

Our sample covers seventy-eight countries over the period 1970-2000. The countries are listed here by group or region.

–Industrial Economies (22): Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

–Latin America and the Caribbean (21): Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela.

–East Asia and the Pacific (8): China, Indonesia, Republic of Korea, Malaysia, Papua New Guinea, the Philippines, Singapore, and Thailand.

–Middle East and North Africa (8): Algeria, Egypt, Israel, Jordan, Morocco, Syria, Tunisia, and Turkey.

–South Asia (4): Bangladesh, India, Pakistan, and Sri Lanka.

–Sub-Saharan Africa (15): Botswana, Burkina Faso, Côte d'Ivoire, Gambia, Ghana, Kenya, Madagascar, Malawi, Niger, Nigeria, Senegal, South Africa, Togo, Zambia, and Zimbabwe.

TABLE B1
DEFINITION AND SOURCES OF THE VARIABLES USED
IN THE REGRESSION ANALYSIS

Variable	Definition	Sources of information
GDP per capita	Total GDP divided by the population of a country. GDP is expressed in 1985 PPP US\$.	Summers and Heston (1991); World Bank (2002).
Growth rate of GDP per capita	Log differences of GDP per capita.	Summers and Heston (1991); World Bank (2002).
Initial GDP per capita	Value of GDP per capita at the beginning of the period. GDP is expressed in 1985 PPP US\$.	Summers and Heston (1991); World Bank (2002).
Investment in human capital	Secondary schooling enrollment rate: number of students enrolled in secondary education (regardless of their age) relative to total population of the corresponding age group.	World Development Network (2002); World Bank (2002).
Financial depth	Ratio of domestic credit to the private sector to GDP.	Computed by Loayza, Fajnzylber, and Calderón (2004) using data from IMF's IFS, central bank publications, and Penn-World Database. Computations follow the methodology of Beck, Demigüç-Kunt, and Levine (2000).
Institutions	First principal component of four governance indicators: rule of law, bureaucratic quality, corruption, and democratic accountability.	Computed by Loayza, Fajnzylber, and Calderón (2004) using data from the International Country Risk Guide (ICRG).
Government consumption	Ratio of real government consumption to GDP (in logs).	World Bank (2002).
CPI	Consumer price index (1995 = 100).	IMF, International Financial Statistics.
Inflation Rate	Annual growth rate of CPI.	IMF, International Financial Statistics.
Real exchange rate overvaluation	Real effective exchange rate, with the level adjusted such that the average for 1976-85 equals Dollar's (1992) index of overvaluation (based on the ratio of actual to income-adjusted Summers-Heston purchasing power parity comparisons).	Easterly (2001).

(continuation Table B1)

Variable	Definition	Sources of information
Trade openness	Residual of a regression of the log of the ratio of exports and imports (in 1995 US\$) to GDP (in 1995 US\$) on the logs of area and population, and dummies for oil-exporting and landlocked countries.	Computed by Loayza, Fajnzylber and Calderón (2004) using data from World Development Network (2002) and World Bank (2002).
Financial openness	Coefficient of the stock of foreign liabilities (foreign direct investment and portfolio investment) as a percent of GDP. Expressed in constant 1995 US\$.	Lane and Milesi-Ferreti (2001, 2003); IMF, Balance of Payments Statistics.
Terms of trade	Terms-of-trade index (1995 = 100).	World Development Network (2002); World Bank (2002).
Terms-of-trade shocks	Log differences of the terms-of-trade index.	World Bank (2002).
Period shifts	Period dummy variables.	Authors' construction.

TABLE B2
DESCRIPTIVE STATISTICS: BASIC STATISTICS^a

Variable	Average	Standard deviation	Minimum	Maximum
Growth rate of GDP per capita	1.26	2.58	-7.94	8.39
Initial GDP per capita	8.52	1.03	6.43	10.24
Investment in human capital	3.78	0.78	0.65	4.92
Domestic credit (% GDP)	3.68	0.62	1.26	5.24
Institutions	0.49	1.83	-3.26	3.47
Government consumption	2.67	0.39	1.46	3.64
Inflation rate (%)	4.74	0.18	4.59	6.14
Real exchange rate overvaluation	107.44	44.00	47.19	555.03
Terms-of-trade shocks	-0.20	4.08	-15.05	18.65
Trade openness	0.07	0.45	-1.17	1.39
Financial openness	0.20	0.24	0.00	2.54

Source: Authors' calculations.

a. Based on a sample of seventy-eight countries, generating 371 observations (in non-overlapping five-year-period averages).

TABLE B3
 DESCRIPTIVE STATISTICS: BIVARIATE CORRELATION ANALYSIS
 BETWEEN GROWTH AND ITS DETERMINANTS^a

Variable	Growth rate of GDP per capita	Initial GDP per capita	Investment in human capital	Domestic credit (% GDP)	Institutions	Government consumption	Inflation rate (%)	Real exchange rate overvaluation	Terms-of-trade shocks	Trade openness	Financial openness
Growth rate of GDP per capita	1.00										
Initial GDP per capita	0.26	1.00									
Investment in human capital	0.29	0.84	1.00								
Domestic credit (% GDP)	0.29	0.58	0.58	1.00							
Institutions	0.29	0.80	0.63	0.56	1.00						
Government consumption	-0.03	0.41	0.30	0.39	0.51	1.00					
Inflation rate (%)	-0.31	-0.13	-0.08	-0.42	-0.24	-0.12	1.00				
Real exchange rate overvaluation	-0.15	0.13	0.11	0.08	0.08	0.09	0.09	1.00			
Terms-of-trade shocks	0.16	0.05	-0.01	-0.01	0.03	-0.06	-0.13	-0.07	1.00		
Trade openness	0.18	-0.04	0.00	0.32	0.11	0.25	-0.38	0.06	0.03	1.00	
Financial openness	0.18	0.39	0.37	0.35	0.31	0.14	-0.20	0.12	0.01	0.35	1.00

Source: Authors' calculations.

a. Based on a sample of seventy-eight countries, generating 371 observations (in non-overlapping five-year-period averages).

TABLE B4
FORECASTING MODELS USED TO COMPUTE THE
CONTINUOUS TREND SCENARIO

Variable	Procedure
I. Structural policies	
Human capital	Projected for 2001-2010 using OLS regression models incorporating linear or quadratic trends and a convergence effect. Inclusion criterion: (i) increase fit of equation and (ii) generate plausible values for the projected variable.
Financial development	Projected for 2001-2010 using OLS regression models incorporating linear or quadratic trends and using ARMA terms. Inclusion criterion: (i) increase fit of equation and (ii) generate plausible values for the projected variable.
Institutions	Projected for 2001-2010 using OLS regression models incorporating linear or quadratic trends and a convergence effect. Inclusion criterion: (i) increase fit of equation and (ii) generate plausible values for the projected variable.
Government consumption	Projected for 2001-2010 using OLS regression models incorporating linear or quadratic trends and using ARMA terms. Inclusion criterion: (i) increase fit of equation and (ii) generate plausible values for the projected variable.
II. Stabilization policies	
Inflation rate	Projected for 2006-2010 using the inflation target established by the Central Bank. Consensus Forecast predictions were used for 2004-2005, while observed inflation was used for 2001-2003.
Real exchange rate overvaluation	Projected for 2001-2010 using OLS regression models incorporating linear or quadratic trends and using ARMA terms. Inclusion criterion: (i) increase fit of equation and (ii) generate plausible values for the projected variable.
III. Openness	
Trade openness	Projected for 2001-2010 using OLS regression models incorporating linear or quadratic trends, ARMA terms and a convergence effects. Inclusion criterion: (i) increase fit of equation and (ii) generate plausible values for the projected variable.
Financial openness	Projected for 2001-2010 using OLS regression models incorporating linear or quadratic trends, ARMA terms and a convergence effects. Inclusion criterion: (i) increase fit of equation and (ii) generate plausible values for the projected variable.
IV. External conditions	
Terms-of-trade shocks	Projected for 2004-2010 using OLS regression models incorporating linear or quadratic trends and using ARMA terms. Actual series used for 2001-2003.
V. Convergence	
Initial GDP per capita	GDP per capita in 2005 projected with the expected growth rate for the period 2001-2005, actual values of GDP in 2001-2005, and estimated panel data models.

Source: Loayza, Fajnzylber, and Calderón (2005).

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REGIONAL CONVERGENCE IN CHILE: NEW TESTS, OLD RESULTS*

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Convergence tests implicitly test the unit root hypothesis for per capita income. Although the statistics do not have critical values under the null hypothesis most papers on this subject use them, with the corresponding problems for inference. This paper determines the existence of convergence in GDP levels and income across the regions of Chile using the traditional tests and also recent unit root tests for panel data that allow for correct inferences. We also analyze convergence in dispersion, evaluating the presence of asymmetries or the formation of regional “clubs” using nonparametric tests. Our main conclusions are: (1) the evidence supports the hypothesis of absolute β convergence in both per capita GDP and income; (2) the convergence rate is higher for income than for GDP; (3) the conditional convergence rate increases when we control for the share of mining on the regional productive structure; (4) the data do not support the existence of convergence clubs; and (5) there is no clear evidence of σ convergence.

JEL: O18, O40, N16, R11

Keywords: Convergence, Economic Growth, Panel Data, Unit Root Tests, Asymmetries, Growth Clubs, Chile.

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1. INTRODUCTION

Traditional convergence tests implicitly evaluate the unit root hypothesis in per capita output series. Although these statistics do not have asymptotic distributions or critical standard values under the null hypothesis, the great majority of works on the subject uses them, with the corresponding problems for inference. For this reason, new tests have been developed in the literature on panel data estimation to analyze the convergence hypothesis correctly. The goal of this paper is to determine if the existing relatively weak evidence that favor the hypothesis of convergence of GDP and income among the regions of Chile holds when such new tests are applied and a more recent database is used. The analysis is conducted using not only the traditional tests (cross-section and panel data), but also the most recent unit root tests developed for panel data, which allow making correct inference. We also analyze convergence in dispersion, constructing confidence intervals for the variance of regional production and income and evaluating the presence of asymmetries or the formation of regional “clubs” through a nonparametric multimodality test.

The theoretical foundation for the empirical analysis is framed within neoclassic growth theory, which attempts to explain whether the different economies converge to a single distribution of per capita output or income levels. In our analysis, these economies are the thirteen regions of Chile, and the time frame is 1960-2000. The implication of this literature is that per capita GDP is trend stationary as a contraposition of the endogenous growth literature, which predicts that this series would be difference stationary. The latter means that temporary shocks will have a permanent effect on the level of GDP, while in the case of the neoclassical model, temporary shocks will have a temporary effect on the level of this variable. Therefore, the stochastic process that underlies the per capita GDP series is a key element for discriminating between these two theories.

The earliest works analyzing the dynamics of regional GDP per capita in Chile find that there is, in fact, convergence in per capita GDP levels, but that the speed or rate of unconditional convergence is relatively slow: 1.3% for the 1960-90 period (Fuentes, 1997) and 1.2% for the 1960-92 period (Morandé, Soto and Pincheira, 1997). A later analysis (Anríquez and Fuentes, 2001) shows that the speed is higher for income (8.9%) than GDP (1.3%), based on data from the National Socioeconomic Characterization (CASEN) survey for the 1987-1994 period. More recent studies find that this convergence rate fluctuates between 0.5% (Soto and Torche, 2004) and 1.0% (Díaz and Meller, 2004). Relatively few works find divergence among the Chilean economies. Some of them only find convergence in certain groups or “clubs” of regions, reporting, for example, that all regions converge except the Metropolitan and II regions (Díaz and Herrera, 1999) or that convergence occurs in all but the I, II, and XII regions (Araya and Oyarzún, 2001).

One of the valid critiques of the empirical focus used in the majority of the previous works is that by regressing the per capita GDP growth rate (expressed

as the change in the log of the level) and its initial level, the analyst is using the typical unit root test (augmented Dickey-Fuller) to estimate coefficients of convergence speeds whose t test, under the null hypothesis, does not have a standard distribution (see Chumacero, 2002, and references therein). Consequently, making inference based on these regressions using the traditional statistics and associated critical values can lead to erroneous results.

This paper differs from previous works in three ways. First, we analyze the growth of regional economic activity using a more updated database that includes—in contrast to the other cases—regional GDP for the 1960-2000 period, with figures recently published by the Central Bank, and data on household income for 1987-2000, from the CASEN survey. We are thus able to capture the recent period of strong turbulence and external crisis (1997-2000) and to observe their potential effects on regional convergence. Second, we use unit root tests recently developed for panel data to evaluate the null hypothesis of the absence of convergence and avoid the problems of inadequate inference mentioned above. To contrast the results, we include estimates and tests of the convergence hypothesis using traditional cross-section and panel data techniques. Third, we use a nonparametric multimodality test to evaluate the presence of regional asymmetries or “clubs” and thus verify whether the apparent bimodality of the empirical distributions is statistically significant.

The remainder of the paper is organized in four sections. The next section (section 2) briefly and intuitively explains the ideas of beta and sigma convergence. Section 3 then describes the construction, periods, frequency and sources of the data used in the estimations. Section 4 outlines the empirical strategy followed and presents our main results. Finally, section 5 concludes.

2. CONVERGENCE THEORY

The fundamental paradigm of economic convergence stems from the Solow (1956) and Swan (1956) model, which was later formalized in a dynamic optimization framework by Cass (1965) and Koopmans (1965). This model predicts that, given an initial stock of capital per worker, an economy converges to a long-run (steady-state) equilibrium in which the output per worker grows at a constant rate equal to the rate of technical change. In the transition, the economy grows above the long-run rate and closes the gap with that rate asymptotically. This generates one of the main implications of the model—namely, that in the steady-state equilibrium, the per capita income of different economies converges to the same level once the savings rate, depreciation rate, and population growth rate are taken into account.

The idea of convergence is also related to the idea that the poorest economy closes the gap with the richest economy in the dynamic transition to the steady state. In other words, the poorest economy grows faster than the richest. In the economic growth model with optimization, an economy's growth rate is an increasing function of the difference between the marginal product of capital

and the agents' rate of intertemporal impatience. That is, economies with a larger difference grow faster. Poor economies have less capital and, therefore, a higher marginal productivity than richer economies. Thus the growth rate of the poorest economy (or the economy that is positioned farthest from its steady state) is higher. As the economy accumulates capital, marginal productivity falls and, therefore, the growth rate also drops until it finally reaches the rate of technical progress.

There are two concepts of convergence related to this model: beta (β) convergence and sigma (σ) convergence.¹

2.1. Beta Convergence

Beta (β) convergence is said to occur when the poorest economies –which are the furthest from their long-run output or income level– grow faster than the richest economies until they achieve the same level of output.² In other words, β convergence is observed when there is a negative relationship between the growth rate of per capita output or income and the initial per capita output level. Formally, this implies finding a negative coefficient for β in a linear relationship between the growth rate and the initial level of output.

An issue that is closely linked with testing this hypothesis, and one that we need to address for the empirical analysis below, is the relationship between the type of growth and the type of stochastic process that underlies the output or income series. Modern economic growth theory can be divided in two strands: exogenous growth and endogenous growth. Our analysis and, therefore, our convergence hypothesis are consistent with the exogenous growth approach.³ According to exogenous growth models, if positive growth is observed in the long run, then this could be equal to the rate of technological change but independent from economic agents' decisions –as well as from their preferences and, therefore, their savings rates. In contrast, endogenous growth models consider the possibility that agents can affect the long-run growth rate through their saving decisions. The main implication for our analysis is that exogenous growth models predict that temporary changes should have temporary effects on output or income, whereas in the endogenous growth models, temporary changes can have permanent effects. That is, exogenous growth models are generally coherent with trend-stationary series, while endogenous growth models are consistent with difference-stationary series, characterized mainly by unit root processes. Consequently, evidence supporting the presence of stationary trend processes in

¹See Barro and Sala-i-Martin (1995).

²For this proposition to hold, preferences (savings rates), technology, depreciation rate, and population growth are assumed equal in both economies. The production function must also show constant returns to scale and fulfill the Inada (1963) conditions.

³Note that under certain endogenous growth models with transitional dynamic, it is possible to observe that a poorer economy will grow faster than the richer one (β convergence). Nevertheless, when both economies reach the steady-state growth rate they will grow at the same speed.

our output and income series is consistent with the predictions of the exogenous growth model, which predict β convergence.

2.2. Sigma Convergence

Sigma convergence is said to exist when the dispersion of per capita income or output, measured as its variance, diminishes over time. Formally, σ convergence is confirmed when the cross-sectional variance of the regional per capital incomes or outputs shows a (statistically) significant decrease between the initial and final periods of the sample. In a world without stochastic shocks, the implicit idea is as follows: in the initial period there is a high dispersion of per capita output –due to the difference between rich and poor regions– that is expected to be lower at the end of the process of convergence toward the steady state.

It can be shown that the existence of β convergence is a necessary but not a sufficient condition for the presence of σ convergence. In practice, it is thus possible to find that the richest economies or regions grow less than the poorest, but ultimately the dispersion remains unchanged over time. This would be the case if the regions that were initially relatively poor grew faster than the wealthy regions and overtook them, leaving the dispersion of per capita income the same as at the initial period. However, since β convergence is a necessary condition, it is not possible to observe σ convergence without β convergence⁴. Note that σ convergence typically implies that the variance of per capita output decreases over time. However, the initial variance converges to its steady-state level, which may be higher or lower than the initial level depending on whether the dispersion of initial per capita output is lower or higher than the steady state, which is, in turn, a function of the shocks experienced by the economies. Beta convergence ensures that the variance will converge to the steady-state level, but it does not say whether the variance diminishes or increases over time.

2.3. Absolute and Conditional Convergence

From an empirical perspective, another dimension of economic convergence analysis involves the distinction between absolute (or unconditional) and conditional convergence. Absolute convergence is said to pertain when all the economies converge regardless of economy-specific factors (economic policies, investment rate, composition of output, and so forth); that is, the poorer economies always grow faster than the richer ones. This implicitly requires that the economies have similar population growth rates, preference parameters, and technology. In this sense, there is also a condition for convergence.

Conditional convergence, in turn, occurs when the relation between the growth rate of per capita output and its initial level is negative once we have

⁴See Barro and Sala-i-Martin (1995) for a formal proof of this result.

controlled for factors that condition the steady state. In other words, the economies converge only when we take into account the factors that are specific to the steady state toward which they are moving.

3. THE DATA

To test the convergence hypothesis on the GDP and income of the thirteen regions of Chile, we use all the data available at the close of this study.

3.1. Per Capita GDP

In the case of regional output, the period of analysis is from 1960 to 2000. Figure 1 shows the trends in gross real per capita output levels for each region (expressed in natural logs) during the period.

These series were constructed from two sources. First, in the numerator, we use the Central Bank of Chile's regional GDP series, in millions of 1986-pesos for the 1960-96 period, and the growth rates from the new series in millions of 1996-pesos for the rest of the span (that is, 1997-2000).⁵ Second, in the denominator, we use the regional population statistics published annually by the National Institute of Statistics (INE), based on the censuses and the institute's own estimates, on June 30th of each year.

3.2. Per Capita Income

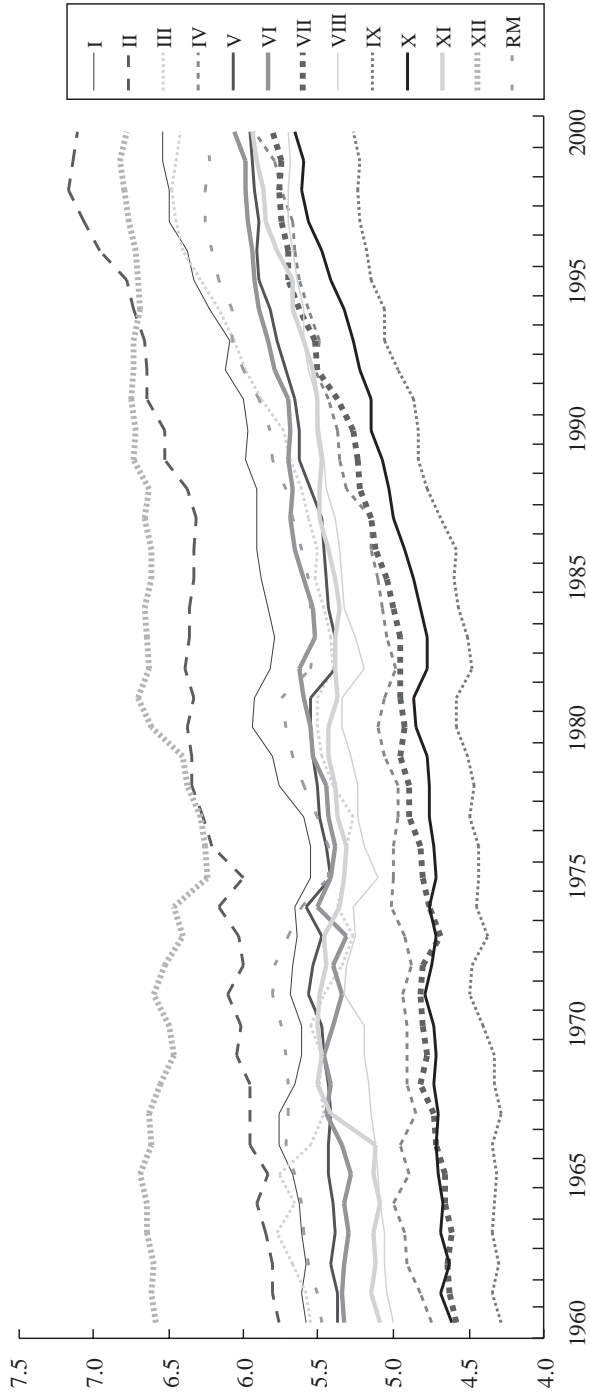
In the case of per capita income, the period of analysis is significantly reduced due to data availability. We used the average household income series⁶ for each region for the years 1987, 1990, 1992, 1994, 1996, 1998, and 2000, following the CASEN surveys that are carried out by the Department of Social Information of the Ministry of Planning and Cooperation (MIDEPLAN). We then calculated the nominal per capita income by region using the number of households in each region from each survey and the regional population. To express these series in real terms, we constructed price indexes by region, weighting the prices of a basket of 35 food products based on information provided by INE.⁷

⁵This base change in the regional GDP series was taken into account in the convergence estimates presented below.

⁶The average household income includes all the incomes of the members of the house like government transfers net of taxes and an imputed amount for house renting in the case that the household own the house.

⁷We considered the wholesale prices of 35 food products in the capital city of each region for the survey years mentioned. We then constructed indexes averaging these prices using the weights of the CPI basket, with 1998 as the base year. To make incomes compatible across time and among regions, we not only took into account price changes between periods, but also adjusted them relative to the Metropolitan Region's index.

FIGURE 1
REGIONAL PER CAPITA GDP
(Chile, 1960-2000, in logs)



Source: Central Bank of Chile.

Figure 2 shows the per capita income trend for each region during the available period.⁸

4. EMPIRICAL STRATEGY AND RESULTS

Following the outline presented above, we first present the empirical tests and their respective results for β convergence in both GDP and regional income, and we then assess the case of σ convergence.

4.1. Beta Convergence in Regional GDP

We first hypothesize whether Chile's regions display absolute convergence in output levels—that is, β convergence. In order to present robust estimates and obtain solid conclusions, we then undertake the typical convergence tests through cross-section and pooled panel data regressions, for both GDP and income series. Finally, we apply recent panel data unit root tests that allow us to make correct inference on the hypothesis under study.

Traditional Convergence Tests

The most commonly used regressions in growth studies are cross-sectional.⁹ The basic idea is to estimate the coefficients of the following equation and evaluate the null hypothesis of divergence (that is, $\beta = 0$) against the alternative hypothesis of convergence, when $\beta \in (-1, 0)$:

$$(1) \quad \frac{y_{i,T} - y_{i,0}}{T} = \alpha + \beta y_{i,0} + u_{i,0}, \quad i = 1, \dots, N$$

where y is the natural log of output or income, T denotes the number of periods, α is a constant (which captures the regions' steady state), β captures the rate or speed of convergence, and u is a disturbance term. Note that here we only consider the growth rate of output in the whole period of analysis (between $t = 0$ and $T = 1$).¹⁰

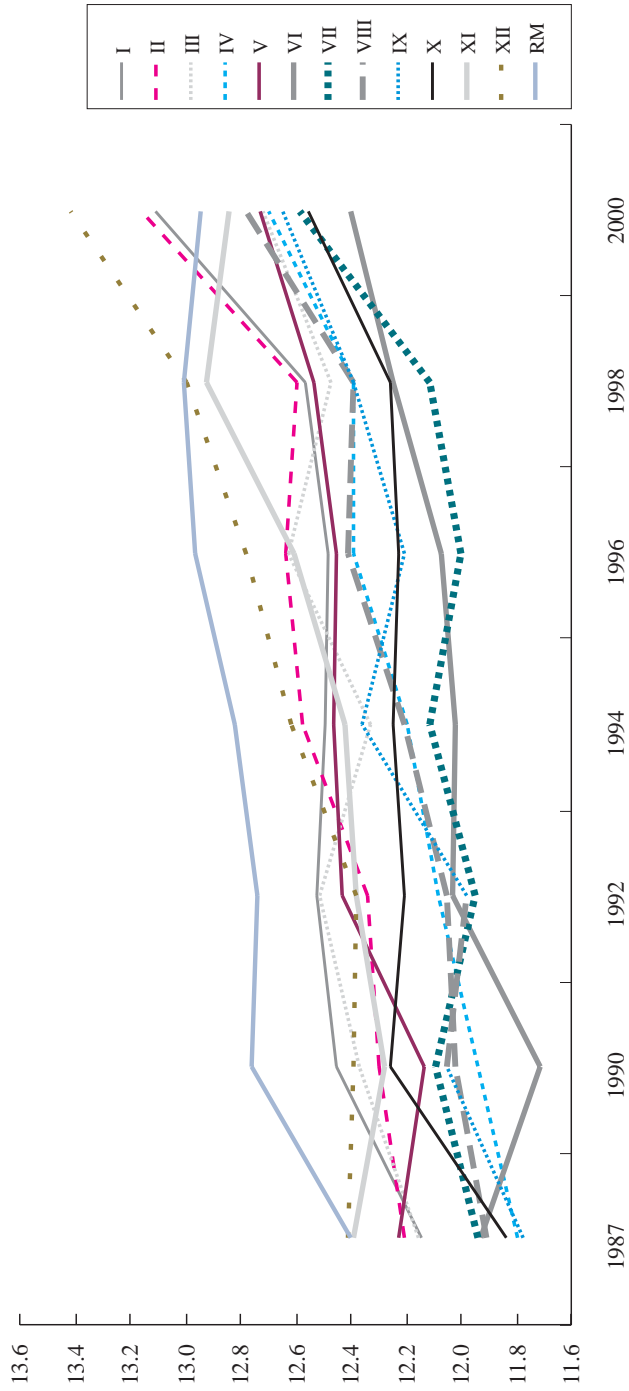
The first evidence in favor of this hypothesis is presented in Figure 3, which shows the negative relationship between the growth rate (from 1960 to

⁸We must warn that we are careful how we interpret the results from estimations based on these series because of the limited quality of the sources. First, our main source for constructing regional income is a household survey that—aside from the conventional measurement error—has been subject to methodological changes through time. Second, the price index is only a proxy of what, strictly speaking, must be a consumer price index for each region.

⁹See, for example, Baumol (1986).

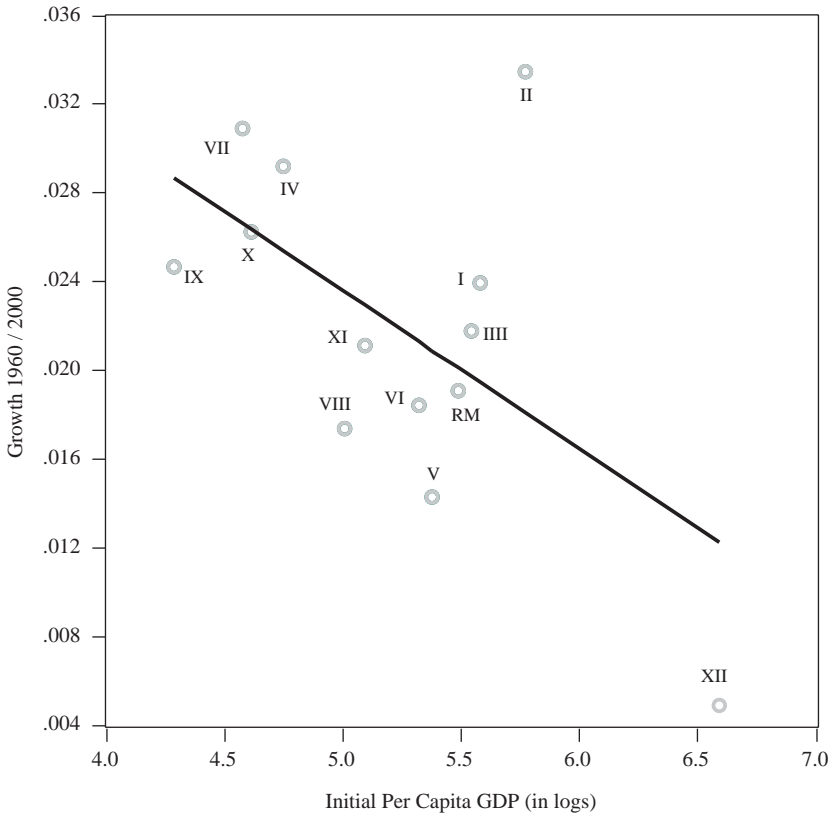
¹⁰Strictly speaking, we should estimate the nonlinear version of equation 1. However, we opted for this simpler specification because the econometric results are very similar and the specification allows us to use panel data unit root tests, as explained below.

FIGURE 2
REGIONAL PER CAPITA INCOME
(Chile, 1987-2000, in logs)



Source: CASEN.

FIGURE 3
 AVERAGE GROWTH RATE AND INITIAL PER CAPITA GDP
 (Chile, 1960-2000)



2000) and the initial level of regional GDP per capita (in 1960). The estimated coefficient in this regression is negative, as expected, and statistically significant.¹¹ The convergence rate is 0.72% (see Table 1). To get an idea of the speed (in years) with which this convergence should take place, we calculated the half-life for closing the gap between the GDP per capita of the relatively poorer regions and the relatively richer ones. In this case, the convergence rate implies that half the gap should be closed in 96.8 years (see Table 1).

This approach is limited, however, for making sufficiently valid inference because of the scarcity of observations (only thirteen, the number of regions); this limitation is of particular concern considering that the number of regions in

¹¹We used White's (1980) covariance matrix estimator to avoid inference problems in the face of the probable presence of heteroskedastic errors.

TABLE 1
TRADITIONAL TESTS FOR β CONVERGENCE IN GDP:
CROSS-SECTION AND POOLED PANEL DATA^a

Coefficient	Convergence in GDP		
	Cross-section ^b	Ten-year pool ^c	Five-year pool ^c
β	-0.00716 (0.0035) [0.0627]	-0.00736 (0.0034) [0.0343]	-0.00852 (0.00412) [0.0410]
Statistics			
R^2	0.33216	0.549739	0.573818
F statistic	5.471203	14.34595	15.98868
P value	0.039237	0.000000	0.000000
No. observations	13	52	104
Years to close half the gap ^d	96.8	94.2	81.4

a. Series: regional GDP per capita (1960-2000). Standard deviations are in parentheses; p values are in brackets.

b. White covariance matrix estimator was used.

c. White covariance matrix estimator was used. Time effects were included; fixed or random effects were not.

d. Calculated as $\ln(1/2)$ divided by the respective beta coefficient.

a country is always small and finite. An alternative approach proposed in the literature is to test the β convergence hypothesis via the panel data technique, estimating an equation similar to the previous one:¹²

$$(2) \quad \frac{y_{i,t} - y_{i,t-1}}{T} = \alpha + \beta y_{i,t-1} + u_{i,t}$$

where, in this case, T denotes the number of periods or years between t and $t - 1$.¹³

One of the advantages of this technique is that it lets us take advantage not only of the cross-sectional dimension, but also of the time dimension, thus providing greater degrees of freedom.¹⁴

In the case of absolute convergence, we chose a pooled panel instead of fixed or random effects mainly because assuming the presence of unobserved idiosyncratic effects (whether fixed or stochastic) would be equivalent to assuming

¹²See, for example, Barro and Sala-i-Martin (1991, 1992).

¹³If, for example, we are analyzing a ten-year panel, the number of periods between t and $t - 1$ is $T = 10$.

¹⁴For the ten-year panel, the number of temporal observations is four, whereas it is eight with the five-year panel.

that each region's output or income converges to a different stationary level, or that they converge conditional on controlling for exogenous components specific to each region. Consequently, this alternative is particularly valid when dealing with conditional convergence, an issue we address below. On the other hand, we do include temporal effects common to all the regions, basically to control for the potential effects of the base change in the regional GDP series in 1997 and the change in methodologies in the different CASEN surveys. The inclusion of the temporal effects does not invalidate the hypothesis of absolute convergence to the extent that it is consistent with the series being trend stationary, which in turn is coherent with the type of growth model we are employing, as was explained in section 2.1.

Thus if we estimate the coefficients that relate the ten- or five-year growth rate with the respective initial output levels, we obtain values of -0.74 and -0.85 percent, respectively (see table 1a). Once again the values are negative and statistically significant, which implies a process of regional convergence in GDP.¹⁵ In this case, half the gap should close in approximately 81 to 94 years.

These estimated values for the GDP convergence coefficient are, at nearly -1% , lower than the levels found in earlier studies on both regional convergence in Chile and developed countries (around 2%).¹⁶ However, they are similar to the findings of more recent works (close to 1% as in Díaz and Meller, 2004; and close to 0.5% as in Soto and Torche, 2004). This suggests that while per capita GDP is converging, the process has slowed somewhat in recent years.

Unit Root Tests

A valid criticism of regressions between the per capita GDP growth rate and initial per capita GDP is that the test does not have a standard distribution under the null hypothesis ($\beta = 0$), so making a comparison using the traditional statistics and related critical values can lead to erroneous conclusion.¹⁷ Essentially, the test in question does not have a Student's t distribution under the null hypothesis, but rather constitutes an augmented Dickey-Fuller unit-root test for panel data, similar to equation 2:¹⁸

$$(3) \quad \Delta y_{i,t} = \delta + \alpha y_{i,t-1} + u_{i,t}$$

One possibility, then, is to examine whether each regional GDP (or income) series independently presents a unit root, but such a procedure suffers from serious

¹⁵The values were generated using White's (1980) covariance matrix estimators.

¹⁶For early works on Chile, see Fuentes (1997); Morandé, Soto, and Pincheira (1997). Cross-sectional evidence for developed countries include convergence coefficients of 1% for the Italian regions, 1.4% for the German regions, 1.6% for the French regions, 1.7% for the American states, 1.9% for the Japanese prefectures, 2.4% for the Canadian provinces, and 3% for the British regions (see Barro and Sala-i-Martin, 1995).

¹⁷See, for example, Evans (1998); Phillips and Sul (2003); Cheung and Pascual (2004).

¹⁸We can assume in equation 2 that $T = 1$ without loss of generality.

power problems.¹⁹ Thus the best alternative is to undertake a panel data unit root test.

The range of panel data unit root tests has grown in recent years. We apply only the most recent to contrast the results with earlier studies and only where such tests are adaptable to the requirements of our hypothesis. We thus apply four tests: Levin, Lee, and Chu (2002); Breitung (2000); the Fisher-ADF and Fisher-Phillips-Perron tests proposed by Maddala and Wu (1999); and Choi (2001).²⁰ Again, the null hypothesis of these tests is that there is a unit root ($\alpha = 0$, without including fixed effects or trend) –that is, that there is no convergence.²¹ In particular, the null hypothesis for Levin-Lee-Chu and Breitung tests is $\alpha = 0$ (equation 3), whereas for the Fisher-ADF and Fisher-Phillips-Perron tests, the null is $\alpha_i = 0$ for $i = 1, 2, \dots, 13$. Implicitly, the first two tests assume a common unit root process for all the regional series; in contrast, the latter tests allow the presence of individual unit root processes. To contrast the robustness of the results of these four tests, in each case we consider two information criteria for the choice of lags (Schwartz and Hannan-Quinn) and use five- and ten-year panels.

Prior to the application of the tests, we removed the temporal effects from the series, for two basic reasons. First, as mentioned earlier, we want to control for effects in the series stemming from the change in the base year, a factor that cannot be adequately addressed when undertaking unit root tests. Second, panel data unit root tests are generally constructed under the assumption of no cross-sectional correlation of errors. We therefore remove the (fixed) temporal (but not idiosyncratic) effects common to the regions to avoid drastic loss of power for the autocorrelation.²²

Table 1b reports the modified t statistics and (in parentheses) the respective p values for the null hypothesis of each test. The criterion is to reject the null whenever the p values are higher than standard levels of significance (1%, 5%, and 10%). Thus, Table 2 shows that three of the four tests reject the unit root hypothesis of no convergence (in other words, it is not possible to discard convergence) in the case of both five- and ten-year data and using both criteria for lag selection. Here again, the empirical evidence tends to confirm the absolute convergence of per capita GDP in the regions of Chile.

4.2. Beta Convergence in Regional Income

Following the same empirical strategy as in the previous section, we analyze the data on regional per capital income.

¹⁹For GDP there are only 40 years (or temporal observations) and for income just 13 years (with 7 temporal observations).

²⁰Particular features of these tests are described in Appendix A.

²¹These tests are designed to allow the evaluation of the absolute convergence hypothesis, in contrast with alternatives such as Im, Pesaran, and Shin (2003) or Hadri (2000), which do not allow the exclusion of fixed effects under the null hypothesis. Including fixed effects or other independent variables in the model (equation 3) would imply that we were, in fact, testing the conditional convergence hypothesis.

²²This procedure is also followed by earlier authors (see Canning, 1999; Im, Pesaran, and Shin, 2003).

TABLE 2
TESTS FOR β CONVERGENCE IN GDP:
PANEL UNIT ROOT TESTS^a

Test	Convergence in GDP			
	Ten-year panel		Five-year panel	
	SIC	HQC	SIC	HQC
Levin, Liu, and Chu (2002) ^{b/d}	-2.77287 (0.0028)	-2.77287 (0.0028)	-1.94704 (0.0257)	-2.06497 (0.0195)
Breitung (2000) ^b	0.37607 (0.6466)	0.37607 (0.6466)	-0.55321 (0.2901)	-0.57268 (0.2834)
Fisher-ADF ^c	44.1537 (0.0146)	44.1537 (0.0146)	40.5353 (0.0345)	41.1876 (0.0297)
Fisher-Phillips- Perron ^{c/d}	56.0911 (0.0005)	56.0911 (0.0005)	69.6781 (0.0000)	69.6781 (0.0000)

a. Modified t statistics of each test. Series: regional GDP per capita (1960-2000). SIC denotes Schwartz information criterion; HQC denotes the Hannan-Quinn information criterion. The null hypothesis is a unit root process (no convergence). P values of the null are in parentheses. See appendix A for further details.

b. Assumes a process with a common unit root.

c. Assumes a process with individual unit roots.

d. Estimations were performed using bandwidth by Andrews (1991) and the kernel quadratic spectral.

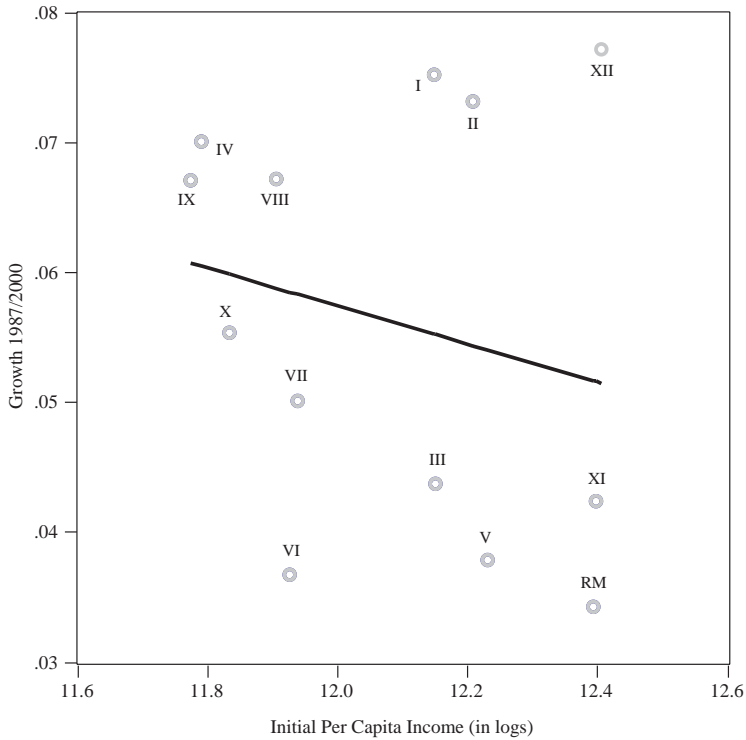
Traditional Convergence Tests

While the relationship between the growth rate from 1987 to 2000 and the initial income level (in 1987) is negative, with a coefficient close to -0.015 , it is not statistically significant at conventional levels (see Figure 4 and Table 3). The cross-section estimations thus do not provide clear evidence of convergence in income.

Nevertheless, the estimations using panel data, which incorporate more information (greater number of observations) since they consider the time dimension, yield evidence in favor of the hypothesis under study. Both two- and four-year estimations confirm the hypothesis of convergence, with faster rates than those found with the GDP estimates: -0.078 and -0.038 , respectively (see Table 3).²³ These convergence rates imply that half the gap between poor and rich regions will close in 18 and 9 years, respectively.

²³Anríquez and Fuentes (2001) find GDP convergence rates somewhat higher than 2% and income convergence rates close to 9% for the 1987-94 period. However, if we rerun the GDP regressions in table 1a for the 1987-2000 period, we still find higher convergence rates for income. Our regression results are available on request.

FIGURE 4
AVERAGE GROWTH RATE AND INITIAL PER CAPITA INCOME
(Chile, 1987-2000)



Unit Root Tests

Analogously, we apply the same set of unit root tests to per capita income series and obtain similar results to the GDP tests. For the two-year data, only the Breitung test does not support the convergence hypothesis, although its probability (p value) is not very high for the size of the sample used (15-16%). For the four-year data, the Breitung and Fisher-Phillips-Perron tests do not support the convergence hypothesis; in the latter case, however, the probability is only slightly higher than 10% (see Table 4). Given the low power of this type of test with small samples such as we use in this section, it is remarkable that we were able to generally reject the null hypothesis of a unit root, which confirms our previous findings.²⁴ Thus the idea of convergence in per capita income is also valid under this approach.

²⁴For a rough idea of the empirical power properties of the tests, see Levin, Lin, and Chu (2002, p. 17); Choi (2001, p. 260). Baltagi and Kao (2000) also discuss the power properties of some of the tests used above.

TABLE 3
TRADITIONAL TESTS FOR β CONVERGENCE IN INCOME:
CROSS-SECTION AND POOLED PANEL DATA^a

Coefficient	Convergence in GDP		
	Cross-section ^b	Four-year pool ^c	Two-year pool ^c
β	-0.01473 (0.0198) [0.4729]	-0.03788 (0.0143) [0.0139]	-0.07810 (0.0330) [0.0208]
Statistics			
R^2	0.0472	0.3216	0.2834
F statistic	0.5447	5.5295	4.6803
P value	0.4759	0.0032	0.0005
No. observations	13	39	78
Years to close half the gap ^d	47.1	18.3	8.9

a. Series: regional per capita income (1987-2000). Standard deviations are in parentheses; p values are in brackets.

b. White covariance matrix estimator was used.

c. White covariance matrix estimator was used. The panels consider growth rates every two or four years, except between the income rates of the 1987 and 1990 CASEN survey. Time effects were included; fixed or random effects were not.

d. Calculated as $\ln(1/2)$ divided by the respective beta coefficient.

TABLE 4
TESTS FOR β CONVERGENCE IN INCOME:
PANEL UNIT ROOT TESTS^a

Test	Convergence in GDP			
	Four-year panel		Two-year panel	
	SIC	HQC	SIC	HQC
Levin, Liu, and Chu (2002) ^{b/d}	-2.43374 (0.0075)	-2.43374 (0.0075)	-2.15993 (0.0154)	-2.17693 (0.0147)
Breitung (2000) ^b	0.37188 (0.6450)	0.37188 (0.6450)	-0.97247 (0.1654)	-1.02172 (0.1535)
Fisher-ADF ^c	35.1434 (0.1086)	35.1434 (0.1086)	39.1113 (0.0476)	38.9737 (0.049)
Fisher-Phillips-Perron ^{c/d}	40.3157 (0.0363)	40.3157 (0.0363)	50.6276 (0.0026)	50.6276 (0.0026)

a. Modified t statistics of each test. Series: regional per capita income (1987-2000). SIC denotes Schwartz information criterion; HQC denotes the Hannan-Quinn information criterion. The null hypothesis is a unit root process (no convergence). P values of the null are in parentheses. See appendix A for further details.

b. Assumes a process with a common unit root.

c. Assumes a process with individual unit roots.

d. Estimations were performed using bandwidth by Andrews (1991) and the kernel quadratic spectral.

4.3. Conditional β Convergence

To complete the sensitivity analysis, we performed conditional β convergence tests. We carried out tests similar to those described above for the 1960-2000 period, whenever feasible incorporating explanatory variables that allow us to approximate the potentially distinct steady states of each region. In this case we were able to carry out panel data tests.²⁵ Here, however, we incorporated fixed effects for each region and other explanatory variables (such as mining and education) to capture idiosyncratic effects that could be affecting the convergence of the regions.²⁶

The results support the existence of conditional convergence of GDP (see Table 3). The importance of mining on the regional productive structure was the only statistically significant variable in the conditional convergence regression.²⁷ Years of education of the labor force and the share of other sectors on total GDP were not statistically significant for explaining growth. This means that regions that are abundant in mineral resources will converge to a different steady state from the rest. For the ten-year GDP panel, we found a coefficient of -0.014 , which implies that half the gap will close in 72 years (see Table 5, column 1). This result contrasts with the one in table 1a, where for the ten-year pooling regression coefficient was -0.0074 and half the gap will close in 94 years. At this point, it is important to notice that the convergence hypothesis relies on the idea that all the economies have the same production function. If natural resources are important for one region, then the aggregate production function and the final steady state will be different for that region.

In sum, the empirical evidence generally backs up the hypothesis of β convergence for both per capita income and GDP, showing higher convergence rates in the conditional case. The increase of the beta coefficients from absolute to conditional convergence tests is also observed in most of the regional evidence for developed countries. Barro and Sala-i-Martin (1995) found coefficients of 1.6% for Italy, 1.6% for Germany, 2.2% for the United States, and 3.1% for Japan. Although the coefficients are not strictly comparable, the average difference between the cross-section and panel coefficient values for these studies is around 0.63 percentage points, closely similar to our findings (about 0.68 percentage points). This fact might reveal the omission of relevant variables –in our case, mining– in the absolute convergence regressions, since those variables may capture differences in the region's steady states. Statistically speaking, the sign of the bias due to relevant variable omission is governed by the correlation between the regressors (the lag of per capita GDP) and the omitted variable (mining). In our case, only a negative correlation between mining and the lag of GDP can

²⁵Because it is not feasible to carry out unit root tests including other dependent variables that are not trends or fixed effects.

²⁶Mining is measured as the mining sector's share of output in region i over total GDP in region i . Education is measured as the average years of schooling of the labor force in each region.

²⁷This is consistent with the findings in Fuentes (1997).

TABLE 5
TESTS OF CONDITIONAL CONVERGENCE IN GDP^a

Coefficient	Conditional convergence in GDP: Ten-year panel ^b						
	Without fixed effects			With fixed effects			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
β	-0.01406 [0.0045]	-0.00962 [0.0353]	-0.01878 [0.0045]	-0.04187 [0.0224]	-0.05248 [0.0038]	-0.04256 [0.0395]	-0.05067 [0.0074]
Mining ^c	0.03026 [0.0647]	0.0335 [0.0416]	0.06571 [0.1270]	0.07169 [0.1052]
Education ^d	0.0024 [0.4027]	0.00383 [0.2118]	0.00072 [0.8984]	-0.00288 [0.6112]
Statistics							
R^2	0.6022	0.5653	0.6151	0.7145	0.7373	0.7146	0.7390
F statistic	11.35	9.75	10.04	5.01	5.15	4.59	4.77
P value	0.00000	0.00000	0.00000	0.00003	0.00002	0.00007	0.00005
Years to close half the gap ^e							
	72.0	72.1	36.9	16.6	13.2	16.3	13.7

a. Series: Regional GDP per capita (1960-2000). Number of observations: 52.

b. P values are in brackets. White covariance matrix estimator was used. Time effects were included. Fixed effects were included as indicated above.

c. Share of mining GDP of region i in the region's total GDP.

d. Average years of schooling of the work force.

e. Calculated as $\ln(1/2)$ divided by the respective beta coefficient.

explain the underestimation of the beta coefficient value. Empirically, regions with lower initial levels of per capita GDP present a higher share of mining on the regional productive structure in the transition to the steady-state equilibrium.

4.4. Sigma Convergence of Regional GDP

As described earlier, another relevant type of convergence is σ convergence. We have shown that, in general, the evidence clearly supports β convergence in GDP and income, which is a necessary but not sufficient requirement for the existence of σ convergence. We must now analyze the behavior of the dispersion of the indicators of output and income across time.

A first piece of evidence of σ convergence in GDP can be seen in figure 1. A quick look suggests that in 2000 (the last available year), the regions presented a lower dispersion of the per capita GDP series than in 1960. Moreover, as can be seen in Table 6, the difference between minimum and maximum per capita output has lowered in recent years, in contrast with the 1970s.

TABLE 6
SIGMA CONVERGENCE IN GDP:
MEASURES OF DISPERSION AND DESCRIPTIVE STATISTICS^a

Statistics	1965	1970	1975	1980	1985	1990	1995	2000
Mean	5.3183	5.3743	5.2897	5.4991	5.4845	5.6719	5.9438	6.1084
Median	5.2865	5.4730	5.3232	5.5021	5.4513	5.6350	5.8908	5.9511
Maximum	6.6788	6.5003	6.2444	6.6144	6.6091	6.7150	6.7719	7.1106
Minimum	4.3215	4.3991	4.4247	4.5870	4.5920	4.8389	5.1517	5.2733
Max. – Min.	2.3573	2.1013	1.8197	2.0273	2.0171	1.8761	1.6201	1.8373
Standard deviation	0.6221	0.5671	0.4986	0.5781	0.5559	0.5166	0.4835	0.5002
Skewness	0.4408	0.1377	0.1957	0.3845	0.5179	0.6116	0.2796	0.4478
Kurtosis	2.9700	2.6406	2.6732	2.5602	2.8251	2.9336	2.2064	2.6311
Jarque-Bera ^b	0.4214	0.1111	0.1408	0.4250	0.5977	0.8129	0.5105	0.5083
Probability ^b	0.8100	0.9460	0.9320	0.8086	0.7417	0.6660	0.7747	0.7756

Source: Central Bank of Chile; authors' calculations.

a. Series: Log of regional per capita GDP (five-year periods, 1965-2000).

b. The null hypothesis is the normality of the series.

A way to verify σ convergence commonly used in the literature consists of constructing the variance of the log of regional GDP and observing its evolution over time. As explained in section 2, if the variance decreases in the period of analysis, then there is evidence in favor of σ -type convergence²⁸.

While the variance of regional GDP shows clear fluctuations, it generally follows a decreasing trajectory (see Figure 5). To test this claim, we construct a 90% confidence interval for the sample variance estimator, in contrast to earlier studies. In spite of a drastic decrease from 0.37 (1960) to 0.25 (2000), the confidence intervals do not allow us to affirm categorically that the reduction was statistically significant at 10%, since the final value of the variance in 2000 falls within the initial confidence interval constructed for 1960.²⁹

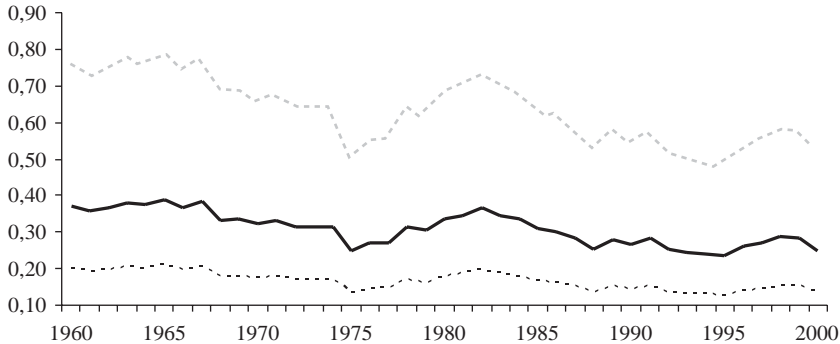
Another way to analyze the dispersion of regional GDP is by estimating its empirical distributions in each year and observing its behavior over time.³⁰ This is carried out through (nonparametric) kernel density estimations of the series distribution. The simplest estimate of a density function is a histogram. Briefly, the weighted kernel function determines the way the bars of the histogram

²⁸If β is less than zero, the variance will converge to its steady-state level. This implies that the variance could increase or decrease over time depending on whether its initial value is below or above the corresponding steady-state value.

²⁹Since we verified that the regional GDP is normally distributed (see Jarque-Bera tests in Table 6), we used an asymptotic confidence interval for the sample variance estimator using the corresponding chi-squared distribution.

³⁰See, for example, Quah (1996c, 1997).

FIGURE 5
SIGMA CONVERGENCE: VARIANCE OF PER CAPITA GDP
AND CONFIDENCE INTERVAL AT 90% (1960-2000)



Source: Central Bank of Chile. Authors' elaboration.

smooth out and become continuous, allowing the analyst to observe a density distribution of the data.³¹

Figure 6 shows the distribution of regional GDP every five years since 1965 (end-of-period data). As shown in the figure, 1965 starts with a partially unimodal distribution that is highly volatile; this pattern is maintained until 1980 (see Table 6). From that year until 1990—basically the period in which economic reforms were applied in Chile—we note the appearance of a bimodal distribution or “club”, as it is known in the growth literature.³² In other words, this period seems to display a transitory convergence among groups of regions, but not among all of the regions as a whole. This feature disappears in the 1990s (see Figure 6).

To confirm this phenomenon, we carried out nonparametric multimodality tests (see Bianchi, 1997) on the per capita GDP series to determine whether the apparent asymmetries are statistically significant.³³ We also considered the series expressed relative to the country's total GDP to check the robustness of our findings.

Under the null hypothesis, the empirical distribution of the series has m modes. The alternative hypothesis is that the distribution has more than m modes. The strategy we follow involves testing first the null hypothesis of $m = 1$ mode. If this is not rejected, then the evaluation of multimodality is finished. If, on the other hand, the null hypothesis is rejected, then we proceed to evaluate a new null hypothesis of $m + 1$ modes, and so on until the new hypothesis is not rejected. We reject the null hypothesis whenever the respective p value is smaller than the standard levels of significance.

³¹We used normal approximations since the Jarque-Bera test yields a high probability in favor of it, as mentioned above, although the results do not change appreciably with other distributions. We used the smoothing parameter (h) as the base case, following Silverman's (1986) method.

³²See, for example, Baumol (1986); Quah (1996a, 1996b, 1996c).

³³Appendix B contains a brief description of the test and the empirical strategy followed.

FIGURE 6
 TEST FOR σ CONVERGENCE IN GDP: KERNEL DENSITIES
 OF REGIONAL PER CAPITA GDP

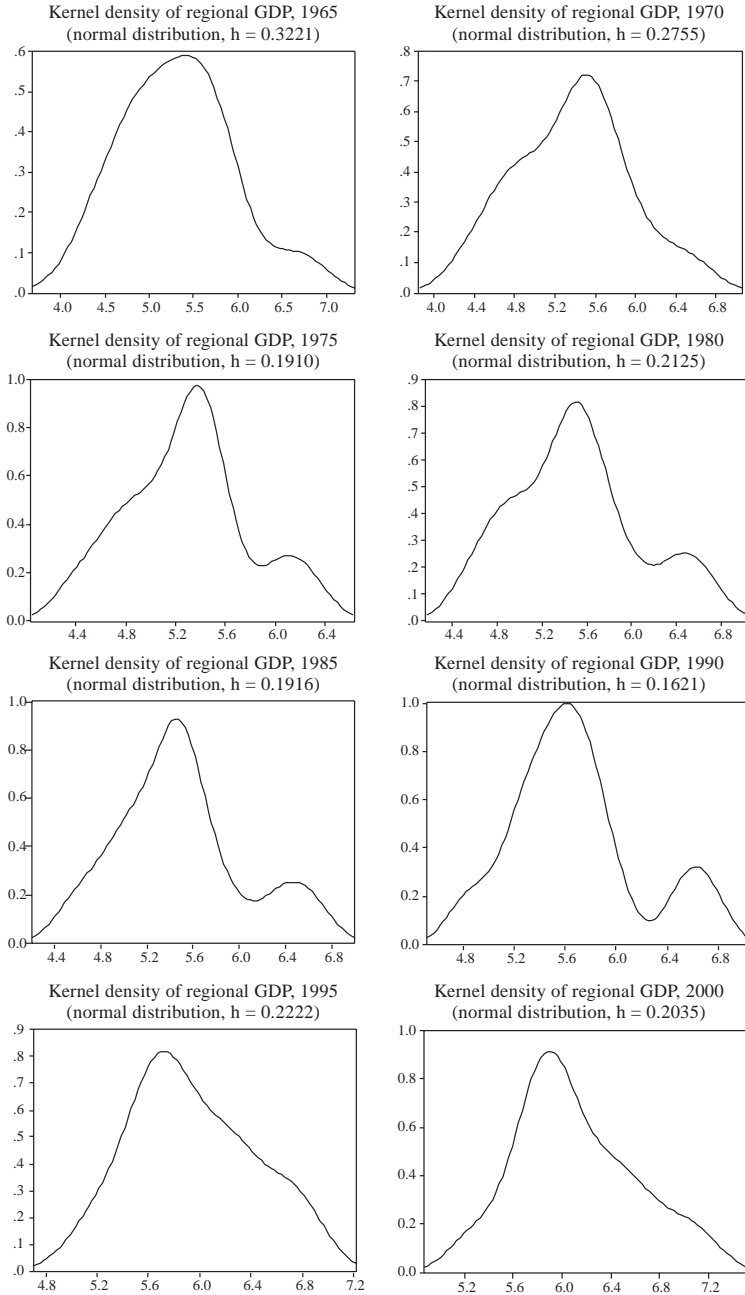


Table 7 presents the results of this test (values of the statistics and p values, respectively). In the case of the series expressed in logs –which is the main series under study– the test concludes that we cannot reject the null hypothesis of unimodality at conventional levels of significance and for the whole period of the analysis (for all the years, the p values are higher than 10%). The results are similar for the cases of GDP in relative terms, with the exception of the years 1960 and 1965 (only at a 10% level of significance). That is, there generally is not statistical evidence in favor of the formation of convergence clubs in Chile.

TABLE 7
SIGMA CONVERGENCE IN GDP: MULTIMODALITY TEST^a

Log of per capita	Statistic ^b		P value ^b	
	$H_0: m = 1$	$H_0: m = 2$	$H_0: m = 1$	$H_0: m = 2$
1960	0.320	...	0.352	...
1965	0.312	...	0.417	...
1970	0.237	...	0.629	...
1975	0.225	...	0.521	...
1980	0.265	...	0.509	...
1985	0.274	...	0.429	...
1990	0.287	...	0.274	...
1995	0.189	...	0.746	...
2000	0.153	...	0.927	...
Relative per capita GDP				
1960	0.047	0.017	0.052	0.158
1965	0.046	0.015	0.061	0.280
1970	0.030	...	0.167	...
1975	0.022	...	0.353	...
1980	0.027	...	0.314	...
1985	0.026	...	0.369	...
1990	0.030	...	0.140	...
1995	0.021	...	0.306	...
2000	0.022	...	0.410	...

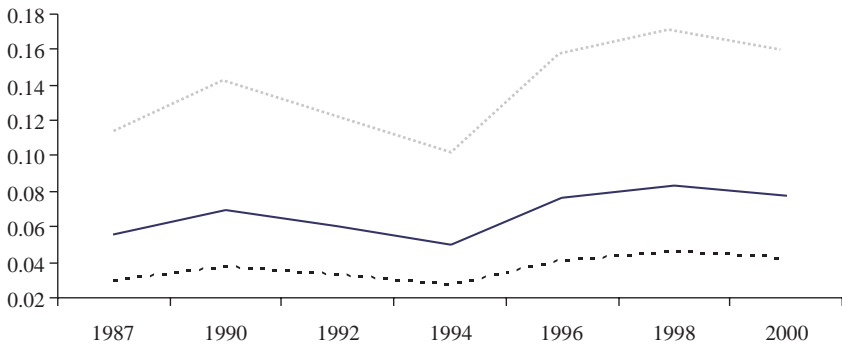
a. Multimodality test (with bootstrapping, 1,000 simulations). The modes correspond to the empirical distribution of the per capita GDP series expressed in logs of levels and in relative terms to the country's total per capita GDP.

b. Statistic and probability under H_0 : the density function of the series has m modes; under H_1 : the density function has more than m modes. The statistic corresponds to the estimated critical bandwidth. See appendix B for further details.

4.5. Sigma Convergence in Regional Income

Contrary to what we found in the case of GDP, σ convergence does not appear to have changed greatly at the level of regional income in the 1987-2000 period. As shown in Figure 7, the variance of regional incomes has generally increased, although not significantly, despite having been reduced in the early 1990s. The evolution of other statistics, such as the difference between the maximum and minimum values, also points in this direction (see Table 8). When we look at the 90% confidence interval, however, the value of the variance toward the end of the period (in 2000) is not statistically different from the initial value (in 1987). This implies that while there is no σ convergence in the period, neither is there a process of divergence that would contradict our results for regional GDP.³⁴ It is very important to emphasize that this behavior is extremely similar to that shown by the variance of regional GDP for the same period (see Figure 5), which indicates consistency in the results. On the other hand, recall that the sources to construct our regional income series are of limited quality, so this fact might also be affecting our findings.

FIGURE 7
SIGMA CONVERGENCE: VARIANCE OF PER CAPITA INCOME
AND CONFIDENCE INTERVAL AT 90% (1987-2000)



Source: CASEN. Authors' elaboration.

When we calculate the empirical distributions through the kernel estimator, we also observe the appearance of supposed regional clubs in bimodal distributions and with high dispersion, especially in the years 1987, 1992, and 1998 (see Figure 8). However, they tend to disappear in 2000.

The application of the multimodality test also reveals that the apparent bimodality of the regional income distribution is not, in fact, statistically significant (see Table 9). Under the null hypothesis of unimodality, the values of

³⁴Alternative explanations for the case of economic agglomeration and growth can be found in Fujita and Thisse (2002).

TABLE 8
SIGMA CONVERGENCE IN INCOME:
MEASURES OF DISPERSION AND DESCRIPTIVE STATISTICS^a

Statistic	1987	1990	1992	1994	1996	1998	2000
Mean	12.0847	12.2108	12.2764	12.3740	12.4505	12.5280	12.8141
Median	12.1480	12.2567	12.3363	12.3579	12.4553	12.4742	12.7233
Maximum	12.4064	12.7586	12.7415	12.8250	12.9600	13.0072	13.4103
Minimum	11.7734	11.7101	11.9491	12.0256	11.9963	12.1101	12.4049
Max. - Min.	0.6330	1.0485	0.7924	0.7995	0.9637	0.8970	1.0054
Standard deviation	0.2356	0.2641	0.2467	0.2226	0.2771	0.2893	0.2782
Skewness	0.0943	0.1448	0.2190	0.3459	0.0418	0.5439	0.7114
Kurtosis	1.5512	3.0781	1.9834	2.5026	2.2983	2.1890	2.7931
Jarque-Bera ^b	1.1562	0.0487	0.6638	0.3932	0.2705	0.9973	1.1196
Probability ^b	0.5610	0.9759	0.7176	0.8215	0.8735	0.6074	0.5713

Source: CASEN; authors' calculations.

a. Series: Log of regional per capita income (1987-2000).

b. The null hypothesis is the normality of the series.

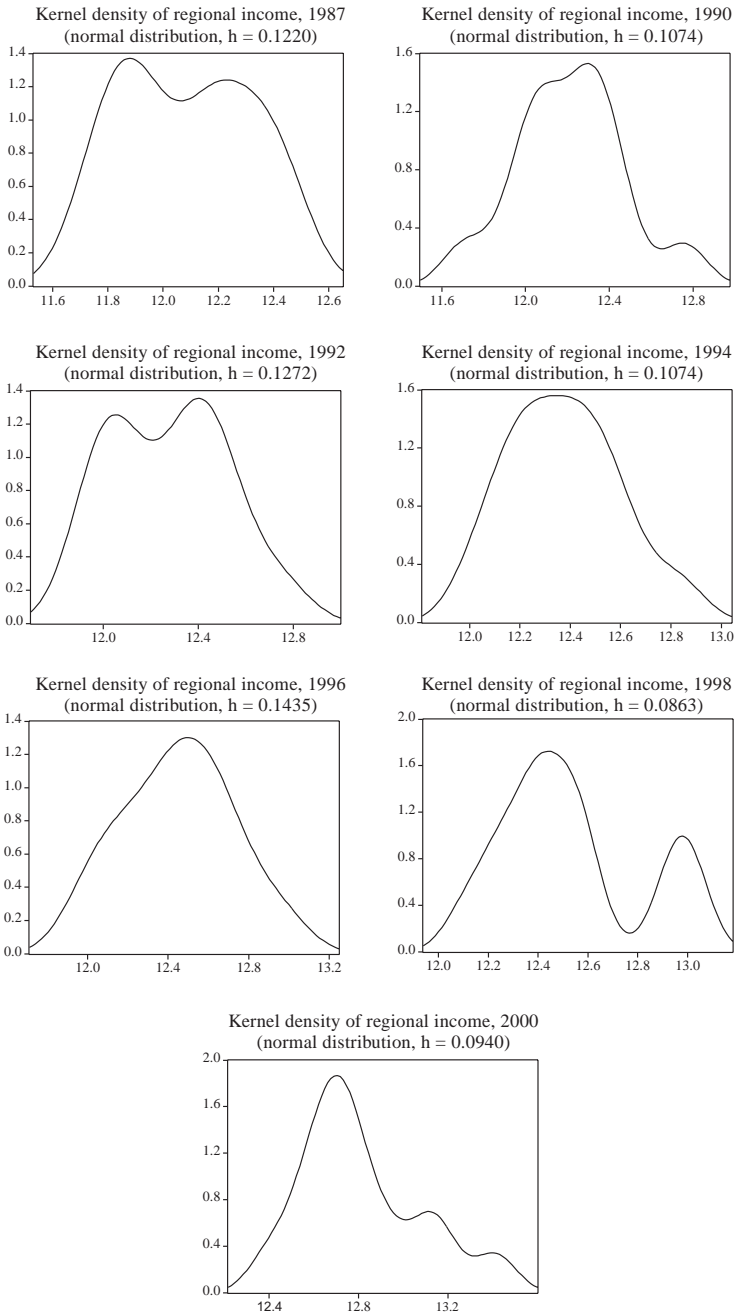
TABLE 9
SIGMA CONVERGENCE IN INCOME:
MULTIMODALITY TEST^a

Log of per capita income	Statistic ^b		P value ^b	
	$H_0: m = 1$	$H_0: m = 2$	$H_0: m = 1$	$H_0: m = 2$
1987	0.16056	0.09120	0.09500	0.10000
1990	0.12038	...	0.53300	...
1992	0.15888	...	0.11700	...
1994	0.09294	...	0.66300	...
1996	0.08739	...	0.91200	...
1998	0.17457	...	0.19000	...
2000	0.11029	...	0.72700	...
Relative per capita income				
1987	0.00911	...	0.46500	...
1990	0.01302	...	0.18800	...
1992	0.01171	...	0.17600	...
1994	0.00901	...	0.40900	...
1996	0.00937	...	0.57800	...
1998	0.01596	...	0.12000	...
2000	0.01214	...	0.45300	...

a. Multimodality test (with bootstrapping, 1000 simulations). The modes correspond to the empirical distribution of the per capita income series expressed in logs of levels and in relative terms to the country's total per capita income.

b. Statistic and probability under H_0 : the density function of the series has m modes; under H_1 : the density function has more than m modes. The statistic corresponds to the estimated critical bandwidth. See appendix B for further details.

FIGURE 8
 TEST FOR σ CONVERGENCE IN INCOME: KERNEL DENSITIES
 OF REGIONAL PER CAPITA INCOME



the statistics and probabilities are such that they allow us to reject the idea of multimodality in the estimated density of the series between 1990 and 2000, at standard levels of significance. In the case of the series expressed in relative terms, it is not possible to reject the unimodality of the series from 1987 on, which is consistent with the results of the same test applied to the GDP series.

5. CONCLUSIONS

The empirical evidence for the 1960-2000 period in Chile tends to support the hypothesis of convergence in regional GDP per capita, for both β -type convergence (convergence in levels) and σ -type convergence (convergence in dispersion).

The unit root tests employed mostly reject the presence of stochastic trend processes in favor of deterministic trend processes (trend stationary processes). That is, the evidence is strongly consistent with the neoclassical growth theory and the presence of convergence in both the regional per capita GDP and income series.

However, this result –which we also found through traditional panel and cross-section convergence tests– is accompanied by slow rates of convergence (relative to the international evidence) of slightly under 1%. This implies that the period for closing half the gap between relatively poor and rich regions ranges from 81 to 96 years.

Our analysis of conditional convergence finds that the speed increases to a range of 1.4% to 5.2% (with half the gap closing in a period of between 72 and 13 years, respectively) when we control for the share of the mining sector. This appears to be consistent with the idea that the regions are converging to their own steady state. Variables like average education of the work force do not appear to be good approximations for characterizing the steady states because they are not statistically significant.

The analysis of σ convergence or convergence of the variance of regional per capita GDP shows that the variance has undergone a (statistically nonsignificant) decrease for the full period. Nevertheless, this drop has not been constant and has included periods in which the estimator increased notably. The volatility of this indicator coincides with the period between the 1975 and 1982 crises, and the recent international turbulence starting with the Asian crisis.³⁵ On the other hand, while the empirical distributions of per capita GDP initially show bimodalities or possible convergence clubs, these are largely rejected through multimodality tests.

With regard to per capita income, the results on convergence are relatively favorable for β convergence, but we do not observe a statistically significant reduction in its dispersion. Given the short span of our income sample, this behavior is extremely similar to that shown by the variance of regional GDP for the same period, which indicates consistency in the findings. Moreover, the application of the multimodality test reveals that the apparent asymmetries or bimodalities of the regional income distribution are not, in fact, statistically significant.

³⁵This does not necessarily imply causality.

APPENDIX A
UNIT ROOT TESTS³⁶

Levin, Lin, and Chu (2002)

This test assumes that there is a common unit root process in the series. It considers the standard specification of an augmented Dickey-Fuller (ADF) test, but applied to panel data:

$$(A1) \quad \Delta y_{i,t} = \alpha y_{i,t-1} + \sum_{j=1}^p \lambda_{ij} \Delta y_{i,t-j} + \delta \mathbf{X} + v_{i,t},$$

where $\alpha = \beta - 1$ is a common coefficient to the series, but different orders of lags (p_i) of $\Delta y_{i,t}$ are allowed in the cross-section; and \mathbf{X} is a vector of deterministic variables (for example, seasonal or trend dummies). The hypothesis to evaluate is

$H_0: \alpha = 0$, against

$H_1: \alpha < 0$ (that the series are weakly stationary or trend stationary).

In general terms, the test follows four stages.

(i) Estimate the ADF regressions (as in equation A1) for each region; find the optimal number of lags (p_i) using t tests; and estimate two auxiliary regressions to generate orthogonal residuals. The residuals are generated by regressing $\Delta y_{i,t}$ and $y_{i,t-1}$ against $y_{i,t-L}$ (where $L = 1, \dots, p_i$) and the relevant deterministic variables (\mathbf{X}). The idea here is to generate approximations of the variables $\Delta y_{i,t}$ and $y_{i,t-1}$ that are free from autocorrelation, an assumption on which the test is built.

(ii) Collect the residuals from the regressions and normalize them by dividing by the standard error of regression A1 (denote them as Δy^* and y^*).

(iii) Use the approximations to obtain estimators of α in the following specification:

$$(A2) \quad \Delta y_{i,t}^* = \alpha y_{i,t-1}^* + u_{i,t}.$$

(iv) Finally, construct a modified t statistic that will be asymptotically standard normal distributed and compare with the pertinent critical values. That is, construct:

$$(A3) \quad t_\alpha = \frac{\hat{\alpha}}{std(\hat{\alpha})},$$

where

³⁶For further detail on the tests described in this appendix, please see the original works cited.

$$std(\hat{\alpha}) = \hat{\sigma}_{\tilde{\varepsilon}} \left[\sum_{i=1}^N \sum_{t=2+p_i}^T (y_{i,t-1}^*)^2 \right]^{-1/2}, \text{ and}$$

$$\hat{\sigma}_{\tilde{\varepsilon}} = \left[\frac{1}{N(T - \bar{p} - 1)} \sum_{i=1}^N \sum_{t=2+p_i}^T (\Delta y_{i,t}^* - \hat{\alpha} y_{i,t-1}^*)^2 \right], \text{ con } \bar{p} = \left(\frac{1}{N} \right) \sum_{i=1}^N p_i, \text{ and where}$$

$\hat{\alpha}$ is the estimator of expression A2.

Breitung (2000)

This test assumes the presence of a single nonstationary process in the series and constructs a modified t statistic that is asymptotically standard normal distributed. It differs from the previous one in two basic aspects. First, in stage (i), remove only the autoregressive component (and not the deterministic component). Second, the (new) approximations are transformed and their trends extracted. The remaining features and the null hypothesis are the same as in the Levin, Lin, and Chu (2002) test.

Fisher-ADF and Fisher-Phillips-Perron

These tests were proposed by Maddala and Wu (1999) and Choi (2001). In contrast with the previous tests, these allow the presence of individual unit root processes. That is, regression A1 is run for each series, but now we evaluate

$H_0: \alpha_i = 0, \forall i$ all the series have a unit root, that is, all the coefficients of persistence are the same and equal to zero); against

$H_1: \alpha_i = 0, \forall i = 1, 2, \dots, N_1; \alpha_i < 0, \forall i = N + 1, N + 2, \dots, N$ (a fraction of the total series is stationary).

In particular, the Fisher-ADF and Fisher-Phillips-Perron tests use the p values (π_i) of the augmented Dickey-Fuller and Phillips-Perron tests, respectively, applied to each series in order to construct a test that under the null hypothesis is asymptotically chi-squared distributed with $2N$ degrees of freedom (where N , in our case, is the number of regions):

$$(A4) \quad -2 \sum_{i=1}^N \log(\pi_i) \rightarrow \chi_{2N}^2.$$

Furthermore, Choi (2001) showed that

$$(A5) \quad \frac{\sum_{i=1}^N \Phi^{-1}(\pi_i)}{\sqrt{N}} \rightarrow N(0,1)$$

where Φ^{-1} is the inverse of the cumulative distribution function of a standard normal.

In all cases it is necessary to specify the number of lags used in the test. In the cases of Levin, Lin, and Chu (2002) and Fisher-Phillips-Perron, it is also necessary to specify the kernel method and the bandwidth selection for the zero-frequency spectral estimation.

APPENDIX B MULTIMODALITY TEST

We use the nonparametric multimodality test proposed by Bianchi (1997). The contrast is based on the estimation of the data density function using kernel methods and on testing the number of groups (“clubs” for the case of economic convergence) within a single distribution using the bootstrap technique.

The key concept in the estimation of the density function ($f(x)$) is the critical bandwidth proposed by Silverman (1981, 1986). In the presence of m regional clubs (for example, $m = 2$, rich regions and poor regions), the $f(x)$ of the data is a mixture of distributions defined by

$$(B1) \quad f(x) = \sum_{j=0}^{m-1} p_j \cdot g_j(x; \mu_j, \sigma_j^2),$$

where each p_j is the proportion of each particular density, with $\sum p_j = 1$, and g_j are the densities, with first and second moments μ_j and σ_j^2 , respectively. For example, if we assume that the clubs are normally distributed, g_j will be defined as follows:

$$(B2) \quad g_j(x; \mu_j, \sigma_j^2) = (\sigma_j^2 \sqrt{2\pi})^{-1} \exp\left[-(x - \mu_j)^2 / (2\sigma_j^2)\right]$$

A critical bandwidth h_m is defined as the minimum value of h that generates a density with at least m modes, which implies that for $h < h_m$ the estimated density function has at least $m + 1$ modes. This leads to the idea of using h_m as a statistic for evaluating:

H_0 : $f(x)$ of the regional GDP or income has m modes, against

H_1 : $f(x)$ has more than m modes.

Thus, a high value for h_m would indicate the presence of more than m modes, rejecting the null hypothesis. The value that is considered “high” is determined through bootstrapping (see Silverman, 1981, 1986; Efron and Tibshirani, 1993).

In general terms, the steps for implementing the test are as follows:

(i) Starting from the data, generate B number of samples (denoted x^*) of size n through bootstrapping and using the following equation:

$$(B3) \quad x_i^* = \bar{y}^* + \left(1 + \frac{\hat{h}_m^2}{\hat{\sigma}^2}\right)^{-1/2} (y_i^* - \bar{y}^* + \hat{h}_m e_i), \quad i = 1, \dots, n$$

where y^* is an $n \times 1$ vector obtained from samples with replacement of the original data (x); \bar{y}^* is its respective mean; $\hat{\sigma}^2$ is the sample variance of x ; e_i are computer-generated standard normal variables; and \hat{h}_m is the critical bandwidth estimator.

(ii) For each bootstrap sample (x^*), calculate the test statistic defined as the critical bandwidth consistent with a distribution of m modes (m -modality) and denoted by \hat{h}_m^* . Denote the values of \hat{h}_m^* as $\hat{h}_m^*(1), \hat{h}_m^*(2), \dots, \hat{h}_m^*(B)$

(iii) Obtain an estimate of the achieved level of significance (ALS) of the test, defined as $NSA_m = \#\{\hat{h}_m^*(b) \geq \hat{h}_m\} / B$

(iv) The null hypothesis of m modes in the density is rejected whenever ALS_m is greater than the standard levels of significance (10%, 5%, 1%).

In short, the strategy pursued involves using this routine and applying the test beginning with the null hypothesis of $m = 1$ mode. If this is not rejected, then the evaluation of multimodality is finished. If, on the other hand, the null hypothesis is rejected, then we proceed to evaluate a new null hypothesis of $m + 1$ modes, and so on until the new hypothesis is not rejected.

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SOURCES OF GROWTH AND BEHAVIOR OF TFP IN CHILE*

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Chile has exhibited sharp cyclical and trend variation in its GDP and TFP growth rates during the last half century. This paper presents new estimates of the sources of Chile's growth and new measures for factor inputs and TFP during 1960-2005. Capital series are adjusted by utilization and labor employment series by hours worked and labor quality measures. Using a Cobb-Douglas function, the paper presents eight series for TFP based on alternative combinations of input measures. Three alternative cyclical measures for GDP suggest that the full period can be divided into three sub-periods of similar length, with similar cyclical features, and that coincide closely with distinct historical eras: 1960-1973, 1974-1989, and 1990-2005. Across the latter time spans, a negative relation between the first and second moments of GDP growth is confirmed, consistent with international experience. This paper also reports econometric evidence on the behavior of Chile's TFP during 1960-2005. TFP dynamics are shaped by cyclical variables (the terms of trade and real exchange rate undervaluation) and structural policy variables (macroeconomic stabilization and microeconomic reform progress), as well as positive interaction effects between macro performance and micro policies.

JEL: 047, D24, C32

Keywords: Economic Growth, Growth Accounting, TFP Dynamics.

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1. INTRODUCTION

Nearly half a century ago, Solow (1957) developed a method for decomposing economic growth based on the contribution of the primary factors of production (capital and labor) and the efficiency with which they are used. This allows decomposing the sources of growth into a “perspiration” component, corresponding to factor accumulation, and an “inspiration” component, corresponding to productivity gains. The latter component can lead to sustained higher GDP growth; hence measuring productivity growth is important.¹ At the same time, good institutions, combined with good policies, should encourage inspiration in a country and thus lead to sustained growth, a hypothesis that is explored in this paper.

The Chilean economy has gone through major changes in its growth pattern and the contribution of growth factors in the last decades, as documented in earlier studies (for example, Loayza and Soto, 2002). Total sector productivity TFP growth has observed strong fluctuations, both in trends and along business cycles. GDP and TFP growth rates were very high in Chile during the “golden years” of 1986-1997, falling to more moderate rates since 1998 (Gallego and Loayza, 2002). Are the earlier estimates robust to longer data series and alternative measures of capital and labor, in comparison to previous studies? What explains the behavior of TFP in Chile from 1960 to the present?

This paper aims at addressing the two latter questions. First, we present new estimates of the sources of Chile’s growth and new measures for factor inputs and TFP (sections 2 and 3). Capital series are adjusted by utilization and labor employment series by hours worked and labor quality measures. Using a Cobb-Douglas function, we identify the contribution of factor inputs and obtain residual TFP series. This work is part of the empirical literature on growth and TFP measures for Chile.² However, in this paper we expand on previous research along two dimensions. We extend the time coverage by using annual data for the period 1960-2005 and we make use of a larger variety of capital and labor series, giving rise to eight alternative measures for the residual TFP series.

There is scant research on the determinants of TFP for Chile. Therefore we analyze the dynamics of TFP in Chile in section 4. We specify and estimate a parsimonious model for TFP, based on cyclical variables and structural policy determinants that help in explaining the short-run and trend behavior of the economy’s aggregate efficiency during the last half century.

¹While it is possible to separate the components of growth into factor accumulation and efficiency, this does not mean that they are unrelated. When TFP increases, the demand for productive factors tends to rise, leading to higher accumulation.

²Recent empirical studies on Chile’s growth include De Gregorio (1997), Rojas, López, and Jiménez (1997), Roldós (1997), Coeymans (1999), Bergoeing, Kehoe, Kehoe and Soto (2002), Beyer and Vergara (2002), Contreras and García (2002), Gallego and Loayza (2002), Solimano and Soto (2003) and Chumacero and Fuentes (2006).

The paper closes with the main conclusions drawn in section 5. Appendix 1 presents data definitions and sources and appendix 2 reports the new 1960-2005 data series that are generated and used in this paper.

2. MEASURES OF AGGREGATE CAPITAL, LABOR AND OUTPUT

This section presents different measures of Chile's stock of capital, labor input and TFP. These measures include adjustments for utilization and input quality, using annual data covering the 1960-2005 period.

Our basic measure of aggregate capital is the stock of physical capital, the sum of investment in machinery and equipment and in buildings and construction. This primary measure does neither reflect changes in capital utilization rate during the business cycle nor take into account changes in the quality of capital.

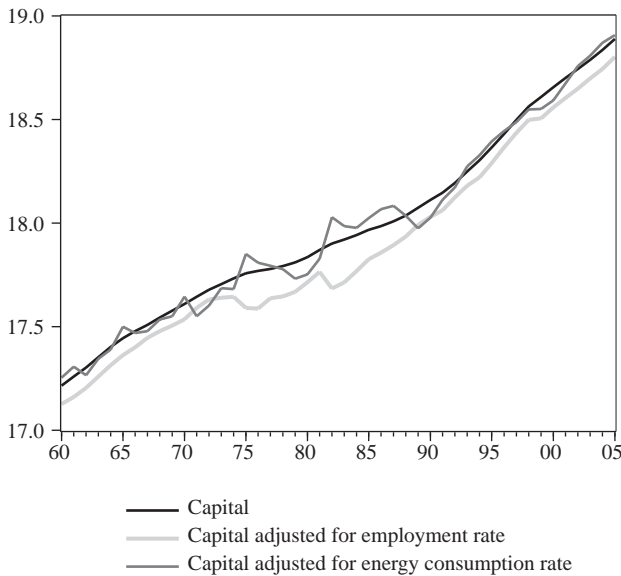
When capital is not adjusted for quality, the variations in capital quality are residually attributed to changes in TFP. To avoid this problem, several authors use the capital quality index proposed by Jorgenson and Griliches (1967), based on a weighted average of investment in machinery/equipment and buildings/construction, where the weights are determined by the relative rates of return on the corresponding investment categories. Greenwood and Jovanovic (2000) provide an alternative measure of capital quality, based on the evolution of the relative price of investment to consumption. We have computed both indexes for the period 1960–2005. We found that capital quality in 2005 is close to the level in 1960, which suggests serious measurement problems. Considering this result and the absence of other adequate quality indexes for Chile, we decided not to adjust capital for quality. Thus all our residual measures for TFP also reflect changes in capital quality.

Not adjusting for capital utilization can lead to errors in measuring TFP along the business cycle, as changes in the use of the physical capital stock are attributed to TFP. If we assume that capital and labor have a relatively similar rate of utilization, we can take the labor unemployment rate as a relevant proxy of the capital utilization rate. However, a drawback of this approach is that it assumes strong complementarity of capital and labor along the cycle.

Costello (1993) proposes an alternative measure of capital input: electricity consumption. In contrast to using labor utilization, the latter approach has the advantage of being based on an independent measure, but it does not consider plausible substitution between electricity and other sources of energy. We use the information on energy consumption, instead of only electricity, to compute a new measure of the degree of capital utilization: the deviation of the actual energy consumption series from its long-term trend, based on a Hodrick-Prescott filter estimate. By multiplying the gross capital stock by one minus the deviation, we obtain a new capital series that adjusts for the degree of utilization.

Figure 1 depicts the evolution of the three alternative capital series for the 1960-2005 period: gross capital, capital adjusted for employment rate and capital adjusted for energy consumption rate. The three measures of capital follow a similar pattern, although the capital series adjusted for utilization using energy consumption is more volatile than the other two series. The definitions and sources of the variables –for capital and all other series used in this paper– are summarized in Appendix 1. Appendix 2 reports the new data series spanning 1960-2005.

FIGURE 1
CAPITAL, CAPITAL ADJUSTED FOR UTILIZATION BASED
ON EMPLOYMENT RATE AND CAPITAL ADJUSTED FOR UTILIZATION
BASED ON ENERGY CONSUMPTION RATE IN CHILE, 1960-2005
(logarithmic scale)



Source: Appendixes 1 and 2.

The high correlation between the three series over the 46 years of our sample –which combines the cyclical and trend correlation– is reflected in Panel A of Table 1. The correlations for variables in levels are very high, ranging from 0.995 to 0.997. The correlations in Panel B (growth rates of variables) are considerably lower, reflecting the strong trend component of all three series.

TABLE 1
 COEFFICIENTS OF CORRELATION BETWEEN THREE MEASURES
 OF CAPITAL, FOR VARIABLES IN LEVELS (PANEL A)
 AND GROWTH RATES (PANEL B)

(A) Variables in levels		
	Capital adjusted for employment rate	Capital adjusted for energy consumption rate
Capital	0.997	0.995
Capital adjusted for employment rate		0.995
(B) Variables in growth rates		
	Capital adjusted for employment rate	Capital adjusted for energy consumption rate
Capital	0.504	0.196
Capital adjusted for employment rate		0.552

Our basic labor employment measure is the number of workers employed in the economy. Our first adjustment to this measure is to correct for the average number of hours worked per week. We then adjust employment for labor quality, using two different methods. The first is based on average years of workforce schooling. The second draws on an index of work quality developed by Jorgenson and Griliches (1967), based on relative wages to weigh labor quality according to labor productivity associated to the acquisition of human capital. The latter index has an advantage over the adjustment based on years of schooling because it reflects labor productivity validated by labor markets.

Figure 2 shows the series for employment, hours worked, years of schooling, and wage-based labor quality during 1960-2005. With the exception of hours worked, all series present a positive trend and similar cyclical behavior.

Table 2 reports the correlations between our four employment series studied: employment, employment adjusted for hours worked, employment adjusted for hours worked and years of schooling, and employment adjusted for hours worked and labor quality. Panel A reflects high correlations between the four employment series, for variables in levels (all above 0.99). In Panel B, for variables in growth rates, the correlations among the four variables continue to be high (ranging from 0.71 to 0.91).

FIGURE 2
EMPLOYMENT, HOURS WORKED, YEARS OF SCHOOLING,
AND WAGE-BASED QUALITY IN CHILE, 1960-2005



Source: Appendixes 1 and 2.

TABLE 2
COEFFICIENTS OF CORRELATION BETWEEN FOUR MEASURES
OF EMPLOYMENT, FOR VARIABLES IN LEVELS (PANEL A)
AND IN GROWTH RATES (PANEL B)

(A) Variables in levels

	Employment adjusted for hours	Employment adjusted for hours and schooling	Employment adjusted for hours and wages
Employment	0.995	0.997	0.994
Employment adjusted for hours		0.995	0.997
Employment adjusted for hours and schooling			0.996

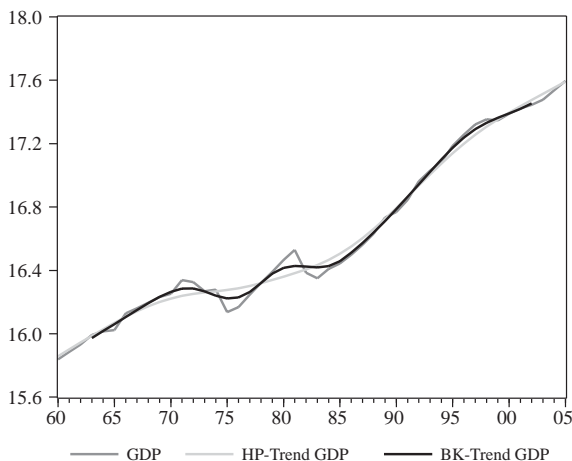
(B) Variables in growth rates

	Employment adjusted for hours	Employment adjusted for hours and schooling	Employment adjusted for hours and wages
Employment	0.847	0.741	0.711
Employment adjusted for hours		0.837	0.844
Employment adjusted for hours and schooling			0.906

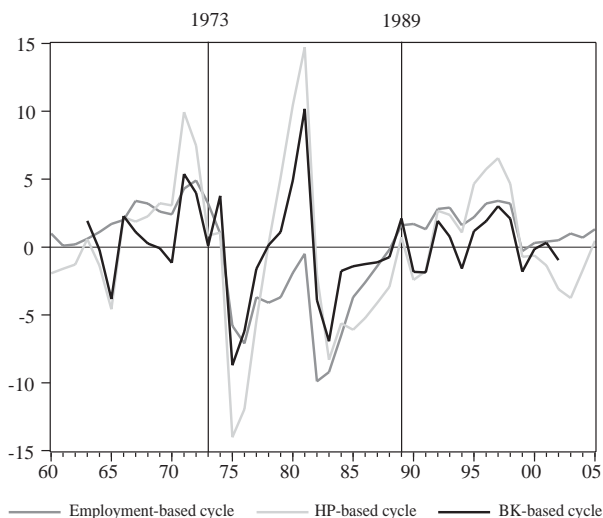
Chile's GDP grew by an annual average rate of 3.89% during 1960-2005. This long-term growth pattern exhibits strong cyclical and trend variations (see Panel A, Figure 3).

FIGURE 3

(A) ACTUAL GDP, HODRICK-PRESCOTT TREND GDP, AND BAXTER-KING TREND GDP IN CHILE, 1960-2005 (LOGARITHMIC SCALE)



(B) CYCLICAL MEASURES BASED ON EMPLOYMENT AND TREND GDP IN CHILE 1960-2005 (IN PERCENTAGE)



Source: Appendixes 1 and 2.

In order to identify trend growth in relevant sub-periods, we proceed to isolate the business cycles effect applying three standard methods. First, we use the employment series, with business cycle measured by the percentage difference between the corresponding year's actual employment rate and the average employment rate in the full 1960-2005 period (9.04%). For the second and third method we apply the Hodrick-Prescott (HK) and Baxter-King (BK) filters to the GDP series to derive the percentage difference between actual and trend GDP in levels. The filtered GDP series are depicted in Panel A of Figure 3, while Panel B shows the cyclical measure based on employment and the two cycle measures of the applied GDP filters.

The correlations between the cyclical measure based on employment and the two cyclical measures based on the trend GDP are presented in Table 3. The correlations between the employment cycle measure based on employment and both cyclical measures based on GDP trends are close to 0.6, while the correlation between the two cyclical measures based on output is considerably higher, at 0.9, as expected.

TABLE 3
COEFFICIENTS OF CORRELATION BETWEEN THREE CYCLICAL
MEASURES BASED ON EMPLOYMENT AND TREND GDP

	HP-based cycle	BK-based cycle
Employment-based cycle	0.600	0.575
HP-based cycle		0.906

The three cyclical measures (Figure 3, Panel B) suggest that the full 46-year period can be divided into three sub-periods of similar length and with similar cyclical features, separated by those years when both employment and GDP levels were close to their trend levels: 1973 and 1989.³ The resulting three periods –1960-1973, 1974-1989 and 1990-2005– are of similar length and roughly coincide with distinct historical eras that differ strongly in terms of international, economic, and political conditions. In this sense, the “golden years” (1986-1997) are not a useful reference period, because they start in a bust year and end in a boom year, thus reflecting a strong cyclical recovery.

Table 4 reports Chile's average GDP growth rates and their standard deviations for the sub-periods that we have identified as relevant, cyclically-

³The selected sub-periods are those in which the cyclical measures are on average close to zero. However, these same periods might not appear to be the most adequate if we take the measures individually. For example, for the 1960-73 period, the cyclical measure based on the HP filter starts below zero, hence our 1960-1973 growth measure includes a slight cyclical recovery component.

TABLE 4
AVERAGE AND STANDARD DEVIATION OF GDP GROWTH IN CHILE,
RELEVANT SUB-PERIODS

	1960-2005	1960-1973	1974-1989	1990-2005	1990-1997	1998-2005
Average GDP growth rate	3.89%	3.12%	2.88%	5.30%	7.14%	3.08%
Standard deviation	5.35%	4.23%	7.25%	3.45%	2.71%	1.82%

adjusted growth periods. The data reflects the following stylized facts. First, the sub-period with the lowest average growth rate (1974-1989) also exhibits the highest volatility. Second, the opposite can be said about the 1990-2005 period. These results confirm the international finding that first and second growth moments are negatively correlated (Ramey and Ramey, 1995). Finally, dividing the third sub-period (1990-2005) in two highlights the significant drop in the growth rate in 1998-2005 relative to 1990-1997, although volatility also slightly decreased.

3. FACTOR CONTRIBUTION TO GROWTH

We now apply the traditional Solow method for decomposing growth into the contributions from factors of production and residual TFP. The decomposition of GDP growth and the measurement of total factor productivity is based on a standard Cobb-Douglas production function, which defines the level of output (Y) as a function of total factor productivity (A) and the factors, capital (K) and labor (L):

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

where α represents the share of capital in output. Extending factor measurement to include changes in factor utilization rate and in quality, we obtain a new version of equation (1):

$$(2) \quad Y_t = \tilde{A}_t \tilde{K}_t^\alpha (L_t H_t Q_t)^{1-\alpha},$$

where \tilde{A}_t represents adjusted TFP, \tilde{K}_t capital adjusted for utilization, H_t hours worked, and Q_t labor quality. The equations for residual calculation of the growth rate of unadjusted and adjusted TFP are then derived as follows:

$$(3) \quad \hat{A}_t = \hat{Y}_t - \alpha \hat{K}_t - (1-\alpha) \hat{L}_t, \quad \text{and}$$

$$(4) \quad \hat{\tilde{A}}_t = \hat{Y}_t - \alpha \hat{\tilde{K}}_t - (1-\alpha) \widehat{L_t H_t Q_t}$$

where the hat represents percent changes. The only parameter required to apply the above method is capital share α . Using national account data from the Central Bank of Chile, we obtain an average share of capital in national income for the 1960-2005 period of 50%. This measure is biased upward, however, because it includes the income share of independent workers. Information from the Universidad of Chile Survey indicates that around 20% of workers in Chile are independent workers. Subtracting independent-workers' income from the national account figure yields a final capital share of 40%. This figure is consistent with international evidence and with previous estimates for Chile obtained from production function estimations (e.g. Roldós, 1997). We carried out a sensitivity analysis using different values of this parameter, and the results were qualitatively similar to those reported below.

Table 5 presents eight selected results for the decomposition of Chilean growth in 1960-2005, based on alternative measures of the contributions of capital and labor.⁴

TABLE 5
SOURCES OF GDP GROWTH IN CHILE, 1960-2005

	GDP growth	Contribution of capital growth	Contribution of labor growth	Contribution of TFP growth
<i>A. Unadjusted capital, various employment measures</i>				
1. Capital and employment	3.89%	1.48%	1.19%	1.22%
2. Capital and employment adjusted for hours	3.89%	1.48%	1.04%	1.37%
3. Capital and employment adjusted for wages	3.89%	1.48%	1.69%	0.72%
4. Capital and employment adjusted for hours and wages	3.89%	1.48%	1.54%	0.87%
<i>B. Capital adjusted for utilization, various employment measures</i>				
5. Capital adjusted for energy consumption rate and employment	3.89%	1.51%	1.19%	1.19%
6. Capital adjusted for energy consumption rate and employment adjusted for hours	3.89%	1.51%	1.04%	1.34%
7. Capital adjusted for energy consumption rate and employment adjusted for wages	3.89%	1.51%	1.69%	0.69%
8. Capital adjusted for energy consumption rate and employment adjusted for hours and wages	3.89%	1.51%	1.54%	0.84%

⁴For reasons of space, we refrain from reporting all the possible combinations of alternative measures of capital and labor. We include only those that we consider the most representative. For instance, we do not show results obtained using capital adjusted for the utilization rate proxied by the employment rate, because the latter assumes strong complementarity of capital and labor during the cycle. Similarly, we do not report the results based on employment adjusted for years of schooling, because we consider more appropriate the quality index based on wages.

The average annual contribution of (unadjusted) physical capital to Chilean growth in 1960-2005 was 1.48% (that is, the 40% capital share times the 3.7% average growth rate of capital), as reflected in measures 1-4 in Table 5. When we use the alternative measure that corrects for the rate of capital utilization (using the energy consumption rate as a proxy for utilization), the estimated contribution of capital to growth increases slightly to 1.51%, as reflected in measures 5-8 of Table 5.

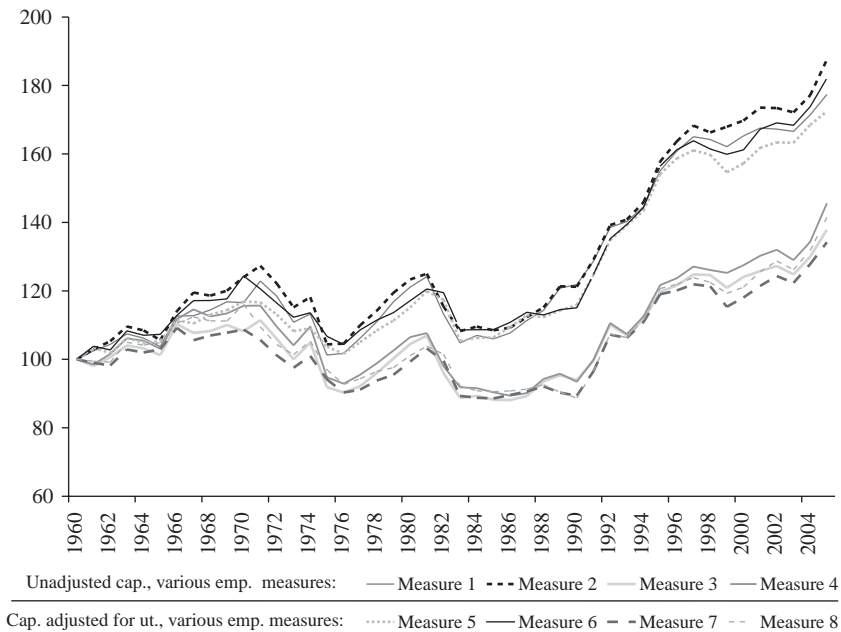
The average annual contribution of unadjusted labor to growth was 1.19% (the 60% share times the average 1.98% growth rate of employment), as reflected in measures 1 and 5. When adjusted for hours worked, the contribution of employment declines to 1.04%, due to the reduction in weekly work hours from 50.4 in 1960 to 45.3 hours in 2005. When adjusted for labor quality, the contribution of employment to growth increases approximately by 0.5 percentage points, which reflects the 0.82% average growth in labor quality between 1960 and 2005.

The contribution of the different measures of capital and employment to growth in Chile are reflected with opposite sign into the residual estimations of TFP growth. For the conventional measures of unadjusted capital and labor contributions (measure 1), average annual TFP growth attained 1.22%; this estimate declines marginally, to 1.19%, when we correct for capital utilization (measure 5). When we adjust for labor quality, annual TFP growth falls to 0.72% (measure 3) or 0.69% (measure 7). By excluding labor quality improvements, the two latter measures of TFP growth reflect only changes in the quality of capital and other gains in production efficiency that are not captured by increases in relative wages of better educated labor. Consequently, these measures of TFP growth rates are not comparable to the previous measures, without adjustment for labor quality. Measures 4 and 8 show an average annual TFP growth of 0.87% and 0.84% respectively. These figures are higher than the ones for measures 3 and 7 due to the reduction in weekly work hours between 1960 and 2005.

We conclude that most of average growth in Chile, in the 1960-2005 period, reflected the accumulation of productive factors, while “inspiration” or efficiency gains have only played a secondary role. Without adjustment for labor quality, TFP growth contributed 1.2% of the 3.9% GDP growth, representing a relative contribution of 31% to Chile’s growth. This share falls to a range of 17-19% when adjusting for labor quality, the contribution of overall efficiency gains shrinks to 0.85% representing only 18% of aggregate growth. Chile’s growth experience confirms that moderate GDP growth is strongly associated to moderate efficiency gains. This is in line with international evidence that shows that high aggregate growth is normally associated to high TFP growth.

Figure 4 depicts our eight annual TFP measures confirming two clusters of TFP series, those derived from employment without labor quality adjustments (measures 1, 2, 5 and 6) and those based on quality-adjusted labor (measures 3, 4, 7 and 8). The figure also suggests the high correlation among the eight measures of TFP. Finally, the TFP series exhibit strong pro-cyclical behavior.

FIGURE 4
ALTERNATIVE MEASURES OF TFP IN CHILE,
1960-2005 (INDEX: 1960 = 100)



For the following analysis, we focus on three estimates of TFP. The first estimate is measure 1, based on unadjusted capital and labor. The strength lies in being the conventional TFP measure derived in most previous empirical work. While this measure is the least preferred by us, it serves as a point of reference.

We select the next two TFP estimates (measures 4 and 8) to reflect employment adjusted by hours and labor quality (measure 4) and, in addition, capital adjusted by utilization (measure 8).

Table 6 reports the sources of growth for our three selected factor measures and TFP estimates, separately for each of our three cyclically-defined sub-periods. Figure 5 depicts the corresponding decompositions.

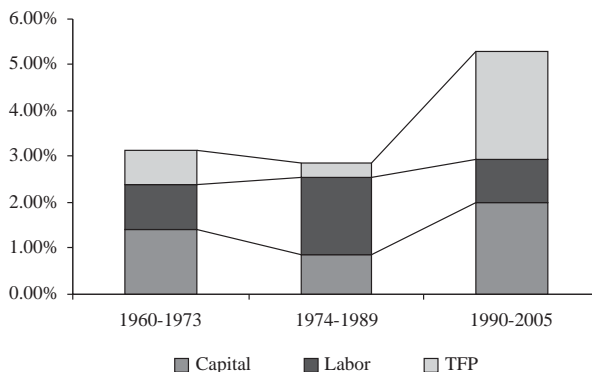
The reported evidence points toward significant differences between the sub-periods under study. The 1960-1973 period is characterized by modest GDP and TFP growth. Capital accumulation made the most important relative contribution to Chilean growth, while labor growth contributes less than capital. This changes radically in the following period, 1974-1989, when GDP growth is even more modest. Now labor growth represents the dominant contribution. When adjusting for labor quality, labor explains all GDP growth during this period. TFP growth collapses to attain only slightly positive or larger negative rates, depending on its measure. A dramatic turnaround of growth and its contributing

TABLE 6
SOURCES OF GDP GROWTH IN CHILE, VARIOUS SUB-PERIODS

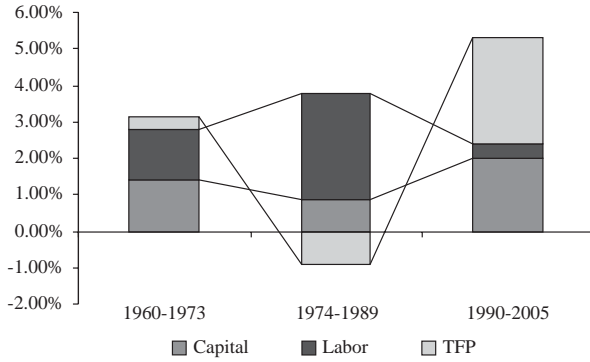
	GDP Growth	Contribution of capital growth	Contribution of labor growth	Contribution of TFP growth
<i>Measure 1: capital and employment</i>				
1960-1973	3.12%	1.42%	0.97%	0.73%
1974-1989	2.88%	0.86%	1.68%	0.34%
1990-2005	5.30%	1.99%	0.95%	2.37%
1990-1997	7.14%	1.98%	1.30%	3.86%
1998-2005	3.08%	1.66%	0.46%	0.96%
<i>Measure 4: capital and employment adjusted for hours and wages</i>				
1960-1973	3.12%	1.42%	1.38%	0.32%
1974-1989	2.88%	0.86%	2.91%	-0.89%
1990-2005	5.30%	1.99%	0.42%	2.89%
1990-1997	7.14%	1.98%	1.14%	4.02%
1998-2005	3.08%	1.66%	-0.45%	1.87%
<i>Measure 8: capital adjusted for energy consumption rate and employment adjusted for hours and wages</i>				
1960-1973	3.12%	1.56%	1.38%	0.18%
1974-1989	2.88%	0.93%	2.91%	-0.97%
1990-2005	5.30%	1.82%	0.42%	3.06%
1990-1997	7.14%	1.61%	1.14%	4.40%
1998-2005	3.08%	1.64%	-0.45%	1.89%

FIGURE 5
SOURCES OF GDP GROWTH IN CHILE, VARIOUS SUB-PERIODS

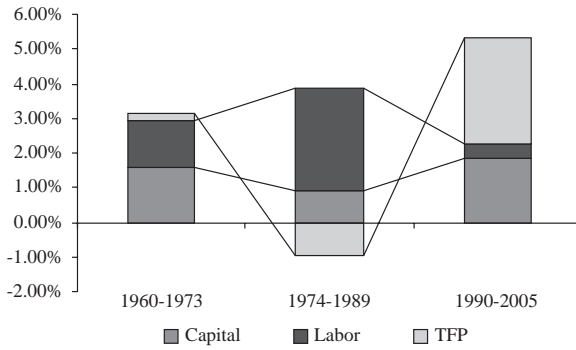
(A) Measure 1: Capital and labor, full sample periods and sub-periods



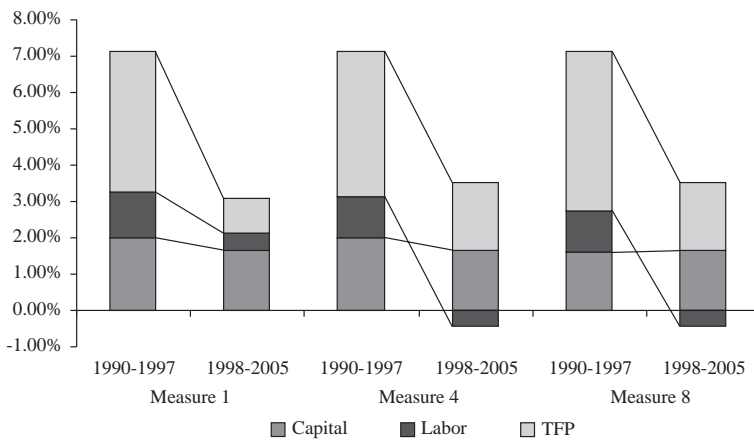
(B) Measure 4: Capital and labor adjusted for hours and wages, full sample periods and sub-periods



(C) Measure 8: Capital adjusted for utilization (energy consumption) and labor adjusted for hours and wages, full sample periods and sub-periods



(D) Three measures, sub-periods 1990-1997 and 1998-2005



factors is observed in the third period, 1990-2005. The contribution of capital to this period's high growth is very substantial, dwarfing capital's contribution during the preceding decades. In contrast, employment contributed little to growth, particularly when considering employment adjusted by hours and wages. The contribution of TFP is particularly impressive after 1989, when TFP growth attains levels that are unprecedented in recent economic history, varying from 2.4% to 3.1%.

Now let's focus more closely on the high-growth sub-period 1990-2005 and its two halves: the 1990-1997 years of very high growth that coincide with a long phase of cyclical expansion and the subsequent 1998-2005 years of more moderate and volatile growth (see Figure 5D). The decline in average GDP growth from 7.14% in 1990-1997 to 3.08% in 1998-2005 was accompanied by an insignificant decline in the contribution of capital and a massive fall in the contribution of labor. We also observe a very significant drop in the contribution of TFP growth, from a range of 3.9% to 4.4% in 1990-1997 to a much lower range of 1.0% to 1.9% in 1998-2005.

However, the latter 1998-2005 period hides very distinct shorter time spans of common GDP and TFP performance: a sharp cyclical contraction in 1998-1999, a slow cyclical recovery in 2000-2003, and a strong recovery toward full employment in 2004-2005 (see Figure 3). TFP growth is particularly strong during the two last sample years (see the data on TFP in Appendix 2), a performance that is largely a result of favorable cyclical conditions, identified in the following section.

4. DETERMINANTS OF TOTAL FACTOR PRODUCTIVITY

The large swings in Chile's TFP growth, documented in the preceding sections, lead us now to undertake a more systematic search for its causes. Good or bad policies that introduce or eliminate distortions probably contribute to the economy's aggregate efficiency, thereby affecting aggregate output.⁵ Therefore, we expect that variables that represent the quality of economic policies (like macroeconomic stability and structural reform progress) and/or institutions (reflected in indicators such as civil liberties) that affect the agents' behavior should be considered among the structural determinants of the economy's aggregate efficiency. Furthermore, policy complementarities could be key to understanding why certain structural reforms or stabilization programs have positively affected TFP growth while others have not.

The above mentioned fact that TFP exhibits pro-cyclical patterns justifies the inclusion of variables related to the economic cycle. For example, an adverse macroeconomic shock can lead to a transitory reduction in output, beyond its

⁵Harberger (1998) considers TFP variations as cost reductions –that is, as efficiency gains or technological changes.

effect on the use of productive factors. The country's terms of trade and real exchange-rate undervaluation are variables that affect the Chilean economic cycle, and therefore we use them as controls in our empirical analysis of TFP.⁶

Our regression analysis is performed for two TFP estimates described in the previous section: measure 4 (with capital and labor adjusted for hours worked and wage-based labor quality), and measure 8 (with capital adjusted for utilization based on the energy consumption rate, and labor adjusted for hours worked and wage-based labor quality). We do not use measure 1 as we know beforehand that it is an imperfect measure of TFP.

The specification for the TFP level includes as determinants—in addition to cyclical variables as the terms of trade and the degree of exchange rate undervaluation (both with an expected positive sign)—an indicator of the overall status of structural reforms (with an expected positive sign), an indicator of macroeconomic instability, measured as the inflation rate divided by one plus the inflation rate⁷ (with an expected negative sign), and an indicator of civil liberties (with an expected positive sign). Appendix 1 describes data sources and variables measurement. Other variables not included could also be important determinants of productivity. An example is technological innovation. However, we do not have time series for this variable in Chile as well as data for other potential TFP determinants, which limits severally our empirical results.

We also control for the potential interaction between macroeconomic instability and structural reform progress. This interaction variable captures the idea of policy complementary (Gallego and Loayza, 2002), applied here to a potential interaction between macroeconomic and structural policies. Hence, we expect structural reforms to have a stronger effect on aggregate economic efficiency under conditions of greater macroeconomic stability. *Paripassu*, government efforts to stabilize the macroeconomy should have larger effects when the economy suffers from fewer distortions as a result of better structural policies.

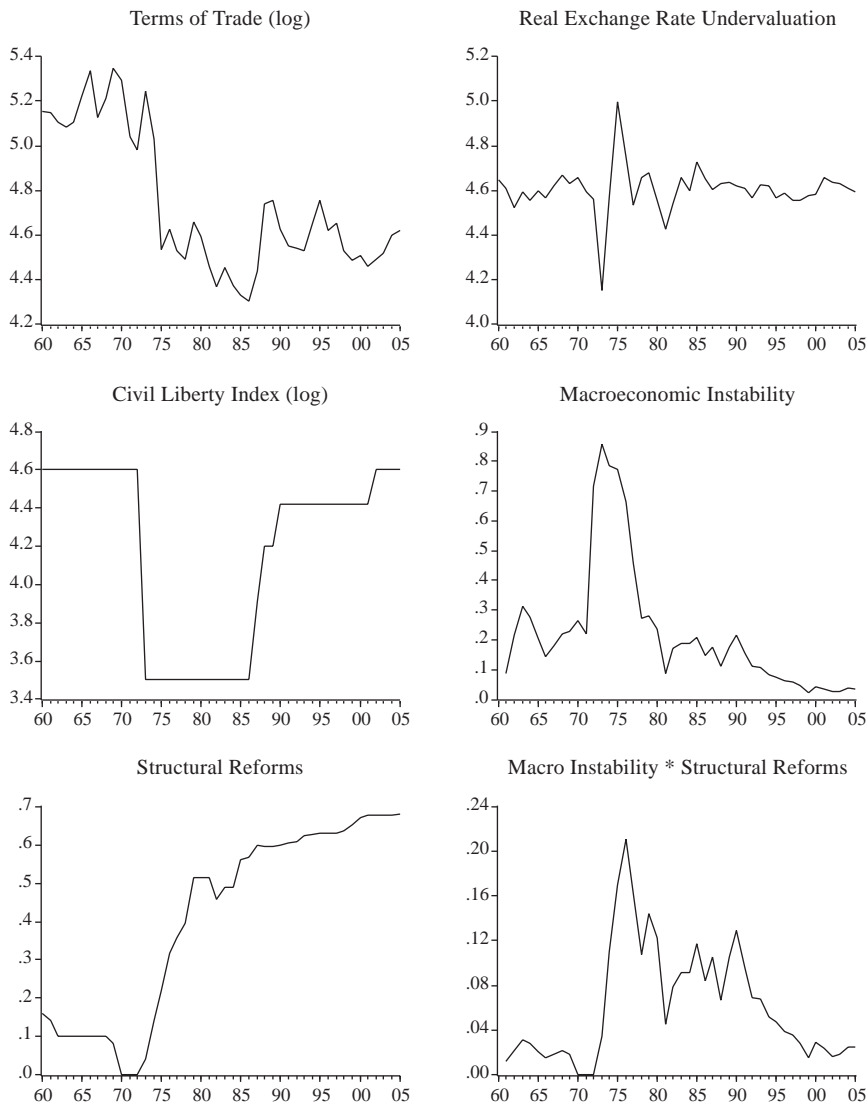
Figure 6 depicts the evolution of the six potential determinants of TFP during 1960-2005. The figure reflects the structural reduction in the country's terms of trade that took place in 1975 and its large volatility before and after 1975. Huge real exchange misalignments were observed during the 1970s and early 1980s; comparatively the RER exhibits lower deviations from fundamentals since the late 1980s.⁸ Civil liberties deteriorated massively during 1973-1986,

⁶The simple correlations between the terms of trade and the two measures of the cyclical component of GDP reported above, based on the Hodrick-Prescott and Baxter-King filters, are close to 0.5 in the 1960-2005 period. Similarly, the correlations between the real exchange rate undervaluation and the two measures of business cycles are close to -0.5. One might argue that the exchange rate undervaluation is an endogenous variable given that it responds to the evolution of productivity; however, lagged values of such variable were always significant in explaining TFP in our subsequent analysis.

⁷Using volatility of inflation instead of its mean does not make much difference, since mean and volatility are highly correlated (the coefficient of correlation between both series is 0.9). Moreover, the growth literature usually uses the mean of inflation as regressor in growth equations (e.g. Fischer 1993).

⁸RER undervaluation is an index constructed as the ratio of observed RER to the equilibrium RER times 100. The variable used is the log of this index, which fluctuates around the $\ln(100)$, which is the value of the index when the RER is equal to its equilibrium level.

FIGURE 6
EXPLANATORY VARIABLES FOR TFP IN CHILE, 1960-2005



improved significantly in the late 1980s. Since 2002 the levels observed are the same as the 1960 levels. Macroeconomic instability deteriorated in the 1970s and recovered gradually since 1978, with the subsequent reduction in inflation, reaching low and stationary levels since 2001. Structural reforms deteriorated in the early 1970s, but they recovered aggressively until 1980 and more gradually during the two subsequent decades.

We proceed to estimate the following regression:

$$(5) \quad \ln(TFP)_t = \Omega(L)\ln(TFP)_t + \Theta(L)X_t + \varepsilon_t$$

where L is the lag operator, $\Omega(L)$ and $\Theta(L)$ are lag polynomials, and X is the vector of explanatory variables presented in figure 6. The estimation strategy of equation (5) follows the general-to-particular approach (Hendry, 1995). Since the dynamic structure in the relation between TFP and the explanatory variables is unknown, we estimate an equation using contemporary and lagged values of the independent variables and lagged values of the dependent variable (the logarithm of the TFP index, $\ln(TFP)$). We then proceed to simplify the equation until finding a parsimonious representation of the relationship that does not lose information compared to the general model. The final model is contrasted against the more general model that includes all lagged variables using a likelihood ratio test. In all cases the null hypothesis that the more parsimonious model is valid cannot be rejected at conventional significance levels. The estimation results are reported in Table 7.

TFP exhibits significant inertia, as reflected by the significant and large coefficients of its own lags. However, an F-test strongly rejects the null hypothesis that all parameter values, except those of lagged dependent variables, are equal to zero. The effect of the business cycle on TFP captured by the terms of trade and the real exchange rate undervaluation shows in both cases the expected positive sign and is economically important. However, while terms of trade have a contemporaneous effect on TFP, the RER undervaluation acts with a lag.

An index of civil liberties is the first institution-related variable included in the regression. This variable shows some short-term impact that with measure 4 (column 1) is positive and with measure 8 (column 2) is negative. However in both cases the long-term effect is equal to zero. Microeconomic policies have a large contemporaneous impact on TFP, which is reduced somewhat by the counter effects of the lags of microeconomic policies. We also find evidence of a significant interactive effect between structural policies and macroeconomic instability: better microeconomic policies have a much higher impact on TFP under conditions of macroeconomic stability (low inflation). There is no evidence that macroeconomic instability has direct effects on TFP in the estimation of model with measure 4, once we take into account the interaction with microeconomic policies, but there is such evidence in the model with measure 8.

In Table 8 we report estimates of the long-term effect of structural reforms and macroeconomic stabilization, based on regression coefficients and structural policy and macroeconomic instability conditions observed in the three historical

TABLE 7
ESTIMATION OF THE DETERMINANTS OF TFP IN CHILE
(ORDINARY LEAST SQUARES, 1960–2005)

Dependent variable is the log (TFP) measured using:	(1) Measure 4: Capital and labor adjusted for hours and wage-based labor quality	(2) Measure 8: Capital adjusted for utilization based in energy consumption rate and labor adjusted for hours and wage-based labor quality
Constant	-1.018** (0.45)	-0.399 (0.35)
<i>Cyclical variables</i>		
Terms of trade	0.114*** (0.04)	0.129*** (0.04)
Terms of trade (t-1)	0.100*** (0.04)	
Terms of trade (t-2)		0.054* (0.03)
Real exchange rate undervaluation (t-1)	0.103* (0.05)	0.131** (0.05)
<i>Policies and Institutions</i>		
Civil liberties index	0.030** (0.02)	-0.045* (0.02)
Civil liberties index (t-1)	-0.105*** (0.03)	-0.087*** (0.02)
Civil liberties index (t-2)	0.110*** (0.02)	0.138*** (0.02)
Structural reforms (t-1)		0.544*** (0.14)
Structural reforms (t-2)	-0.237** (0.12)	-0.224* (0.13)
Macroeconomic instability (t-1)		-0.131** (0.05)
Macroeconomic instability (t-2)		0.189*** (0.06)
Structural reforms x Macroeconomic instability	-0.797*** (0.20)	-0.643** (0.30)
Structural reforms (t-2) x Macroeconomic instability (t-2)	0.726*** (0.11)	
<i>Initial Conditions</i>		
TFP (t-1)	0.559*** (0.09)	0.876*** (0.15)
TFP (t-2)		-0.522*** (0.14)
TFP (t-3)	0.287*** (0.09)	0.386*** (0.09)
Adjusted R squared	0.960	0.960
Standard error of the regression	0.025	0.024

Note: standard errors of estimated parameters are reported in parenthesis. Model residuals pass all standard specification tests, namely, the Q test at the residual level, the squared residuals, and the normality test. The estimated equation also passes the CUSUM and CUSUM squared tests, proving stability. The F-test strongly rejects the null hypothesis that all parameters except those of the lagged dependent variable are equal to zero.

*, **, *** statistically significant at 10%, 5% and 1% level.

TABLE 8
OVERALL MARGINAL EFFECTS OF STRUCTURAL REFORMS
AND MACROECONOMIC INSTABILITY ON TFP

<i>Macroeconomic instability measures</i>	Effect of structural reforms	
	TFP measure 4	TFP measure 8
Average 1960-1974 = 0.34	1.68 (0.9)*	0.90 (0.5)
Average 1975-1989 = 0.28	1.71 (0.9)*	0.54 (0.4)
Average 1990-2005 = 0.08	1.81 (0.8)**	1.05 (0.4)**
<i>Structural reforms measures</i>	Effect of macroeconomic instability	
	TFP measure 4	TFP measure 8
Average 1960-1974 = 0.08	-0.04 (0.1)	0.02 (0.1)
Average 1975-1989 = 0.48	-0.22 (0.5)	-1.00 (0.4)***
Average 1990-2005 = 0.64	-0.30 (0.7)	-1.36 (0.5)***

Note: Standard deviations are reported in parenthesis.

*, **, *** statistically significant at 10%, 5% and 1%.

sub-periods (1960-1974, 1975-1989, and 1990-2005). The reported effects represent the overall marginal effects of structural reforms (SR) and macroeconomic instability (MI), which are defined as:

$$(6) \quad \frac{\partial \ln TFP}{\partial \ln SR} = \beta_0 + \beta_1 \ln MI > 0$$

$$\frac{\partial \ln TFP}{\partial \ln MI} = \alpha_0 + \alpha_1 \ln SR < 0$$

where β_0 is the coefficient of the SR in the equation of TFP and β_1 is the interaction coefficient, α_0 is the coefficient of macroeconomic instability, and α_1 corresponds to the interaction coefficient.

The two sets of results (in columns 1 and 2) illustrate the complementarity of structural reforms and macroeconomic stabilization. For example, the 1960–1974 period featured high inflation, as reflected in a macroeconomic instability figure of 0.34, while the combined long-term coefficient of structural reforms is only 1.7 (measure 4). On the other hand, under the low inflation conditions observed in the sub-period 1990-2005, reflected in a macroeconomic instability coefficient of 0.076, the combined long-term coefficient of structural policies reaches 1.81. Thus, an increase in the structural reforms index of 5 percentage points (which is equivalent to the increase in the index between 1990 and 1994) contributes to a long-term increase of the TFP level of almost 8.4% in 1960-1974, 8.6% in 1975-1989, and 9.0% in 1990-2005, according to measure 4

estimates. Under measure 8, the results for each period are smaller but the differences among periods are larger. An increase in the structural reform index of 5 percentage point will induce a long-term increase in TFP of 1.9%, 2.7% and 5.3% for each one of the periods, respectively. Therefore, structural reforms had a substantially smaller effect (which could even be zero) in the case of very high macroeconomic instability (1960-1974). Although the results of both columns differ because the dependent variable is measured differently, they demonstrate that the two explanatory variables are complementary.

Analogous results are reported in Table 8 to quantify the effects of the reduction in macroeconomic instability, conditional on different levels of structural reform progress. Macroeconomic instability has its biggest impact in the most recent period, when the structural reform progress index is highest (1990-2005): the long-term coefficient is -0.30 (measure 4), which is much larger than the impact of stabilization under conditions of larger microeconomic distortions in 1960-1974. Reducing the macroeconomic instability index by 10 percentage points raises the long-term TFP level by 0.4% in 1960-1974, 2.2% in 1975-1989, and 3% in 1990-2005 (measure 4). The long-run effect of macro-instability changes when measure 8 is used. For the first period, for example, the effect on TFP would be zero. With reforms at the average level for 1975-1989, the effect of macroeconomic instability is one-to-one with inflation-reduction efforts. In this case, when structural reforms are more advanced, we observe an important effect of macroeconomic stabilization. We observe again complementarity among structural reforms and macroeconomic stability.

Table 9 reports the long-term parameter estimates associated with the other three independent variables: terms of trade, civil liberties and RER undervaluation. Two variables show a positive, statistically significant effect under both different specifications. However, the civil liberties index is not statistically significant.

TABLE 9
LONG-TERM EFFECT OF INDEPENDENT VARIABLES

Long-term parameters	TFP measure 4	TFP measure 8
Terms of trade	1.39 (0.7)**	0.70 (0.3)***
Civil liberties	0.22 (0.2)	0.03 (0.1)
RER undervaluation	0.67 (0.4)*	0.50 (0.2)**

Note: Standard deviations are reported in parenthesis.

*, **, *** statistically at 10%, 5% and 1%.

How does our model address the question of what explains the evolution of TFP? The following discussion presents an exercise in which we look at how much of the variation in TFP is explained by different right-hand-side variables. We analyze the full period (1963-2005) and the latest fourteen-year sub-period

(1993-2005). The policy interaction effect was taken separately and was not added to either structural reforms nor macroeconomic stability.

For the full sample period we used the steady-state version of the model results reported in Table 7, combining contemporaneous and lagged coefficients of the dependent and independent variables. Then we use the latter model, combining long-term coefficient estimates and actual average changes in independent variables between the sub-periods 1962-1965 and 2002-2005, to predict the change in the steady state value of TFP.

Table 10 reports the results of the latter exercise for both TFP measures. The model based on measure 4 does a fairly good job predicting long-term TFP growth, with actual and predicted average TFP growth equal to 0.75%, while model with measure 8 over predicts the value of TFP for that period. The greater contribution of TFP in both models corresponds to structural reforms. The Table also shows that the reduction in the long-term level of the terms of trade has been the most important cause of reduced TFP growth.

TABLE 10
EXPLAINING TFP GROWTH BETWEEN 1962-1965 AND 2002-2005

	(1) TFP measure 4	(2) TFP measure 8
<i>Average annual TFP growth</i>		
Actual	0.75%	0.46%
Predicted	0.75%	0.70%
<i>Contribution of cyclical variables</i>		
Terms-of-trade loss or gain	-1.89%	-0.95%
Real exchange rate devaluation or appreciation	0.10%	0.08%
<i>Contribution of better policies and institutions</i>		
Improvement in macroeconomic instability	0.00%	-0.10%
Improvement in structural reforms	2.54%	1.66%
Improvement in civil liberties	0.00%	0.00%
Improvement in policy complementarity	0.00%	0.03%

To analyze TFP growth in the 1990-2005 period, we used the short-term version of the model results reported in Table 7, based on individual coefficients for the contemporaneous and lagged coefficients of the dependent and independent variables. We use the latter model's coefficients and combine them with the actual changes in independent variables between 1989 and 2005. Results are reported in Table 11. Now the lags of the dependent variable play a very important role, reflected in figures of the last row of the table. The model again predicts TFP growth fairly well, with initial conditions providing the most important

TABLE 11
EXPLAINING TFP GROWTH: 1990-2005

	(1) TFP measure 4	(2) TFP measure 8
<i>Average annual TFP growth</i>		
Actual	2.62%	2.80%
Predicted	2.19%	2.27%
<i>Contribution of cyclical variables</i>		
Terms-of-trade loss or gain	-0.18%	-0.08%
Real exchange rate devaluation or appreciation	-0.01%	-0.02%
<i>Contribution of better policies and institutions</i>		
Improvement in macroeconomic instability	0.00%	-0.11%
Improvement in structural reforms	0.15%	0.17%
Improvement in civil liberties	0.28%	0.27%
Improvement in policy complementarity	0.01%	0.33%
<i>Initial conditions</i>	1.94%	1.72%

contribution. The cyclical variables, terms of trade shocks and exchange rate undervaluation, have marginal effect on TFP. On the other hand, structural reforms and civil liberties have a positive effect. Finally, macroeconomic instability had a negative direct effect on TFP, but taking into account the interaction term policy the final effect becomes positive.

5. CONCLUSIONS

Chile has exhibited sharp cyclical and trend variation in its GDP and TFP growth rates during the last 45 years. This paper contributes to Chile's empirical growth literature in two dimensions. First, we provide new estimates of the sources of Chilean growth and new measures for factor inputs and TFP during 1960-2005. Second, we focus on the behavior of TFP, providing evidence that TFP dynamics are shaped by both cyclical variables and structural policies during the last half-century in Chile.

The paper reports alternative capital series: with and without adjustment for capital utilization. While for long-term capital growth it matters little if capital is adjusted for utilization, the differences between adjusted and unadjusted capital is significant over the business cycle. Among our two alternative utilization choices—labor employment rate and energy consumption rate—our preferred choice is the latter because it does not assume high complementarity between capital

services and labor. Regarding labor, we also present time series with and without adjustment –in this case adjustments of labor employment are for hours worked and for labor quality (schooling or wage-based quality adjustment; our preferred choice is the latter).

We use three alternative cyclical measures for GDP, based on employment-rate deviations from their sample average, and actual GDP deviations from GDP trend estimates based on the Hodrick-Prescott and Baxter-King filters. These measures suggest that the full 46-year period can be divided into three sub-periods of similar length and with similar cyclical features, separated by those years when both employment and GDP levels were close to their trend levels: 1973 and 1989. The resulting three periods –1960-1973, 1974-1989 and 1990-2005– are of similar length and roughly coincide with distinct historical eras that differ strongly in terms of international, economic, and political conditions. During 1974-1989 (1990-2005) average growth is the lowest (highest), while growth volatility is the highest (lowest). This negative relation between the first and second moment of GDP growth is consistent with international experience.

Using a standard Cobb-Douglas production function, based on alternative combinations of capital and labor measures –with and without adjustment for capital utilization, hours worked, and labor quality– we obtain eight alternative measures of the contribution of productive factors and residual TFP to Chilean growth. The contribution of factor accumulation and efficiency gains to growth differs markedly across the three periods that were identified above.

Whereas the contribution of capital is dominant during the 1961-1973 period of modest growth, labor contributes the most and efficiency gains the least to growth during the slow-growth period spanned from 1974 to 1989. In contrast to the three preceding decades, all three growth determinants contribute more during the high-growth period of 1990-2005. However, the large role of TFP growth stands out in this period, contributing aggregate growth by an amount that is unprecedented in Chile's recent economic history.

The high-growth period can be divided into two distinct sub-periods: a period of high GDP and TFP growth in 1990-1997 and a period of moderate GDP growth and low TFP growth in 1998-2005. And the latter sub-period hides very distinct shorter time spans that mark a full business cycle with common GDP and TFP performance: a sharp cyclical contraction in 1998-1999, a slow cyclical recovery in 2000-2003, and a strong recovery toward full employment in 2004-2005.

The evidence on the determinants of TFP reported in this paper suggests that, in addition to cyclical factors (approximated by the terms of trade and real exchange rate undervaluation), TFP growth reflects efficiency gains from macroeconomic stabilization (measured by lower inflation) and microeconomic reforms (reflected by an index of structural reform progress). We also provide evidence on significant interaction effects between macroeconomic and microeconomic factors for the dynamic behavior of TFP. The evidence for Chile during 1960-2005 suggests that the impact of microeconomic reforms on TFP is weaker (stronger) under conditions of high (low) macroeconomic instability. The

reverse is also true: macroeconomic stabilization efforts yield larger gains in economic efficiency when the quality of microeconomic policies is higher.

Our evidence also points out that a significant factor behind higher TFP growth in 2004-2005 has been benefiting from exceptionally favorable terms of trade (i.e., exceptionally high copper prices). This suggests dominance of cyclical over structural factors in the most recent spurt in TFP performance.

Macroeconomic stability has been largely attained in Chile, and hence it can be ruled out as a significant future growth factor. Therefore we conclude that achieving high TFP and GDP trend growth in the future will be conditional on significant additional efforts in implementing further microeconomic and sector reforms in support of additional efficiency gains and major improvements in labor quality.

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APPENDIX 1
DATA DEFINITIONS AND SOURCES

This appendix describes the series used and their respective sources.

Variable	Definition and construction	Source
GDP	Real GDP in millions of 1996 pesos.	Central Bank of Chile.
Employment	Labor force times the employment rate.	<i>Indicadores de Empleo</i> , National Institute of Statistics
Hours worked	Average weekly hours worked.	<i>Ocupación y desocupación en el Gran Santiago</i> , University of Chile.
Years of schooling	Average years of schooling.	<i>Ocupación y desocupación en el Gran Santiago</i> , University of Chile until 2003. The data was extended to 2005 with forecasts based on a AR(1) model.
Wage-adjusted labor quality index	Weighted average of employment with different levels of education, relative to total labor, where the weights are relative wages. Index base: 1970 = 100.	Roldós (1997) through 1997, updated to 2005 based on <i>Ocupación y desocupación en el Gran Santiago</i> , University of Chile.
Capital stock	Sum of real capital stock of machinery/equipment and buildings/construction, in millions of 1996 pesos.	Hoffman (2000) through 1984, Pérez (2003) through 2001, updated to 2005 based on unpublished capital stock series of the Central Bank of Chile.
Energy consumption	Sum of consumption of the five main energy sources in Chile (expressed in tetracalories): hydroelectricity, coal, natural gas, oil, and wood.	Data published by National Energy Commission (NEC) until 2003. The data was extended to 2005 with information based on NEC's forecasts of coal and natural gas consumption, and data on hydroelectrical production and oil imports from the Central Bank of Chile.
Macroeconomic instability index	The index of macroeconomic instability is defined as inflation/ $(1 + \text{inflation})$, where inflation is measured by the average rate of change of CPI. The range of the index is $[-1, 1]$. Higher values indicate more macroeconomic instability.	Central Bank of Chile.

Variable	Definition and construction	Source
Structural reform index	Aggregate structural reform index based on sector reform indexes for progress in the areas of foreign trade, financial development, taxation, privatization, and labor legislation. The index ranges from 0 to 1.	Lora (1997) through 1997, updated through 2001 by K. Schmidt-Hebbel and M. Tapia, and updated through 2005 by the authors.
Civil liberties	The index measures civil liberties as the rights to free expression, to organize or demonstrate, as well as rights to a degree of autonomy such as provided by freedom of religion, education, travel, and other personal rights. The original series, which extends from 1 (the freest) to 7 (the least free) is converted linearly to a series that ranges from 0 (the least free) to 100 (the freest).	Comparative Survey of Freedom (produced by Freedom House) from 1973-2005. For 1960-1970, we assume that the index takes the value assigned for 1971-1973.
Terms of trade	Index of external relative prices of exports and imports.	Bennett and Valdés (2001) through 2001, updated to 2005 with information from the Central Bank of Chile.
Exchange rate undervaluation	The index of undervaluation is defined as the logarithm of $(RER/RER^*) \times 100$, where RER is the actual real exchange and RER* denotes the equilibrium real exchange rate. RER (and RER*) is the effective real exchange rates defined as the weighted sum of bilateral real exchange rate rates, given by the trading partner's CPI times the corresponding nominal exchange rate divided by the Chilean CPI, for Chile's main trading partners. Thus an increase in the RER reflects a real depreciation of the domestic currency.	Aguirre and Calderón (2005).

APPENDIX 2
SERIES OF GDP, PRODUCTIVE FACTORS, AND TFP IN CHILE,
1960-2005

Series	Real GDP	Capital	Employment rate	Energy consumption	Energy consumption rate	Employment	Hours worked	Years of schooling	Wage-based labor quality index
Units	Millions of 1996 pesos	Millions of 1996 pesos	%	Tetracalories	%	Thousands of persons	Hours per-week	Years	Index: 1970:100
1960	7560031	29969903	91.53	49950	97.62	2323	50.5	5.0	89.0
1961	7921585	31305185	90.64	52318	95.55	2343	50.1	5.5	95.5
1962	8296960	32701327	90.74	60200	103.22	2387	49.7	5.5	94.3
1963	8821839	34373857	91.14	61776	99.89	2440	48.8	5.4	93.6
1964	9018132	36123473	91.61	65377	100.11	2495	48.7	5.3	93.0
1965	9091026	37666675	92.21	64086	93.32	2554	49.0	5.2	92.4
1966	10104779	38962085	92.52	71741	99.72	2605	49.4	5.3	91.9
1967	10432839	40201995	93.91	76588	102.06	2687	45.7	5.6	95.5
1968	10806354	41599570	93.71	77976	100.08	2717	47.4	5.8	97.0
1969	11208437	43012777	93.11	82235	102.15	2730	48.0	5.8	97.8
1970	11438913	44427380	92.92	79514	96.08	2776	45.3	6.0	100.0
1971	12463292	46028914	94.76	92554	109.34	2868	47.3	6.5	104.1
1972	12312091	47596838	95.44	92735	107.69	2922	47.6	6.7	106.2
1973	11626919	48892125	93.74	89087	102.21	2907	47.1	6.7	104.9
1974	11740218	50285730	91.49	92819	105.63	2796	46.7	6.1	99.9
1975	10181813	51495729	84.73	80482	91.09	2625	47.6	6.5	103.2
1976	10509082	52101295	83.39	85723	96.59	2725	47.9	6.6	106.7
1977	11377821	52614374	86.82	88303	99.07	2884	47.3	7.0	110.6
1978	12259786	53331339	86.45	91478	102.17	3013	47.8	7.2	111.3
1979	13133789	54305103	86.82	97885	108.76	3070	48.3	7.3	112.8
1980	14149128	55703028	88.58	99008	109.30	3225	48.6	7.5	111.8
1981	15093823	57661991	90.05	96052	105.10	3372	49.5	7.6	112.2
1982	13067946	59447295	80.57	81498	88.95	3044	48.4	7.6	115.1
1983	12611997	60657937	81.28	89045	94.08	3203	47.5	7.8	115.2
1984	13380300	61989472	84.04	94435	96.86	3370	48.2	8.0	117.9
1985	13845925	63547640	86.77	95604	94.37	3561	48.2	8.3	118.5
1986	14620775	64723552	87.88	97127	91.51	3752	48.9	8.3	121.8
1987	15584908	66250978	89.07	102922	91.90	3896	49.3	8.4	125.7
1988	16724365	68117675	90.25	117683	99.07	4123	49.5	8.3	121.5
1989	18490498	70696131	92.10	137133	108.53	4352	49.7	8.8	128.7
1990	19174198	73396922	92.24	143899	106.99	4450	50.5	9.0	133.6
1991	20702363	76034311	91.84	145983	101.98	4518	49.7	9.0	132.7
1992	23244204	79661233	93.33	153416	100.72	4724	49.6	8.9	126.6
1993	24868105	84242129	93.45	155782	96.14	4992	49.7	9.1	134.7
1994	26287606	88854976	92.05	165754	96.15	5029	49.3	9.4	131.9
1995	29081342	94586306	92.69	175571	95.76	5095	48.5	9.3	132.0
1996	31237289	100956331	93.67	189537	97.27	5182	48.5	9.5	136.6
1997	33300693	108104225	93.88	206515	99.90	5281	48.4	9.4	136.6
1998	34376598	115305256	93.66	219660	100.60	5375	48.9	9.6	135.8
1999	34115042	120662999	90.19	242301	105.25	5255	47.0	9.7	139.8
2000	35646492	126424780	90.84	256679	105.99	5311	47.7	9.8	138.2
2001	36854918	132177327	90.87	260245	102.14	5326	47.0	9.9	138.3
2002	37670155	138089797	91.04	262401	99.21	5381	46.9	10.0	135.1
2003	38900435	144191813	91.50	272942	98.48	5550	47.2	10.1	138.4
2004	41273362	151401404	91.18	281666	97.75	5661	47.2	10.3	135.6
2005	43832310	159577079	91.84	299413	100.27	5717	45.3	10.5	129.8

APPENDIX 2, CONTINUED

	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP
	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Measure 7	Measure 8
1960	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1961	102.49	102.94	98.06	98.54	103.37	103.82	98.94	99.43
1962	104.36	105.29	100.63	101.57	101.80	102.71	98.22	99.14
1963	107.45	109.61	104.04	106.16	106.20	108.32	102.88	104.98
1964	106.19	108.43	103.24	105.45	104.85	107.05	101.99	104.17
1965	103.74	105.61	101.25	103.12	105.39	107.30	102.92	104.82
1966	112.64	114.05	110.31	111.73	111.45	112.83	109.20	110.60
1967	112.73	119.54	107.71	114.59	110.46	117.16	105.57	112.35
1968	114.43	118.60	108.28	112.53	113.01	117.18	106.97	111.23
1969	116.81	120.08	110.03	113.41	114.39	117.64	107.79	111.15
1970	116.51	124.00	108.22	115.63	116.90	124.37	108.66	116.06
1971	122.92	127.35	111.45	115.70	116.65	120.62	105.69	109.49
1972	118.39	122.11	105.96	109.51	113.07	116.41	101.15	104.32
1973	110.87	115.22	99.99	104.10	108.26	112.28	97.56	101.35
1974	113.22	118.18	104.86	109.61	109.07	113.61	100.97	105.31
1975	101.26	104.37	91.84	94.74	103.69	106.75	94.13	96.96
1976	101.73	104.55	90.32	92.88	101.64	104.32	90.27	92.69
1977	106.17	109.91	92.15	95.49	105.02	108.59	91.16	94.34
1978	110.98	114.20	95.97	98.85	108.45	111.45	93.78	96.46
1979	116.82	119.44	100.25	102.59	111.31	113.64	95.51	97.58
1980	121.10	123.35	104.47	106.51	115.15	117.12	99.33	101.10
1981	124.17	125.00	106.87	107.68	119.91	120.56	103.19	103.83
1982	113.22	115.48	95.95	98.00	117.40	119.48	99.59	101.48
1983	104.79	108.24	88.77	91.82	105.33	108.60	89.31	92.19
1984	106.99	109.57	89.30	91.56	106.26	108.62	88.76	90.81
1985	105.99	108.48	88.18	90.35	106.39	108.68	88.58	90.57
1986	107.72	109.26	88.10	89.41	109.44	110.80	89.59	90.75
1987	111.34	112.33	89.29	90.12	112.92	113.73	90.65	91.31
1988	114.32	115.16	93.54	94.28	112.32	112.94	92.06	92.59
1989	120.85	121.34	95.39	95.79	114.29	114.52	90.23	90.41
1990	121.84	121.21	93.95	93.42	115.90	115.07	89.40	88.71
1991	128.69	129.11	99.60	99.88	124.66	124.81	96.51	96.56
1992	138.52	139.22	110.11	110.60	134.83	135.23	107.19	107.42
1993	140.28	140.82	107.04	107.36	139.14	139.38	106.27	106.35
1994	144.60	145.88	111.69	112.57	143.41	144.38	110.88	111.50
1995	155.09	157.77	119.71	121.66	154.07	156.40	119.03	120.70
1996	160.83	163.70	121.61	123.68	158.73	161.23	120.12	121.88
1997	165.05	168.26	124.81	127.12	161.06	163.85	121.88	123.86
1998	164.23	166.31	124.64	126.11	159.78	161.46	121.35	122.51
1999	162.12	167.92	120.88	125.23	154.63	159.90	115.35	119.28
2000	165.27	169.76	124.07	127.49	157.18	161.19	118.05	121.09
2001	167.58	173.53	125.75	130.27	161.77	167.22	121.44	125.57
2002	167.25	173.40	127.27	131.99	163.39	169.09	124.36	128.73
2003	166.61	172.15	124.81	128.99	163.26	168.39	122.35	126.20
2004	171.44	177.14	129.98	134.33	168.50	173.79	127.79	131.81
2005	177.36	187.55	137.87	145.59	172.49	182.12	134.16	141.44

* TFP is an index equal to 100 in 1960.

PRODUCTIVIDAD SECTORIAL EN CHILE: 1986-2001*

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The purpose of this paper is to estimate total factor productivity growth by sector of activity for the Chilean economy in 1986-2001. The main problem that we face is the lack of data on the stock of capital by sector for the whole period. We design a methodology to generate capital stock series by sector. After adjusting the generated series on the stock of capital by an utilization factor and the employment series by their relative quality, we estimate TFP by sector. Our results indicate that the sector with the largest productivity increase in this period has been commerce. Our results match evidence from other countries where it has been found that the sectors with the largest increase in productivity are those sectors that use intensively information technology.

JEL: O41, O47

Keywords: Productivity, Activity Sectors, Growth.

1. INTRODUCCIÓN

Está ampliamente documentado en la literatura que las diferencias en el crecimiento en los distintos países se explican básicamente por diferencias en el crecimiento de la productividad (Easterly y Levine, 2002). La acumulación de factores, si bien es importante, no alcanza la misma relevancia.¹ Beyer y Vergara

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¹Además, en cada país la productividad total de los factores (PTF) es generalmente el componente más importante en la explicación del crecimiento. Así, por ejemplo, Solow (1957) encuentra que la PTF explica un 52% de la tasa de crecimiento de Estados Unidos entre 1902 y 1949. Denison (1967) estima que para el período 1950-62 la PTF explica un 42% del crecimiento de Estados Unidos y un 62% en un grupo de países europeos.

(2002) encuentran que, para una muestra de 107 países en el período 1980-2000, un 80% de la diferencia de crecimiento entre el decil que más aumentó y el que menos lo hizo lo explican las diferencias en productividades. Dichos autores, no obstante, reconocen que sus estimaciones pueden estar abultadas, ya que no corrigen por calidad y utilización de los factores.

Las estimaciones que se han hecho para Chile son consistentes con lo anterior. En efecto, las diferencias entre períodos de alto y bajo crecimiento se explican básicamente por distintos incrementos de la PTF. En el Cuadro 1 se hace una descomposición del crecimiento en Chile por quinquenios desde 1960 hasta 2003.² Se observa que un 74% de la diferencia de crecimiento entre el período de más elevado crecimiento de la economía (1991-1995) y el de menor incremento (1971-1975) se explica por las diferencias de productividad en ambos períodos. Si se toma la diferencia entre el segundo período de más alto crecimiento (1986-1990) y el segundo de más bajo crecimiento (1981-85) la PTF explica un 60% de la diferencia. En el Cuadro 2 se ajusta el trabajo por un índice de calidad y el capital por un índice de utilización,³ de acuerdo a la metodología utilizada para calcular el PIB potencial.⁴ Sigue siendo la evolución de la PTF la que explica la mayor parte de las diferencias.

Una pregunta interesante que surge al observar las cifras de PTF es qué sectores son los que más están contribuyendo a este aumento en productividad. Basu *et al.* (2003) encuentran que las diferencias del desempeño de la PTF entre EE.UU. y Reino Unido para el período 1990-2000 se explican principalmente por las diferencias en el crecimiento de la productividad de industrias que no producen tecnología de la información entre ambos países. Por su parte, Fernald y Ramnath (2004) analizan la aceleración de la PTF en EE.UU. entre los períodos 1990-1995 y 1995-2000. Los autores encuentran que dicha aceleración de la PTF no viene mayoritariamente de sectores productores de tecnología de la información, sino más bien de aquellos sectores que son fuertes usuarios de esta tecnología. Así, por ejemplo, dos de los sectores con mayores incrementos de productividad son los sectores *wholesale* y *retail*, que son grandes usuarios de tecnología de la información. Estos autores estiman que un 75% de la aceleración en la productividad de la economía norteamericana en la segunda mitad de los 90 tiene su origen en estos sectores. El tercer mayor contribuyente de la aceleración de productividad es el sector financiero, el cual explica un 32% de la aceleración de la productividad de la segunda mitad de los 90.⁵ Es interesante destacar que el sector financiero es también un importante usuario de la tecnología de la información.

² Siguiendo los supuestos del Ministerio de Hacienda (2004), se asume una participación del capital de 45% y del trabajo de 55%.

³ El trabajo se ajusta por un índice de escolaridad y el capital se corrige por un índice que utiliza la tasa de desempleo.

⁴ Ver Ministerio de Hacienda (2004).

⁵ Estos sectores contribuyen con más de un 100% a la aceleración de la productividad, ya que otros sectores contribuyen negativamente a la aceleración de la PTF.

CUADRO 1
PTF
(Sin ajustes de calidad)

	Crecimiento PIB	Contribución de:		
		Trabajo	Capital	PTF
1960-1965	3,8	0,7	1,7	1,3
1966-1970	4,7	0,0	1,6	3,1
1971-1975	-2,2	0,1	0,8	-3,2
1976-1980	7,5	2,1	0,4	2,1
1981-1985	-0,7	0,9	0,7	-2,3
1986-1990	6,7	3,2	1,5	2,1
1991-1995	8,7	1,1	2,8	4,9
1996-2000	4,2	0,3	3,0	0,9
1998-2003	2,5	-0,1	2,0	0,5

CUADRO 2
PTF
(Con ajustes de calidad)

	Crecimiento PIB	Contribución de:		
		Trabajo	Capital	PTF
1960-1965	3,8	2,2	1,8	-0,2
1966-1970	4,7	1,3	16,0	1,8
1971-1975	-2,2	2,4	-0,1	-4,6
1976-1980	7,5	1,3	1,4	4,9
1981-1985	-0,7	2,3	0,3	-3,4
1986-1990	6,7	2,6	2,2	1,9
1991-1995	8,7	2,9	2,2	3,5
1996-2000	4,2	1,2	2,8	0,2
1998-2003	2,5	0,8	1,8	-0,1

Jorgenson y Stiroh (2000) y Oliner y Sichel (2000) analizan la contribución de la innovación tecnológica (IT) y la productividad (PTF) a nivel agregado en base al modelo estándar de crecimiento (Solow, 1957), donde el capital se desagrega en capital IT y capital no-IT. También analizan si el crecimiento de la PTF observado está centrado en industrias que producen información y comunicación tecnológica (IT) o que usan dicha IT. Los resultados son consistentes con los anteriormente citados, ya que muestran que las industrias que usan IT han

tenido incrementos más fuertes de la productividad que aquellas que producen IT. Específicamente, Oliner y Sichel (2000) estiman que un 48% de la aceleración en la productividad de la economía norteamericana en la segunda mitad de los 90 se atribuye a industrias que usan IT, mientras que un 27% tiene su origen en industrias que producen IT.

En Chile, si bien hay un número amplio de estudios sobre PTF a nivel agregado y sus determinantes (Rojas *et al.*, 1997; Roldós, 1997; Coeymans, 1999; Beyer y Vergara, 2002, *op. cit.*; Chumacero y Fuentes, 2002; Bergoening *et al.*, 2002; Fuentes *et al.*, 2006, entre otros), hay menos sobre la productividad a nivel sectorial. La razón es que los datos a nivel sectorial, sobre todo los de capital, son más bien escasos. Existe una serie de artículos que dan cuenta de las fuertes diferencias de productividad en los distintos subsectores de la industria manufacturera (Fuentes, 1995; Camhi *et al.*, 1997), debido a que al interior de este sector sí hay bases de datos más amplias.

Alvarez y Fuentes (2004) realizan un análisis de las fuentes de crecimiento en Chile para el período 1986-2003 haciendo la distinción entre el sector transable y no transable. Los resultados muestran que tanto la contribución de la PTF como la acumulación de factores (capital y trabajo) explican en forma similar el dinamismo del sector no transable en el primer subperíodo de los años de rápido crecimiento (1987-1991), mientras que en el período 1992-1998 la expansión del sector no transable se debió básicamente a acumulación de factores. A diferencia de esto, el sector transable se expande debido a la acumulación de capital y trabajo, y casi sin aumento de la productividad en los años 1987-1991, mientras que la PTF es importante para explicar el crecimiento de ese sector entre 1992 y 1998.

El objetivo de este artículo es hacer estimaciones de la productividad total de los factores a nivel sectorial. El principal desafío que se enfrenta es la ausencia de series de *stock* de capital por sectores para un período largo de tiempo. Sólo se tienen datos de *stock* de capital para el período 1996-2001.⁶ Se diseña una metodología para, a partir de dichos datos y otra información, generar cifras de *stock* de capital para el período 1986-1995. Se ajustan los datos de capital por un índice de utilización sectorial del capital y los de trabajo por un índice de calidad sectorial del trabajo. Con ello se estiman los crecimientos de la productividad para el período 1986-2001 para seis sectores de la economía chilena (industria; electricidad, gas y agua; construcción; comercio, restaurantes y hoteles; transporte y comunicaciones; y servicios financieros).⁷ Asimismo, se hacen estimaciones para los subperíodos 1986-1995 y 1996-2001.

⁶Obtenidos de Pérez (2003).

⁷La agricultura, la minería y los servicios comunales no se estiman, ya que los datos de *stock* de capital muestran alta volatilidad, lo que genera dudas con respecto a su confiabilidad. Es importante destacar que los seis sectores que se analizan en este estudio corresponden al 30-35% del *stock* de capital de la economía, por lo que se hace difícil sacar conclusiones de productividad a nivel agregado en base a estos datos aisladamente.

El artículo se organiza de la siguiente forma. Luego de esta introducción, en la sección 2 se hace una estimación del *stock* de capital sectorial para el período 1986-1995, de forma de obtener la serie de *stocks* sectoriales de capital para el período completo del estudio (1986-2001). En la sección 3 se corrigen los *stocks* de capital y de trabajo por índices de utilización y calidad respectivamente. Con ello se calcula la PTF sectorial. Las conclusiones se presentan en la sección 4. En el Apéndice 1 se entregan las series de datos que se utilizaron para la estimación de los *stocks* de capital por sectores. El Apéndice 2 contiene las series de trabajo y capital ajustadas. Finalmente, el Apéndice 3 contiene las participaciones del capital y el trabajo en cada sector.

2. UNA ESTIMACIÓN DEL *STOCK* DE CAPITAL POR RAMAS DE ACTIVIDAD ECONÓMICA PARA 1986-1995

A la fecha se cuenta con una serie de *stock* de capital sectorial construida por el Banco Central de Chile (Pérez, 2003) para el período 1996-2001.⁸ Sin embargo, se estima que un estudio más acabado sobre contribuciones al crecimiento sectorial debiera considerar un período más largo. En particular, se eligió el período 1986-2001 porque: (i) el período previo incluye fuertes saltos de crecimiento de la economía, que pudiesen ensuciar las medidas de crecimiento de la PTF; (ii) se cuenta con mayor información desde ese período en adelante; (iii) el año 1986 fue año base en las estimaciones de Cuentas Nacionales hasta hace unos años,⁹ lo que lo hace conveniente para nuestros propósitos, dado que nuestras estimaciones se basan en la matriz insumo-producto de un año base.

Luego, dada la inexistencia de series de capital por sectores para el período 1986-1995, es necesario desarrollar una metodología que permita estimar una serie de *stock* de capital como aproximación a la serie verdadera. De esta forma, se podrá establecer la contribución de los factores y de la productividad al crecimiento sectorial para el período 1986-2001.

2.1. La Metodología

Se optó estimar la serie de *stock* de capital en base a la identidad de inventarios perpetuos. Esta identidad nos dice que el *stock* de capital por sector para el período t es igual al *stock* de capital en el período $t-1$ menos la tasa a la cual se deprecia el *stock* de capital y más la formación bruta de capital fijo (en adelante, FBCF) por sector en el período t . Esto es:

⁸El Cuadro A.1.1 en el Apéndice 1 muestra la serie de *stock* de capital sectorial construida por Pérez (2003).

⁹En la actualidad el año base es 1996.

$$(1) \quad S_{i,t} = S_{i,t-1}(1 - d_i) + FBCF_{i,t}$$

donde:

$S_{i,t}$ = *stock* de capital del sector i en el período t

d_i = depreciación económica en el sector i

$FBCF_{i,t}$ = formación bruta de capital fijo del sector i en el período t

En este contexto, el *stock* de capital en el período t-1 en el sector i es:

$$(2) \quad S_{i,t-1} = \frac{S_{i,t} - FBCF_{i,t}}{(1 - d_i)}$$

La ecuación (2) indica que si se toma como punto de partida la serie de *stock* de capital por actividad económica generada por Pérez (2003) para el año 1996, y si la depreciación y la FBCF sectorial para el año 1996 son conocidas, se puede estimar el *stock* de capital sectorial para el año 1995. Luego, con el *stock* de capital estimado para el año 1995, y si la depreciación y la FBCF sectorial del año 1995 son conocidas, se puede estimar el *stock* de capital por sector para el año 1994. De esta forma, se puede aplicar esta secuencia hasta completar la serie del *stock* de capital necesaria para estimar la contribución de la PTF al crecimiento sectorial.

El método seleccionado implica que para estimar la serie de *stock* de capital sectorial es necesario contar con la serie de FBCF por sector, como también conocer los valores a los que se deprecian los *stocks* de capital sectoriales.

A la fecha sólo se cuenta con la FBCF sectorial para los años 1986 y 1996. Sin embargo, existe información sobre la FBCF por activo. Los activos constituyen una amplia gama de bienes durables que se encuentran en la FBCF de Cuentas Nacionales. La FBCF por activo permite, bajo ciertos supuestos, generar una aproximación a la FBCF por sector económico. A continuación se explica la metodología y los supuestos que se utilizan para construir una serie aproximada de FBCF por sector.

La estimación de la serie de FBCF por actividad económica parte de las matrices de inversión 1986 y 1996. Esas matrices contienen información sobre la inversión de los distintos activos j en las actividades¹⁰ i. La matriz de inversión del año 1986 cuenta con 75 activos y 75 actividades y la matriz de inversión del año 1996 cuenta con 73 activos y 73 actividades. El primer paso fue reducir el orden de las matrices. Ambas matrices fueron agregadas a 16 filas y 9 columnas, donde las filas corresponden a los activos y las columnas a los sectores. Se elimi-

¹⁰Las actividades corresponden a todos los sectores económicos, pero a un mayor nivel de desagregación.

narón las filas irrelevantes, es decir, aquellos activos donde no existe inversión y se sumaron algunas columnas de manera de obtener 9 sectores (agricultura; minería; electricidad, gas y agua; industria; construcción; comercio, restaurantes y hoteles; transporte y telecomunicaciones; servicios financieros y servicios comunales). De esta forma se obtuvieron dos matrices de inversión reducidas de orden 16×9 .

El Gráfico 1 muestra la matriz de inversión reducida para el año 1986, donde, por ejemplo, $IB_{1,1}^{86}$ es la inversión del activo 1 en el sector 1 en el año 1986 (la matriz de inversión del año 1996 tiene iguales características).¹¹

El segundo paso para construir la serie de FBCF por actividad económica es estimar, en base a las matrices de inversión reducidas de los años 1986 y 1996, las estructuras de inversión para los años 86 y 96.

Las estructuras de inversión son matrices que permiten calcular la inversión en un sector específico utilizando los datos de inversión por activos. Específicamente, son matrices que en sus columnas presentan la razón entre la inversión de un activo j en un sector i y la inversión total del activo j en todos los sectores en el período t . Así, por ejemplo, la primera celda (fila 1, columna 1) de la matriz del año 86 sería $IB_{1,1}^{86} / \sum_1^9 IB_{1,i}^{86}$ es decir, la razón entre la inversión del activo 1 en el sector 1 y la inversión total en la economía del activo 1 en el año 1986. El Gráfico 2 presenta esta estructura de inversión para el año 1986 (la matriz del año 1996 tiene iguales características).¹²

El tercer paso es estimar las estructuras de inversión para el período 1987-1995. Para esto se supone que la estructura de inversión del período t (donde t pertenece al período 1987-1995) será un promedio de las estructuras de inversión de los años 1986 y 1996, ponderado por la distancia entre el período t y los años 1986 y 1996.

Así, la forma general de una celda de la matriz que define la estructura de inversión es:

$$EIB_{ji}^t = (1-t) \times (IB_{ji}^{86} / \sum_1^9 IB_{ji}^{86}) + t \times (IB_{ji}^{96} / \sum_1^9 IB_{ji}^{96})$$

donde EIB_{ji}^t = estructura de inversión bruta del activo j en la actividad i en el período t .

$IB_{ji}^{86} / \sum_1^9 IB_{ji}^{86}$ = razón entre la inversión del activo j en la actividad i y la inversión total en el activo i en el año 1986.

¹¹El Cuadro A.1.2 en el Apéndice 1 muestra las matrices de inversión reducidas para los años 1986 y 1996.

¹²El Cuadro A.1.3 en el Apéndice 1 muestra las estructuras de inversión para los años 1986 y 1996.

$IB_{ji}^{96} / \sum_1^9 IB_{ji}^{96}$ = razón entre la inversión del activo j en la actividad i y la inversión total en el activo i en el año 1996.

t = ponderador que toma valor 0 para el año 1986; 0,1 para 1987; 0,2 para 1988.....;1 para 1996.

Así, por ejemplo, la estructura de inversión para el año 1987 del activo 1 en el sector 1 es:

$$EIB_{11}^{87} = (0,9) * (IB_{11}^{86} / \sum_1^9 IB_{j1}^{86}) + 0,1 * (IB_{11}^{96} / \sum_1^9 IB_{j1}^{96})$$

El Gráfico 3 presenta la matriz que define la estructura de inversión para el año 1987 (las matrices de los años 1988-1995 tienen iguales características).

GRAFICO 1
REPRESENTACION GRAFICA DE LA MATRIZ DE INVERSION REDUCIDA 1986

Matriz de Inversión Bruta 1986	
Sectores	
1,2	i 9

Activos	1 · j · 16	$IB_{1,1}^{86} \dots \dots \dots IB_{1,9}^{86}$ $\dots \dots \dots IB_{j,i}^{86} \dots \dots \dots$ $IB_{16,1}^{86} \dots \dots \dots IB_{16,9}^{86}$
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GRAFICO 2
REPRESENTACION GRAFICA DE LA ESTRUCTURA DE INVERSION 1986

		Matriz IB 1986			Estructura de Inversión Bruta 1986
		Sectores			Sectores
		1,2 . i .. 9			1,2 . i .. 9
Activos	1 · j · 16	$IB_{1,1}^{86} \dots \dots \dots IB_{1,9}^{86}$ $IB_{16,1}^{86} \dots \dots \dots IB_{16,9}^{86}$	$\sum_1^9 IB_{1,j}^{86}$ $\sum_1^9 IB_{16,j}^{86}$	1 · j · 16	$IB_{1,1}^{86} / \sum_1^9 IB_{1,i}^{86} \dots \dots \dots IB_{1,9}^{86} / \sum_1^9 IB_{1,i}^{86}$ $IB_{16,1}^{86} / \sum_1^9 IB_{16,i}^{86} \dots \dots \dots IB_{16,9}^{86} / \sum_1^9 IB_{16,i}^{86}$



GRAFICO 3
REPRESENTACION GRAFICA DE LA ESTRUCTURA
DE INVERSION 1987

		Estructura inversión 1987	
		Sectores	
		1,2 i..... 9	
Activos	1	$EIB_{1,1}^{87} \dots\dots EIB_{1,9}^{87}$	
	⋮		
	j		
	⋮		
	16	$EIB_{16,1}^{87} \dots\dots EIB_{16,9}^{87}$	

Por último, en base a las estructuras de inversión y a las series de FBCF por activo,^{13, 14} se construye la FBCF por sector. La FBCF de cada activo se asigna según la estructura de inversión en las distintas actividades. Luego, las columnas que contienen la FBCF por actividades se reducen en 9 sectores económicos. En términos matriciales, las series de FBCF por sector se calculan como la multiplicación entre las matrices de FBCF por activo transpuestas y las matrices que definen la estructura de inversión, de acuerdo a la siguiente expresión:

$$FBCF_i^t = (FBCF_j^t)^T * EIB_{ji}^t$$

donde $FBCF_i^t$ = formación bruta de capital fijo del sector i en el período t.

$(FBCF_j^t)^T$ = formación bruta de capital fijo del activo j en el período t transpuesta.

EIB_{ji}^t = estructura de inversión bruta del activo j en la actividad i en el período t.

De esta forma se obtienen 9 matrices de FBCF por sector de orden 1x9, una para cada año, como la que se representa en el Gráfico 4.^{15, 16}

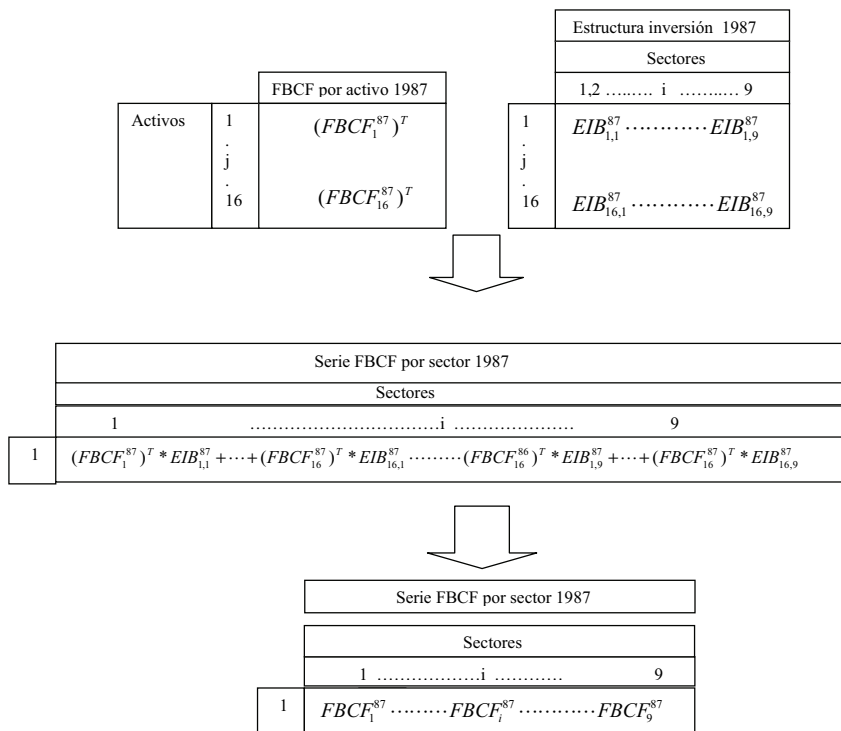
¹³La serie de FBCF por activo 1986-1995 (pesos 1996) utilizada se construyó en base a (1) serie empalme FBCF total 1986-1996 y (2) FBCF por activo 1986-1996 en base 1996 (ver Apéndice 1, Cuadro A.1.4).

¹⁴Se tiene información sobre la FBCF por activo para los años 1987-1995, pero no se sabe en cuál actividad económica son utilizados.

¹⁵El Cuadro A.1.5 en el Apéndice 1 muestra la FBCF por actividad económica 1986-1996.

¹⁶Una forma alternativa de calcular las estructuras de inversión para el período 1987-1995 es asociar la interpolación de las matrices a la trayectoria del precio relativo de la inversión con respecto al producto (en vez de interpolarlas linealmente). Sin embargo, las estimaciones de las series de FBCF por sector y de *stock* de capital sectorial son poco sensibles al supuesto de interpolación de las estructuras de inversión y, por lo tanto, el estudio utiliza las estructuras de inversión calculadas bajo el supuesto de interpolación lineal. El Cuadro A.1.6 en el Apéndice 1 muestra la formación bruta de capital fijo con esta metodología y se observa que, con la excepción del sector construcción y sólo en algunos años, los datos no son muy diferentes de los que se obtienen con una interpolación lineal. En términos de productividad por sectores las diferencias son aún menores.

GRAFICO 4
 REPRESENTACION GRAFICA DE LA MATRIZ DE FBCF POR
 ACTIVIDAD ECONOMICA PARA 1987



Por otra parte, para estimar la serie de *stock* de capital sectorial también es necesario conocer los valores a los que se deprecian los *stocks* de capital en cada sector. Sin embargo, no existen datos oficiales sobre depreciación económica por sector, por lo que es necesario realizar supuestos sobre la vida útil de los activos en los distintos sectores, de manera de obtener tasas de depreciación sectorial. En este estudio, las fuentes de información de vida útil de activos consideradas son la contabilidad de las empresas y el Servicio de Impuestos Internos (S.I.I.).^{17, 18}

¹⁷El Cuadro A.1.7 en el Apéndice 1 muestra la depreciación por actividad económica y la fuente de información utilizada para cada sector. La depreciación promedio (ponderada por la participación en FBCF total) es de 6%, lo que parece bastante razonable.

¹⁸Es importante destacar que los supuestos de vida útil constituyen unos de los parámetros más significativos en el método del inventario perpetuo. Pérez (2003) reconoce que los *stocks* de capital son sensibles a los supuestos de vida útil de los activos, ya que establecen el período de tiempo en que los activos permanecerán en el *stock* de capital. Por lo mismo, en este estudio se dejan de lado tres sectores (minería, agricultura y servicios comunales), que arrojan mayor volatilidad en el *stock* de capital, y por lo tanto las conclusiones para la PTF son menos confiables.

Finalmente, se calcula la serie de *stock* de capital sectorial para el período 1986-1995, utilizando el *stock* de capital sectorial para 1996 de Pérez (2003),¹⁹ la serie estimada de FBCF por sector y las tasas de depreciación sectorial.²⁰

2.2. FBCF Sectorial

En el Cuadro 3 se presenta la razón entre la FBCF y el valor agregado de los 6 sectores analizados para el período 1986-2001. Si se toman los años de rápido crecimiento 1986-1998 se aprecia que todos los sectores experimentan un fuerte crecimiento de la inversión en relación al valor agregado. Las tasas más altas de crecimiento se producen en la industria (aumento de la razón inversión a valor agregado de 20 puntos porcentuales), electricidad, gas y agua (19 puntos porcentuales) y transporte y comunicaciones (18 puntos porcentuales), seguidos por la construcción y los servicios financieros (10 puntos porcentuales). Es interesante destacar que el comercio y el sector electricidad, gas y agua tienen *peaks* a fines de los 80 muy similares a los que se producen nuevamente a mediados de los 90.

En el período 1998-2001 se destaca una desaceleración en la razón FBCF/valor agregado en todos los sectores, especialmente destaca el sector electricidad, gas y agua y el sector transporte y telecomunicaciones, los cuales presentan una fuerte disminución (7 puntos porcentuales). Lo anterior es consistente con la significativa disminución en la inversión agregada en este período. El resto de los sectores presentan una importante disminución en el año 1999. En los años posteriores la relación entre FBCF y valor agregado se mantiene estable, aunque a un nivel más bajo que el alcanzado previamente.

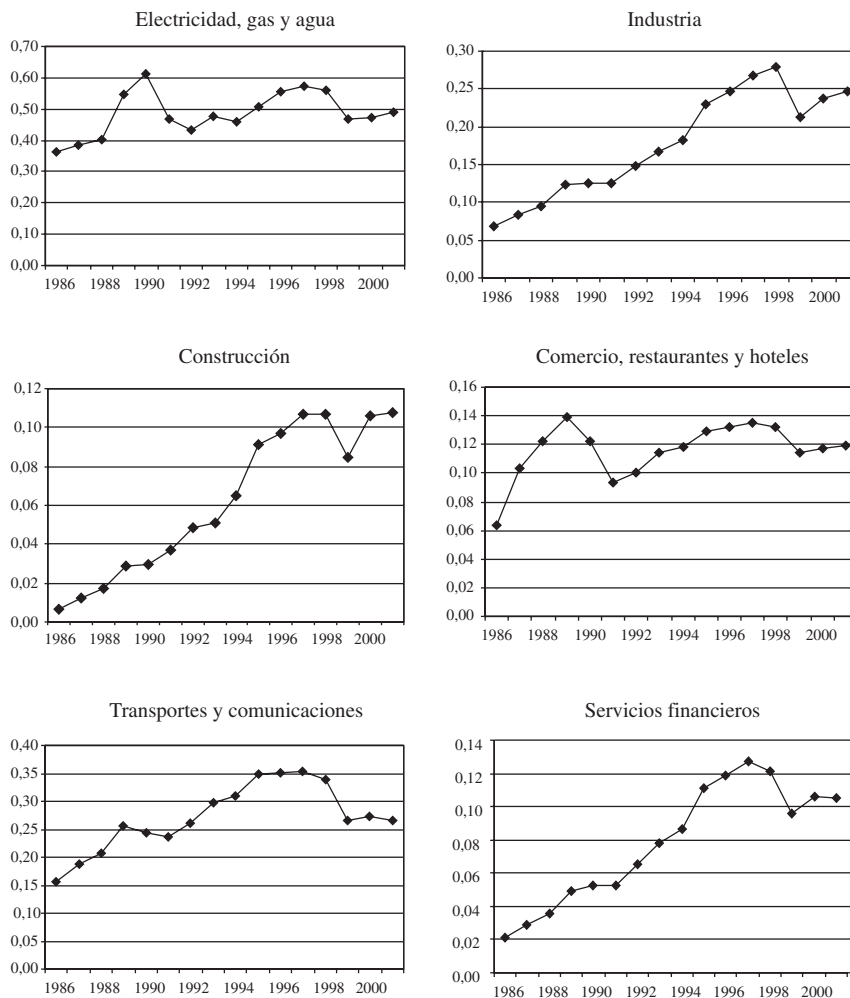
3. PTF SECTORIAL 1986-2001

En esta sección se calcula la PTF sectorial para el período 1986-2001. Dado que se tiene información oficial del *stock* de capital para el período 1996-2001, se hacen también estimaciones separadas para este subperíodo.

¹⁹En términos generales, existen dos tipos de medición para medir los activos de una economía: el método directo y el método indirecto (estimaciones basadas en modelos de comportamiento). Las primeras son altamente costosas en tiempo y recursos, razón por la cual se realizan en pocos países. Ante la falta de datos directos sobre el capital para Chile se hace necesario utilizar el método indirecto. En este trabajo se utilizó el método de inventarios perpetuos para calcular el *stock* de capital sectorial. Este método tiene como desventaja la utilización de supuestos como formación de capital y depreciación. Ver Pérez (2003) para encontrar un resumen detallado sobre los distintos métodos de medición.

²⁰El Cuadro A.1.8 en el Apéndice 1 muestra la serie de *stock* de capital sectorial para los sectores analizados para el período 1986-2001. La agricultura, minería y servicios comunales no se estimaron, ya que los datos no son confiables.

CUADRO 3
FBCF / VALOR AGREGADO POR SECTOR 1986-2001 POR SECTOR.



3.1. Metodología

La tasa de crecimiento de la PTF, o contribución de la PTF al crecimiento del valor agregado, se mide como el residuo del crecimiento económico que no puede ser explicado por la acumulación de los factores de producción (capital y trabajo). Esta descomposición está basada en una función de producción neoclásica, de manera que la contribución de la PTF al crecimiento del valor agregado real del sector i se obtiene de la siguiente fórmula:²¹

²¹Se supone que los mercados de los factores de producción son competitivos.

$$(4) \quad \Delta PTF_i = \Delta VA_i - \alpha_{iL} \times \Delta L - \alpha_{iK} \times \Delta K$$

donde ΔPTF_i = tasa de crecimiento de la PTF en el sector i
 ΔVA_i = tasa de crecimiento del valor agregado real en el sector i
 ΔL = tasa de crecimiento del trabajo en el sector i
 ΔK = tasa de crecimiento del capital en el sector i
 α_{iL} = participación del trabajo en el sector i
 α_{iK} = participación del capital en el sector i

Las series de producto están disponibles directamente de Cuentas Nacionales. Como medida de producto se utiliza el valor agregado sectorial en pesos de 1996. Para las series previas a 1996 (que están con base 1986), se usa un empalme simple.

Las cifras de empleo provienen del Instituto Nacional de Estadísticas (INE). Para una mejor medición de este factor se hace un ajuste por la calidad relativa del trabajo de cada sector, representado por una medida de salarios relativos.²² Para esto se construye un índice salarios por sector IW_i^t y IW_G^t , donde IW_i^t es el índice salarial en el sector i en el período t y IW_G^t es el índice salarial general en el período t. IW_i^t es igual a 100 para todo i en 1996 y IW_G^t es igual a 100 en 1996. Luego, el trabajo se corrige de acuerdo a la siguiente expresión:

$$(5) \quad L_i^t \times \frac{IW_i^t}{IW_G^t}$$

donde L_i^t es el número de ocupados en el sector i en el período t. Los salarios por actividad económica provienen del INE.²³ La idea detrás de esta corrección es que existen distintos tipos de trabajadores, los cuales tienen distintos niveles de productividad, reflejo de factores como edad, experiencia y educación. En la medida que los sectores van evolucionando van cambiando su *mix* de trabajadores hacia más o menos calificados. Para controlar esas diferencias se utiliza una medida de salarios relativos; si un sector ha ido aumentando sus salarios relativos al resto de la economía, es probable que sea porque está utilizando trabajadores relativamente más capacitados.

El capital se obtiene de acuerdo a la metodología presentada en la sección previa. Para evitar los problemas en la medición de la PTF que se produ-

²²En este estudio, a diferencia del trabajo de Fuentes *et al.* (2006), no se ajusta el factor trabajo según horas trabajadas, ya que el INE no dispone de datos de horas trabajadas desagregadas por sector económico.

²³La excepción es el sector agrícola, sobre el cual el INE no publica salarios. Para este sector se usó la encuesta CASEN.

cen por sub o sobreutilización de este factor, se corrige por la tasa de desempleo sectorial en relación al desempleo natural del sector de acuerdo a la siguiente expresión:

$$(6) \quad K_i^t * \frac{(1 - \mu_i^t)}{(1 - \mu_i^N)}$$

donde K_i^t es el *stock* de capital en el sector i en el período t , μ_i^t es el desempleo nacional del sector i en el período t y μ_i^N desempleo natural del sector i . Se supone que el desempleo natural del sector i es constante en el tiempo.²⁴ El capital no se corrige por calidad. El número de trabajadores ocupados y desocupados por actividad económica proviene del INE. Las series de trabajo y capital ajustadas se encuentran en el Apéndice 2.

Por último, para estimar la contribución del capital, el trabajo y la PTF al crecimiento de cada sector es necesario obtener la participación del trabajo y del capital en el producto sectorial.

La información de Cuentas Nacionales y del INE permite estimar la contribución del trabajo de cada sector $\alpha_{iL} = \frac{W_i * L_i}{VA_i}$, donde W_i es el salario en el sector i , L_i es el número de ocupados en el sector i y VA_i es el valor agregado en el sector i . Según estos cálculos, la participación del trabajo en la economía alcanza a un 40% (α_{iL} ponderado por la importancia relativa del sector i en la economía). No obstante, el Ministerio de Hacienda (2004), para estimar el PIB potencial de la economía chilena, considera que la participación del trabajo en la economía es un 55%. Para ser consistentes con dicha cifra, se decidió reescalar la participación del trabajo sectorial en 15%. De esta manera se obtiene la contribución del trabajo corregida para cada sector, α_{iL}^C . Para hacer nuestros cálculos de contribución al crecimiento, se tomó el promedio de la participación del trabajo de cada sector en el período 1996-2001 y se supone constante para el período analizado (ver Apéndice 3). La contribución del capital al sector i , α_{iK} , suponiendo retornos constantes a escala, es $1 - \alpha_{iL}^C$.

3.2. PTF Sectorial

Con los antecedentes anteriores se puede calcular la contribución del trabajo, del capital y de la PTF al crecimiento sectorial. El primer paso es hacer los cálculos para el período 1996-2001, que es donde se cuenta con todas las series oficiales. Luego completamos las estimaciones para 1986-2001. En el Cuadro 3 se muestran los resultados para este subperíodo. Cinco de los nueve sectores

²⁴Dado este supuesto, el valor que toma μ_i^t no es importante, ya que se utilizan las variaciones del *stock* de capital.

considerados tendrían crecimiento negativo de la PTF, lo que coincide con un período de baja en crecimiento del PIB en relación al período inmediatamente anterior. De hecho, el crecimiento promedio de la economía en este período fue 4,1% en comparación con 7,7% de los diez años anteriores. Minería presenta un fuerte incremento en la PTF (6,34%), lo que probablemente está influenciado por las importantes inversiones que se hicieron en los años previos. Se trata precisamente de un sector donde las inversiones toman un período largo de tiempo, por lo que las mediciones de productividad están algo sesgadas. En otras palabras, no es de extrañar que se observen crecimientos negativos de la PTF en el período en que se realiza la inversión y muy positivos en el período posterior a ella. Agricultura también presenta un fuerte incremento en la PTF (5,92%),

En el resto de los sectores se observan crecimientos de la PTF en el rango (-1,49% a 2,45%). Las mayores contribuciones al crecimiento en este período provienen del factor capital (Cuadro 4), a excepción de la agricultura, minería y los servicios comunales donde la PTF es la mayor fuente de crecimiento. Se debe destacar que, aunque la inversión como porcentaje del PIB cayó luego de la recesión de 1999, siguió manteniendo tasas relativamente elevadas.

CUADRO 4
PTF 1996-2001

	Crecimiento PIB	Contribución de:		
		Trabajo	Capital	PTF
Agricultura	4,12	-2,76	0,95	5,92
Minería	8,09	-1,45	3,20	6,34
Industria	1,51	-1,66	3,43	-0,26
Electricidad, gas y agua	3,58	-1,79	4,19	1,18
Construcción	-0,10	-1,64	3,98	-1,44
Comercio, restaurantes y hoteles	2,54	0,38	2,50	-0,34
Transporte y comunicaciones	6,78	2,10	5,22	-0,54
Servicios financieros y empresariales	4,13	0,88	3,74	-1,49
Servicios comunales	3,59	-0,37	1,51	2,45

En el Cuadro 5 se presentan los crecimientos de la PTF para el período completo (1986-2001) para 6 sectores de la economía. Según estos cálculos, el comercio es el sector donde más aumento de la productividad ha habido en el período 1986-2001. Lo interesante es que esto coincide con los estudios para otros países,²⁵ que muestran que los sectores con mayor aumento de la PTF corresponden a aquellos que usan intensivamente la tecnología de la información.

²⁵Fernald y Ramnath (2004) (*op. cit.*) y Basu *et al.* (2003) (*op. cit.*).

El sector comercio es específicamente mencionado en dichos estudios como un fuerte usuario de tecnología de la información,²⁶ a la vez que es uno de los sectores con mayor incremento de la PTF.

CUADRO 5
PTF 1986-2001

PTF	1986-1996	1986-2001
Industria	-0,48	-0,45
Electricidad, gas y agua	0,84	0,67
Construcción	2,21	0,95
Comercio, restaurantes y hoteles	3,93	2,65
Transportes y comunicaciones	1,96	1,23
Servicios financieros y empresariales	2,73	1,38

El sector financiero, el eléctrico, la construcción y el transporte y comunicaciones han tenido incrementos en la PTF promedio en estos 16 años de entre 0,7% y 1,4%. Aunque por estrecho margen, el segundo sector donde más crece la PTF es el financiero, que es también otro sector usuario de tecnología de la información.

En cuanto a la contribución al crecimiento para el período completo (Cuadro 6) se observa que la PTF ha sido más relevante en el comercio (donde explica 36% del crecimiento). En el sector financiero la contribución al crecimiento de la PTF es 19%. Por su parte, para los sectores eléctrico, construcción y sector transporte y telecomunicaciones la PTF explica entre un 13% y un 16% del crecimiento del sector. En estos sectores la inversión es la que ha jugado el rol más relevante.

CUADRO 6
PTF 1986-2001

	Crecimiento PIB	Contribución de:		
		Trabajo	Capital	PTF
Industria	4,77	0,89	443,00	-0,45
Electricidad, gas y agua	0,03	0,08	4,28	0,67
Construcción	5,87	2,02	2,90	0,95
Comercio, restaurantes y hoteles	7,39	1,92	2,82	2,65
Transporte y comunicaciones	9,02	2,90	4,80	1,23
Servicios financieros y empresariales	7,26	3,90	1,98	1,38

²⁶Por ejemplo, programas computacionales que permiten mejor manejo de los inventarios y ajustar los precios de forma más eficiente.

4. CONCLUSIONES

En este artículo se han estimado crecimientos de la productividad total de los factores para el período 1986-2001. El principal desafío ha sido completar la serie de *stock* de capital sectorial, que sólo está disponible para 1996-2001. Se diseñó una metodología para estos efectos y se calculó la serie de *stock* de capital por sectores para todo el período. Esta serie tiene un alto potencial para desarrollar estudios en el tiempo y a nivel sectorial. De hecho, permite completar paneles con esta variable y con ello expandir la escasa literatura que existe en Chile en términos de crecimiento sectorial.

Luego se calcularon las PTF sectoriales para todo el período y para el subperíodo 1996-2001. Se estudiaron 6 sectores de la economía y se obtuvo que el sector comercio es donde el incremento de la productividad ha sido más elevado, tanto en términos absolutos (sobre 2,7 puntos del crecimiento anual de este sector se explican por este factor) como en términos relativos (36% del crecimiento de este sector tiene su origen en incrementos de la PTF). Este sector es muy intensivo en el uso de la tecnología de la información. Esto es interesante porque coincide con estudios para otros países, que muestran que los sectores donde ha habido una mayor aceleración de la PTF han sido precisamente en aquellos sectores usuarios de la tecnología de la información, en contraposición con los sectores productores de dicha tecnología. En particular, la aceleración de productividad en Estados Unidos en la segunda parte de los 90 se explica en forma importante por la mayor productividad en el sector *retail*.

El segundo sector con mayor incremento en productividad es el sector financiero, también intensivo en el uso de la tecnología de la información y también citado en diversos estudios internacionales como uno de los con mayor incremento en PTF.

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APENDICE 1

CUADRO A.1.1.
 STOCK DE CAPITAL NETO POR RAMAS DE ACTIVIDAD
 (Miles de millones de pesos de 1996)

Ramas de actividad	1996	1997	1998	1999	2000	2001
Agricultura	2.516	2.621	2.736	2.830	2.971	3.073
Minería	4.401	4.855	5.316	5.394	5.484	5.629
Industria manufacturera	7.329	8.173	8.922	9.227	9.690	10.054
Electricidad, gas y agua	4.113	4.464	4.915	5.303	5.554	5.917
Construcción	1.061	1.245	1.373	1.339	1.393	1.432
Comercio, restaurantes y hoteles	2.660	2.915	3.186	3.373	3.597	3.808
Transporte y comunicaciones	3.236	3.705	4.250	4.708	5.222	5.687
Servicios financieros y empresariales	2.125	2.344	2.578	2.756	2.949	3.226
Servicios sociales y personales	3.727	4.040	4.370	4.728	5.076	5.400

Fuente: Pérez 2003.

CUADRO A.1.2.
MATRIZ DE INVERSIÓN REDUCIDA 1986-1996
(Corresponden al Gráfico 1)

Matriz de inversión reducida 1986 Activo/Rama de actividad	Agrícola	Minería	Industria manufacturera	Electricidad, gas y agua	Construcción	Comercio	Transporte	Servicios financieros	Servicios comunales
Producción agrícola	2.522	0	0	0	0	0	0	0	0
Producción de frutas	12.939	0	0	0	0	0	0	0	0
Producción pecuaria	1.914	0	0	0	0	0	0	0	0
Silvicultura	2.572	0	0	0	0	0	0	0	0
Cobre	0	8.312	0	0	0	0	0	0	210
Fabricación de textiles	2.377	10	20	0	0	3	0	0	0
Industria del caucho	0	0	0	0	0	11	0	0	0
Fabricación de productos minerales no metálicos	0	115	0	0	0	0	0	0	0
Industria metálica básica	0	696	23	0	0	0	112	0	0
Fabricación de productos metálicos	259	8.579	5.940	1.217	41	1.797	1.177	697	1.193
Fabricación de maquinaria no eléctrica	16.949	25.150	37.572	4.475	3.466	8.604	6.026	8.609	8.605
Maquinaria y equipos y accesorios eléctricos	196	14.632	5.590	2.008	444	1.208	5.048	1.396	2.334
Construcción de material de transporte	10.927	6.966	7.768	1.879	574	4.623	22.595	1.645	8.085
Fabricación de muebles y accesorios	0	364	2.380	439	0	1.639	410	658	1.335
Otras industrias manufactureras	0	0	44	0	0	95	0	11	751
Construcción	8.842	45.089	18.251	35.141	0	9.685	11.037	1.802	75.905

Matriz de inversión reducida 1996 Activo/Rama de actividad	Agrícola	Minería	Industria manufacturera	Electricidad, gas y agua	Construcción	Comercio	Transporte	Servicios financieros	Servicios comunales
Producción agrícola	42.361	0	0	0	0	0	0	0	0
Producción de frutas	39.631	0	0	0	0	0	0	0	0
Producción pecuaria	63.258	0	0	0	0	0	0	0	0
Silvicultura	27.353	0	0	0	0	0	0	0	0
Cobre	0	1.308	0	0	0	0	0	0	0
Fabricación de textiles	11.060	1	246	0	1	235	10	37	193
Industria del caucho	3	19.041	777	0	0	0	0	0	0
Fabricación de productos minerales no metálicos	0	0	5.549	0	0	58	276	4.364	240
Industria metálica básica	0	1.360	64	14	111	883	1.396	4	6
Fabricación de productos metálicos	176	9.992	70.598	44.005	12.044	2.502	1.473	2.961	11.549
Fabricación de maquinaria no eléctrica	82.380	271.284	587.998	116.826	26.996	103.041	40.024	215.617	54.666
Maquinaria y equipos y accesorios eléctricos	6.528	29.959	87.911	57.082	21.007	16.324	107.098	20.178	123.609
Construcción de material de transporte	50.120	57.179	211.762	3.893	220.556	8.156	197.045	54.222	27.836
Fabricación de muebles y accesorios	827	3834	57.430	10.195	167	5.443	1.349	13.005	11.155
Otras industrias manufactureras	200	733	3.648	51	1.141	3.304	1.409	14.851	29.571
Construcción	111.623	339.213	319.058	263.835	0	340.290	331.652	125.494	885.536

Fuente: Cálculos propios a partir de la matriz de inversión 1986 y 1996 (BCCh).

CUADRO A.1.3.
ESTRUCTURA DE INVERSION 1986-1996
(Corresponden al Gráfico 2)

Matriz de inversión reducida 1986 Activo/Rama de actividad	Agrícola	Minería	Industria manufacturera	Electricidad, gas y agua	Construcción	Comercio	Transporte	Servicios financieros	Servicios comunales
Producción agrícola	1	0	0	0	0	0	0	0	0
Producción de frutas	1	0	0	0	0	0	0	0	0
Producción pecuaria	1	0	0	0	0	0	0	0	0
Silvicultura	1	0	0	0	0	0	0	0	0
Cobre	0	1	0,004	0,008	0	0	0	0	0,080
Fabricación de textiles	0,907	0	0	0	0	1	0	0	0
Industria del caucho	0	0	0	0	0	0	0	0	0
Fabricación de productos minerales no metálicos	0	1	0	0	0	0	0	0	0
Industria metálica básica	0	0,838	0,028	0	0	0,029	0,106	0	0
Fabricación de productos metálicos	0,012	0,410	0,284	0,058	0,002	0,086	0,056	0,033	0,057
Fabricación de maquinaria no eléctrica	0,142	0,211	0,315	0,037	0,029	0,072	0,050	0,072	0,072
Maquinaria y equipos y accesorios eléctricos	0,006	0,445	0,170	0,061	0,014	0,037	0,153	0,042	0,071
Construcción de material de transporte	0,168	0,107	0,119	0,029	0,009	0,078	0,340	0,025	0,124
Fabricación de muebles y accesorios	0	0,050	0,329	0,061	0	0,227	0,057	0,091	0,185
Otras industrias manufactureras	0	0	0,049	0	0	0,105	0	0,012	0,834
Construcción	0,028	0,142	0,058	0,111	0	0,032	0,033	0,006	0,240

Matriz de inversión reducida 1996 Activo/Rama de actividad	Agrícola	Minería	Industria manufacturera	Electricidad, gas y agua	Construcción	Comercio	Transporte	Servicios financieros	Servicios comunales
Producción agrícola	1	0	0	0	0	0	0	0	0
Producción de frutas	1	0	0	0	0	0	0	0	0
Producción pecuaria	1	0	0	0	0	0	0	0	0
Silvicultura	1	0	0	0	0	0	0	0	0
Cobre	0	1	0	0	0	0	0	0	0
Fabricación de textiles	0,939	0,000	0,021	2,0E-05	7,7E-05	2,0E-02	8,7E-04	3,1E-03	0,016
Industria del caucho	0,000	0,961	0,039	0	0	0	0	0	5,139E-06
Fabricación de productos minerales no metálicos	0	0	0,529	0	0	0,005	0,026	0,416	0,023
Industria metálica básica	0	0,354	0,017	0,004	0,029	0,230	0,364	0,001	0,002
Fabricación de productos metálicos	0,001	0,064	0,455	0,283	0,078	0,016	0,009	0,019	0,074
Fabricación de maquinaria no eléctrica	0,055	0,181	0,392	0,078	0,018	0,069	0,027	0,144	0,036
Maquinaria y equipos y accesorios eléctricos	0,014	0,064	0,187	0,122	0,045	0,035	0,228	0,043	0,263
Construcción de material de transporte	0,060	0,069	0,255	0,005	0,265	0,010	0,237	0,065	0,034
Fabricación de muebles y accesorios	0,008	0,037	0,555	0,099	0,002	0,053	0,013	0,126	0,108
Otras industrias manufactureras	0,004	0,013	0,066	0,001	0,021	0,060	0,026	0,270	0,539
Construcción	0,023	0,069	0,065	0,054	0	0,069	0,068	0,026	0,180

Fuente: Cálculos propios a partir de la matriz de inversión 1986 y 1996 (BCCCh).

CUADRO A.1.4.
FORMACION BRUTA DE CAPITAL FIJO POR ACTIVO 1986-1995
(Millones de pesos 1996)

Especificación	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Agropecuario-Silvícola	116.364	158.508	150.593	153.406	147.541	129.706	197.625	200.951	191.550	199.022	172.603
Agricultura	12.289	35.784	30.330	31.593	30.123	31.418	33.943	36.191	40.347	43.317	42.361
Fruticultura	56.428	65.350	62.496	67.828	50.682	39.221	59.655	51.661	48.606	54.546	39.631
Resto	47.648	57.375	57.767	53.985	66.737	59.068	104.027	113.099	102.597	101.158	90.611
Minería	33.736	34.247	26.565	22.812	24.826	22.909	10.576	4.792	551	453	1.308
Resto minería	33.736	34.247	26.565	22.812	24.826	22.909	10.576	4.792	551	453	1.308
Industria Manufacturera	485.176	708.712	884.175	1.302.712	1.208.468	1.204.022	1.585.382	1.861.059	2.115.778	2.964.165	3.158.839
Textil, prendas de vestir y cuero	3.484	5.096	5.517	8.356	7.939	7.660	8.370	10.455	7.202	10.733	11.784
Madera y muebles	23.565	27.937	36.672	43.091	44.517	44.253	51.724	62.300	67.462	94.873	103.405
Química, petróleo, caucho y plástico	3.902	57.039	83.902	115.918	82.369	2.749	0	6.382	5.716	18.310	19.821
Fabricación de productos minerales no metálicos	2.712	3.307	3.775	4.906	5.053	5.014	6.215	7.363	7.813	9.615	10.485
Metálica básica	632	471	380	1.056	891	1.264	1.879	1.301	1.701	3.599	3.838
Productos metálicos, maquinaria y equipos	447.714	611.713	749.721	1.124.552	1.062.864	1.128.628	1.495.836	1.737.816	1.983.780	2.775.747	2.954.597
Resto	3.167	3.149	4.209	4.834	4.834	14.454	21.358	35.442	42.103	51.287	54.910
Construcción	1.496.538	1.697.568	1.905.332	2.376.821	2.590.944	2.583.883	3.091.371	3.720.032	3.832.845	4.393.138	4.907.995
Total	2.131.815	2.599.035	2.966.665	3.855.751	3.971.778	3.940.520	4.884.954	5.786.834	6.140.724	7.556.777	8.240.744

Fuente: Serie empalme FBCF total 1986-1996 (BCCh) y FBCF por activo 1986-1996 en base 1996 (empalme simple).

CUADRO A.1.5.
FORMACION BRUTA DE CAPITAL FIJO POR RAMAS DE ACTIVIDAD 1986-1996
(Corresponde al Gráfico 4). Interpolación lineal
(Millones de pesos 1996)

Especificación	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Minería	355.264	409.043	448.706	572.643	555.315	503.190	570.303	625.168	620.365	733.836	733.893
Industria	201.088	261.022	319.992	460.165	469.562	499.250	654.679	789.721	894.948	1.219.220	1.345.052
Electricidad, gas y agua	185.536	207.593	228.334	284.638	290.875	283.292	335.088	384.001	393.276	470.700	495.900
Construcción	8.502	16.276	25.660	47.045	52.562	64.510	96.943	126.037	159.078	243.715	282.024
Comercio, restaurantes y hoteles	85.865	155.428	193.321	254.592	233.757	195.381	246.466	303.546	329.700	411.348	458.771
Transporte y comunicaciones	119.068	154.537	187.326	264.442	273.046	287.833	370.599	446.364	492.991	636.463	703.197
Servicios financieros y empresariales	33.902	50.461	68.396	107.074	116.310	133.127	184.039	236.310	280.143	393.169	450.734

Fuente: Cálculos propios a partir de la matriz de inversión 1986 y 1996 (BCCh).

CUADRO A.1.6.
FORMACION BRUTA DE CAPITAL FIJO POR RAMAS DE ACTIVIDAD 1986-1996
(Corresponde al Gráfico 4). Interpolación según precios relativos
(Millones de pesos 1996)

Especificación	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Minería	355.264	419.461	462.999	601.779	612.747	484.230	585.877	689.366	651.845	833.434	733.893
Industria	201.088	252.172	306.958	434.278	432.961	503.928	644.049	757.981	877.803	1.166.663	1.345.052
Electricidad, gas y agua	185.536	213.479	236.304	298.399	316.962	274.977	337.556	402.503	400.471	493.597	495.900
Construcción	8.502	12.547	19.693	33.451	42.261	69.828	92.570	107.656	149.613	209.251	282.024
Comercio, restaurantes y hoteles	85.865	156.316	197.364	265.032	239.771	198.321	243.815	293.654	324.451	403.056	458.771
Transporte y comunicaciones	119.068	153.540	185.411	261.438	261.462	294.249	371.430	438.512	490.710	627.091	703.197
Servicios financieros y empresariales	33.902	45.081	60.287	90.452	89.632	140.280	179.798	212.987	268.790	354.500	450.734

Fuente: Cálculos propios a partir de la matriz de inversión 1986 y 1996 (BCCh).

CUADRO A.1.7.
DEPRECIACION ECONOMICA POR RAMAS DE ACTIVIDAD 1996

Ramas de actividad	Depreciación (%)	Fuente
Agricultura	8,5	S.I.I.
Minería	10	Contabilidad de empresas
Industria	7	S.I.I.
Electricidad, gas y agua	5,8	S.I.I.
Construcción	12,2	Contabilidad de empresas
Comercio, restaurantes y hoteles	6,5	Contabilidad de empresas
Transporte y comunicaciones	9,8	Contabilidad de empresas
Servicios financieros y empresariales	9,7	Contabilidad de empresas
Servicios comunales	2,5	S.I.I.

Fuente: Contabilidad de empresas y S.I.I.

CUADRO A.1.8.
SERIE STOCK DE CAPITAL POR RAMAS DE ACTIVIDAD 1986-2001
(Miles de millones de pesos en 1996)

Especificación	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Industria	3.532	3.543	3.615	3.822	4.024	4.242	4.600	5.067	5.608	6.434	7.329	8.173	8.922	9.227	9.690	10.054
Electricidad, gas y agua	2.502	2.564	2.644	2.775	2.905	3.020	3.180	3.379	3.577	3.840	4.113	4.464	4.915	5.303	5.554	5.917
Construcción	767	689	631	601	580	574	601	654	733	887	1.061	1.245	1.373	1.339	1.393	1.432
Comercio, restaurantes y hoteles	860	960	1.091	1.274	1.425	1.528	1.675	1.870	2.078	2.534	2.660	2.915	3.186	3.373	3.597	3.808
Transporte y comunicaciones	1.104	1.151	1.225	1.371	1.509	1.649	1.858	2.122	2.407	2.808	3.236	3.705	4.250	4.708	5.222	5.687
Servicios financieros y empresariales	1.520	1.423	1.354	1.329	1.317	1.322	1.379	1.481	1.618	1.854	2.125	2.344	2.578	2.756	2.949	3.226

Fuente: Cálculos propios a partir de la matriz de inversión 1986 y 1996 (BCCh).

APENDICE 2

CUADRO A.2.1.
 STOCK DE CAPITAL NETO POR RAMAS DE ACTIVIDAD AJUSTADO
 (Millones de pesos de 1996)

Año / Sector	Industria manufacturera	Electricidad, gas y agua	Construcción	Comercio	Transporte y comunicaciones	Servicios financieros
1986	3.529.418	2.501.602	766.537	860.190	1.104.331	1.520.353
1987	3.543.380	2.564.103	689.295	959.706	1.150.644	1.423.340
1988	3.615.336	2.643.718	630.861	1.090.645	1.225.206	1.353.673
1989	3.822.428	2.775.021	600.941	1.274.346	1.370.578	1.329.441
1990	4.024.420	2.904.944	580.189	1.425.270	1.509.308	1.316.795
1991	4.241.960	3.019.750	573.915	1.528.008	1.649.228	1.322.193
1992	4.599.702	3.179.692	600.840	1.675.154	1.858.204	1.378.879
1993	5.067.444	3.379.271	653.575	1.869.815	2.122.464	1.481.438
1994	5.607.670	3.576.548	732.917	2.077.977	2.407.453	1.617.882
1995	6.434.353	3.839.809	887.216	2.354.256	2.807.986	1.854.116
1996	7.329.000	4.113.000	1.061.000	2.660.000	3.236.000	2.125.000
1997	8.332.193	4.630.679	1.208.180	2.961.556	3.828.756	2.400.819
1998	9.051.977	5.019.153	1.312.273	3.258.360	4.399.422	2.628.086
1999	8.970.137	5.048.331	1.143.173	3.321.669	4.674.669	2.710.781
2000	9.496.642	5.348.651	1.238.780	3.586.368	5.230.136	2.893.854
2001	9.921.434	5.763.426	1.302.392	3.797.619	5.723.729	3.167.831

Fuente: Cálculos propios en base a datos del INE y BCCh.

CUADRO A.2.2.
 NUMERO DE OCUPADOS POR RAMAS DE ACTIVIDAD AJUSTADO
 (Miles de personas)

Año / Sector	Industria manufacturera	Electricidad, gas y agua	Construcción	Comercio	Transporte y comunicaciones	Servicios financieros
1986	500	27	145	647	229	153
1987	573	31	184	671	238	169
1988	637	28	243	708	265	185
1989	727	28	290	747	293	196
1990	744	26	321	749	307	214
1991	772	27	320	758	313	233
1992	815	27	349	830	334	241
1993	869	30	433	928	354	269
1994	862	33	403	940	371	296
1995	851	31	416	932	393	310
1996	845	39	406	926	387	353
1997	845	35	413	941	404	370
1998	809	33	407	968	437	401
1999	716	32	292	979	446	396
2000	701	30	309	945	473	405
2001	693	29	328	954	468	421

Fuente: Cálculos propios en base a datos del INE.

APENDICE 3

CUADRO A.3.1.
PARTICIPACION DEL TRABAJO POR RAMAS DE ACTIVIDAD
(%)

Sector / Año	1996-2001
Industria	41
Electricidad, gas y agua	23
Construcción	37
Comercio, restaurantes y hoteles	73
Transporte y comunicaciones	59
Servicios financieros	56

Fuente: Cálculos propios en base a datos del INE y CASEN.

MICRO EFFICIENCY AND AGGREGATE GROWTH IN CHILE*

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Using plant-level data on Chilean manufacturing firms for the 1980-2001 period, we estimate and characterize disaggregate total factor productivity. We use these estimates to study the microeconomic sources of aggregate efficiency, a fundamental part of aggregate growth. By decomposing productivity dynamics into production reallocation and within plant efficiency changes, we find that reallocation accounted for almost all of total efficiency gains in Chile during the past few decades. The entry of new, more productive units explains most of these reallocation gains. Within-plant productivity growth contributes positively only during the 1990s, due perhaps to a lag between the implementation of major market oriented structural reforms –mostly undertaken during the late 1970s and early 1980s– and their complete effect on the economy. Our findings suggest that once reforms were consolidated, unbounded within-plant efficiency gains driven by technology adoption and innovation occurred.

JEL: L16, L60, O30, O47

Keywords: Plant Dynamics, Total Factor Productivity, Growth, Chilean Manufacturing.

1. INTRODUCTION

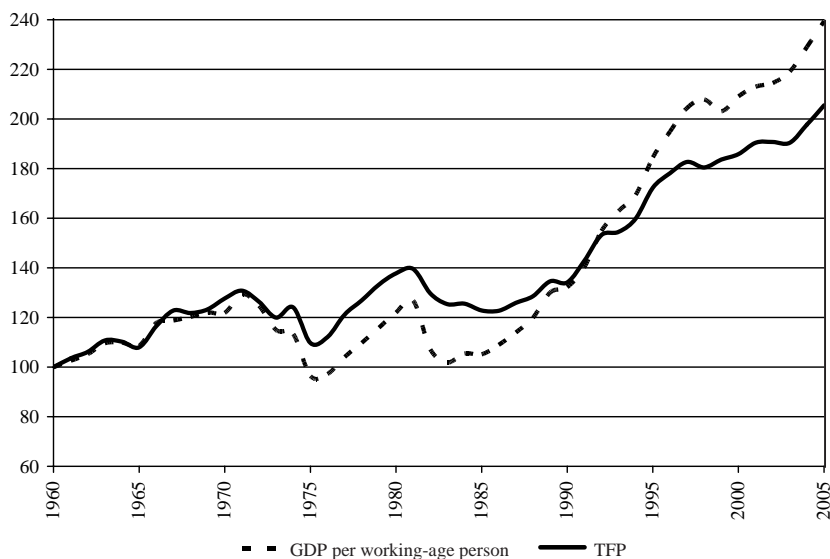
The growth of output is mostly accounted for by the dynamics of aggregate efficiency. Chilean GDP per working-age person and aggregate total factor

*We thank the Instituto Nacional de Estadísticas for providing the manufacturing plant-level data used in this paper. We also thank the research assistance provided by Rafael Labarca. We acknowledge financial support from the IADB, Fondecyt # 1050499, and an institutional grant to CEA from the Hewlett Foundation. Useful comments and suggestions have been provided by two anonymous referees and by participants in several seminars and conferences, especially John Haltiwanger, Alejandro Micco, Klaus Schmidt-Hebbel, and Raimundo Soto.

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productivity (TFP) display high-comovement since 1960 (Figure 1).¹ The evidence for other developed and developing economies, reported by Kehoe and Prescott (2002) and Solimano and Soto (2006) respectively, is similar. This positive correlation between output and productivity growth is stronger the longer is the time period considered. Thus, to understand aggregate growth, we must first understand aggregate efficiency.²

FIGURE 1
GDP PER WORKING-AGE PERSON AND TFP
(Index 1960 = 100)



Source: Authors' calculations.

Two sources of productivity gains drive aggregate efficiency over time: the exposure of economic units to better methods of production (within-plant efficiency gains), and the Schumpeterian creative destruction process through which efficient firms thrive while inefficient ones disappear (reallocation driven efficiency gains). The former results from the adoption of new and better technologies and the implementation of more efficient production processes; the latter, from the reshuffling of resources from less to more productive firms and the entry and exit process. A number of papers report evidence for developed

¹TFP is calculated assuming a Cobb-Douglas production function and a share of capital of 0.35. We multiply employment by average working hours according to Instituto Nacional de Estadísticas. We use capital series from Ministerio de Hacienda (2004), updated to 2005 using national accounts.

²There is also a recent literature on economic development that has stressed the role of differences in TFP as a major force in accounting for the large disparities in international income levels (Parente and Prescott, 2000; Prescott, 2002). In this paper, however, we focus exclusively on growth.

and developing economies on the importance of plant dynamics in accounting for aggregate efficiency gains.³

The recent Chilean experience provides a rich setting to investigate these sources of efficiency gains. During the second half of the 1970s and the early 1980s, Chile carried out several market oriented reforms. Most distortions on prices and quantities were eliminated and producers were forced to compete in foreign markets. Overall, these reforms provided an environment that favored efficiency, both through the displacement of resources from less to more efficient producers and from the generalized adoption of better technologies and production processes. The study of plant-level productivity dynamics allows a complete understanding of these sources of aggregate growth.

In this paper we explore the connection between reallocation and productivity dynamics using 22 years of longitudinal data, covering the Chilean manufacturing sector. In our analysis we track the dynamics of productivity at the plant level, the entry and exit of plants, and the reshuffling of resources across continuing firms. Most papers studying the recent Chilean growth experience have only partially analyzed the available evidence, as they have missed the reallocation effects by concentrating exclusively on aggregate data.⁴ Other papers, such as Levinsohn and Petrin (2003), have identified reallocation effects in Chile using only data for 1979-86. Those papers, however, are unable to capture the complete dynamics resulting from reforms by focusing on a period of time too early and too short to allow these policies to fully affect the economy.

Our TFP estimates show the existence of productivity heterogeneity at the micro level.⁵ In particular, even within narrowly defined sectors, at any period of time there are wide differences in TFP. This heterogeneity suggests that reallocation can be a potentially important source of efficiency gains in Chile. Our results show this is indeed the case. By decomposing aggregate total factor productivity into production reallocation and within plant efficiency changes, we find that reallocation accounted for almost all of total efficiency gains in Chile over the past few decades. The entry of new, more productive firms drives most of these aggregate gains. Within-plant productivity growth contributes positively only during the 1990s, consistently with the existence of a lag between the implementation of major market oriented structural reforms –mostly undertaken during the late 1970s and early 1980s– and their complete effect on

³See Bartelsman and Doms (2000) for a recent review of the literature.

⁴For a recent analysis, see De Gregorio (2004).

⁵Since estimates of plant-level TFP are usually not available, it is common to use average labor productivity to study the connection between efficiency and the behavior of plants. TFP is, however, a better measure for two reasons. First, labor productivity is endogenous to TFP. Second, its evolution is determined not only by changes in multi-factor efficiency but also by the reallocation of inputs. The separate understanding of each of these sources of output per capita growth is quite relevant. For instance, while the former is unbounded and accounts for long-run growth, the latter is bounded by the efficient allocation of resources and correlates with the business cycle. Thus, a full characterization of aggregate efficiency allows a comprehensive understanding of long and short run growth.

the economy. Once reforms were consolidated, unbounded within-plants efficiency gains driven by technology adoption and innovation occurred.

Market economies restructure continuously as a response to changing conditions. Our results, and those of a growing literature based on longitudinal databases at the micro level, suggest that productivity growth at the aggregate level is closely linked to the ability of the economy to efficiently reallocate inputs and outputs across firms. Thus barriers to this efficient reallocation process reduce aggregate efficiency and growth. For instance, a production subsidy to incumbent firms allows inefficient plants to stay longer in business. At the same time, more efficient firms that would have entered the market are left out. Financial restrictions, trade barriers, firm entry costs, inefficient bankruptcy procedures, bureaucratic red tape, tax burden, labor regulations, and the lack of human capital for technology adoption, all distort the natural process of resource reallocation. Chang *et al.* (2005), for instance, provide empirical evidence of a link between growth and measures of market flexibility and ease of entry and exit, whereas Hopenhayn and Rogerson (1993) and Bergoeing, Loayza and Repetto (2004) develop theoretical models showing that this link is a result of the ability of the economy to easily reshuffle resources towards more productive uses. These distortions have both static and dynamic effects. The resulting inefficient allocation of resources initially pushes the economy inside its production possibilities frontier. In the long run, because new firms are blocked out, the adoption of new and better technologies is delayed. In all cases, growth is reduced.

A number of papers have analyzed different aspects of plant-level TFP using Chilean data using similar estimation methods. Pavcnik (2002) studies the effects of trade reform on the behavior of within-plant productivity growth. She finds that TFP of continuous plants in import competing sectors grew much faster than plants in export oriented or nontraded sectors after trade was liberalized. Alvarez and López (2005a) compare the performance of exporters and non exporters. They find evidence of self-selection into export markets. They also find that plant TFP increases after plants begin to export, a fact consistent with learning by exporting. Bergoeing, Hernando and Repetto (2005b) study different aspects of the dynamics of TFP in the 1980s and the 1990s. Their results show that exiting plants experience a downward trajectory of productivity prior to exit, and that entering survivors quickly improve their productivity. They also show that more efficient plants are less likely to fail. Finally they show that all these effects were more pronounced in the 1990s than in the 1980s. Alvarez and López (2005b) look for productivity spillovers coming from export activity in manufacturing, in both downstream and upstream sectors. Their results suggest that there are positive forward spillovers, as exports in sectors producing intermediate inputs have a positive effect on the productivity of firms in downstream industries.

The current paper adds to this growing literature on plant-level TFP by connecting manufacturing aggregate efficiency to plant dynamics. The paper is organized as follows. The next section describes the manufacturing data we use, the estimation algorithm and the theoretical framework of firm exit behavior that

supports it. In Section 3 we characterize plant-level TFP. In Section 4 we study the contribution of reallocation and within plant efficiency changes into aggregate productivity dynamics. The final section concludes.

2. PLANT LEVEL PRODUCTIVITY: DATA, THEORY, AND ESTIMATION PROCEDURE

In what follows we describe the data used in this study, a theory of plant exit and input demand based on plant specific productivity shocks, and the algorithm we use to estimate plant-level TFP based on this theory, originally developed by Olley and Pakes (1996).

The data

The data in this study come from the *Encuesta Nacional Industrial Anual* (ENIA), an annual survey of manufacturing conducted by the Chilean statistics agency, the *Instituto Nacional de Estadísticas* (INE). The ENIA covers all manufacturing plants that employ at least ten individuals. Thus, it includes all newly created and continuing plants with ten or more employees, and it excludes plants that ceased activities or reduced their hiring below the survey's threshold. The ENIA collects detailed information on plant characteristics, such as manufacturing sub-sector at the 4-digit ISIC level, sales, employment, investment, intermediate inputs and location. The available data cover the 1980-2001 period.

The treatment of entry and exit is somewhat complicated by the fact that plants falling below the minimum employment boundary do not appear in the survey. Thus a plant interviewed in any given year, but that fails to enter the sample in the following year might not represent an exit. Similarly, a plant appearing for the first time in any given year does not necessarily correspond to an entry, as it might represent a growing plant that surpasses the ten people boundary. To reduce the extent of spurious identification of plant entry and exit, we artificially raised the sample threshold to 15 employees, following the strategy in Micco (1995).⁶

Unfortunately, the ENIA does not report plant-level prices, so we constructed deflators at the 3-digit level from INE's wholesale price indices. The use of a common industry-level deflator might be problematic, as within-industry price differences are imputed as productivity shocks.⁷ Nominal output was thus deflated using these 3-digit ISIC level price indices. Deflators for materials were

⁶We also excluded plants that report no employment, no blue-collar workers, wages, no production days, zero gross production, negative value added, gross production lower than value added, exports larger than total sales, or no ISIC code.

⁷See Eslava *et al.* (2004) for the relative relevance of plant-level technology shocks vis a vis demand shocks.

also constructed at the 3-digit ISIC level, using the 1996 input-output table. All real variables are expressed in 1992 Chilean pesos. Capital series were constructed using information on investment and depreciation (Bergoeing, Hernando and Repetto, 2005b).

We excluded the tobacco industry (314) and petroleum refineries (353) from the analysis, because they are organized as monopolies, operating with very few plants. The estimation strategy we use below assumes plant specific shocks are technology driven, and thus rules out markup shocks. Syverson (2004) shows that the failure of this assumption invalidates the strategy we use.⁸ The 27 sub-sectors used in this study account for 92% of total real gross revenue in the ENIA.

Table 1 presents some basic statistics of our data set at the 3-digit ISIC sector level. The first row shows mean values, whereas the second row shows standard errors. Entry and exit rates in the first two columns show some variation across sectors. Overall, 5.7% and 6.3% of firms enter and exit the market in any given year, respectively. Gross output, capital stock and materials are expressed in (natural log of) 1992 Chilean pesos. Labor inputs are measured as the annual average of employees working at the firm, corrected by the number of days the firm operated in any given year. Electricity is directly measured in quantities, as the ENIA gathers information on electricity bought, sold and generated measured in thousands of KW per hour. Output and inputs also show wide variation across and within sectors, a fact consistent with idiosyncratic technology and efficiency differences. Across-plant shocks to efficiency lead to input purchase decisions that vary significantly even under identical production functions. Naturally, firms that hire more inputs and that produce more efficiently generate more output.

The theory

Assume the economy is populated by a continuum of heterogeneous firms, each one with its own level of productivity.⁹ In every period, given factor prices and the market structure, the manager of each firm decides whether to quit production and exit, or to stay in business. The exit decision is irreversible. The manager's decisions are made after facing an idiosyncratic productivity shock that is a random draw from an exogenous Markov process. If the firm continues in operation, the manager purchases variable factors and chooses investment. If the plant quits production, the plant is worth a sell-off value equal to Y . Exit decisions are based on maximizing expected discounted net cash flows. The firm's problem is

$$(1) \quad V_t(\omega_t, k_t) = \max \{ \Psi, \sup_{i_t \geq 0} \pi_t(\omega_t, k_t) - c(i_t) + \beta E_t V_{t+1}(\omega_{t+1}, k_{t+1}) \}$$

⁸See the estimation strategy section below for a discussion.

⁹In this paper we refer to firms and plants as equivalent economic units, although our data set collects information on plants and not on firms. According to Central Bank statisticians, about 3.5% of plants belong to a multi-plant firm in our data set.

TABLE 1
 BASIC STATISTICS AT THE SECTOR LEVEL
 (Mean and Standard Deviation)

	Entry Rate	Exit Rate	Gross Output	Unskilled Labor	Skilled Labor	Capital Stock	Electricity	Materials
311	0.053 0.224	0.059 0.236	12.62 1.60	3.65 1.10	1.56 1.24	10.78 2.12	4.45 1.83	12.08 1.64
312	0.059 0.235	0.059 0.236	13.64 1.82	3.71 1.16	2.08 1.42	11.92 2.02	5.28 1.84	12.94 2.02
313	0.041 0.198	0.068 0.252	13.99 1.78	3.95 1.11	2.47 1.43	12.38 2.08	5.23 1.78	12.88 1.84
321	0.043 0.204	0.059 0.236	12.89 1.35	3.66 1.13	1.54 1.29	11.22 1.74	4.63 1.71	12.01 1.41
322	0.063 0.243	0.084 0.277	12.38 1.25	3.55 1.04	1.37 1.16	10.38 1.62	3.62 1.24	11.75 1.30
323	0.040 0.197	0.068 0.252	13.02 1.41	3.61 0.95	1.61 1.03	11.01 1.84	4.59 1.67	12.30 1.51
324	0.054 0.226	0.067 0.250	12.62 1.34	3.79 1.12	1.37 1.20	10.55 1.82	3.87 1.43	11.97 1.27
331	0.077 0.267	0.086 0.281	12.80 1.42	3.86 1.08	1.35 1.14	11.10 1.85	4.82 1.68	11.92 1.52
332	0.076 0.266	0.087 0.282	12.08 1.36	3.51 1.02	1.23 1.11	10.38 1.80	3.78 1.40	11.38 1.37
341	0.067 0.251	0.061 0.239	13.80 1.90	4.04 1.29	2.35 1.61	12.48 2.39	5.81 2.67	13.02 1.94
342	0.049 0.216	0.062 0.241	12.50 1.37	3.24 1.08	1.67 1.30	11.20 1.76	3.97 1.40	11.36 1.53
351	0.064 0.245	0.047 0.211	13.96 1.60	3.57 1.15	2.21 1.35	12.45 1.96	6.02 2.30	12.88 1.71
352	0.041 0.198	0.044 0.206	13.88 1.49	3.54 1.17	2.61 1.31	12.11 1.82	4.71 1.58	12.96 1.50
354	0.055 0.229	0.049 0.216	13.92 1.69	3.62 0.98	2.06 1.24	12.22 1.84	5.40 1.25	13.17 1.76
355	0.046 0.209	0.050 0.217	12.58 1.42	3.49 1.12	1.66 1.19	11.25 1.77	4.94 1.53	11.69 1.53

(Cont. Table 1)

	Entry Rate	Exit Rate	Gross Output	Unskilled Labor	Skilled Labor	Capital Stock	Electricity	Materials
356	0.075 0.264	0.053 0.224	13.00 1.29	3.68 1.04	1.72 1.13	11.55 1.72	5.43 1.59	12.11 1.39
361	0.058 0.235	0.070 0.256	12.68 1.77	4.27 1.38	1.90 1.48	11.15 2.08	5.87 1.47	11.29 1.85
362	0.028 0.164	0.045 0.208	13.26 1.69	4.07 1.16	2.15 1.36	11.91 2.14	5.40 2.07	11.98 1.57
369	0.060 0.237	0.056 0.230	12.86 1.67	3.63 1.03	1.60 1.31	11.35 2.16	4.77 2.07	11.73 1.70
371	0.054 0.227	0.048 0.214	13.93 1.82	4.24 1.30	2.45 1.47	12.50 1.91	6.30 2.35	12.94 1.89
372	0.057 0.232	0.051 0.220	15.24 2.63	4.48 1.63	3.09 1.80	13.40 2.61	7.49 3.03	14.37 2.85
381	0.060 0.238	0.060 0.238	12.83 1.39	3.61 1.01	1.64 1.18	10.96 1.88	4.41 1.49	11.88 1.46
382	0.064 0.245	0.058 0.233	12.62 1.41	3.50 1.14	1.76 1.27	11.15 1.73	4.37 1.44	11.61 1.55
383	0.049 0.216	0.049 0.216	13.31 1.54	3.73 1.07	2.08 1.30	11.65 1.84	4.71 1.68	12.29 1.44
384	0.062 0.240	0.066 0.248	12.44 1.67	3.60 1.12	1.70 1.26	11.30 1.81	4.42 1.51	11.59 1.81
385	0.040 0.197	0.032 0.175	12.85 1.19	3.32 0.90	1.79 1.14	11.33 1.37	4.30 1.27	11.70 1.24
390	0.043 0.203	0.053 0.224	12.30 1.07	3.29 0.79	1.41 0.97	10.53 1.63	3.86 1.22	11.22 1.16
All	0.057 0.232	0.063 0.242	12.85 1.58	3.65 1.11	1.67 1.29	11.13 2.00	4.57 1.80	12.04 1.63

Source: Authors' estimates.

The first row shows the mean, whereas the second row shows the standard deviation.

Outputs and inputs are expressed in natural logs.

where the function $c(\bullet)$ represents the cost of investment, β the firm's discount factor, E_t the expectation operator conditional on all information known at time t , and V_t the value function at period t . The profit function of the firm is represented by $\pi_t(\omega_t, k_t)$, which depends on the current value of the state variables, capital (k_t) and productivity (ω_t). The function is indexed by time to account for changing

market structures and factor and output prices. The law of motion for capital is given by

$$(2) \quad k_{t+1} = (1 - \delta)k_t + i_t$$

where i_t is current period's gross investment.

Conditional on capital stock, k_t , equilibrium exit decisions are given by a cut-off level of productivity $\omega_\tau^*(k_t)$ as shown by Ericson and Pakes (1995). If $\omega_\tau \geq \omega_\tau^*(k_t)$ the firm stays in business, and if $\omega_\tau < \omega_\tau^*(k_t)$, the firm exits. This cut-off is decreasing in k_t if the difference between the expected discount value of profits and the sell-off value depends positively on capital; i.e. larger firms lose more if they choose to quit. In other words, a larger capital stock allows firms to stay in business even if current productivity is relatively low. Finally, if a plant stays, its investment demand is given by $i_t = i_t(\omega_t, k_t)$. Pakes (1994) shows that for any capital stock, the investment function i_t is strictly increasing in ω_t , whenever investment is strictly positive. The monotonicity of the cut-off and investment demand functions are a key ingredient for the algorithm originally developed by Olley and Pakes (1996) and further extended by Levinsohn and Petrin (2003) that is outlined in the next subsection.

The Olley-Pakes and Levinsohn-Petrin estimation strategies

The first step in constructing series of TFP is estimating a production function. Within this theoretical framework, the empirical estimation of production functions is problematic because productivity, a state variable in the firm's decision problem, is not observed by the econometrician. Two biases in OLS estimation of the production functions are introduced. First, there is a simultaneity problem, as factor demands are correlated with the unobserved productivity term. Specifically, if firms with higher productivity are more likely to purchase inputs, then OLS estimates of the corresponding coefficients are biased upwards.¹⁰ Second, there is a selection problem since conditional on survival the econometrician only observes plants with productivity greater than the cut-off. The expectation of productivity depends negatively on capital since firms with a larger capital stock can afford to survive with a lower productivity level. Thus, the capital coefficients are biased downwards.

Fixed effects regressions do not solve the simultaneity problem since they require the productivity term to be constant over time. Given the length of the period considered and since structural reforms were undertaken during the period studied, it is highly unlikely that productivity remained constant. As a matter of fact, the results in Pavcnik (2002) for the 1979-86 period suggest that fixed effects regressions do not fully control for the endogeneity problem, and thus that plant-level productivity is not constant over time. Similarly, balancing the panel of

¹⁰See Griliches and Mairesse (1995) for a thorough analysis of the simultaneity problem.

firms does not solve the selection problem, since firms that remain in the panel are firms that survived.

To circumvent these problems we use a general estimation procedure proposed by Olley and Pakes (OP) and modified by Levinsohn and Petrin (LP).¹¹

Let the production function of firm i at time t be

$$(3) \quad y_{it} = \beta_0 + \beta_s l_{it}^s + \beta_u l_{it}^u + \beta_k k_{it} + \beta_m m_{it} + \omega_{it} + \mu_{it}$$

where y_{it} is log of firm's i gross output at time t . The variable inputs of production are l_{it}^s (the log of skilled labor), l_{it}^u (the log of unskilled labor), and m_{it} (the log of intermediate inputs—energy and materials). The natural logarithm of the stock of capital, k_{it} , is a state variable. The unobserved shock ω_{it} is the log of plant-specific productivity, whereas μ_{it} is a mean zero error that accounts for measurement error and for unexpected productivity shocks that do not affect the choice of inputs. The former random shock is a state variable of the problem, whereas the latter is not.

OP uses the fact that the investment demand depends upon the current state variables, but does not affect current production. Thus investment can be used as a proxy for the unobserved productivity shock. Specifically, ω_{it} is approximated by a polynomial expansion in investment and capital. The selection problem is corrected through an intermediate step in which the exit probability of any given plant is estimated using polynomial expansions in capital and investment. This estimated exit probability is later used to control for the cut-off level productivity under which a plant exits.

A major limitation of the Olley-Pakes strategy is investment lumpiness: a large number of firms report zero investment in many years. Unfortunately, the invertibility of the investment demand function depends crucially upon observing strictly positive investment. LP shows that intermediate inputs can also be used as proxies for productivity, as their demand also depends upon the state variables of the problem. Thus, instead of using polynomials in investment and capital, the strategy uses polynomials in intermediate inputs and capital. LP use the orthogonally conditions of the problem —i.e., current capital stock and lagged variable input demands are not correlated with current productivity innovations— and GMM to identify the coefficients of the production function. The method allows for the test of overidentifying restrictions.

The dataset and the estimation method have a number of limitations that might induce to error in our estimations of TFP below. First, we do not observe labor effort, labor hoarding and capital utilization. If these vary, the growth rate of observed inputs does not fully capture their service flows. Second, the algorithm used and described below assumes that productivity is the only unobserved plant-specific state variable.¹² Instrumental variables techniques are preferred in cases

¹¹See Olley and Pakes (1996), and Levinsohn and Petrin (2003).

¹²Different market structures are allowed, but these must be either constant over time or random in such a way that it does not represent a state variable of the firm.

where other shocks, such as demand shocks, are relevant. Unfortunately, obtaining good instruments at the plant level is a difficult task in most cases. An exception is Syverson (2004) that uses market segmentation in the ready-mix concrete industry to identify an exogenous source of variability in demand. Third, we do not allow for externalities from the activity of other firms. Fourth, we assume that all firms within a 3-digit industry use the same production function. Idiosyncratic productivity shocks are the only difference across firms within an industry. Finally, we assume that output elasticities are constant over time.

3. THE DYNAMICS OF PLANT-LEVEL PRODUCTIVITY IN CHILE

In this section we characterize the estimates of plant-level TFP. We use these measures to describe the evolution of productivity over time. The TFP estimates behave according to expected patterns. Moreover, we find extensive heterogeneity in micro efficiency, a necessary condition for reallocation to be a relevant source of aggregate efficiency.

Production function estimates

We use the LP estimation strategy to estimate production functions for gross revenue, with electricity demand as the proxy for productivity.¹³ The LP estimation method allows for the use of any intermediate input (lagged) as an instrument in the GMM identification equations. We chose electricity because quantities are directly measured at the plant-level in the ENIA. Materials must be deflated, introducing possible biases as we lack data on process at the individual level.¹⁴

Gross production, and not value added, is the correct output concept at this level of disaggregation. GDP is a value added measure as the economy uses capital and labor for producing goods and services. Intermediate inputs are netted out in the aggregation process. Alternatively, gross output is the right measure at the plant level as plants' output consists of final and intermediate goods. Firms combine capital, labor and intermediate inputs (materials and energy) to produce this gross output.¹⁵

Table 2 presents the estimated elasticities of unskilled (blue collar) and skilled labor, capital, materials and electricity and their bootstrapped standard errors. The reported elasticities exhibit wide variation across sectors. Most coefficients are precisely estimated. Only capital cannot be precisely estimated in many sectors, perhaps due to its little variability over time, as investment

¹³Only a very small fraction of observations report no electricity consumption (about 1.5% of them.) Some plants generate and sell electricity. Our measure of electricity is consumption plus generation minus sales.

¹⁴Results using materials as a proxy instead are available upon request.

¹⁵See Basu and Fernald (1995) for a discussion on production functions at different levels of aggregation.

TABLE 2
PRODUCTION FUNCTION ESTIMATES

	Food Products 311-312	Beverages 313	Textiles 321	Wearing Apparel 322	Leather Products 323	Footwear 324	Wood 331
Blue collar labor	0.0955 (0.0107)	0.0788 (0.0324)	0.0579 (0.0184)	0.0730 (0.0183)	0.0471 (0.0494)	0.1035 (0.0274)	0.1053 (0.0172)
Skilled labor	0.1170 (0.0066)	0.2338 (0.0298)	0.1878 (0.0173)	0.1795 (0.0146)	0.2269 (0.0487)	0.1451 (0.0615)	0.1539 (0.0163)
Capital	0.0941 (0.0333)	0.1096 (0.0577)	0.0101 (0.0320)	0.0597 (0.0565)	0.0954 (0.0902)	0.2100 (0.0522)	0.0018 (0.0495)
Materials	0.5943 (0.0165)	0.5748 (0.0207)	0.5709 (0.0191)	0.5791 (0.0166)	0.5254 (0.0451)	0.6066 (0.0338)	0.5998 (0.0175)
Electricity	0.0880 (0.0176)	0.0743 (0.0612)	0.2457 (0.0412)	0.0812 (0.0230)	0.0947 (0.1287)	0.0636 (0.0293)	0.2021 (0.0707)
Sum of coefficients Chi ² CRS (p-value)	0.9888 0.786	1.0712 0.3729	1.0725 0.0160	0.9725 0.6458	0.9895 0.9456	1.1287 0.0078	1.0630 0.2562
N observations	24032	1978	6345	5431	918	2509	6064
	Furniture 332	Paper 341	Printing and Pub. 342	Chemicals 351	Other chemicals 352	Misc. Petr. and Coal 354	Rubber 355
Blue collar labor	0.0890 (0.0203)	-0.0046 (0.0306)	0.1861 (0.0161)	-0.0408 (0.0363)	0.0857 (0.0255)	-0.0574 (0.0503)	0.1195 (0.0291)
Skilled labor	0.1116 (0.0265)	0.1163 (0.0314)	0.1725 (0.0180)	0.1676 (0.0367)	0.2076 (0.0271)	0.1173 (0.0611)	0.1767 (0.0346)
Capital	0.0000 (0.1025)	0.0100 (0.0152)	0.2000 (0.0348)	0.0489 (0.0820)	0.2405 (0.0897)	0.1781 (0.1100)	0.1475 (0.0888)
Materials	0.7117 (0.0235)	0.6503 (0.0264)	0.5186 (0.0224)	0.5655 (0.0287)	0.5717 (0.0350)	0.8139 (0.0767)	0.4863 (0.0345)
Electricity	0.2254 (0.0903)	0.1900 (0.0797)	0.0100 (0.0138)	0.0285 (0.0331)	0.0000 (0.0461)	0.0910 (0.1044)	0.0493 (0.0431)
Sum of coefficients Chi ² CRS (p-value)	1.1377 0.0073	0.9620 0.6536	1.0871 0.0316	0.7698 0.0165	1.1056 0.2131	1.1428 0.375	0.9793 0.8603
N observations	2322	1360	3346	1194	3396	330	1122

(Cont. Table 2)

	Other Plastic 356	Pottery and China 361	Glass 362	Oth.Non Met.Minerals 369	Iron and Steel 371	Non-ferrous metal 372	Fabricated metal 381
Blue collar labor	0.0895 (0.0140)	0.2963 (0.1092)	0.0947 (0.1016)	0.0639 (0.0247)	-0.0167 (0.0464)	0.0096 (0.0484)	0.0820 (0.0125)
Skilled labor	0.1483 (0.0138)	0.1877 (0.0541)	0.2600 (0.0997)	0.1732 (0.0375)	0.1983 (0.0613)	0.1068 (0.0472)	0.1812 (0.0132)
Capital	0.0438 (0.0639)	0.0000 (0.1250)	0.1976 (0.2243)	0.1015 (0.0688)	0.9800 (0.3804)	0.0422 (0.1026)	0.0027 (0.0562)
Materials	0.5905 (0.0157)	0.4272 (0.0673)	0.5745 (0.0901)	0.5685 (0.0226)	0.5611 (0.1110)	0.6843 (0.0351)	0.6153 (0.0149)
Electricity	0.1855 (0.0782)	0.4349 (0.1731)	0.2780 (0.2389)	0.1222 (0.0414)	0.0500 (0.0858)	0.0000 (0.0711)	0.2176 (0.0676)
Sum of coefficients	1.0577	1.3461	1.4048	1.0293	1.7727	0.8429	1.0987
Chi ² CRS (p-value)	0.2486	0.1337	0.1588	0.7013	0.0298	0.2927	0.0487
N observations	4155	279	422	2441	650	651	7572

	Non elec. Machinery 382	Elect. Machinery 383	Transport Eq. 384	Prof. and Scient. Eq. 385	Other 390
Blue collar labor	0.0470 (0.0180)	-0.0067 (0.0427)	0.0611 (0.0247)	0.1297 (0.0792)	0.0016 (0.0439)
Skilled labor	0.1745 (0.0193)	0.2563 (0.0463)	0.1746 (0.0365)	0.1221 (0.0612)	0.2507 (0.0484)
Capital	0.0998 (0.0827)	0.0000 (0.1953)	0.2831 (0.0135)	0.0700 (0.2380)	0.1887 (0.1098)
Materials	0.5862 (0.0205)	0.6844 (0.0307)	0.6053 (0.0293)	0.5182 (0.0611)	0.5226 (0.0423)
Electricity	0.0408 (0.0375)	0.2950 (0.1121)	0.0815 (0.0444)	0.0100 (0.1054)	0.1329 (0.0829)
Sum of coefficients	0.9483	1.2291	1.2057	0.8500	1.0965
Chi ² CRS (p-value)	0.5343	0.1781	0.1393	0.5413	0.3912
N observations	3120	1180	1953	374	1051

Source: Author's estimates. Bootstrapped standard errors in parentheses using 250 replications.

behaves in a lumpy manner. In about 75% of sectors, the null hypothesis of constant returns to scale cannot be rejected.

The estimated degrees of returns to scale vary from 0.77 (chemical industry) to 1.77 (iron and steel basic industries). The largest elasticity of unskilled labor corresponds to the manufacturing of china, pottery and earthenware, a point elasticity of 0.30. The most skilled-labor elastic sector is the manufacture of glass products, with an elasticity of 0.26. The statistically significant coefficients on capital vary between 0.09 (food products) and 0.98 (iron and steel basic industries).

Pavcnik (2002), using data from the ENIA, obtains elasticities that are quite different from those presented here. She uses a much shorter data set (up to 1986 only), and the OP strategy with investment as a proxy to perform her estimates. Moreover, although she includes materials, she excludes energy from the analysis. Levinsohn and Petrin (2003) perform estimates for four 3-digit sectors (311, 321, 331 and 381), using the same sub-sample of the ENIA that Pavcnik uses. Although we get different point estimates, most of the coefficients they obtain are of the same order of magnitude as ours. Since we use the same methodology and proxies as LP, the differences in coefficients must be due to the samples and deflators used, and to the LP assumption that investment becomes productive immediately.

Characterizing plant-level productivity

Next, we characterize the dynamics over time of our estimates of TFP. Let $\hat{\omega}_{it}$ represent the estimated of the level of TFP of plant i at time period t , using the production coefficients previously estimated with the LP version of the algorithm. That is,

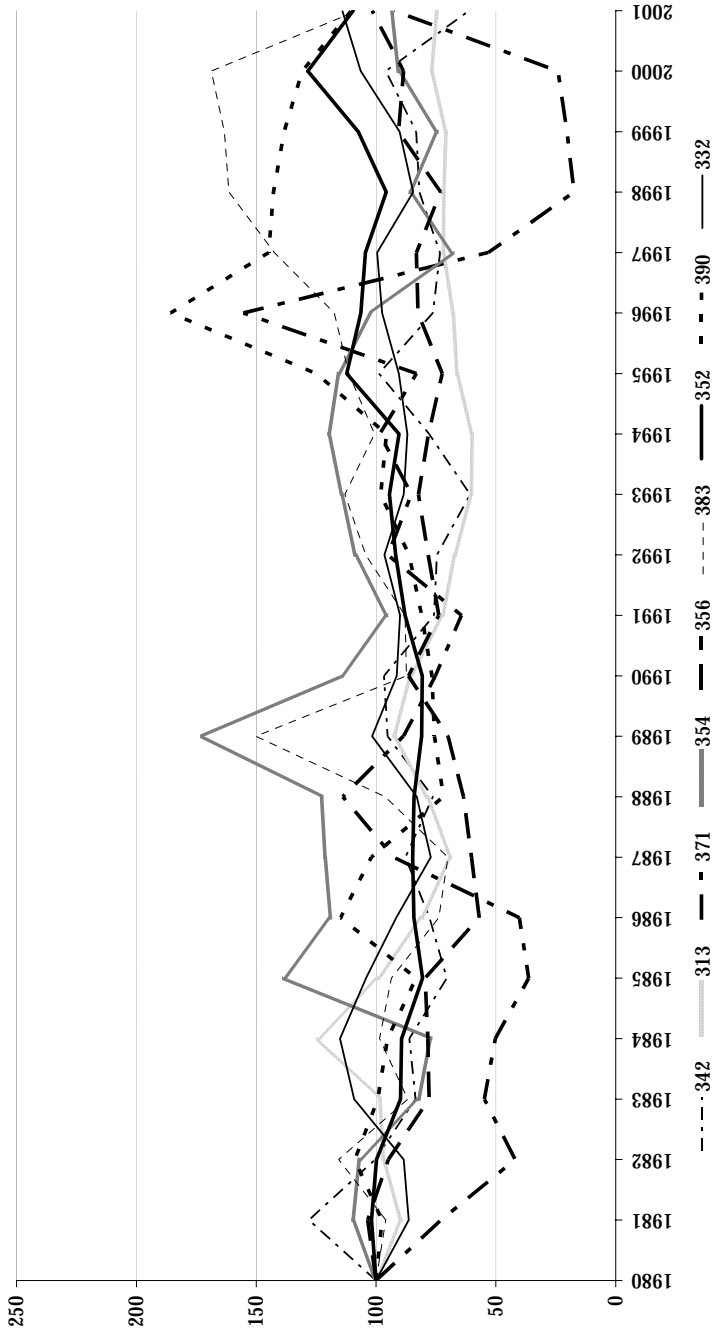
$$(4) \quad p_{it} = \hat{\omega}_{it} = y_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_s l_{it}^s - \hat{\beta}_u l_{it}^u - \hat{\beta}_m m_{it}$$

Following the literature, we define aggregate productivity at the 3-digit industry level as

$$(5) \quad \Omega_t = \sum_i \theta_{it} \exp(\hat{\omega}_{it})$$

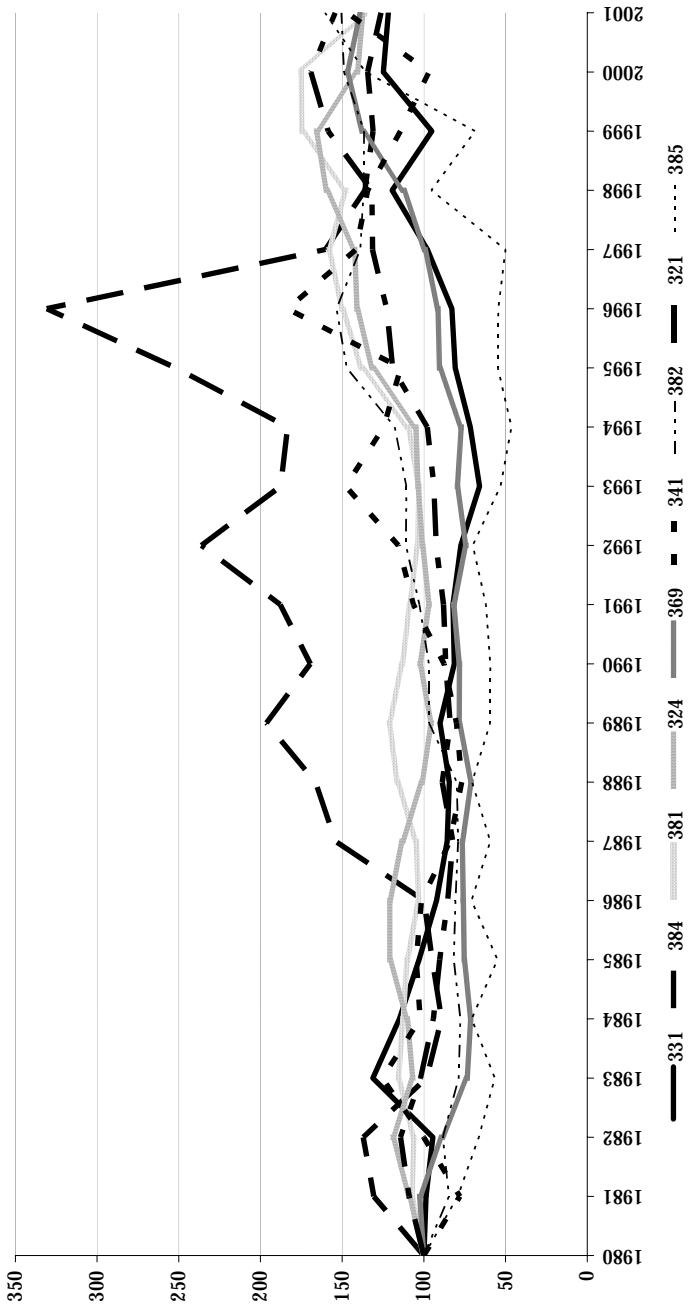
where θ_{it} is the share of plant's i gross revenue in sectoral gross revenue at time t . Figures 2a-2c displays the full dynamics of this weighted average productivity at the industry level. All series are normalized to 100 in 1980. Sectors were classified according to their average productivity growth rate over the period. These rates vary from -2.3% and 7.1% per year (sectors 342, printing and publishing, and 372, non-ferrous metal industries, respectively). Although productivity fluctuates largely over time, 23 out of the 27 sectors display a positive annual average productivity growth, indicating that most manufacturing sectors

FIGURE 2A
WEIGHTED AVERAGE PRODUCTIVITY AT THE INDUSTRY LEVEL
LOW PRODUCTIVITY GROWTH INDUSTRIES



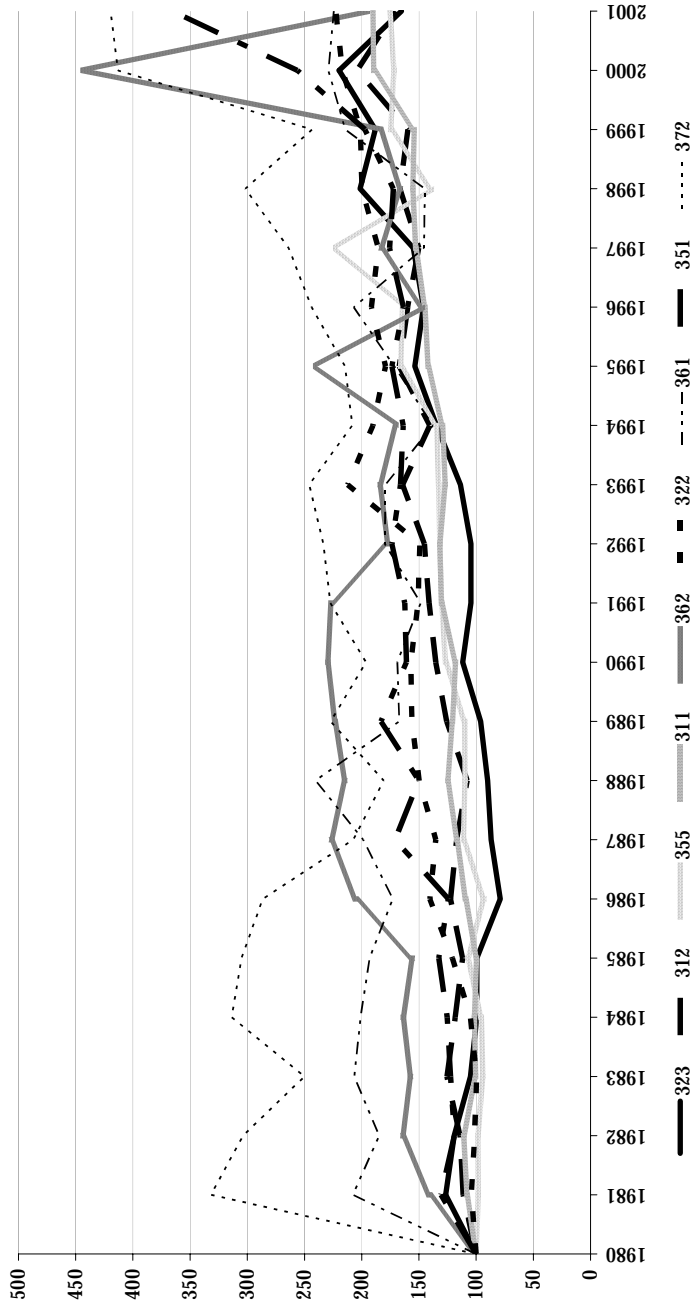
Source: Authors' calculations.

FIGURE 2B
WEIGHTED AVERAGE PRODUCTIVITY AT INDUSTRY LEVEL
MID PRODUCTIVITY GROWTH INDUSTRIES



Source: Authors' calculations.

FIGURE 2C
WEIGHTED AVERAGE PRODUCTIVITY AT INDUSTRY LEVEL
HIGH PRODUCTIVITY GROWTH INDUSTRIES

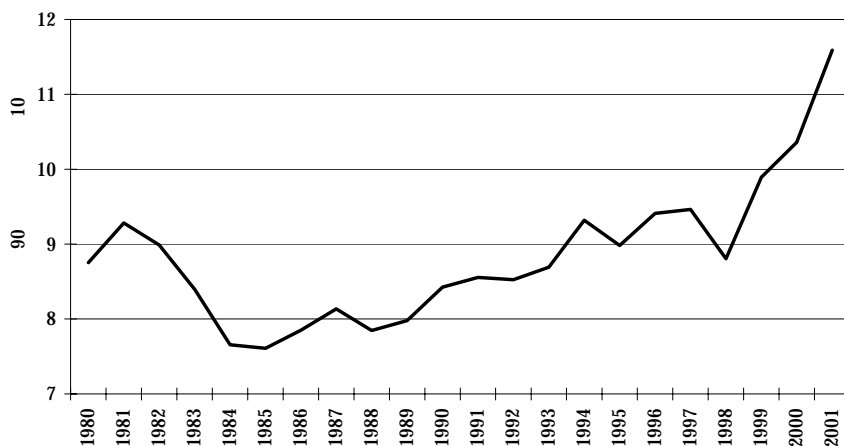


Source: Authors' calculations.

have become more productive in Chile over the period of analysis – the exception being sectors 313, 342, 354 and 371. In other words, mean productivity growth is positive reflecting that, over time, industries are growing faster than inputs.

Our estimates of TFP show that there are wide differences in efficiency levels, even within a sector in any given year. Figure 3 provides evidence of such heterogeneity. The figure shows the ratio of productivity for plants in the ninetieth percentile of the productivity distribution relative to the productivity of plants in the tenth percentile. These ratios are large, ranging from 8.1 to 11.6. Calculations for specific three-digit sectors are consistent. These large differences in productivity are a necessary condition for reallocation to be a quantitatively relevant source of efficiency gains.

FIGURE 3
TFP DISPERSION
ALL SECTORS



Source: Authors' calculations.

It is interesting to note that over the 1990s, plant-level dispersion increased, in spite of the reduction in aggregate volatility relative to the 1980s.¹⁶ This higher relative heterogeneity during the 1990s may reflect a higher degree of flexibility after the full implementation of market structural reforms a decade earlier.¹⁷ Greater flexibility allows for a more heterogeneous group of firms to enter the market and for greater process experimentation, as credit markets deepened and bankruptcy laws and dismissal costs were lowered. Moreover, trade

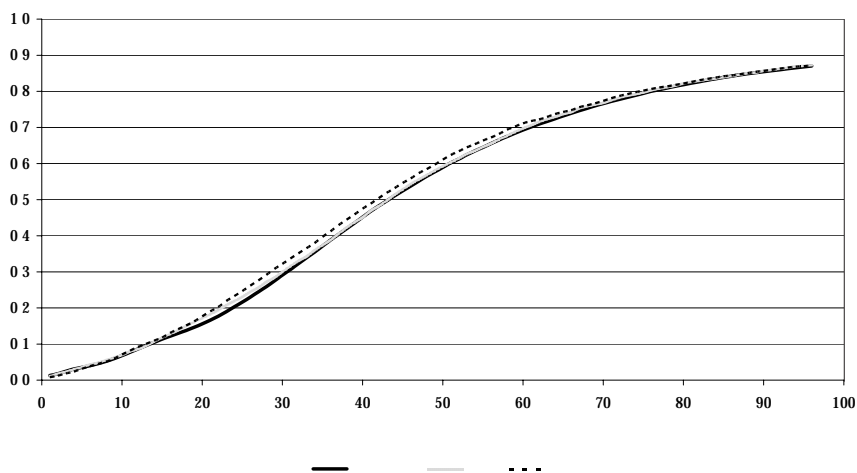
¹⁶Comin and Mulani (2005) shows that volatility at the aggregate level has decreased in Canada and the US over the past two decades, meanwhile volatility at the firm level has increased.

¹⁷Eslava *et al.* (2004) also find that productivity heterogeneity increased after major reforms were implemented in Colombia.

reform segmented firms into those that export and those that do not, depending upon their efficiency. Trade opening selected the best firms into export markets, those who could profitably pay the costs of exporting, and left the less efficient surviving firms to exclusively produce for the domestic market.¹⁸ Finally, the rise in TFP dispersion is also consistent with increases in market segmentation, as less productive plants can survive whenever there are departures from complete output homogeneity.

In general, our estimates of plant-level efficiency are consistent with expected patterns. For instance, Figure 4 presents the cumulative distribution of productivity for incumbent plants, shutdowns and startups. No matter the level of productivity, the TFP distribution of plants that exit is to the left of the distribution of productivity of continuing plants. In other words, the probability of exceeding any given level of productivity is higher among continuing plants than shutdowns, and thus the first distribution first order stochastically dominates the second one. The Barrett and Donaldson (2003) test does not reject the hypothesis of first order stochastic dominance in both cases. The p-values are 7.15% for the comparison between the CDF of continuing plants and entrants, and 0.00% for the comparison between the CDF of continuing plants and shutdowns.¹⁹ Moreover, bigger, older, and more outward oriented plants are more productive.²⁰

FIGURE 4
CUMULATIVE DISTRIBUTION OF TFP



Source: Authors' calculations.

¹⁸See Melitz (2003) for a theoretical model and Bergoening, Micco and Repetto (2005) for Chilean evidence.

¹⁹The test rejects the hypothesis that the distribution of TFP of entrants stochastically dominates that of shutdowns, and viceversa.

²⁰See Bergoening, Hernando and Repetto (2005b) for a complete characterization of Chilean plant-level productivity dynamics.

4. THE MICRO SOURCES OF AGGREGATE PRODUCTIVITY IN CHILE

In this section we use our estimates of plant-level TFP to study the microeconomic sources of aggregate growth in Chile during the past two decades. We do so by disentangling aggregate productivity dynamics into two processes: first, the changes in efficiency within firms; second, the reallocation arising from the expansion and contraction of continuing plants as well as from the entry and exit of economic units.

We follow Foster, Haltiwanger, and Krizan (1998) in decomposing productivity growth into four elements: (i) a within-plant effect, given by incumbents' productivity growth weighted by initial output shares; (ii) a between-plant effect, that captures the gains in aggregate productivity coming from the expanding market share of high productivity plants relative to the initial aggregate productivity level; (iii) an entry effect which is the sum of the differences between each entering plant's productivity and initial aggregate productivity, weighted by its market share; and (iv) an exit effect given by the sum of the differences between each exiting plant's productivity and initial aggregate productivity, weighted by its market share.²¹ The decomposition is given by:

$$(6) \quad \Delta P_t = \sum_{i \in C} \theta_{it-k} \Delta p_{it} + \sum_{i \in C} (\Delta \theta_{it})(p_{it} - P_{t-k}) \\ + \sum_{i \in N} \theta_{it}(p_{it} - P_{t-k}) - \sum_{i \in X} \theta_{it-k}(p_{it-k} - P_{t-k})$$

where Δ refers to changes over the k -year interval; P_t is the log aggregate productivity level of the sector in year t ; θ_{it} is the share of plant's i value added in sectoral value added at time t , and C , N , and X are sets of continuing, entering, and exiting plants, respectively. Thus, incumbents contribute to aggregate log productivity growth if they become more efficient, or if the more productive plants increase their market share. New plants contribute positively to productivity growth whenever their higher productivity is higher than the initial industry average. Exiters do so whenever they are less productive than the initial industry average. The last three terms of the decomposition capture the effects of heterogeneity. If all plants were identical, then the within-continuers effect would constitute the only source of aggregate gains.

Table 3 displays our decomposition results. We report them for the full period and four sub-periods: 1981-83, 1983-90, 1990-97, and 1997-2001. We also present total log TFP growth using total GDP from national accounts for comparison. Over the early 80s crisis, aggregate manufacturing TFP in the ENIA grew due to the reallocation of resources. Thus TFP growth reduced the extent of the crisis within the manufacturing sector. Plants that failed were less productive

²¹There exist several alternative decomposition methods that follow this tradition. See Foster, Haltiwanger, and Krizan (1998) for further discussions on alternative decomposition methods.

TABLE 3
DECOMPOSITION OF LOG TFP GROWTH IN MANUFACTURING

	Total Change		Decomposition of TFP Growth in ENIA					
	National	Manufact.	Incumbents		Entry	Exit	% of Total	
	Accounts	ENIA	Within	Across			Within	Total Realloc.
1983-1981	-0.107	0.209	-0.019	0.174	0.045	-0.008	-9.1	109.1
1990-1983	0.067	-0.027	-0.027	-0.002	0.036	0.033	100.0	0.0
1997-1990	0.309	0.265	0.181	-0.045	0.152	0.022	68.1	31.9
2001-1997	0.041	0.053	0.119	0.008	0.185	0.259	225.5	-125.5
2001-1980	0.323	0.566	0.019	-0.045	0.724	0.133	3.3	96.7

Source: Authors' estimates.

than the average, and resources were reshuffled towards more productive incumbents. Although entry exerted a positive effect, its contribution was low relative to that of reallocation across incumbents. Within-plant productivity growth was negative.

During the rest of 1980s aggregate TFP fell, driven by a negative contribution of within-plant productivity growth. Over the 1990s, however, TFP grew significantly with a positive contribution of the within-plant effect. Except for the slowdown experienced after 1997, total reallocation is large and positive.

Overall, reallocation captured almost all TFP growth in the long run -96.7% during the 1980-2001 period-. This effect was mostly driven by the entry of new, more productive economic units. Compared to firms that were already producing in the early 1980s, entrants faced a more flexible economy, a superior technology, better access to credit markets, and a higher supply of skilled labor.

5. CONCLUDING REMARKS

Using Chilean manufacturing plants data for the 1980-2001 period, we have estimated micro level TFPs and found that reallocation is key for aggregate efficiency changes. The reshuffling of resources across incumbents, and especially the entry and exit process, accounted for almost all of total efficiency gains in Chile during the last two decades. Moreover, within-plant productivity growth contributes positively only during the 1990s, consistently with the existence of a lag between the implementation of major market oriented structural reforms -mostly undertaken during the late 1970s and early 1980s- and their complete effect on the economy. Once reforms were consolidated, unbounded within-plant efficiency gains driven by technology adoption and innovation occurred.

The policy implication is evident: exposing firms to the best practices -for instance through market oriented policies- is key to generate conditions

that promote aggregate growth. On the opposite side, rigidities that block the natural process of birth, expansion, and death of plants, and the reallocation of resources among economic units, impede growth and limit development. Indeed, flexibility is key to growth.

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PROCYCLICAL PRODUCTIVITY IN MANUFACTURING

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We study the cyclical behavior of labor productivity in eighty industries of the Chilean manufacturing sector in the 1979-2001 period. We find that labor productivity at the sector-level is procyclical but it is a-cyclical when using aggregate data. We provide an analytical and empirical explanation for this divergence. We also use an econometric model to quantify the determinants of productivity. The results indicate that technology shocks account for one half of productivity growth, thus supporting the supply shocks hypothesis as the main source of business cycles in Chile. The other 50% of the productivity changes is explained by reallocation of resources from less to more productive sectors as well as the presence of increasing returns. Variations in factor utilization were insignificant.

JEL: E32, J24, C1

Keywords: Productivity, Procyclical, Manufacturing, Aggregation Bias.

1. INTRODUCTION

It is now generally accepted that aggregate labor productivity tends to rise during booms and fall during recessions¹. This fact is at odds with classical economic theory which suggests that labor productivity should be countercyclical

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¹See Baily *et al.* (2001) and Basu *et al.* (2001) for US evidence and econometric tests. Estrella (2004) challenges this evidence using spectral analysis to find that productivity in the US is uncorrelated to business cycles. De Long and Waldmann (1997) provide evidence of procyclicality for European economies. Solimano and Soto (2006) find that average productivity is also procyclical in 12 Latin American economies in the 1960-2004 period.

as a result of the law of diminishing returns to factors. Traditional explanations for this puzzle are procyclical technology shocks (e.g., Kydland and Prescott, 1982), imperfect competition and increasing returns (e.g., Hall, 1990), and variable capital utilization and labor hoarding (e.g., Burnside *et al.*, 1993).

An important limitation of this literature is its reliance on aggregate data. While useful, aggregate data are limited by biases arising from the construction of aggregate series of productivity, capacity utilization, and resource relocation. As shown in this paper, the composition of aggregate productivity indexes can severely distort the measurement of the cyclical properties of productivity. A second limitation is that most of the evidence is only available for developed economies.² Data from developing economies –which remains largely unexplored– could provide important insights to understand the response of firms to shocks, given that economic cycles tend to be more pronounced in emerging economies.

In this paper we use data from the Chilean manufacturing firms for the 1979-2001 period to study the cyclical behavior of labor productivity at the sector level, its determinants, and its relationship with economic activity. The Chilean case is interesting because its economy is very dynamic, small for international standards but quite open to foreign markets, and largely free of preferential tax treatments for selected industries. The economy has grown at impressive rates in the last two decades while, at the same time, it has been subject to significant external shocks. Consequently, firms have had to continuously adjust to a changing environment. Studies using macroeconomic data suggest that the impressive annual growth rate of 5% in the last 20 years is largely the result of technological innovation and a dramatic change in capital-labor ratios (Bergoeing *et al.*, 2002). At the microeconomic level, Camhi *et al.* (1997) provide evidence that productivity increased in the 1979-1994 period as a result of the entry of new firms that were more efficient than incumbents.

A simple model is developed in section 2 to provide a framework for the analysis, embedding five alternative hypotheses on the correlation between labor productivity and economic cycles. In section 3 we encompass these hypotheses in a testable specification, which takes into account the nature of the data, the need to control for changes in the use of intermediate goods, and the implications of aggregating firm-level productivity. Section 4 describes the structure of the data and presents evidence of procyclical labor productivity at the aggregate level. However, we find no evidence of procyclicality when using the aggregate data of the ENIA firms; correlation is 0.06. When studying this correlation industry by industry we found that most sectors exhibit significant procyclical productivity; the simple average of the individual correlations is around 0.64. Section 5 reconciles this apparently conflicting individual and aggregate evidence both from an analytical and empirical point of view. It documents that aggregation

²Exceptions are Bergoeing *et al.* (2004), Eslava *et al.* (2004), Schor (2004) and Casacuberta, Gandelman, and Soto (2004).

biases arising in the construction of the aggregate productivity series distort the cross-industry correlation between cycles in labor productivity and economic activity. This reflects the substantial heterogeneity not only in the productivity structure of ENIA firms but also in the timing of the cycles of the different industries. Productivity is procyclical across industries but the cyclical phases of the industries are significantly different between each other, leading to an aggregate a-cyclical productivity.

Section 6 tests the determinants of productivity in the Chilean industry using an econometric model that allows us to quantify the relative contribution of the above mentioned explanations of procyclical productivity. The results indicate that technology shocks account for around one half of productivity changes in the 1979-2001 period, thus supporting the supply shocks hypothesis as the main source of business cycles in Chile. The other half of the productivity changes are explained mainly by the exploitation of increasing returns in the 1980s and by reallocation effects between industries of different productivity in the 1990s. Variations in the utilization rates of inputs tend to play a less significant contribution to changes in productivity in the long run. Section 7 collects the main conclusions.

2. ALTERNATIVE EXPLANATIONS FOR LABOR PRODUCTIVITY CYCLES

We develop a stylized, flexible model of market interaction to derive our average labor productivity measure and its correlation with business cycles. The starting point of the analysis is the following generalized function:

$$(1) \quad Y_{it} = A_{it} F(u_{it} K_{it}, e_{it} L_{it}) Y_t^\nu$$

where F is a generic production function, Y_{it} is the real value added of the firm i at time t , A_{it} is a strictly positive level of technology, K_{it} is the stock of capital and u_{it} its utilization rate, L_{it} represents total hours worked and e_{it} is the effort per unit of work, and Y_t is the aggregate output of the industry in which the firm operates. Utilization and effort variables are in the $[0,1]$ interval. Parameter ν in the internal $[0,1]$ denotes the existence of external effects, as described below.

Assume that each firm faces a demand curve with constant price-elasticity. The inverse demand curve is:

$$(2) \quad P_{it} = D_{it} e^{\eta_{it}} Y_{it}^{-\phi}$$

where P_{it} is the price of the good produced by the firm, D_{it} is a parameter that captures idiosyncratic features in the demand, η_{it} is a stochastic i.i.d. shock that affects all firms, and ϕ is a constant that allows for either competitive ($\phi = 1$) or imperfectly competitive behavior ($\phi < 1$).

Technology evolves according to the following law of motion:

$$(3) \quad A_{it} = (1 - \rho) A_0 + \rho A_{it-1} + \varepsilon_{it}$$

where ε_{it} is a stochastic i.i.d. technology shock and ρ is a constant with values between 0 and 1. These three equations describe the structure of the economy. We assume equilibrium at all times.

Productivity cyclicalness is assessed using the correlation between cyclical measures of output and average labor productivity. When such correlation is positive, labor productivity is said to be procyclical; likewise, when it is negative productivity is dubbed countercyclical. Cyclical fluctuations in labor productivity arise as a result of supply and demand shocks. Consequently, we study the sign of $d(Y_{it}/L_{it})/d\tau_{it}$ (where τ_{it} is either a supply or a demand shock) and its correlation to output under alternative assumptions about the structure of the economy. There are five cases of interest, which we discuss below, stressing either supply side elements (as in the business cycle literature) or demand-driven elements, as in classical economics or in the more recent models of factor hoarding and of external effects affecting firm's production and productivity.

Traditional Model. This model assumes that there are no external effects, unused capital, or idle labor in the firm. It also assumes that technology is stationary. Consequently, the production function becomes $Y_{it} = A_i F(K_{it}, L_{it})$ and the response of productivity to demand shocks (η_{it}) is:

$$(4) \quad \frac{d(Y_{it}/L_{it})}{d\eta_{it}} = A_i \left(\frac{L_{it} F_{it}^l - F_{it}}{L_{it}^2} \right) \frac{\partial L_{it}}{\partial \eta_{it}} \leq 0$$

where $F_{it}^l = \partial L_{it} / \partial Y_{it}$ denotes the derivative of the production function with respect to labor. Equation (4) is usually negative because $\partial L_{it} / \partial \eta_{it}$ is positive and the term in the parenthesis is negative since $L_{it} F_{it}^l$ is the equilibrium payment to labor. Therefore, average labor productivity is countercyclical. The intuition is that firms do not change their production technology and, therefore, in the short run demand shocks induce a movement along the (decreasing) marginal productivity curve.

Technology shocks. This explanation –as proposed in the real business cycles literature pioneered by Kydland and Prescott (1982)– focuses on technology shocks (ε_{it}) as the driving force of economic cycles. Assume that there are no external effects, unused capital, or idle labor in the firm. In such case, the production function is similar to that in the traditional model, except that productivity is now time-varying. Average labor productivity becomes procyclical since:

$$(5) \quad \frac{d(Y_{it} / L_{it})}{d\varepsilon_{it}} = A_{it} \frac{Y_{it}}{L_{it}} \frac{\partial Y_{it}}{\partial A_{it}} \frac{\partial A_{it}}{\partial \varepsilon_{it}} > 0$$

Labor hoarding. Following Baily *et al.* (2001), assume that there are no external effects, technology shocks, or unused capital but labor comprises time allocated to production, q_{it} , and time dedicated to maintenance and training, m_{it} . Naturally, $q_{it} + m_{it} = L_{it}$. The component m_{it} is thought of as producing human capital and/or providing maintenance to the stock of capital that, otherwise, should be added to the capital input measure or included as a new factor in the production function. From equation (1) $q_{it} = e_{it}L_{it}$, hence $m_{it} > 0$ when $e_{it} < 1$. Hoarding occurs due to the existence of labor rigidities in the short run (e.g., fire and hire costs); firms adjust the effort of workers and reassign the labor force to non-directly productive activities such as maintenance or training. The response of average labor productivity to demand shocks in this case is:

$$(6) \quad \frac{d(Y_{it} / L_{it})}{d\eta_{it}} = A_i \left(\frac{e_{it}F_{it}^l - F_{it}}{l_{it}^2} \right) \frac{\partial L_{it}}{\partial \eta_{it}} + A_i F_{it}^l \frac{\partial e_{it}}{\partial \eta_{it}}$$

Equation (6) is similar to that of the traditional model, except for the scaling to e_{it} and the second term. Since the latter is positive, labor productivity could be procyclical if m_{it} is large enough (or effort e_{it} is small enough). That is, introducing varying levels of effort, the response of labor productivity to a demand shock could be the opposite of that in the traditional model.

Increasing returns to scale. In the absence of technology shocks and labor hoarding, one should expect that firms vary the effective utilization of inputs proportionally when the production function has increasing returns to scale (Hall, 1990 and Basu, 1996). It can be assumed that the rate of capital utilization displays a linear relationship with labor demand, $u_{it}K_{it} = \phi L_{it}$. The production function becomes $Y_{it} = A_i F(\phi L_{it}, L_{it})$ and the response of labor productivity to a demand shock is procyclical, since:

$$(7) \quad \frac{d(Y_{it} / L_{it})}{d\eta_{it}} = A_i \frac{\partial L_{it}}{\partial \eta_{it}} \left(\frac{L_{it} (dF_{it} / dL_{it}) - F_{it}}{L_{it}^2} \right) > 0$$

External effects. Following Caballero and Lyons (1992) assume that production takes place in the traditional environment, except for the presence of external effects not associated to input variations. These externalities could emerge from the increased possibilities of matching among agents (and profits) that arise in large-size markets. Since the magnitude of transactions between firms and their

customers is the key factor in the transmission of short-run external effects, these externalities are captured in the production function through a factor that consider the level of aggregate economic activity ($\nu > 0$). The effect of economic activity on the fluctuations of average labor productivity is clearly positive:

$$(8) \quad \frac{d(Y_{it} / L_{it})}{d\eta_{it}} = A_i \frac{\partial Y_{it}}{\partial Y_t} \frac{Y_{it}}{L_{it}} > 0$$

3. MODEL ENCOMPASSING

When confronting these alternative explanations of procyclical labor productivity with the data it is necessary to setup an encompassing model and deal with the existence of intermediate inputs and market power. Fernald and Basu (2000) show that conventional measures of labor productivity (e.g., value added per worker) are sensitive to changes in intermediate goods and, thus, do not provide a reliable basis for assessing its cyclical properties. We start by including intermediate inputs in the production function and, then, decompose gross-output growth in terms of variations in utilization of inputs, imperfect competition, and technical change. Next, we focus on aggregation issues.

Dealing with intermediate inputs

As a starting point, consider the following gross-output (GY) equation

$$(9) \quad GY_{it} = F^i(\tilde{K}_{it}, \tilde{L}_{it}, M_{it}, T_{it})$$

where $\tilde{K}_{it} = u_{it}K_{it}$ and $\tilde{L}_{it} = e_{it}L_{it}$, M_{it} represents intermediate inputs and T_{it} is a technology index included to capture the correct Solow residual in the empirical estimations.

Let the firm's production function be locally homogeneous of degree γ in total inputs (constant returns implies that $\gamma = 1$). Returns to scale can be written in two equivalent forms. First, as the sum of output elasticities

$\gamma_{it} = \frac{F_{it}^K \tilde{K}_{it}}{Y_{it}} + \frac{F_{it}^L \tilde{L}_{it}}{Y_{it}} + \frac{F_{it}^M M_{it}}{Y_{it}}$. Second, if the firm minimizes costs, the *local* degree of returns to scale is the inverse of the elasticity of costs with respect to output

$\gamma_{it}(GY_{it}) = \frac{C_{it}(GY_{it})}{GY_{it} MC_{it}(GY_{it})} = \frac{C_{it}(GY_{it}) / GY_{it}}{MC_{it}(GY_{it})} = \frac{AC_{it}(GY_{it})}{MC_{it}(GY_{it})}$ where C_{it} is the total cost function, AC_{it} is the average cost, and MC_{it} is the marginal cost. Increasing returns may reflect overhead (fixed) costs or decreasing marginal cost; both imply that average cost exceeds marginal cost. If increasing returns take the form of

overhead costs, then $\gamma_{it}(GY_{it})$ is not a constant structural parameter, but depends on the level of output of the firm. As production increases, returns to scale fall as the firm moves down its average cost curve.

Assume that firms charge a price that is a markup over marginal cost $\mu_{it} = P_{it} / MC_{it}$. The markup is a behavioral parameter while returns to scale are a property of the production function. Nevertheless, they are related:

$$(10) \quad \gamma_{it}(GY_{it}) = \frac{C_{it}(GY_{it})}{GY_{it}MC_{it}(GY_{it})} = \frac{P_{it}}{MC_{it}(GY_{it})} \frac{C_{it}(GY_{it})}{P_{it}GY_{it}} = \mu_{it}(1 - s_{it})$$

where s_{it} is the share of pure economic profit in gross revenue. From equation (10) it is clear that if economic profits are small (or zero as in perfect competition) markups tend to be approximately equal to returns to scale.

Taking log differences of equation (9) –which we denote by d – we can express changes in gross output as:

$$(11) \quad dGY_{it} = \frac{F_{it}^K \tilde{K}_{it}}{Y_{it}} d\tilde{K}_{it} + \frac{F_{it}^L \tilde{L}_{it}}{Y_{it}} d\tilde{L}_{it} + \frac{F_{it}^M M_{it}}{Y_{it}} dM_{it} + dt_{it}$$

Cost minimization puts additional structure to this equation. If firms take the price of all the inputs as given, the first order conditions for cost minimization are $P_{it}F_{it}^j = \mu_{it}P_{it}^j$ where $j=K, L$, or M . These conditions allow us to write output elasticities as the product of the markups multiplied by the share of the expenditure on each input divided by gross output:

$$(12) \quad F_{it}^j = \mu_{it} \frac{P_{it}^j J_i}{P_{it}GY_{it}} = \mu_{it}s_{it}^j$$

The shares s_{it}^K , s_{it}^L and s_{it}^M add up to less than one when firms make pure profits. Substituting for output elasticities in equation (11) and making explicit the utilization level of capital and effort by worker we obtain:

$$(13) \quad dGY_{it} = \mu_{it} \left(s_{it}^K (dK_{it} + du_{it}) + s_{it}^L (dL_{it} + de_{it}) + s_{it}^M dM_{it} \right) + dt_{it}$$

collecting terms

$$(14) \quad \begin{aligned} dGY_{it} &= \mu_{it} \left(s_{it}^K dK_{it} + s_{it}^L dL_{it} + s_{it}^M dM_{it} \right) + \mu_{it} (1 - s_{it}^M) \left[\frac{s_{it}^K du_{it} + s_{it}^L de_{it}}{1 - s_{it}^M} \right] + dt_{it} \\ &= \mu_{it} dx_{it} + \mu_{it} (1 - s_{it}^M) dw_{it} + dt_{it} \end{aligned}$$

hence, the growth in gross output (dGY_{it}) can be written as a function of a revenue-weighted measure of growth in inputs (dx_{it}), a proxy for variations in capital utilization and effort (dw_{it}), and a residual that captures technical change (dt_{it}).

Since we are interested in average labor productivity defined as value added per worker, it is necessary to adjust equation (14) accordingly. Valued added growth is calculated by subtracting from gross output the contribution of intermediate goods weighed by revenue share. Define the growth rate in a firm's value added dVA_{it} as:

$$(15) \quad dVA_{it} = \frac{dGY_{it} - s_{it}^M dM_{it}}{1 - s_{it}^M}$$

consequently,

$$(16) \quad dVA_{it} = \mu_i \left(\frac{s_{it}^K}{1 - s_{it}^M} dK_{it} + \frac{s_{it}^L}{1 - s_{it}^M} dL_{it} + dw_{it} \right) + (\mu_i - 1) \frac{s_{it}^M}{1 - s_{it}^M} dM_{it} + \frac{dt_{it}}{1 - s_{it}^M}$$

Equation (16) implies that valued added growth does not subtract the full productive contribution of intermediate inputs. In the presence of markups the output elasticity of intermediate goods is greater than its revenue share. Changes in output will not lead to proportional changes in the use of intermediate inputs. Therefore, value-added growth does not subtract off the full productive contribution of intermediate inputs. It is possible that value added growth could be a function of primary input growth alone, in the case where intermediate inputs move in tandem with primary inputs (e.g., fixed proportions).

Equation (16) can also be rewritten as:

$$(17) \quad dVA_{it} = \mu_i \left(\frac{s_{it}^K}{1 - s_{it}^M} dK_{it} + \frac{s_{it}^L}{1 - s_{it}^M} dL_{it} \right) + \frac{\mu_i}{1 - s_{it}^M} dw_{it} + \left(\frac{\mu_i}{1 - s_{it}^M} - 1 \right) \frac{s_{it}^M}{1 - s_{it}^M} (dM_{it} - dGY_{it}) + \frac{dt_{it}}{1 - s_{it}^M}$$

Again, equation (17) indicates that value added growth is related to growth rates of primary inputs, factor utilization, the share of intermediate goods in output ratio, and technology changes.

Aggregation

Since the empirical analysis is performed at the industry level, aggregation is necessary. Aggregate inputs are defined as the simple sum of industry levels quantities. The aggregate value added growth rate is defined as $dVA_t = \sum_{i=1}^N \theta_i dVA_{it}$, where θ_i is the firm's share of nominal value added in the industry. Fernald and Basu (2000) show that using this definition and equation (17) it is possible to derive the basic aggregation equation:

$$(18) \quad dVA_t = \bar{\mu}_t^v dx_t^v + du_t + R_t + dt_t^v$$

where $dx^v = s_L^v dL + s_K^v dK$ is the growth in revenue-share-weighted aggregate primary inputs, $\bar{\mu}_t^v = \sum_{i=1}^N w_{it} \mu_{it}^v$ is the average-firm value-added markup, $du_t = \sum_{i=1}^N w_{it} \mu_{it}^v du_{it}$ is the average-firm utilization growth (weighted by markups), and $dt_t^v = \sum_{i=1}^N w_{it} \frac{dt_{it}}{1 - \mu_{it}^v}$ is the average value-added technology change.

Variable R_t represents the various outcomes that arise from the reallocation of resources and production within each industry due to the heterogeneity of firms. First, reallocating resources from low- to high-markup firms shifts resources towards uses that are more highly valued by consumers. If the variability of firms' inputs is correlated with market power, then imperfect competition affects aggregate productivity even if the average markup is small. Second, shifting labor and capital from firms where it has a low shadow value to firms where it has a high shadow value increases aggregate output and average productivity. Third, reallocation of materials reflects the extent to which measured real value added depends on the intensity of intermediate-input use. Firm-level value added is useful for national accounting, regardless of technology or market structure. However, with imperfect competition, value-added growth does not subtract off the full marginal product of intermediate inputs. Growth in primary inputs captures some of this productive contribution, but some "wedge" may remain.

Aggregate labor productivity growth is defined as $z_t = \frac{VA_t}{L_t}$, hence:

$$(19) \quad \begin{aligned} dz_t &= dVA_t - dL_t = \bar{\mu}_t^v dx_t^v + du_t + R_t + dt_t^v - dL_t \\ &= \bar{\mu}_t^v dK_t^v + (\bar{\mu}_t^v - 1)dL_t + du_t + R_t + dt_t^v \end{aligned}$$

4. EVIDENCE ON AVERAGE LABOR PRODUCTIVITY

The industrial sector in Chile represented around 18% of GDP in the 1979-2001 period and accounted for nearly 35% of exports and 15% of employment (see Table 1). The share of industry in GDP has gradually declined over the years as a result of the expansion of services, yet it remains as an important sector in terms of wealth creation, labor demand, and exports. For the empirical section we split the sample in two sub-periods. The first sub-period, running from 1979 to 1990, is characterized by major structural and sector reforms (including domestic market liberalization, privatization of state-owned firms, and opening the economy to foreign competition) and also by the severe recession of

1982- 1983. The second sub-period of 1991-2001 is characterized by macroeconomic stability, vigorous growth, and a marked increase in average productivity levels. While this period is considered to be one of the most successful in Chilean history (dubbed the “golden decade”), the depth and length of the 1998-2001 recession unveiled an important sensitivity of the economy to negative shocks.

These two distinctive periods of Chile’s economic history allow us to study the response of firms and sectors to very different environments. As the economy underwent deep structural transformations in the 1980s and 1990s, relative prices changed dramatically. The relative price between traded and non-traded goods changed as a result of opening to foreign competition; the relative price of factors and intermediate goods changed as a result of market liberalization; and the relative cost of technology changed as firms were granted access to international markets at stable, competitive exchange rates. Consequently, there were significant changes in the incentives faced by firms, leading to substantial adjustments within firms, among firms, and across sectors. In all sectors, firm entry and exit was substantial. Bergoing and Repetto (2006) estimate entry and exit rates at around 6% per year. The 1991-2001 period, on the other hand, was comparatively more stable, thus allowing firms to engage in longer-horizon investments. The response of industrial firms was not as vigorous as that of GDP, as seen in Table 1, but exports expanded substantially.

Aggregate figures, however, hide a wealth of experiences at the sector and firm level. In order to explore the microeconomic side of economic growth in Chile, we use data from the National Annual Manufacturing Survey (ENIA) produced by the Chilean Bureau of Statistics (INE). The ENIA survey provides information for about 5,000 plants per year, operating with more than ten workers in eighty industries from 1979 to 2001. In this study, the unit of observation for the empirical analysis is a four-digit International Standard Industry Classification (ISIC) code industry.

TABLE 1
SIZE OF THE CHILEAN INDUSTRY

Period	Share of industry (%) in:		
	GDP	Employment	Exports
1979-2001	17.7	15.6	35.9
1979-1990	19.5	15.4	30.9
1991-2001	15.8	15.5	41.4

Source: author’s elaboration based on Central Bank of Chile (2005).

The database was initially obtained for the period 1979-1997 and later updated to 2001 using plant-level information and our aggregation methodology. Plant-level data is available for the 1979-2001 period but inconsistencies make it difficult to aggregate the information to obtain robust industry series at the four-digit ISIC level. As a robustness check of our calculation, we matched our aggregation for 1997 to that provided by ENIA. The methodology to deal with data inconsistencies is as follows. First, we removed observations with discontinuity in information across time. Second, we removed observations with no information on value added and employment, those where value added was greater than gross output, and those where value added and/or gross output were negative. As customary in empirical studies of productivity cycles, value added is defined as gross output less the total costs of intermediate goods and services plus the net change in inventories. After these adjustments we were left with a database of eighty sectors (hereafter, the ENIA sample). Although we excluded 21 sectors from the database, we deemed the restricted sample to be representative of manufacturing since the value added of the eighty industries included in the restricted sample represents more than 98% of the total value added of the original database for the whole period. We then computed a measure of total worked days, as the product of two variables reported by ENIA: average total occupation and total working days per year.³ Then, labor productivity is obtained as the quotient of value added and total days worked.

Table 2 shows the growth of the Chilean economy and industry in the 1979-2001 period. GDP grew on average at around 4.8% while employment expanded at around 2.3%, leading to an average increase in labor productivity of 2.5% per year. Industrial output and labor productivity grew more moderately at around 3% and 1%, respectively. With regards to the sample of firms used in this paper, we present data for the aggregate, average and median firm, the latter to avoid the distorting effect of a few sectors where very large firms operates. It can be seen that the growth rate of value-added in ENIA firms is comparable to that of GDP and much higher than that of the industrial sector as measured by national accounts. Employment in ENIA firms—obtained directly from the surveys—grew much slower than in the rest of the economy or the industrial sector. This explains why average labor productivity in ENIA firms grew much faster than in the rest of the economy. The differences in employment growth between ENIA firms and the rest of the economy lies in that ENIA excludes micro businesses (less than 10 employees) that are typically labor intensive. Finally, it can be seen that among ENIA firms there are differences in long-run dynamics: while in most sectors both output and growth expanded, value added in a few sectors actually contracted. However, even in these latter sectors, labor productivity ought to have expanded on average since only in six of them productivity actually decreased.

³*Average total occupation* is the average of data on employees, workers, and employers per firm surveyed on four occasions in each year (February, May, August, and November). *Total working days* is the number of days in which each firm was in activity.

TABLE 2
EVOLUTION OF VALUE ADDED, EMPLOYMENT AND PRODUCTIVITY
IN THE CHILEAN ECONOMY, INDUSTRIAL SECTOR, AND
ENIA FIRMS, ANNUAL GROWTH RATE (%) 1979-2001

	National Accounts		Sample of ENIA firms				
	GDP	Industrial Sector	Aggregate	Average firm	Median firm	Number of industries with	
						Positive growth	Negative growth
Value Added	4.8	3.0	4.2	3.5	3.1	62	18
Employment	2.3	2.0	0.4	0.2	0.1	41	39
Productivity	2.5	1.0	3.8	3.3	3.3	74	6

Source: author's elaboration based on Central Bank of Chile (2005) and ENIA.

A second interesting aspect of ENIA firms is their structural (cross section) and dynamic (time series) heterogeneity in productivity. A few sectors have very high productivity levels that distort to a large extent the average of the manufacturing sector. These are the tobacco, petroleum, copper mining, pulp plants, and paper and printing firms. Figure 1 plots average labor productivity for the ENIA sample and a sub sample excluding the sectors with largest productivity (hereafter called the restricted sample). It can be noted that when excluding those sectors, average industrial productivity is reduced by about 25%. The dispersion of productivity between sectors remains stable throughout the period. Despite the distortion in average productivity levels induced by the most productive sectors, the dynamic (time series) behavior of industrial productivity is largely unaffected, as is apparent in Figure 1. It can be seen that, after 1991, productivity recovers its pre-crisis level and starts to increase at a steady pace (around 5% per year), justifying the split of the sample in two sub periods (1979-1990) and (1991-2001) for the empirical analysis.

Figure 2 presents histograms of average labor productivity for the complete and restricted samples. The first graph shows clearly the large differences in productivity between the five most productive sectors and the rest of the industries. On average, these five sectors have productivity levels around ten times higher than the average ENIA industry. Substantial heterogeneity in productivity nevertheless persists in the restricted sample, as indicated in the second histogram.

We also study changes in the distribution of relative productivity using the quintile-based transition matrix. For 1979 and 2001, we compute the quintiles of the distribution of firms in the ENIA sample according to their productivity levels. In the last column of Table 3 it can be seen that there are substantial differences in productivity levels, being sectors in the fifth quintile around ten times more productive than those in the first two quintiles.

FIGURE 1
AVERAGE LABOR PRODUCTIVITY
ALL ENIA FIRMS IN 1979 = 100

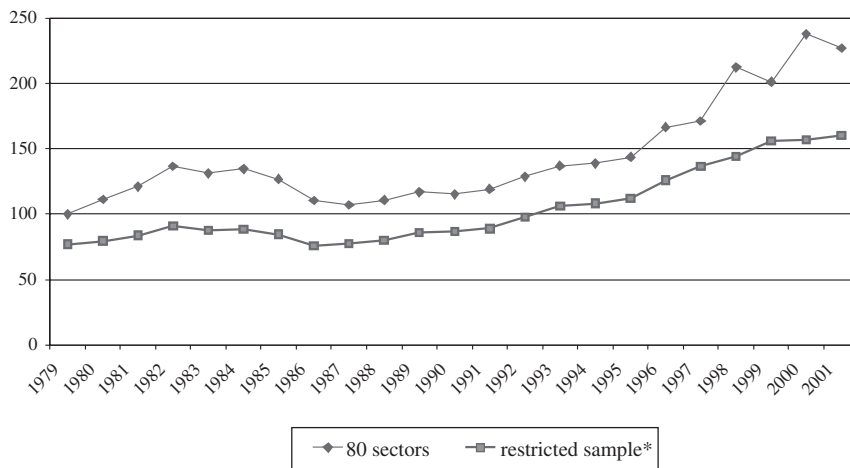
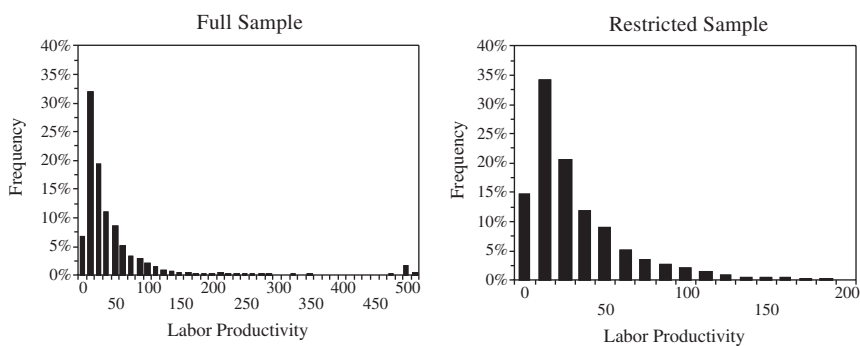


FIGURE 2
HISTOGRAMS OF LABOR PRODUCTIVITY AT THE SECTOR LEVEL,
1979-2001



Also note that sectors have very similar productivity levels in the first three quintiles, suggesting the possibility of significant dynamic adjustments among sectors in terms of productivity. The transition matrix confirms this suspicion. It computes the percentage of sectors that were in one quintile in 1979 and continued to be in such quintile or moved to different quintile in 2001. Note that we use relative productivity. So, if productivity in all sectors increases by say 5%, relative productivity and its distribution by quintiles remain unaffected. The results are presented in Table 3, with quintiles identified from 1 to 5, indicating that, for example, 12.5% of the sectors in the lowest productivity quintile in

1979 moved to the second quintile by 2001. As expected, sectors in the high productivity tail tend to remain in their origin quintiles. Around 70% of firms in the fifth quintile in 1979 –i.e. where productivity levels are around four times the average productivity in manufacturing– remained in such quintile by 2001. This is reasonable because these sectors are capital intensive, have ample access to financial resources and tend to lead in technology adoption. On the other hand, around half of the sectors at the lower end of productivity levels remain in such quintiles by 2001. It should be noted, however, that there is substantial mobility. Around 60% of the sectors that in 1979 had average productivity levels in the third quintile, changed quintile by 2001. We thus conclude that the dynamics of labor productivity have been important within and among industries in the manufacturing sector.

Finally, we study the cyclical behavior of average labor productivity using the correlation between detrended measures of labor productivity and value added. We detrend both variables using the Hodrick-Prescott (1997) filter.⁴ Table 4 presents the correlations for the economy and the industrial sector, for the complete period of analysis and the two sub-periods. For the whole economy there is evidence of procyclicality in labor productivity; correlation is 0.76 for the entire period and 0.90 in the sub period 1991-2001. This fact has been reported in previous studies (e.g., Bergoing and Soto, 2005). Nevertheless, at the industry level measured by national accounts we found the somewhat surprising result that correlations are negative, although statistically insignificant. The sample of ENIA firms presents also non-significant correlations in both sub-periods, reproducing the results of the industrial sector according to national accounts. This, again, points to the need of studying labor cyclicity at the sector level, which we undertake in the next section.

TABLE 3
TRANSITION MATRIX OF SECTOR PRODUCTIVITY LEVELS

		Quintiles in 2001					Relative productivity by quintile in 2001(*)
		1	2	3	4	5	
Quintiles in 1979	1	56.3	12.5	18.8	12.5	0.0	0.3
	2	31.3	56.3	6.3	6.3	0.0	0.5
	3	0.0	31.3	43.3	18.8	6.3	0.6
	4	12.5	0.0	25.0	37.5	25.0	1.0
	5	0.0	0.0	6.3	25.0	68.8	4.0

Source: author's elaboration based on ENIA.

Note: (*) Computed as average productivity by quintile as fraction of total manufacturing average productivity.

⁴The HP filter presents some limitations (King and Rebelo, 1993; Harvey and Jaeger, 1993). In a previous version of this paper we used three detrending methods: linear trends, the HP filter, and a heuristic filter proposed by Rotemberg (1999). Since the main conclusions were insensitive to the detrending method, we report only the HP filtered results.

TABLE 4
CORRELATIONS BETWEEN VALUE ADDED CYCLES AND
AVERAGE LABOR PRODUCTIVITY CYCLES

	GDP and labor productivity	Industry value added and industrial labor productivity	ENIA firms value added and labor productivity
1979-2001	0.76	-0.12	0.06
1979-1990	0.71	-0.19	0.07
1991-2001	0.90	0.06	0.03

Source: author’s calculation based on ENIA and Central Bank of Chile (2005).

This evidence is clear on two accounts. First, aggregate figures may distort our understanding of the dynamics of labor productivity as they smooth out important changes in productivity levels experienced by the different sectors. Second, aggregate figures may be distorted by a few very large sectors in which labor productivity is markedly higher than in the rest of the sample. Both elements suggest the importance of exploring the link between labor productivity and economic fluctuations at the sector –instead of the aggregate– level.

5. AGGREGATION BIAS

In this section we document the aggregation biases arising in the construction of the aggregate productivity series and their distorting effect on the cross-industry correlation between cycles in labor productivity and economic activity. To obtain cycles, we detrend the series for each industry using the Hodrick-Prescott filter and then compute the cyclical correlations between value added and labor productivity.

5.1. Value Added-Labor Productivity Cyclical Correlations

Consistently with our results using national accounts data, the cyclical correlation between manufacturing labor productivity and value added using the full ENIA sample is not statistically different from zero.⁵ This result contrasts significantly with the average of the cyclical correlations across industries that is positive and greater than 0.6. Consequently, the average correlation differs significantly from the correlation of aggregates. This result is unexpected considering the strong evidence of procyclicality found at the industry level in

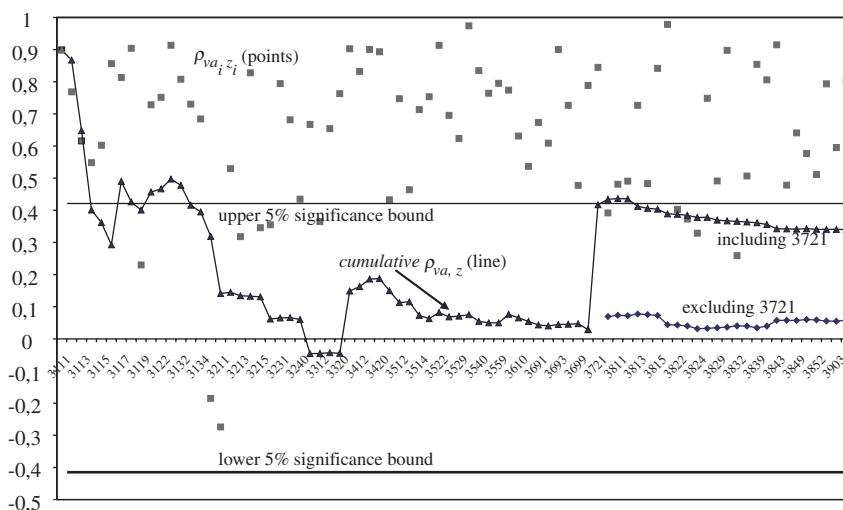
⁵This is considering the 95% confidence level. Standard error bounds computed as $\pm 2 / \sqrt{T}$.

the literature across countries (e.g., Inklaar, 2005; Jimenez and Marchetti, 2002). Hart and Malley (1999) is the only study we are aware of which finds a result similar to ours. However, they do not give much attention to this dichotomy nor attempts to explain its nature.

In Figure 3 we ordered the industries according to their ISIC codes (Revision 2) and we plotted the individual productivity-value added correlations (dots) together with the cumulative productivity-value added correlations (solid line). The cumulative correlations were obtained as the productivity-value added correlations of successive aggregations of industries. Hence, the first point to the left in the cumulative correlation line is the cyclical correlation for the first industry according to the ISIC four-digit code, while the last point to the right corresponds to the cross-industry aggregate correlation. Note how the cross-industry aggregate figure is distorted by the biggest industry (sector 3721 of non-ferrous metal industries), which accounts for 14% of the sample value added.

Indeed, if we exclude the ISIC category 3721, the cumulative correlation displays a smoother pattern and it is constant around 0.05 when we successively aggregate the last 50% of the industries ordered according to their ISIC codes. The cumulative correlation is decreasing when we aggregate industries with ISIC codes between 31xx and 35xx (mainly food, beverages, tobacco), and then it fluctuates around 0.05 when we incorporate industries with ISIC codes between 35xx and 39xx (i.e., from chemicals to machinery).

FIGURE 3
DIFFERENT MEASURES OF PRODUCTIVITY-VALUE ADDED
CYCLICAL CORRELATIONS



There is a clear pattern of industry clustering related to their ISIC codes. Evidence of clustering in the ISIC space is not novel for other countries but it has never been reported for Chile.⁶ In the figure we also graphed the 95% confidence level significance bounds, indicating that sectoral correlations within these bounds are not statistically different from zero. Considering this, we can see that aggregate productivity is a-cyclical regardless of the final aggregation of industries and it is mainly procyclical at the industry level, as most of the industries present a positive and statistically significant productivity-value added correlation. Returning to our general result, the question is why does the aggregate correlation differ so much from the average one. In the next subsection we present a decomposition of the aggregate correlation that aims to explain this apparently contradictory result.

5.2. Aggregate Correlation Decomposition and Aggregation Bias

In this subsection we describe in detail our calculations of cyclical correlations and identify the aggregation bias. Let $\tilde{v}a_{it} = va_{it} - \hat{v}a_i$ be the cyclical value added for industry i in time t , defined as the difference between actual value added and its trend $\hat{v}a_i$. Accordingly, $\tilde{z}_{it} = z_{it} - \hat{z}_i$ is the detrended labor productivity in industry i . For convenience, we compute the trend of the level of the variables and not of their logs.⁷ This allows us to define:

$$\begin{aligned}
 \tilde{v}a_t &= \sum_{i=1}^N \tilde{v}a_{it} \\
 (20) \quad \tilde{z}_t &= \frac{\sum_{i=1}^N va_{it}}{\sum_{i=1}^N l_{it}} - \frac{\sum_{i=1}^N \widehat{va}_i}{\sum_{i=1}^N l_{it}} \equiv \sum_{i=1}^N \tilde{z}_{it} \frac{l_{it}}{l_t} - \sum_{i=1}^N \widehat{z}_i \frac{l_{it}}{l} \equiv \sum_{i=1}^N \bar{z}_{it}
 \end{aligned}$$

where N is the number of industries, and \bar{z}_{it} is a detrended weighted labor productivity i . Note that $z_{it} \frac{l_{it}}{l_t}$ measures the contribution of labor productivity in sector i to total labor productivity in an industry, weighted by its labor share. Following Navarro (2005) The aggregate cyclical correlation between value added and labor productivity is defined as:

⁶Using census data for the US, Bernard *et al.* (2005) find evidence of complementarity in demand or supply among close industries in the US Standard Industry Classification (SIC) space.

⁷Working with logs or levels does not change the qualitative results on the distribution and aggregates of cyclical correlation.

$$(21) \quad \rho_{\tilde{v}a, \tilde{z}} = \frac{\sigma(\tilde{v}a_{it}, \tilde{z}_{it})}{\sigma(\tilde{v}a_{it})\sigma(\tilde{z}_{it})}$$

where $\sigma(\tilde{v}a_{it}, \tilde{z}_{it})$ is the covariance between value added and labor productivity and $\sigma(\tilde{v}a_{it})$ and $\sigma(\tilde{z}_{it})$ are the standard deviations of each variable. Now consider the definition of the covariance term and use equation (20) to obtain:

$$(22) \quad \sigma(\tilde{v}a_{it}, \tilde{z}_{it}) = \sum_{i=1}^N \sigma(\tilde{v}a_i, \hat{z}_i) + \sum_{i \neq j} \sum_{j \neq i}^N \sigma(\tilde{v}a_i, \hat{z}_j)$$

or equivalently,

$$(23) \quad \rho_{\tilde{v}a, \tilde{z}} = \sum_{i=1}^N \rho_{\tilde{v}a_i, \hat{z}_i} \frac{\sigma(\tilde{v}a_i)\sigma(\hat{z}_i)}{\sigma(\tilde{v}a)\sigma(\hat{z})} + \sum_{i \neq j} \sum_{j \neq i}^N \rho_{\tilde{v}a_i, \hat{z}_j} \frac{\sigma(\tilde{v}a_i)\sigma(\hat{z}_j)}{\sigma(\tilde{v}a)\sigma(\hat{z})}$$

The correlation between detrended aggregate value added and detrended labor productivity is explained by the aggregation of the sector specific correlations between value added and weighted labor productivity and by the aggregation of the cross correlations between value added in sector i and weighted productivity in sector j . Although $\rho_{\tilde{v}a_i, \hat{z}_i}$ does not measure exactly the individual correlations ($\rho_{\tilde{v}a_i, \hat{z}_i}$) reported in this paper, we could write equation (23) as follows (details are given in the Appendix):

$$(24) \quad \rho_{\tilde{v}a, \tilde{z}} = \sum_{i=1}^N \rho_{\tilde{v}a_i, \hat{z}_i} \frac{\sigma(\tilde{v}a_i)\sigma(\hat{z}_i)}{\sigma(\tilde{v}a)\sigma(\hat{z})} - \sum_{i=1}^N \rho_{\tilde{v}a_i, \hat{z}_i''} \frac{\sigma(\tilde{v}a_i)\sigma(\hat{z}_i'')}{\sigma(\tilde{v}a)\sigma(\hat{z}_i'')} + \sum_{i \neq j} \sum_{j \neq i}^N \frac{\sigma(\tilde{v}a_i)\sigma(\hat{z}_j)}{\sigma(\tilde{v}a)\sigma(\hat{z})} - \sum_{i \neq j} \sum_{j \neq i}^N \frac{\sigma(\tilde{v}a_i)\sigma(\hat{z}_i'')}{\sigma(\tilde{v}a)\sigma(\hat{z}_i'')}$$

$$\text{where } \hat{z}_i'' = \sum_{i=1}^N \tilde{z}_{it} \left(1 - \frac{L_{it}}{L_t}\right) - \sum_{i=1}^N \tilde{z}_{it} \left(1 - \frac{L_{it}}{L_t}\right).$$

It becomes clear, then, that the first term of equation (23) is increasing in $\rho_{\tilde{v}a_i, \hat{z}_i}$, the size of the industry in terms of its contribution to total employment, and the relative volatility of the industry value added and productivity $\rho_{\tilde{v}a_i, \hat{z}_i}$. Note also that according to the second term of equation (23) $\rho_{\tilde{v}a_i, \hat{z}_i}$ is also increasing in the co-movements between the industries, approximated by $\rho_{\tilde{v}a_i, \hat{z}_i}$.

5.3. Interpretation of Results

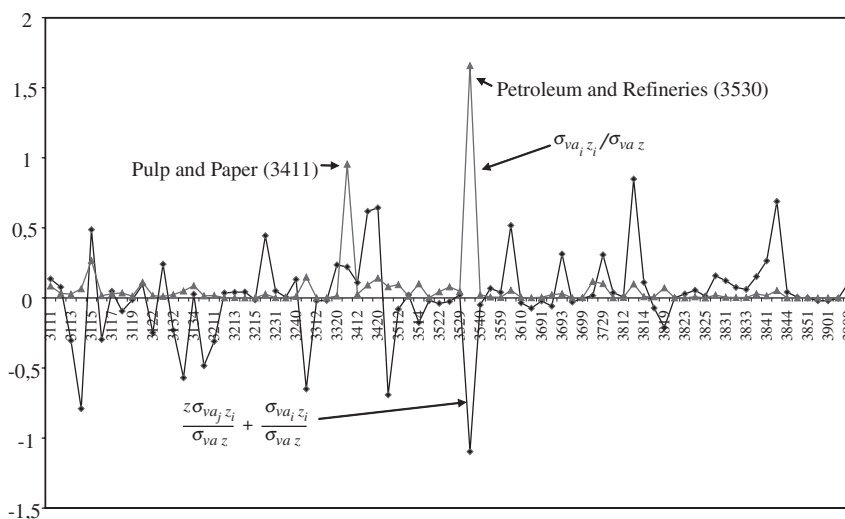
To illustrate how equation (23) works to explain our results consider the aggregate correlation for the sample of 79 industries (excluding sector 3721), $\rho(\tilde{v}a, \tilde{z}) = 0.06$. In addition, note that, in apparent contradiction, $\sum_{i=1}^N \rho(\tilde{v}a_i, \tilde{z}_i) / N = 0.64$. When computing the decomposition of $\rho(\tilde{v}a, \tilde{z})$ given by equation (22) we obtained that the first term of the right hand side is equal to 0.30 while the second term is -0.24 . Finding that the first term is positive is not surprising because in most of the industries $\rho(\tilde{v}a_i, \tilde{z}_i)$ is positive. It follows, then, that the reason for the coexistence of aggregate a-cyclical productivity and average procyclical productivity is the presence of aggregate negative cross-correlations between value added and productivity cycle among industries. This indicator of negative co-movement across industries is summarized by the value of -0.24 that we obtained for the second term of the right hand side of equation (22).

This explains why the cumulative correlation line in Figure 3 is decreasing as we aggregate industries. When we add industry i to the sample and calculate $\rho(\tilde{v}a, \tilde{z})$ what matters is not only the value of $\rho(\tilde{v}a_i, \tilde{z}_i)$ in that particular industry, but also how its productivity and value added is related with the value added and productivity in all other industries. If an increase in productivity in industry i has a positive effect on value added in the rest of the industries and/or if an increase in productivity of the rest of the industries has a positive effect on the value added of industry i , we should expect $\rho(\tilde{v}a, \tilde{z})$ to increase when such industry is added to the sample.

What actually happens in the Chilean data is exactly the opposite. That is, according to our results, productivity and value added cycles at the aggregate level seem to be negatively correlated across industries in Chilean manufacturing. To illustrate this point, in Figure 4 we show the decomposition of $\rho(\tilde{v}a, \tilde{z})$ based on equation (23). For every industry, we graph $\sigma(\tilde{v}a_i, \tilde{z}_i)$ and $\sigma(\tilde{v}a_i, \tilde{z}_i) + \sum_{j \neq i}^N \sigma(\tilde{v}a_j, \tilde{z}_j)$ relative to $\sigma(\tilde{v}a, \tilde{z})$. This presentation of the covariance data allows us to identify the contribution of every industry to the aggregate covariance. Note that $\sigma(\tilde{v}a_i, \tilde{z}_i)$ is the covariance between value added and weighted productivity in industry i and $\sum_{j \neq i}^N \sigma(\tilde{v}a_j, \tilde{z}_j)$ is the sum of the covariances between productivity in industry j and value added in the other industries. If, consistently with the evidence of the literature, labor productivity leads the cycle we can interpret $\sum_{j \neq i}^N \sigma(\tilde{v}a_j, \tilde{z}_j)$ as the effect of productivity shocks in sector j on the value added of the other industries.

Note that $\sigma(\tilde{v}a_i, \tilde{z}_i)$ is positive for all industries. However, if we consider $\sigma(\tilde{v}a_i, \tilde{z}_i) + \sum_{j \neq i}^N \sigma(\tilde{v}a_j, \tilde{z}_j)$ we see that the addition of some industries to the sample increases $\sigma(\tilde{v}a, \tilde{z})$ while the addition of some others decreases it. The most

FIGURE 4
DECOMPOSITION OF THE CUMULATIVE COVARIANCE BETWEEN
THE CYCLICAL COMPONENTS OF VALUE ADDED
AND LABOR PRODUCTIVITY



prominent example is that of Petroleum Refineries (sector 3530). Although productivity is highly procyclical in this industry, its cycle is negatively correlated to the value added of the other 78 industries in the sample. Then, including this industry in the sample reduces the aggregate productivity-value added correlation. Since this industry contributes to more than 6% of the total value added in the sample, the effect of adding this industry to the sample is large. A similar pattern is observed for Pulp and Paper industries (sector 3411), which produces about 5% of the total value added. Again, this industry displays procyclical productivity but its productivity cycle is negatively correlated to the value added of the other industries, even though the net effect of including sector 3411 on $\sigma(\tilde{v}\tilde{a}, \tilde{z})$ is positive.

In general, we observe a negative association between $\sigma(\tilde{v}\tilde{a}_i, \tilde{z}_i) + \sum_{j \neq i}^N \sigma(\tilde{v}\tilde{a}_j, \tilde{z}_j)$ and the share of each sector in total value added. Indeed, the correlation is -0.23 and significant at 5% confidence level. The largest industries distort the aggregate $\sigma(\tilde{v}\tilde{a}, \tilde{z})$ not because they do not show procyclical productivity but because their productivity cycles are negatively correlated to the activity of the majority of the other industries in the sample. This group of industries generating cross countercyclical behavior represents 62% of total value added.

To summarize, our results provide evidence of significant heterogeneity not only in the structure but also in the cycles of the different industries. Productivity is procyclical across industries but the cyclical phases of the industries are significantly different between each other, leading to an aggregate a-cyclical productivity. In particular, this behavior could be explained in view of the high

concentration of Chilean manufacturing. Although the biggest industries display procyclical productivity, the cycles of these industries are not related or they are negatively related to the ones of the other industries in ENIA. This is one of the main results of our paper.

At this point it seems natural to ask what determines the cyclical of productivity. Our previous discussion proved useful to clarify that productivity is procyclical in most of the industries in Chilean manufacturing. That allows us to narrow down our question and instead analyze the determinants of procyclical productivity in Chilean manufacturing. This is what we do in the next section.

6. TESTING ALTERNATIVE THEORIES OF PROCYCLICAL LABOR PRODUCTIVITY

In this section we test the specification in section 4 using data for 58 of the original eighty sectors contained in the ENIA sample. Data limitations preclude us from using the full sample. First, we excluded several “residual” industries, i.e. those labeled by the INE as “not elsewhere classified”, since data were unwarranted. Second, 26 industries were dropped from the database because irregularities in the data on costs made estimations unreliable.⁸ Nevertheless, the industries considered in the econometric testing represent on average 86% of the industry gross output in the 1979-2001 period.

Shares of the different inputs were obtained as the average use of inputs in the whole period of analysis. To compute the share of capital in each sector it was necessary to compute a series of the required payments for unit of capital and estimate the user cost for each unit of capital. An adequate measure of cost of capital in each sector was unavailable; consequently as a proxy we used the sum of the average real lending interest rate of the financial system plus a depreciation rate of 10%, as suggested by Bustos *et al.* (2000). Using lending rates is supported by the fact that most financing of firms in Chile are loans from the banking sector, given that the equity market is shallow.

Estimation of equation (19) would require an index of capital utilization. Abbott *et al.* (1998) suggest to use as a proxy the growth rate in hours worked. We therefore estimate:

$$(25) \quad dy_i = c_i + \mu_i dx_i + \alpha_i dh_i + dt_i$$

where dh is the growth rate in hours worked. Although ENIA data do not include hours worked, additional data on hours worked from the employment surveys of the INE were used to correct the measure of labor input. This equation allows us to compute an appropriate measure of technical change, dt_i , as a residual.

⁸We excluded sectors such as canning of seafood, some textiles, furs, non-metal furniture, chemicals, pottery and china, manufacture of tools, and shipbuilding.

Equation (25) can be estimated for each industry. As noted by Fernald and Basu (2000), although one could estimate these equations separately for each industry, some parameters (particularly the utilization proxies) are then estimated rather imprecisely. To control for this problem, the 59 sectors were combined into four groups and the constant and the utilization proxy were restricted to be equal across groups.⁹ Each system was estimated using three-stage least squares using instrumental variables to avoid correlation between technology shocks and inputs across sectors. The instruments include all lagged independent variables, the rate of growth in the real price of oil (deflated by CPI), the rate of growth in real government spending, and the rate of growth in the real effective exchange rate. Table 5 presents a summary of the econometric results.

TABLE 5
ECONOMETRIC RESULTS

	Group 1	Group 2	Group 3	Group 4			
c	0.016 *	c	0.008	c	0.025 *	c	-0.001
α	0.028	α	0.223 *	α	0.103	α	-0.295 *
μ_{3111}	1.072 *	μ_{3211}	1.358 *	μ_{3513}	1.466 *	μ_{3812}	1.337 *
μ_{3112}	0.863 *	μ_{3213}	0.724 *	μ_{3521}	0.730 *	μ_{3814}	1.148 *
μ_{3113}	1.535 *	μ_{3214}	1.598 *	μ_{3522}	0.989 *	μ_{3815}	0.345
μ_{3115}	0.846 *	μ_{3215}	1.197 *	μ_{3523}	1.628 *	μ_{3819}	1.822 *
μ_{3116}	0.586 *	μ_{3220}	1.340 *	μ_{3529}	1.174 *	μ_{3822}	1.833 *
μ_{3117}	1.014 *	μ_{3231}	-0.244	μ_{3230}	0.711 *	μ_{3823}	1.809 *
μ_{3118}	0.864 *	μ_{3233}	1.014 *	μ_{3540}	1.045	μ_{3829}	0.894 *
μ_{3119}	1.325	μ_{3240}	1.423 *	μ_{3559}	0.738 *	μ_{3831}	2.406 *
μ_{3121}	0.762	μ_{3311}	1.852 *	μ_{3562}	0.760 *	μ_{3832}	0.758 *
μ_{3122}	1.022 *	μ_{3312}	1.364 *	μ_{3696}	0.874 *	μ_{3833}	1.573 *
μ_{3131}	0.477	μ_{3319}	0.721 *	μ_{3699}	1.318 *	μ_{3839}	1.212 *
μ_{3132}	1.481 *	μ_{3220}	1.445 *	μ_{3710}	1.447 *	μ_{3843}	1.658 *
μ_{3133}	1.364 *	μ_{3411}	0.828 *	μ_{3721}	0.451	μ_{3844}	1.513 *
μ_{3134}	1.425 *	μ_{3412}	1.394 *			μ_{3849}	1.047 *
μ_{3140}	2.342 *					μ_{3852}	1.999 *
						μ_{3909}	1.835 *

Note (*) significant at 95% confidence.

Source: author's calculation.

⁹The groups were formed according to their 2-digit level ISIC classification. Consequently we formed groups for categories 31 (15 industries), 32 to 34 (14 industries), 35 to 37 (13 industries), and 38 to 39 (17 industries).

TABLE 6
 SOURCES OF PRODUCTIVITY GROWTH
 (Average annual growth rates)

	Change in observed productivity	Change in markups	Change in labor and capital utilization	Technical change	Reallocation of inputs
1979-2001					
Average	0.09	0.01	0.00	0.05	0.02
Standard deviation	0.23	0.07	0.14	0.25	0.10
1979-1990					
Average	0.04	0.03	0.04	-0.02	0.00
Standard deviation	0.24	0.06	0.09	0.28	0.09
1991-2001					
Average	0.14	0.00	-0.03	0.12	0.04
Standard deviation	0.23	0.07	0.18	0.19	0.10

Source: author's calculation.

After estimating equation (25) we calculated the sum of the group-specific constant and the residual of each equation as the measure of technical change in the gross-output production function. These results were inserted in the aggregation equation (19) to decompose aggregate productivity into a technological component plus various non-technological components, including the effects of markups and reallocation of inputs.

The results for the 1979-2001 period and the two sub-periods are presented in Table 6. These results suggest that technical change is the main explanation of the dynamics of productivity in the Chilean industry in the two periods of analysis; one half of total productivity gains are due to improved technologies.¹⁰ However there are marked differences between the two sub-periods. For the 1979-1990 period, technical change is slightly negative, while for the 1991-2001 it accounts for over 80% of productivity growth. These results match closely those by Bergoening and Repetto (2006) using a similar database but a very different estimation procedure, in particular the slightly negative contribution of TFP in the 1980s.

¹⁰Using standard sources of growth analysis, Fuentes *et al.* (2006) also assign to TFP a significant contribution to GDP growth in the 1990-2005 period (around 60%).

Reallocation of resources among sectors appears to have been significant only during the 1990s. Again this result is similar to that found by Bergeois and Repetto, although their point estimate of the contribution of relocation to productivity is markedly higher. Their result however is largely driven by *intra* industry relocation, whilst ours refers to *inter* sector relocations. Variations in input utilization were insignificant in the long run, reflecting the fact that we are reporting long-period averages that tend to net out intraperiod variations. Nevertheless, differences become apparent when comparing sub-periods: in the early 1979-1990 period increased utilization of labor and capital plays a significant contribution to productivity growth, while in the 1991-2001 period there is a negative contribution reflecting, most likely, the impact of the reduction in the number of hours worked.

7. CONCLUSIONS

This paper studies the dynamics of labor productivity during economic cycles in Chilean in the 1979-2001 period. We use data from the Chilean manufacturing sector to study the cyclical behavior of labor productivity at the industry level, its determinants, and its relationship with economic activity.

The paper presents evidence of procyclical labor productivity at the macroeconomic level. However, we find no evidence of correlation between labor productivity and economic activity when using the aggregate data of manufacturing sectors. In addition, when undertaking the analysis sector by sector we found that most industries exhibit significant procyclical productivity. We provide an analytical and empirical explanation for these apparently conflicting results. We document that aggregation biases arising in the construction of the aggregate productivity series distort the cross-industry correlation between cycles in labor productivity and economic activity. This reflects both the substantial heterogeneity of ENIA firms and the distorting effect of the timing of cycles in the different industries. Productivity is procyclical across industries but the cyclical phases of the industries are significantly different between each other, leading to an aggregate a-cyclical productivity.

We also test the determinants of productivity in the Chilean industry using an econometric model that allows us to quantify the relative contribution of technology shocks, changes in markups, variations in the utilization rates, and reallocation of resources among from less to more productive sectors. We found that for the 1979-2001 technical change is the main explanation of the dynamics of productivity. Nevertheless, this contribution is not smooth in time. In the 1979-1990 period, technical change does not contribute to productivity growth, while for the 1991-2001 it accounts for over 80% of productivity growth. With regards to the other determinants of productivity changes, reallocation of resources from less to more productive industries appears to have been significant only

during the 1990s while changes in input utilization were significant mostly in the 1979-1990 period.

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APPENDIX
DERIVATION OF EQUATION (24)

Let $\sigma(\tilde{v}a_{it}, \tilde{z}_{it}) = \sum_{i=1}^T (\tilde{v}a_{it} - \dot{\tilde{v}a}_{it})(\tilde{z}_{it} - \dot{\tilde{z}}_{it}) / (T-1)$ be the covariance between value-added and labor productivity. A dot on a variable indicates average over time. Let $\sigma(\tilde{v}a_{it}) = \sqrt{\sum_{i=1}^T (\tilde{v}a_{it} - \dot{\tilde{v}a}_{it})^2}$ and be $\sigma(\tilde{z}_{it}) = \sqrt{\sum_{i=1}^T (\tilde{z}_{it} - \dot{\tilde{z}}_{it})^2}$ the corresponding standard deviations. Then, the covariance can be written as:

$$(A1) \quad \sigma(\tilde{v}a_{it}, \tilde{z}_{it}) = \sum_{i=1}^T (\tilde{v}a_{it} - \dot{\tilde{v}a}_{it})(\tilde{z}_{it} - \dot{\tilde{z}}_{it}) / (T-1) = \sum_{i=1}^T \left(\sum_{i=1}^N va_{it} - \sum_{i=1}^N \dot{v}a_{it} \right) \left(\sum_{i=1}^N z_{it} - \sum_{i=1}^N \dot{z}_{it} \right) / (T-1)$$

Consider the second term in parenthesis in equation (A1) and subtract $\sum_{i=1}^N z_{it} - \sum_{i=1}^N \dot{z}_{it}$. Then we can rewrite $\sigma(va_{it}, z_{it})$ as

$$(A2) \quad \sigma(\tilde{v}a_{it}, \tilde{z}_{it}) = \sum_{i=1}^T \left(\sum_{i=1}^N \tilde{v}a_{it} - \sum_{i=1}^N \dot{\tilde{v}a}_{it} \right) \left(\left[\sum_{i=1}^N \tilde{z}_{it} - \sum_{i=1}^N \dot{\tilde{z}}_{it} \right] + \left[\sum_{i=1}^N \hat{z}_{it} - \sum_{i=1}^N \dot{\hat{z}}_{it} - \sum_{i=1}^N z_{it} - \sum_{i=1}^N \dot{z}_{it} \right] \right) / (T-1)$$

then

$$(A3) \quad \sigma(\tilde{v}a_{it}, \tilde{z}_{it}) = \sum_{i=1}^T \left(\sum_{i=1}^N \tilde{v}a_{it} - \sum_{i=1}^N \dot{\tilde{v}a}_{it} \right) \left(\left[\sum_{i=1}^N \tilde{z}_{it} - \sum_{i=1}^N \dot{\tilde{z}}_{it} \right] + \left[\sum_{i=1}^N \hat{z}_{it}'' - \sum_{i=1}^N \dot{\hat{z}}_{it}'' \right] \right) / (T-1)$$

where

$$(A4) \quad \hat{z}_{it}'' = \sum_{i=1}^N \tilde{z}_{it} \left(1 - \frac{L_{it}}{L_t} \right) - \sum_{i=1}^N \tilde{z}_{it} \left(1 - \frac{L_{it}}{L_t} \right)$$

replacing by their corresponding definitions,

$$(A5) \quad \sigma(\tilde{v}a_{it}, \tilde{z}_{it}) = \sum_{i=1}^N \sigma(\tilde{v}a_i, \tilde{z}_i) + \sum_{i \neq j}^N \sigma(\tilde{v}a_i, \tilde{z}_j) + \sum_{i=1}^T \left(\sum_{i=1}^N \tilde{v}a_{it} - \sum_{i=1}^N \dot{\tilde{v}a}_{it} \right) \left(\sum_{i=1}^N \hat{z}_{it}'' - \sum_{i=1}^N \dot{\hat{z}}_{it}'' \right) / (T-1)$$

$$(A6) \quad \sigma(\tilde{v}a_{it}, \tilde{z}_{it}) = \sum_{i=1}^N \sigma(\tilde{v}a_i, \tilde{z}_i) - \sum_{i=1}^N \sigma(\tilde{v}a_i, \hat{z}_{it}'') + \sum_{i \neq j}^N \left(\sum_{j \neq i}^N \sigma(\tilde{v}a_i, \tilde{z}_j) \right) - \sum_{i \neq j}^N \left(\sum_{j \neq i}^N \sigma(\tilde{v}a_i, \hat{z}_{it}'') \right) / (T-1)$$

where $\sigma(va_i, z_j)$ is the covariance between the cyclical value added of sector i and cyclical productivity of sector j . Accordingly $\sigma(\tilde{v}a_i, \hat{z}_{it}'')$ denotes the cyclical covariance between sector i value added and the productivity measure \hat{z}_{it}'' .

The relevance of the expression (A6) is that it allows relating the aggregate covariance with the individual ones. Note that the first two terms of (A6) consider the contribution of the individual covariances to the aggregate. The two other terms control for the cross covariances between valued added in sector i and productivity in sector j . In a way, these last two terms are related to the co-movement between the sectors. Equivalently, we can write (A6) in terms of correlations,

$$\rho_{\tilde{v}a, \tilde{z}} = \sum_{i=1}^N \rho_{\tilde{v}a, \tilde{z}} \frac{\sigma(\tilde{v}a_i)\sigma(\hat{z}_i)}{\sigma(\tilde{v}a)\sigma(\hat{z})} - \sum_{i=1}^N \rho_{\tilde{v}a, \hat{z}_i} \frac{\sigma(\tilde{v}a_i)\sigma(\hat{z}_i^*)}{\sigma(\tilde{v}a)\sigma(\hat{z}_i^*)} + \sum_{i \neq j} \sum_{j \neq i} \frac{\sigma(\tilde{v}a_i)\sigma(\hat{z}_j)}{\sigma(\tilde{v}a)\sigma(\hat{z})} - \sum_{i \neq j} \sum_{j \neq i} \frac{\sigma(\tilde{v}a_i)\sigma(\hat{z}_i^*)}{\sigma(\tilde{v}a)\sigma(\hat{z}_i^*)}$$

which is expression (24) in the main text.

RESÚMENES EN ESPAÑOL

CHILE'S ECONOMIC GROWTH

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El elevado crecimiento del PIB per cápita de Chile observado entre 1991 y 2005, de 4,1% promedio anual, excedió significativamente el crecimiento promedio mundial y constituyó también un claro quiebre con el crecimiento pasado del país. ¿Cuánto del crecimiento reciente constituye crecimiento de tendencia y cuánto es cíclico, influido por las condiciones externas que enfrenta el país? ¿Cuáles son los principales determinantes del crecimiento de largo plazo y de las fluctuaciones cíclicas de acuerdo con la literatura empírica reciente? ¿Cuáles son las principales fortalezas y debilidades para el crecimiento de Chile y, basado en las anteriores, cuáles son las reformas propuestas por los estudios técnicos y los programas presidenciales más recientes? Esta revisión responde a las preguntas anteriores, comenzando con los hechos que caracterizan el crecimiento promedio y la volatilidad del crecimiento, a nivel agregado, regional y sectorial. Luego se revisan los estudios del crecimiento de tendencia en Chile, que incluyen desde las descomposiciones de las fuentes del crecimiento hasta los estudios econométricos y de simulaciones de los determinantes profundos del crecimiento, basados en evidencia internacional de datos de paneles y series de tiempo nacionales, así como en investigación focalizada en reformas individuales. A continuación se presentan estudios sobre las fluctuaciones de corto plazo y las recuperaciones cíclicas, también basados en evidencia internacional y nacional. Este número de Cuadernos de Economía publica seis nuevos y relevantes trabajos de investigación sobre el crecimiento de Chile. Luego el artículo revisa selectivamente las propuestas de políticas y reformas en apoyo de un mayor crecimiento, presentadas por autores académicos, organizaciones internacionales y candidaturas presidenciales en el año 2005. Un epílogo con breves reflexiones sobre el crecimiento potencial de Chile y los principales retos de políticas en sustento de un mayor crecimiento cierra este artículo.

COMPLEMENTARITIES BETWEEN INSTITUTIONS AND
OPENNESS IN ECONOMIC DEVELOPMENT: EVIDENCE
FOR A PANEL OF COUNTRIES

CÉSAR CALDERÓN

The World Bank

RODRIGO FUENTES

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El objetivo del presente trabajo es evaluar las fuentes de crecimiento de Chile y de las economías mundiales en los últimos años, poniendo énfasis en el rol de la complementariedad de las políticas económicas. Por tal motivo, evaluamos los determinantes del crecimiento económico para una muestra de 78 países y con información para el período 1970-2000. A diferencia del enfoque de Gallego y Loayza (2002), el presente trabajo contrasta directamente la interacción existente entre las políticas de liberalización comercial y financiera con: a) las condiciones iniciales de la economía; b) con las políticas de capital humano, y c) con la calidad de la institucionalidad.

REGIONAL CONVERGENCE IN CHILE: NEW TESTS, OLD RESULTS

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Los tests tradicionales de convergencia evalúan implícitamente la hipótesis de raíz unitaria en las series de producto per cápita. A pesar de que bajo la hipótesis nula estos estadísticos no tienen distribuciones asintóticas ni valores críticos estándares, la gran mayoría de los trabajos sobre el tema los emplean con los consiguientes problemas de inferencia. El objetivo del trabajo es determinar la existencia de convergencia en niveles en los PIB e ingresos de las regiones de Chile, empleando no sólo la batería tradicional de tests (corte transversal y paneles de datos), sino fundamentalmente los más recientes test de raíz unitaria para paneles y así poder hacer inferencia apropiadamente. Se analiza, además, la convergencia en dispersión construyendo intervalos de confianza para la varianza de la producción e ingresos regionales y evaluando la presencia de asimetrías o formaciones de “clubes” regionales mediante un test no paramétrico de multimodalidad. Se concluye que: (1) la evidencia respalda la hipótesis de convergencia β absoluta, tanto en PIB como en ingresos; (2) las tasas de convergencia de ingresos son mayores a las del PIB, pero ambas son relativamente bajas comparadas con la evidencia internacional; (3) no obstante, la tasa de convergencia condicional se ve estadísticamente incrementada si se controla por participaciones sectoriales como minería; (4) a pesar de que las distribuciones empíricas del PIB e ingresos muestran aparentes “clubes” regionales, estos hallazgos no son estadísticamente significativos; (5) se encuentra evidencia a favor de convergencia β en PIB para el período 1960-2000, mientras que la dispersión de ingresos (estadísticamente) no ha cambiado durante el período 1987-2000.

SOURCES OF GROWTH AND BEHAVIOR OF TFP IN CHILE

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Este trabajo presenta nuevas estimaciones de las fuentes del crecimiento de Chile y nuevas medidas de factores de producción y PTF durante el período 1960-2005. Usando una función de producción Cobb-Douglas, el trabajo presenta ocho series de PTF basadas en combinaciones alternativas de medidas de factores productivos. El trabajo también reporta evidencia econométrica acerca del comportamiento de la PTF durante 1960-2005. La dinámica de la PTF es afectada por variables cíclicas (términos de intercambio y subvaluación del tipo de cambio real), variables relacionadas con políticas estructurales (estabilización macroeconómica y progreso en reformas microeconómicas) y también por efectos positivos de interacción entre desempeño macro y políticas micro.

PRODUCTIVIDAD SECTORIAL EN CHILE: 1986-2001

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El objetivo de este artículo es hacer estimaciones de productividad total de los factores a nivel sectorial. El principal desafío que se enfrenta es la ausencia de series de stock de capital por sectores para un período largo de tiempo. Sólo se tienen datos de stock de capital para el período 1996-2001. Se diseña una metodología para, a partir de dichos datos y otra información, generar cifras de stock de capital para el período 1986-1995.

Con ello, más un ajuste por utilización de las series de capital y un ajuste de calidad relativa para las series de trabajo, se hacen estimaciones de PTF sectorial para 1986-2001. Según estos cálculos, el mayor incremento de productividad en este período se ha producido en el sector comercio. Esto coincide con estudios para otros países, que muestran que los sectores con mayor incremento de la productividad corresponden a aquellos que usan intensivamente la tecnología de la información.

MICRO EFFICIENCY AND AGGREGATE GROWTH IN CHILE

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En este trabajo analizamos las fuentes microeconómicas de la eficiencia agregada, principal determinante del crecimiento agregado. Con este fin, estimamos y caracterizamos la productividad total de factores utilizando datos chilenos de plantas manufactureras durante el período 1980-2001. Al descomponer los cambios en eficiencia agregada que resultan de reasignación productiva y de variaciones al interior de las plantas, encontramos que la primera explica casi la totalidad de la mayor productividad alcanzada durante las últimas dos décadas. Estas ganancias por reasignación, a su vez, se generan principalmente por la entrada de plantas nuevas más eficientes.

PROCYCLICAL PRODUCTIVITY IN MANUFACTURING

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Estudiamos el comportamiento cíclico de la productividad en ochenta industrias del sector manufacturero chileno entre 1979 y 2001. Encontramos que a nivel de sectores la productividad es inambiguamente procíclica, pero que en el agregado es acíclica. Damos una explicación analítica y empírica para este fenómeno. Finalmente usamos un modelo econométrico que permite cuantificar la contribución al crecimiento de productividad de cuatro componentes. Los resultados indican que la mitad del crecimiento de productividad se debe a cambios tecnológicos, lo que apoya la hipótesis que los shocks de oferta son la principal fuente del ciclo económico en Chile. El resto del crecimiento de productividad se explica por la reasignación de recursos desde sectores con baja productividad hacia aquellos más productivos y por el aprovechamiento de economías de escala. Las variaciones en el uso de insumos resultan poco significativas.