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CHILE

SELECTED ISSUES

July 21, 2015

Approved By
Western Hemisphere Department

Prepared By Luc Eyraud and Marika Santoro (all WHD) with research assistance provided by Ehab Tawfik. These Selected Issues papers have benefited from discussions with staff from the Central Bank of Chile and government officials.

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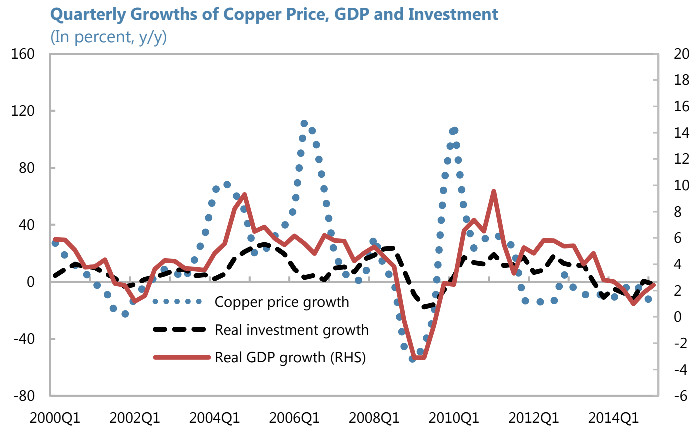
THE END OF THE COMMODITY SUPERCYCLE AND GDP GROWTH: THE CASE OF CHILE[1]

A. Introduction

1. The sharp decline in copper prices since 2011 has exacted a toll on Chile's GDP growth. Copper prices decreased by almost 40 percent between the peak of February 2011 and May 2015 from $4.5 per pound to $2.9. Given the importance of the copper sector (which represents 10 percent of Chile GDP, originates half of exports, and receives half of FDI inflows as of 2014), a large macroeconomic effect was inevitable. GDP growth slowed down, from 6.1 percent in Q3 2012 (yoy, SA) to 0.9 percent in Q3 2014, with the contribution of investment falling from 4.1 to -2.8 percent over the same period.



Source: Central Bank of Chile.

2. With copper prices unlikely to return to recent peaks in the coming years, the question arises as to whether Chile's long-term GDP growth will be affected. In June 2015 copper future contracts settled at $2.6–2.7 per pound, with a stable price profile across delivery dates until 2020. Moreover, the normalization of U.S. interest rates and China's gradual move towards a less metal-intensive growth model pose downside risks to copper prices. Some even argue that commodity prices have entered the downward phase of a super-cycle (Erten and Ocampo, 2012; Jacks, 2013; Canuto, 2014). With Chile's growth heavily reliant on capital accumulation in the past two decades (IMF, 2014), lower terms of trade could hamper mining investment and ultimately reduce potential growth in Chile.

3. Still, there is some uncertainty, both from theoretical and empirical standpoints, about the relationship between commodity prices and long-run GDP growth. Theoretically, a negative commodity price shock may have either no effect on long-term growth (if it is a pure demand shock), a positive effect (if it triggers a reallocation of resources towards more productive sectors), or a negative effect (if lower investment has negative externalities on the economy). At the empirical

[1] Prepared by Luc Eyraud. Ehab Tawik provided excellent research assistance. This chapter benefited from the comments of Rodrigo Caputo, Roberto Cardarelli, Benjamin Carton, Jorge Roldos, and the participants of the May and June 2015 seminars at the IMF and the Central Bank of Chile.

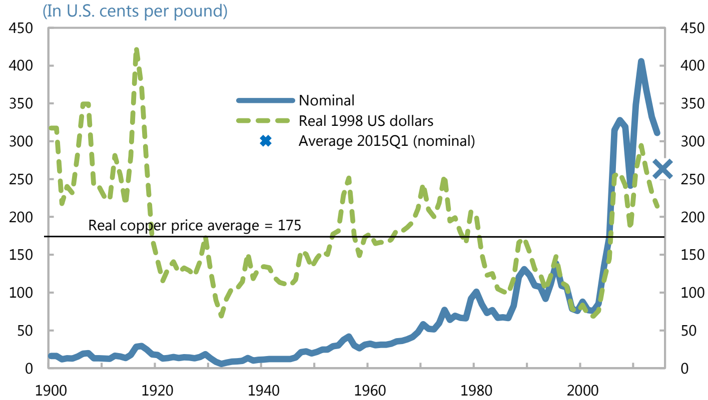
level, many papers question the traditional view that a smaller commodity exporting sector is beneficial to long-term growth by showing that it depends on the quality of institutions, the country's openness to trade, and the level of human capital (De Gregorio, 2009).

4. **This chapter attempts to quantify the effect of lower copper prices on Chile's growth at various time horizons.** Section A discusses the copper outlook and argues that copper prices are unlikely to return to historical highs in the near future. Section B provides theoretical and empirical evidence supporting the view that long-term GDP growth will not be affected, but the transition towards a lower GDP level can take up to a decade.

B. Copper Price Outlook: Temporary or Structural Decline?

5. **This section evaluates the claim that copper prices are in the downward phase of a super cycle.** The macroeconomic effect of commodity price shocks crucially depends on their size and persistence. The first step of this analysis is thus to come up with a working assumption regarding the future behavior of copper prices. To this end, the section discusses some statistical properties of the price series with a long-term perspective, and presents the results of a simple regression model of copper prices.

Historical Price of Copper
(In U.S. cents per pound)



Source: U.S. Geological Survey.

6. **In the long-term, real copper prices tend to revert from historical highs to their mean.**[2] While nominal copper prices show a clear upward trend, real copper prices (deflated by the US CPI) seem to present a cyclical pattern with a tendency to return to long-run equilibrium. Simple Dickey-Fuller stationarity tests show that about 15 percent of the gap is closed every year on average (Frankel, 2011).[3] This suggests that real copper prices would need to depreciate by another

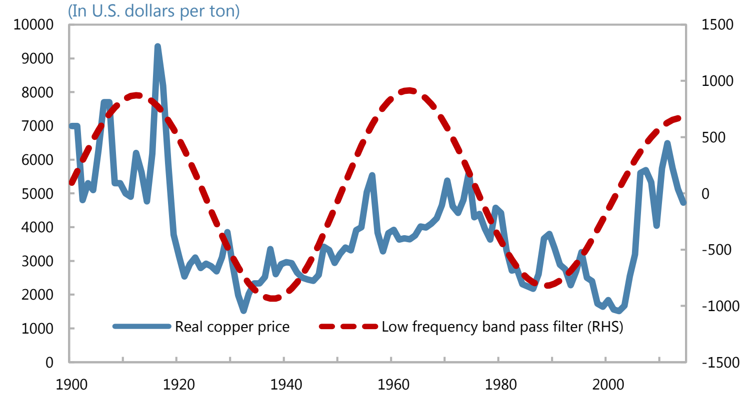
[2] This section uses 1900–2014 data from the U.S. Geological Survey (http://minerals.usgs.gov/minerals/pubs/historical-statistics/).

[3] The coefficient of the lagged dependent variable (-0.15) provides an estimate of the adjustment speed.

5 percent (resp. 20 percent) from their Q1 2015 (resp. average 2014) level to reach the long-term mean. This is approximately the size of the real decline projected by the July 2015 World Economic Outlook (WEO) between 2014 and 2020.[4]

7. **Real copper price fluctuations combine several cycles of various durations, including a supercycle of about 50–60 years, which may have peaked in 2012–14**. Two separate exercises are conducted to extract these cycles. First, we use a tool called spectral analysis which decomposes the price series into components with different periodicities[5] (Appendix 1). Applied from 1900, the spectral analysis identifies three main cycles for real copper prices: a "supercycle" of 50–60 years, a medium cycle of 20 years and a short cycle of about 10 years.[6] Second, a band-pass filter is applied to real copper prices to extract its longest cycle.[7] The filtered series shows three long episodes of copper price booms (followed by long periods of moderation), which can be intuitively associated with global demand booms, such as the industrialization of the late 19th century, the reconstruction period after World War II, and the urbanization of the Chinese economy since the 1990s. Based on this analysis, the supercycle appears to have plateaued in 2012–14.

Copper Price Supercycle
(In U.S. dollars per ton)



Source: US Geological Survey.

8. **Looking ahead, the expected growth slowdown in China and the normalization of global interest rates could exert further pressure on copper prices**. Appendix 2 presents a simple econometric model, where copper prices are a function of a short set of determinants, including China GDP growth, the U.S. real effective exchange rate, the U.S. long interest rates, and market price expectations (as measured by future contracts). Using medium-term forecasts contained in the July 2015 WEO, the equation predicts a 10–15 percent decline in nominal copper

[4] Consulting firms forecast higher long-term real copper prices than the historical mean based on the assumption that marginal production costs will increase due to lower ore grades and the need to exploit deeper deposits. This break in the historical pattern is implicitly predicated on the absence of major technological innovations that would modify the marginal cost curve.

[5] In this chapter, the terms "periodicity," "period," and "time horizon" are used as synonyms. A long-term (resp. short-term) cycle is a cycle with a long (resp. short) period or periodicity, measured as its peak-to-peak duration.

[6] Technically, the periodicity of these three cycles corresponds to peaks in an indicator called "periodogram" (at the frequencies 0.1, 0.33, and 0.49). In the case of the shortest cycle, a visual analysis of the data confirms a succession of 10-year patterns, peaking in 1906, 1916, 1927, 1938, 1955, 1972, 1978, 1989, 1995, and 2008.

[7] The asymmetric Chistiano-Fitzgerald filter is applied to the 40–60 year window.

prices relative to 2014, as the expected depreciation of the U.S. REER should not be sufficient to offset the combined negative effect from lower China GDP growth and higher U.S. rates.

C. Does the Level of Commodity Prices Affect Long-Term Growth?

9. **This section provides theoretical and empirical evidence showing that commodity price shocks are likely to have only a temporary effect on GDP growth**. After reviewing the main arguments of the theoretical debate, we use three different methods to estimate the impact of lower commodity prices on GDP growth at different time horizons, as well as the speed of convergence towards equilibrium.

Although there is no consensus in the literature, most theoretical models suggest that a permanent decline in commodity prices has a permanent effect on the *level* of GDP, and a temporary effect on its *growth rate*. Appendix 3 and Table 1 summarize the results of several models. Most of them predict that a decline in commodity prices has a long-run impact on the levels of output and capital stock. Because the capital stock adjusts gradually to reflect the change in the marginal value of production, GDP growth is affected during the transition to the new steady-state. A relevant empirical question is thus how GDP growth behaves on the path towards a lower output level.

Table 1. Theoretical Impact on GDP of A Decline in Commodity Price

	Short-term		Long-term	
	GDP level	GDP growth	GDP level	GDP growth
Neoclassical investment model	-	-	-	Ø
Tobin's Q investment model	-	-	-	Ø
Commodity extraction model	-/+	-/+	Ø	Ø
Salter-Swan model	Ø	Ø	Ø	Ø
Salter-Swan with learning by doing	+	+	+	+
Institutional model	+	+	+	+
Solow growth model	-	-	-	Ø
Endogenous (AK) growth model	-	-	-	-
Price volatility model	Ø	Ø	Ø	Ø

Note: -/+ denotes a negative/positive effect. Ø denotes no effect.

Statistical approach

10. To test the assumption that lower commodity prices affect GDP growth only in the short-term, we first look at the statistical properties of the relationship between GDP and copper prices in Chile. Specifically, we use a co-spectral analysis, which provides insights on the co-movement between two time series at various time horizons (Appendix 1). The technique is applied to the log differences of real copper prices and Chile real GDP over the period 1900-2014. We also use an alternative specification with de-trended GDP and the logarithm of real copper prices, both series being stationary.

11. The results suggest that the correlation between copper prices and GDP weakens in the long run. To measure the strength of the relationship between the growths of copper prices and Chile GDP at different time horizons, we use an indicator called "coherency" (Appendix 1). This indicator shows that the co-movement of the two series is stronger for their short-term fluctuations than for their long cycles.[8] Another result of the cospectral analysis is that copper prices lead output fluctuations. This is evidenced by the "phase angle," which measures the lead-lag relationship between the two series at different periodicities. In our sample, the phase angle is almost always positive, which means that the copper price series leads real GDP regardless of the time horizon.

Event analysis

12. To assess the short-term macroeconomic impact of a decline in copper prices, we conduct an event analysis of the copper price and business cycles in Chile. Extending Spilimbergo (1999), we identify six copper price cycles since the mid-1980s and analyze the behavior of real GDP before and after the copper price peaks.[9] This analysis is only relevant to assess the short-term effect of a copper price shock: after a few quarters, GDP is affected by a multitude of other factors, which are likely to conceal the effect of the initial commodity shock.

13. The event analysis confirms that the business and copper price cycles are tightly linked in Chile. In the sample, real copper prices decline, on average, by 25 percent in the year following the peak. The two series follow broadly the same pattern: in general, GDP growth peaks one or two quarters after copper prices, then decelerates by about 1 percentage point on a quarterly basis in the following two years.[10] The GDP deceleration occurs mainly because investment decelerates

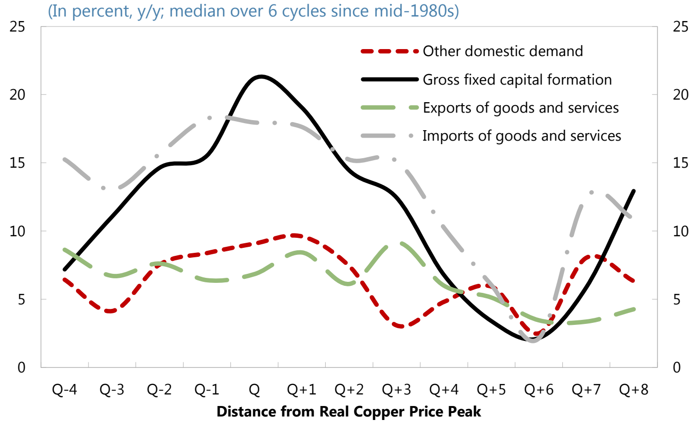
[8] Strictly speaking, this finding does not prove that copper prices do not affect long-term growth, but it is a supporting argument. If long-term growth was impacted, it is very likely that the long cycles of copper and output growths would co-move.

[9] The analysis is constrained by the availability of quarterly data, which start in 1986. The peaks are 1989Q1, 1995Q3, 1997Q2, 2006Q3, 2008Q2, and 2011Q1.

[10] We compute the difference between (i) the average year-on-year quarterly growth rate over the 4 quarters preceding the peak and (ii) the average growth rate during the 8 quarters following it. Interestingly, the implied elasticity (0.04 = 1/25) is very close to the short-term effect on GDP growth estimated by the VECMs presented in the next section.

strongly after the peak, dragging down imports (one fourth of which are capital goods, on average), whereas consumption and exports do no show a clear pattern.

Real GDP Components Before/After Copper Price Peak
(In percent, y/y; median over 6 cycles since mid-1980s)



Source: Central Bank of Chile and Fund staff calculations.

Econometric Analysis

14. The behavior of GDP after a commodity price shock can also be analyzed within a Vector Error Correction Model (VECM). Assuming that copper prices have transitory effects on GDP growth and a permanent effect on the GDP level, the VECM constitutes a natural instrument to estimate transitional dynamics when a shock moves variables away from equilibrium.[11] Constrained by the data availability, our quarterly sample starts in 1990. Most of the specifications have a four-lag structure determined by standard lag length criteria.

15. A cointegration relationship exists between copper prices, real GDP, and national saving rate. We tested the existence of long-term relationships between real GDP, nominal copper prices and the following variables: the openness ratio, the investment rate, the national savings rate,[12] population growth, the price level, inflation, and the REER. Our baseline model includes the log of Chile real GDP, the log of nominal copper prices, and the log of the national savings rate.[13] Over the period considered, the three variables are cointegrated.[14] The levels of GDP and copper prices are positively related in the long-run, suggesting that Chile does not suffer from Dutch

[11] The method is similar to Collier and Goderis (2012), who estimate an annual panel VECM over 1963–2008 in 120 countries using aggregate commodity price indices.

[12] The savings rate is calculated as the difference between nominal GDP and "other domestic demand," in percent of GDP.

[13] The models passes a number of standard tests, including length lag tests for the unrestricted VAR, integration of individual variables, and Johansen cointegration tests.

[14] Nominal and real copper prices have followed a similar evolution since the 1990s, and both are found to be integrated over the period, which is the reason why they can be used interchangeably in the equation (the previous section shows that *over a longer period*, the log of real copper prices is likely to be stationary).

disease, probably because of its sound institutional and policy framework. The sign of the savings rate could signal a consumption smoothing behavior, with national savings increasing with copper prices—partly because of the structural fiscal rule in place since 2000. The model (as well as alternative specifications) is described in Appendix 4.

16. After a copper price shock, the transition towards the new steady state takes several years. Depending on the model, the length of convergence spans over 5–10 years.[15] Following a 20 percent nominal price shock, GDP stabilizes at a level which is between 2 and 4 percent below baseline in the long run.[16] This effect is similar in magnitude and duration to that estimated by Fornero and others (2015) in a SVAR with persistent shocks. Results are robust to alternative specifications, including (i) a shorter period (e.g., the commodity boom of 2003–14), (ii) using alternative variable definitions (real copper prices, GDP per capita), (iii) fewer lags, (iv) annual data,[17] and (v) with an exogenous block including China GDP growth, the change in the Fed funds rate and the change in the VIX index (Appendix 4).

17. The effect of the price shock on GDP growth is frontloaded. In all models, GDP does not decline linearly over 5–10 years. Most of the growth decline is concentrated in the first three years. At the WEO projection horizon (5 years), GDP growth is found to be 0.1–0.2 percentage point below baseline for a 20 percent price shock. The precise point estimate is very sensitive to the specification. For instance, annual models generally produce a faster adjustment, and consequently, a smaller growth deceleration in the fifth year, perhaps because of their smaller number of lags.

18. The negative effect on GDP growth is, to a large extent, driven by lower capital accumulation. To assess the effect of a copper price shock on capital accumulation, we estimate annual VECMs since 1960 (longest sample available).[18] Over this period, we find alternative cointegration relationships between nominal copper prices, real GDP, the capital stock, and either the openness ratio or the REER and a linear trend (all variables in logarithm). We also estimate another model with two cointegration relationships, and impose (and test) restrictions on the long-term and short-term coefficients to identify the equations.[19] Short-term dynamics include dummies for the 1975 and 1982 crises. Overall, these models show that a 20 percent fall in nominal copper

[15] Simulations use the following Cholesky ordering for the baseline model: copper prices, savings rate, and GDP.

[16] 20 percent corresponds to the estimated size of the "permanent" shock, proxied by the decline between the average copper price during the boom years (2006–14) and the average price projected in the WEO over 2015–20.

[17] Annual regressions are conducted over 1990–2014 and 1960–2014. Over the longer period, we find a cointegration relationship between Chile real GDP (in log), real copper prices (in log), the openness ratio (exports plus imports divided by GDP, in log), and the investment ratio (gross fixed capital formation in percent of GDP, in log).

[18] The capital stock variable is only available at the annual frequency. The models' results are not reported here but available from the author upon request.

[19] One cointegration relationship relates GDP per capita and capital stock; the other one relates GDP per capita, openness ratio and real copper price.

prices reduces capital accumulation by about 0.1–0.3 percentage points (relative to the baseline) after five years.

19. Total factor productivity (TFP) effects seem less important. The negative effect on capital accumulation could potentially be (partly) offset by a positive response of TFP growth if lower copper prices were to trigger a reallocation of resources from mining towards higher-productivity sectors. To test whether the data confirm this hypothesis, we re-estimate the quarterly VECM (over 1990–2014 with the national savings rate and nominal copper prices) but differentiate between mining and non-mining output. We do not find evidence of reallocation between the two sectors after the shock. The fall in mining output is marginal, suggesting that the supply elasticity of copper output is quite small. Most of the output decline occurs in the non-mining sector, perhaps because of negative wealth effects or because some copper-related production is recorded in other sectors (e.g., infrastructure). Using the model's output estimates and assumptions on TFP growths in each sector, we find that aggregate TFP growth would decline marginally (by less than 0.05 percentage point) in the medium-run after a 20 percent nominal copper price shock.[20]

D. Conclusion

20. This chapter suggests that the fall in copper prices is likely to have a persistent (although not permanent) effect on GDP growth. While the impact of lower copper prices on output peaks in the first 3 years after the shock, the transition towards the new lower steady-state GDP level generally takes 5–10 years. From a production function perspective, the reduction in GDP growth is mainly driven by lower capital accumulation, while the TFP channel seems less important.

[20] We assume TFP growth rates of -5 percent a year in the mining sector and +0.5 percent in the non-mining sector—a calibration close to actual 2013 estimates according to CORFO (2014).

Appendix 1. Spectral Analysis Concepts

Spectral analysis

Stationary time series can be written as a linear combination of orthogonal cyclical (trigonometric) functions, also known as their Fourier representation. The "spectrum" of a time series, which is the central concept of the spectral analysis, is the Fourier representation of the autocovariance function of the series. The spectrum enables to identify the frequency components that make the greatest contribution to the overall variance of the series. The sample counterpart of the theoretical (infinite) spectrum is called the "periodogram." A peak of the periodogram at frequency f (or w) denotes a cycle of period T=1/f (or 2pi/w) in the original series.[21]

Co-spectral analysis

The spectral analysis can be extended to a multivariate case in order to measure the co-movement between series. The most commonly indicators are called the "coherence" or "coherency" (which estimates the correlation between the series at a particular frequency), the "phase angle" (measuring the lead-lag between the cycles of the two series at a particular frequency) and the "gain" (which calculates the difference in the cycle amplitude).

Band-pass filters

A "low (resp. high) pass" filter passes low (resp. high)-frequency signals and blocks high (resp. low)-frequency ones. A "band pass" filter passes signals whose frequency lies in a certain frequency band. An example of such filter is the Christiano-Fitzgerald (CF) filter, which is used to isolate the cyclical component of a time series by specifying a range for its duration. This chaper uses the full sample asymmetric form of the CF filter, which is the most general form. The alternative, using a fixed-length filter (such as the Baxter-King filter) would require that we rely on the same number of lead and lag terms for every weighted moving average. This would imply losing observations at the beginning and the end of the sample. The asymmetric filter does not impose this requirement and can be computed until the last data point of the sample.

[21] T denotes the period, f the frequency, w the angular frequency.

Appendix 2. A Simple Model of Copper Prices

This appendix presents the results of quarterly models of nominal copper prices, which are estimated over 1991–2014 with OLS. Appendix Table 2.1 reports the estimates of the baseline model (column 2) and alternative specifications (columns 3–6).

Appendix Table 2.1. Nominal Copper Price Equations

Dep. Var:	DL(COP)	DL(COP)	DL(COP)	DL(COP)	DL(RCOP)
DL(real GDP China)(-1)	5.73 (4.26)**	5.59 (4.07)**	5.75 (4.31)**	2.91 (2.39)*	5.53 (4.13)**
D(US10 year bond yield)(-6)	-0.07 (-2.73)**		-0.07 (-2.79)**	-0.06 (-2.10)*	-0.07 (-2.73)**
DL(US REER)(-6)	-0.89 (-2.18)*	-0.91 (-2.18)*		-0.80 (-1.75)	-0.84 (-2.07)*
D(Net Position Traders)	0.00 (4.91)**	0.00 (4.57)**	0.00 (4.92)**		0.00 (4.89)**
Dummy Q4 2008	-0.60 (-6.81)**	-0.63 (-6.91)**	-0.61 (-6.90)**	-0.68 (-6.43)**	-0.57 (-6.48)**
Dummy Q2	0.06 (2.56)*	0.06 (2.74)**	0.06 (2.55)*	0.01 (0.52)	0.05 (2.27)*
Constant	-0.13 (-3.79)**	-0.12 (-3.58)**	-0.13 (-3.75)**	-0.06 (-1.85)	-0.13 (-3.79)**
D(Fed Fund Rate)(-5)		-0.04 (-1.84)			
DL(US NEER)(-6)			-0.89 (-2.39)*		
Observations:	86	86	86	94	86
R-squared:	0.61	0.59	0.61	0.40	0.59
F-statistic:	20.41	18.83	20.79	11.57	19.02

Note: COP (resp. RCOP) denotes the nominal (resp. real) copper price; t-statistics in parentheses; ***(**, *) = significant at the 1 (5, 10) percent level.

In the baseline model, copper prices (in log difference) are found to be affected by (i) China real GDP (in log difference); (ii) the real effective exchange rate of the dollar (in log); (iii) an indicator of market expectations (net open position of non-commercial traders in copper futures, in log); (iv) the US real fed fund rate (in log); and (v) some time dummies. This model explains about 60 percent of the volatility of copper prices over the period. All estimated coefficients are consistent with priors. Copper prices are positively affected by China's growth and the position of non-commercial traders,[22] and negatively affected by global interest rates[23] and the U.S. dollar.[24] The beta coefficients (standardized by the relative standard deviation of each regressor) show that market expectations and China's growth are the main drivers of copper prices. Growth in other regions (Japan, Europe, U.S.) were not found to impact copper prices in a consistent manner.

The model is robust to alternative specifications using real copper prices, the U.S. fed fund rate, real bond yields, and the nominal effective exchange rate of the dollar. An equation excluding the net position of traders is also included, as this variable is correlated with China's growth and impairs the stability of the coefficients.

[22] If large institutional investors (not involved directly in production or distribution of commodities) increase their long positions, it means that they have a bullish bias on the market and expect prices to increase.

[23] If the real interest rate is high, producers are encouraged to extract copper now, sell it, and invest the proceeds in bonds. The result is a fall in demand or rise in supply, which drives down the spot price of copper.

[24] The negative effect of the dollar on commodity prices can be explained by two factors: (i) a "demand effect:" as the price of commodities is set in dollars, foreign countries have to buy commodities at a higher price (in domestic currency), and therefore the demand for commodities declines, which reduces their price; and (ii) a "portfolio reallocation effect:" when the dollar goes up, investors move from the commodity to the currency market.

Appendix 3. Theoretical Effects of Commodity Price Shocks on GDP Growth

This appendix discusses the effects of a permanent exogenous commodity price shock on the GDP of commodity producers. The analysis is conducted in models where commodities are a produced good rather than a production factor.

Models typically highlight four main transmission channels: (i) *Return*: a commodity price decline affects the return of investment and extraction, whether it is measured as the marginal productivity of capital, profitability, or capital gains on commodity prices (see below); (ii) *Savings*: lower commodity prices erode the income generated by the commodity sector, reducing savings and investment other factors being equal; (iii) *Resource reallocation:* capital and labor move from the commodity sector to sectors producing other tradable and non-tradable goods; and (iv) *Governance*: some models assume that a contraction of the commodity sector could foster entrepreneurship and reduce rent-seeking behaviors.

Static neoclassical investment model

A permanent exogenous decline in the price of output decreases the marginal productivity of capital (in nominal terms) and hence the firm's demand of capital until the identity between user cost of capital and marginal capital productivity is restored at a higher productivity level. With a Cobb-Douglas function, it is easy to show that the demand for capital depends positively on the output price. In the absence of adjustment costs, the effect is instantaneous. Thus, **the model predicts a instantaneous negative effect on GDP growth and permanent negative effect on the GDP level.** Intuitively, at lower copper prices, some projects are not going to be profitable and production will be permanently scaled down with a one-off effect on growth.

Tobin's Q investment model with adjustment costs

In a Tobin's Q model, investment decisions are forward-looking and depend on the gap between the marginal cost of capital and the marginal value (in terms of future profits) of an additional unit of capital—this value depends on future output prices.

The results of the previous model remain valid: **negative price shocks have a temporary negative effect on GDP growth and a permanent negative effect on the GDP level.** In addition, the standard Tobin's Q model generally incorporates capital adjustment costs, so that **the deceleration of the capital stock is gradual rather than instantaneous**.

An important implication of the model is that the effect of a price decline depends on the persistence of the shock. Temporary shocks affect only marginally the sum of future profits, while permanent shocks have a stronger effect on the Q. Therefore, **the short-term effect on investment and GDP growth is stronger for permanent shocks**.

Commodity extraction model

In this model, the production/extraction decision today is driven by the expected future rate of increase in commodity prices, not by their current level (Box 1). **The short-term effect of the shock will thus depend on how it impacts price expectations**:

- If the negative shock is temporary and prices are expected to recover, the expected growth rate of prices may temporarily exceed the interest rate. Producers will have incentives to postpone production until prices bounce back. GDP growth will immediately decline. Compared to previous investment models, production declines because of the expected capital gain, not because investment is not profitable at current prices.

- If the negative shock is believed to be permanent and copper prices do not recover to the pre-shock level (but resume growing at the same rate as in the baseline following the shock), short-term GDP growth will be unaffected.[25]

Regardless of the persistence of the shock, **there is no effect on long-term growth**. The reason is that production growth depends on the gap between the expected price increase and interest rate; there is no reason to assume that this gap is affected by the initial shock. In addition, output growth in the long-term would most likely be zero, as the stock of commodity is eventually depleted.

Box 1. Hotelling's Rule

The Hotelling's rule states that non-renewable resources should grow at a pace equal to the interest rate. It may be derived from a social welfare maximization program (Van der Ploeg, 2011). It can also be understood intuitively from a simple arbitrage condition in the commodity market (Frankel 1986, 2011). The decision whether to leave deposits in the ground (and sell them later) versus to extract and sell them at today's price is governed by an arbitrage condition between the interest rate and expected future rate of increase in commodity price. Indeed, one should be indifferent between keeping the resources underground (in which case the return is the capital gain on reserves) and extracting and selling them to get a market return on the proceeds. If producers expect prices to grow at a rate below the interest rate, they will extract all the commodity now, sell it, and invest the proceeds in financial securities. Then, the commodity price will collapse until the expected price growth matches the interest rate. On the opposite, if commodity prices increase faster than the interest rate, producers are better off not bringing the commodity out of the ground, which increases the price of commodities today (due to the supply shortage) and reduces expected capital gains.

[25] Another possible scenario is that prices decline and stay permanently low (instead of growing at the same pace as in the baseline). In this case, producers will have an incentive to extract and sell all commodities immediately, resulting in a short-term boost of production growth.

In the simplest version of the model, there is perfect substitutability between the financial asset and natural resource, so the discrete decision of the producer is basically to extract or not *all* resources today. In an open economy where interest rates and copper prices are set exogenously, a gap between these variables can persist. The arbitrage condition becomes: expected rate of increase equals the interest rate minus a "convenience yield" which includes extraction costs (growing with the level of production). If copper prices grow at a rate below the interest rate, producers extract copper until growing extraction costs have restored the parity. In this case, not all resources are extracted.

Salter-Swan model

The Salter Swan model, used to describe Dutch disease effects, is an appealing framework to understand the effects of a negative commodity price shock, which is theoretically equivalent to a decline in the stock of natural resources.

A natural resource shortfall results in a **reallocation of capital and labor from the non-tradable sector towards the non-commodity tradable sector**. In the simplest version of the model, the shift affects neither the aggregate production nor its growth rate; it simply induces a **change in the production structure** (Van der Ploeg, 2011). Interestingly, even if the non-commodity tradable sector has higher productivity, the resource shift does not increase real aggregate output, because prices are also lower in the non-commodity tradable sector, which implies that its weight in total production is also lower (assuming that output is aggregated with price-based fixed weights, e.g. in a Laspeyres index).

Salter-Swan model with learning by doing

To generate a long-term growth effect, additional assumptions are necessary (Van der Ploeg, 2011). For instance, the capital and labor reallocation has a permanent growth effect if the non-commodity tradable sector benefits most from learning by doing and other positive externalities—meaning that productivity increases with the size of production or employment in this sector. In this case, **a permanent negative commodity price shock boosts GDP growth in the long run.**

Institutional models

Some models explain the poor long-term performance of commodity exporters by weaker institutions and governance rather than Dutch disease. Natural resources may foster corruption, conflicts, wastage, and rent seeking behaviors. Conversely, a reduction in the size of the commodity sector could be beneficial. In these models, **the effect of a negative shock on GDP growth and level is positive and permanent.**

Solow growth model

Growth models can incorporate commodity prices in two alternative ways, as an output or as an additional factor of production. In the following, we consider the first case, which is the most relevant to Chile.[26] The Solow model assumes that the economy produces and consumes a single good. Incorporating a relative price between capital/consumption and the produced good marginally modifies the formulas. In the steady state, the stock of capital depends positively on the price of output, but the long-term growth rate does not depend on prices (it depends only on technological progress). Therefore, **a commodity price decline is accompanied by a temporary negative effect on GDP growth and a permanent negative effect on the GDP level.**

During the convergence towards the new (lower) steady state, growth will be slower than in the baseline. Indeed, a decline in the relative price of output is equivalent to a decline in the savings rate (as lower savings are generated for a given level of real income).[27] As less saving and investment are generated at each period, the growth rate is (temporarily) slower during the transition.

AK growth model

In an endogenous growth model (such as the model of learning by doing of Romer (1986) where technical progress is related to the overall stock of capital in the economy), a decline in the price of output would generate less savings and less investment, with a permanent negative effect on GDP growth, because the stock of capital has positive externalities at the macroeconomic level. Thus, **the negative effect on GDP growth and level is permanent.**

Models focusing on commodity price volatility

Some argue that the adverse growth effect of natural resources results mainly from the volatility of commodity prices, and the related impact on investment and consumption. In particular, there is some evidence that real exchange rate volatility (either due to the volatility of the commodity or to a Dutch disease effect) may hurt investment. This volatility channel could potentially be more important than direct effects. In this case, **a decline in the price level, not accompanied by higher volatility, could have no effect on GDP growth and GDP level.**

[26] In models with exhaustible resources as production factor, production and capital growth is generally negative in the steady state (with output and capital stock converging towards zero), because of the scarcity of the commodity. A change in the stock of resources lifts (up or down) the path but does not affect the steady state (Van der Ploeg, 2011). This result is also valid in a simple endogenous AK model (Aghion and Howitt, 2009).

[27] $sPY = s'Y$ with $s'=sP$.

Appendix 4. Econometric Results

Appendix Table 4.1. Various VECM Models Relating GDP and Copper Prices

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8 [1/]	Model 9 [1/]
Period	1990-2014	1990-2014	1990-2014	1990-2014	1990-2014	2003-2014	1990-2014	1990-2014	1960-2014
Cointegrating Equation									
Log (real GDP)(-1)	1.00	1.00	1.00		1.00	1.00		1.00	1.00
Log (copper price)(-1)	-0.37		-0.37	-0.30	-0.43	-0.33		-0.33	
	[-5.14]		[-5.24]	[-5.12]	[-4.75]	[-17.39]		[-6.54]	
Log (national savings rate)(-1)	1.09	1.33	0.96	0.89	0.92	0.69	0.77	1.12	
	[2.68]	[2.62]	[2.28]	[2.70]	[1.84]	[7.93]	[4.27]	[3.80]	
Constant	-15.06	-17.09	-15.25	1.19	-15.25	-15.77	-7.89	0.15	-15.67
Log (real copper price)(-1)		-0.46							-0.42
		[-4.10]							[-2.86]
Log (real GDP per capita)(-1)				1.00					
Log (non-mining GDP)(-1)							1.00		
Log (mining GDP)(-1)							-0.50		
							[-6.14]		
Log (openness ratio) [2/]									-1.52
									[-6.02]
Log (investment ratio) [2/]									-1.29
									[-2.81]
Short-Term Dynamics									
Number of lags	4	4	4	4	2	6	4	1	1
Alpha of dlog(real GDP) equation	-0.03	-0.02	-0.03	-0.04	-0.03	-0.07	-0.06	-0.09	-0.05
Exogenous Variables									
dummy 2008Q4, Q1, Q3	X	X	X	X	X	X	X		
dlog(China GDP), d(VIX), d(fed fund rate)			X						

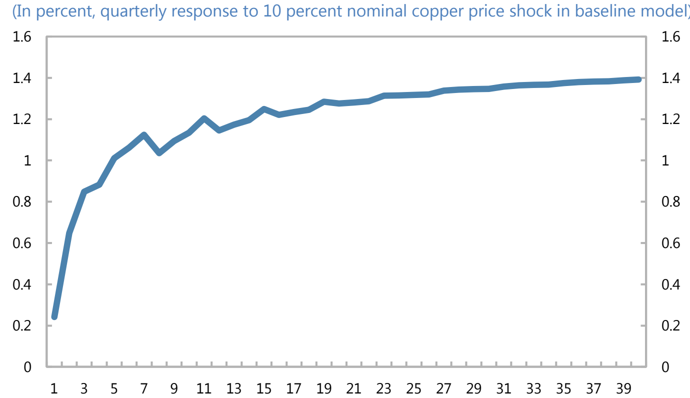
1/ Annual models. Model 9 includes time dummies for 1975 and 1982.

2/ Openness is measured as exports plus imports divided by GDP. Investment ratio is measured as GFCF divided by GDP.

Note: t-statistics in brackets.

Impulse Response Function: Log Real GDP

(In percent, quarterly response to 10 percent nominal copper price shock in baseline model)



Source: Fund staff calculations.

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ASSESSING THE POTENTIAL ECONOMIC IMPACT OF THE STRUCTURAL REFORM AGENDA IN CHILE[1]

A. Introduction

1. **The Chilean government launched an ambitious economic and structural reforms agenda in March 2014**, **with the objective to foster stronger and more inclusive growth**. The agenda spans a wide range of areas (see table below), including boosting Chile's infrastructure network (mainly energy, transportation, and telecommunication) and improving the quality of human capital through a reform of the education system.[2]

Structural Reform Agenda

Reform Areas	Main Measures	Status
Tax Reform	Capital Income Tax	Passed
	Excise and Broadening of VAT Base	Passed
Public Education	Repeal Private Co-payments and Student Selection	Passed
	Eliminate For-Profit Institutions	Passed
	Increase Expenditure in Schools	Announced
	Improve Early Education	Announced
	Universal Tertiary Education	Announced
Labor Market	Repeal Gender-Biased Rules	In Congress
	Increase Day Care Facilities	Announced
	Increase Unionization	In Congress
Energy	Ease Permits	Announced
	New Concessions to Foster Public Private Partnerships	Announced
	Incentivize Renewable Energy	Announced
Telecommunication	Reduce digital divide	Announced
Transportation	Improve Roads and Connectivity	Announced
	New Transportation Lines	Announced
	New Ports	Announced

2. **The agenda has the potential to lift the country to a higher-growth path over the next few decades**. Previous studies have shown that Chile suffer from an infrastructure gap relative to OECD economies (Calderon and Serven, 2004; ECLAC, 2014). Chile also displays a gap in the quality of human capital, as measured by lower average schooling years of its labor force and lower PISA scores relative to the OECD average. These structural weaknesses could have contributed to the slowdown in TFP growth during the last decade, as highlighted by Corbo (2014). To help finance the cost of the reforms (in particular, the

[1] Prepared by Marika Santoro. Ehab Tawik provided excellent research assistance. This paper benefited from the comments of Roberto Cardarelli, Romain Duval, Jorge Roldos, and the participants of the April and June 2015 seminars at the IMF and the Central Bank of Chile.

[2] While the government reform agenda comprises many other measures, including a reform of the labor market, of the constitution, and of social security programs, this chapter focuses only on policies that most directly affect Chile economy's growth potential. In particular, we'll consider the tax and education reforms, and the infrastructure plan within the broader "*Agenda de Productividad, Innovacion y Crescimiento*" that was announced by the government in early 2014, and started being implemented in the 2014 Budget law. Also, this chapter des not address the potential impact on GDP from lower inequality in the distribution of income, an important objective of the reforms (see IMF, 2014).

education reform) the authorities completed a fiscal reform in September 2014, which changed Chile's income tax system. While matching the increase in outlays with new permanent revenues is prudent, higher taxes on capital income might have a dampening effect on corporate savings and investment (see also IMF, 2014; Santoro and Wei, 2012).

3. Quantifying the impact of the structural reforms on long-term GDP is subject to a great deal of uncertainty. This mainly reflects the complexity of the reforms, and the fact that they will likely bring results only in the longer run. The objective of this chapter is to estimate the potential impact of the 2014 economic and structural reform agenda on GDP level and growth. We do this in two ways. First, we quantify the gaps that Chile has accumulated relative to OECD average in both infrastructures and quality of human capital, and assess the potential GDP gains associated with closing those gaps. Second, using these estimates, we assess the impact on GDP from i) the education reform, ii) the tax reform and iii) investment in infrastructure, using a general equilibrium model which help illustrating the trade-offs and short-term transitional dynamic from the combined set of reforms.

B. Quantifying the Structural Gaps

4. Infrastructure and human capital gaps can hinder potential GDP. Infrastructure gaps have been estimated following two main approaches. The first one calculates these gaps as deviation from an "optimal" level, conditional on the country's economic development (Perrotti and Sanchez, 2011; Liberini, 2006). In this case, the level of GDP is one of the determinants of the optimal stock of infrastructure—higher levels of GDP imply higher demand for infrastructure. The second approach first quantifies the gaps based on cross-country comparisons, and then estimates the contribution to GDP from different endowments of infrastructure capital (Calderon, and Serven, 2004; Calderon, Moral-Benito and Serven, 2014). We follow this approach and consider infrastructure capital as one of the factors that explains cross-country differences in GDP. Higher human capital affects GDP through its impact on labor productivity, as shown in the seminal work by Mincer (1974). The productivity-augmenting effects of higher human capital can be measured through estimating the relationship between an individual's schooling and his labor earnings.

Infrastructure

5. Chile ranks below OECD averages in terms of infrastructure. *Electricity*, as measured by installed generating capacity per worker, is about 55 percent below OECD average. *Transportation*, in terms of km of roads per worker, is 67 percent below OECD average (Figure 1). Using alternative measures of electricity and transportation infrastructure, such as and technical losses in electricity generations and distribution, quality of roads, and km of railroads, Chile still ranks way behind OECD peers (Figure 2). By contrast, Chile is broadly in line with OECD average in *Telecommunication* infrastructure, measured as number of landlines and cell phones per worker. A composite indicator of the infrastructure gap can be estimated as the principal component of electricity, transportation, and telecommunication indicators. Using a panel of 65 countries, we find that a composite indicator of infrastructure (*Z*) has the following shape: [3]

$$logZ_t = 0.4 * \log(ELECT) + 0.4 * \log(TRANS) + 0.3 * \log(TELECOM) \quad (1)$$

Based on this indicator, Chile 10-year average infrastructure capital is about 50 percent below the OECD average, but is above the average for Latin American countries.

6. **Removing the infrastructure gap can have a significant impact on potential output**. In order to estimate the implication of the infrastructure gap on GDP, following the general approach by Hall and Jones (1999) and by Calderon and Serven (2004), we construct a production function that accounts for the contribution of infrastructure:

$$F(A, Z; K, L) = A\, Z^{\gamma} K^{\alpha} L^{\beta}, \quad (2)$$

where *A* is total factor productivity (TFP), *K* is the stock of capital and *L* is the labor input. Using a panel of 88 countries, Calderon, Moral-Benito and Serven (2014) estimate jointly the contribution of infrastructure, capital and labor (γ, α, and β) to output, and find that Υ=0.1. Using this parameter, equation (2) implies that the GDP loss from the infrastructure gap relative to OECD average is about 7 percent.

Infrastructure Gap

Year	OECD	LAC
	(percentage diff. from)	
A. *1992-2012*		
Z	-52.5	17.7
GDP	-7.2	1.6
B. *2002-2012*		
Z	-49.2	19.9
GDP	-6.6	1.8
C. *2012*		
Z	- 45.0	20.0
GDP per worker	-5.8	1.8

Human capital

7. **Chile also has a significant gap relative to OECD standards in terms of human capital**. As of 2010, the average years of schooling of Chile's labor force was about 12 percent below OECD level, using Barro and Lee (2014). Based on the 2012 PISA scores (widely used as a measure of education quality and cognitive skills of the labor force), Chile ranks 15 percent below the OECD average.[4]

Human Capital Gap

Year	OECD	LAC
	(percentage diff. from)	
Schooling years (s)	-12.2	17.8
GDP per worker (1)	-6.0	7.0
GDP per worker (2)	-7.2	9.3

(1) Cubas, Ravikumar and Ventura (2013)

(2) Bills and Klenow (2000)

[3] This result is very similar to Calderon, Moral-Benito and Serven (2014).

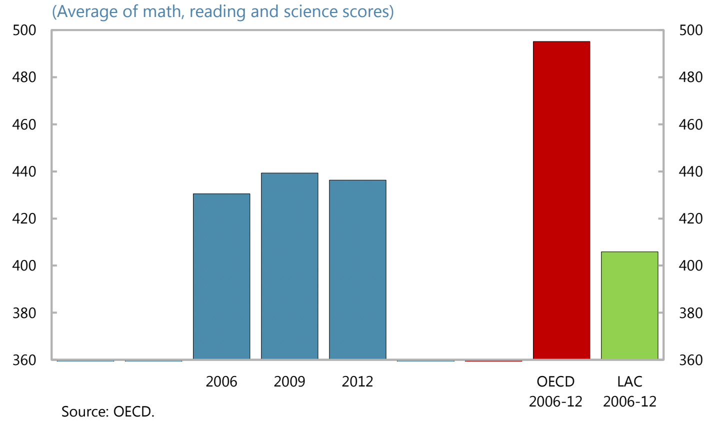
[4] The Programme for International Student Assessment (PISA) study is organized and conducted by the OECD to ensure comparability across countries. The PISA sample covers students between 15 years and 3 months of age and 16 years and 2 months of age, independent of their educational attainment.

8. Removing this gap has the potential to increases output by about 7 percent. To measure the GDP loss implied by the human capital gap, we decompose the labor input in the production function following Bills and Klenow (2000):

$$F(A, S; K, L) = A\, K^{\alpha} [\phi(S)\, L]^{\beta}, \qquad (3)$$

where S is the level of education or quality of human capital expressed as the number of schooling years, and $\phi(S)$ is the return on education. Using data by Barro and Lee (2010) on the number of schooling years and two different functions and parameter specifications for $\phi(S)$ by Bills and Klenow (2000) and Cubas, Ravikumar and Ventura (2013), the GDP loss implied by equation (3) (relative to the OECD average) from Chile's lower level of human capital is between 6 and 7 percent.

Chile PISA Score, 2000-2012
(Average of math, reading and science scores)



Source: OECD.
Note: LAC includes LA5, ARG, CSI and URY.

C. Assessing the Reforms Within a General Equilibrium Model

9. The tradeoffs between the short-term impact of the tax reform and the longer-term impact of the structural reforms can be illustrated with the help of a general equilibrium model. We use the IMF's Global Integrated Monetary and Fiscal model (GIMF), comprising three regions: Chile, Emerging Asia and Rest of the World. GIMF has optimizing behavior by households and firms; two sectors (tradable and non-tradable goods sectors); sticky prices and wages; real adjustment costs; liquidity-constrained households who do not save and have no access to credit; and households with finite planning horizons who optimize their saving and borrowing decisions (for a detailed description of the model see Kumhoff, Laxton, Muir and Mursula, 2010). The model enables us to combine in a unified framework the negative impact of the tax reform, which will dominate in the short run, with the positive effects of the structural reforms, bearing fruits in the longer run. It is important to note up front that these scenarios are illustrative, and should not be interpreted as forecasts or exhaustive of the possible policy options for Chile.

10. The structural reforms considered in the model are:

a. **Energy**: The economic agenda announced in 2014 aims at reducing electricity marginal costs by 30 percent by 2017 (Chile's is currently facing one of the highest prices of electricity in Latin America). To do so, the agenda involves improving the connectivity between the two national interconnected grids (the Central and Great Northern grids); boosting incentives to utilize renewable sources (so that they represent 45 percent of the electricity generation capacity over the next decade); and facilitate the involvement of private sector by easing the regulatory practices behind the release of permits. In GIMF, the impact of these measures is modeled as a TFP shock. [5]

b. **Transportation:** the agenda aims at strengthening urban and intercity connectivity and port infrastructure (including thorough the construction of a large port in the central area of the country), also by incentivizing the direct involvement of the private sector. Improved transportation infrastructure is also assumed to boost TFP in the model.

c. **Telecommunication**: the agenda aims at boosting internet access, data transmission, and coverage of the fiber optic national network, including through establishing a *Fondo de Desarollo de Telecommunicaciones*. Implementing these measures would improve productivity, and we thus model this measure as a TFP shock.

d. **Education**: the education reform announced by the authorities involves substantial changes at all levels of education through a series of bills. Three of them have already been approved by Congress (*Ley de Inclusion*), and eliminate the selection of students, copayment, and scope for profits in Chile's primary and secondary schools that receive public funding. Other bills are currently under discussion that aims at reforming the access to tertiary education, for example by providing free enrollments to high standards schools for the lowest 60 percent of the income distribution. The reform agenda also contemplates greater spending on public education, including on teachers' formation, schools' infrastructure, and child care facilities. In GIMF, we follow equation (3) and model these measures as a labor augmented shock in the model's production function.

11. The model also incorporates an increase in taxes on capital income and consumption from the 2014 reform. The tax law approved in September 2014 changed Chile tax system, including by i) gradually increasing corporate tax rates, ii) reducing the top marginal personal income tax rate, and iii) offering firms the choice between an integrated tax system which is less generous than the old one (as dividends are taxed at a higher rate and shareholders can only partially deduct that tax from their final taxes) and a new semi-integrated regime (where dividends are taxed when accrued, independently if distributed or not) (Box 1). Preliminary estimates by the SII suggest that, under the new regime, the effective marginal tax rate on capital income increases by 3 percentage points in 2018. In GIMF, higher capital taxation reduces the return on capital, inducing firms to invest less and also weakening private consumption as household income falls. In addition, the 2014 reform increases taxes on consumption, by extending the VAT tax base (including on real estate) and increasing excise taxes on a series of non-primary goods (such as tobacco and alcohol). In GIMF, this is modeled as an increase in lump-sum taxes and in consumption tax rates so that the overall increase in fiscal revenues from the fiscal reform is 3 percent of GDP.

[5] The size of the increase in productivity is calibrated to result in the same increase in GDP as discussed in the previous section.

12. The results of the model depend on a number of key parameters and assumptions.

- *The effectiveness of the reforms in closing the gaps:* we simulate three different scenarios in which the structural measures manage to close 20, 50 and 80 percent of Chile's human capital and infrastructure gap, respectively.

- *The speed at which the gaps are closed;* for the infrastructure gap, we consider three scenarios in which the gap is closed (to the extent specified above) after 5, 10, 15 years, respectively.[6] For the human capital gap, considering the longer time needed for education reforms to yield their fruits, we consider three scenarios, in which the gap is closed in 10, 15, and 20 years, respectively.

- *The "credibility" of the reforms*: economic agents in the model may react to the reforms (or their announcement) with some delay, depending on the extent to which they internalize (and anticipate) future income changes. This affects, in particular, how rapidly the productivity and human capital shocks affect private investment in the model. We thus consider three different scenarios, one with fully credible (and thus immediately effective) policies, one where policies are completely internalized by agents after 2 years, and one where this happens after 4 years.

GIMF Simulations: Scenarios

	Low	Medium	High
	(in percent)		
Effectiveness	20	50	80
Infrastructure gaps closed	20	50	80
Human capital gaps closed			
	(in years)		
Speed	15	10	5
Infrastructure	20	15	10
Human capital			
Credibility			
All measures	4	2	immediate

- *The elasticity of output to infrastructure* in the model's production function, that is, the parameter Y in the production function described by equation (3). We use two values, the Y=0.1 found in Calderon et al (2013), and a higher value, Y=0.2.

13. Model simulations confirm that the net impact of the reforms is subject to a great deal of uncertainty. The tax reform affects negatively investment and consumption decisions in the short run, while both infrastructure and human capital will build up only gradually. In the long run, the net impact of the reforms mainly depends on their effectiveness, whereas in the short and medium run the degree of credibility and speed of implementation are more important. Figure 3a and 3b show two paths for a scenario in which 50 percent of both infrastructure and human capital

[6] Within each time span, gaps are closed linearly with the exception of energy. Given the speed at which capacity has already been built up in 2015 (Bachelet's speech, May 21), we assume that 40 percent of energy generation gaps are closed within the first 5 years. This implies that almost 30 percent of the overall infrastructure gap is closed in the first 5 years. The education gap is closed linearly but only after the first 5 years (that is, it begins to be closed only after 5 years) in order to capture the fact that education reforms generally have an impact on the quality of the labor force only after a number of years (OECD 2013, 2015).

gaps are closed. While the long-run results are identical, the level of real GDP after 5 years is 2–3 percentage points lower in a "low credibility" scenario relative to the "high credibility" scenario, for a medium speed in implementation (Figure 3.a). And in a "high credibility" scenario, the level or real GDP is 3 percentage point lower after 5 years when infrastructure and human capital gaps are closed at a "low speed" (after 15 and 20 years, respectively) relative to when the gaps are closed at "high speed" (in 5 and 10 years) (Figure 3.b). Under the worst-case scenario, real GDP immediately falls relative to the no-reform baseline and is still -0.6 percent below baseline by 2020 and only marginally above by 2025. Under the most optimistic scenario, GDP immediately increases by 1.3 percent and is about 14 percent above baseline by 2025 (Figure 4).

14. The most likely (median) scenario entails an increase of real GDP by about 6 percent in 2025, with a small negative impact during the first two years. This scenario (black line in Figure 4) is the median of all the possible scenarios that were constructed combining the key parameters described above. It is characterized by an infrastructure gap that is closed by 50 percent in 10 years; a human capital gap closed by 50 percent in 15 years; partial credibility (2 years); and an elasticity of output to infrastructure of 0.1. Under this scenario, private investment declines by about 2 percent in the first two years, reflecting higher taxes on capital income. However, the impact on real GDP is buffered by fiscal and monetary policy easing and a REER depreciation,[7] with real GDP only slightly (by 0.2 percent) below its no-reform baseline level in 2015 and about 0.3 percent in 2016. By 2020, as the positive effects of the structural reforms are fully internalized by agents, real GDP will be about 2 percent higher than in our no-reform baseline, with TFP growth increasing by ¾ percent. Investment and consumption would be 3 and 0.4 percent higher than the baseline case by 2020, respectively, and exports are 1 percent higher as the REER further depreciates with reforms increasingly bearing fruits.

Median Scenario

	2015	2016	2020	2030	SS
	(percentage deviation from baseline)				
GDP	-0.2	-0.3	1.9	7.5	8
Consumption	-0.6	-0.9	0.3	3.1	4.4
Investment	-1.6	-1.7	3.2	7.3	5.8
Export	0.2	0.1	0.9	7.8	8.1
Import	-0.6	-0.7	2.7	2.3	2.4
REER (+=Deprec)	0.1	0.1	0.4	2.6	2.6

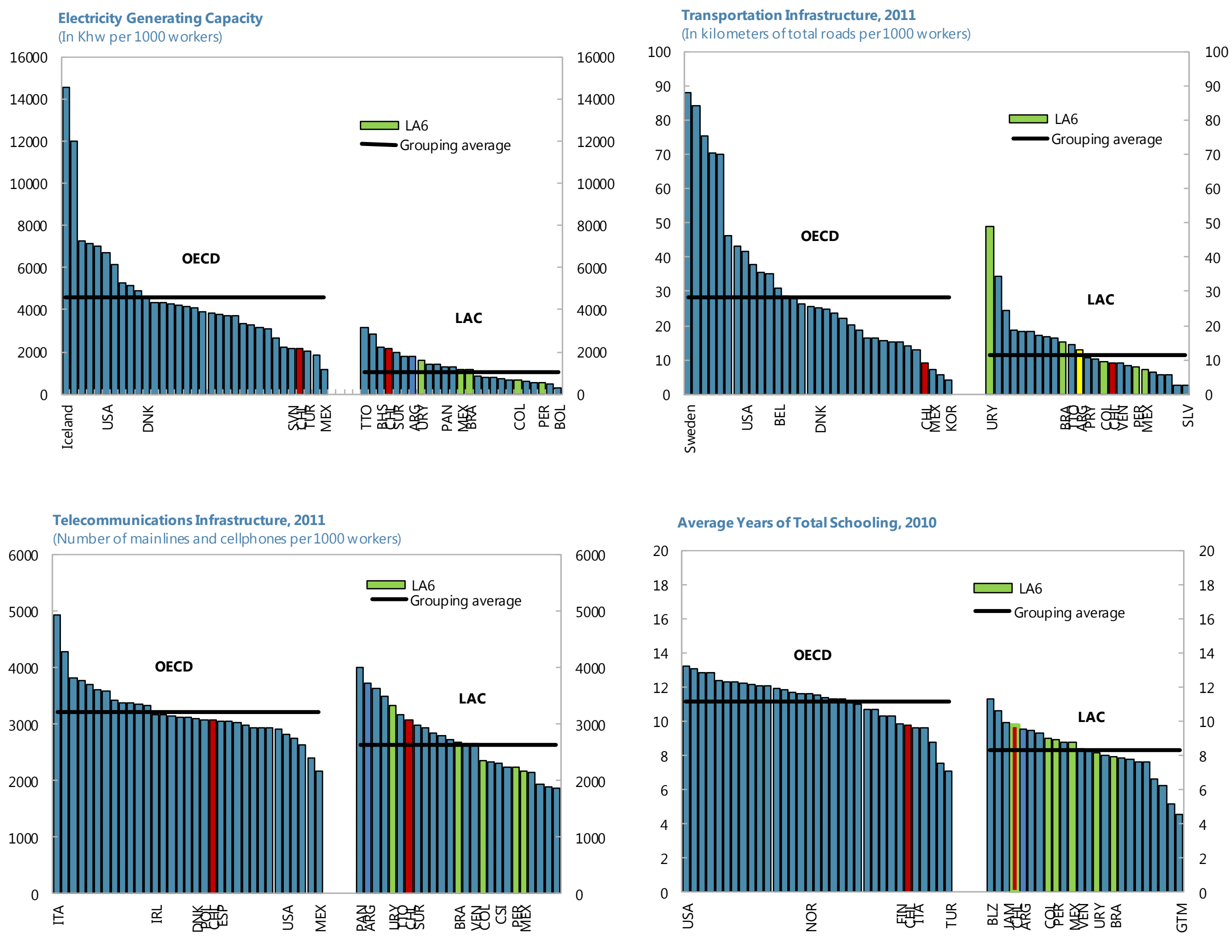
D. Conclusions

15. The 2015–18 reform agenda has the potential to increase long-run GDP, but the design, credibility and speed of the reforms are crucial for a smooth transition to a higher productive potential of the Chilean economy. Chile has accumulated gaps in infrastructure and human capital relative to average OECD economies. Some of those gaps have constrained productivity growth, including through high energy costs, transportation bottlenecks, and a range of

[7] There are a few reasons why in GIMF the short-term impact of higher taxation is relatively small. First, weaker private demand prompts firms to demand less labor, which lowers the marginal cost of production and thus the price for domestically produced goods. The resulting fall in inflation leads the monetary authority to reduce the nominal policy rate. The resulting lower real interest rate reduces the cost of capital, offsetting the initial impact of higher taxation. Lower real interest rate also leads to a depreciation of the real effective exchange rate, which boost net exports. Finally, the automatic fiscal stabilizers also operate, which also offset the initial negative impact of higher taxation on private demand.

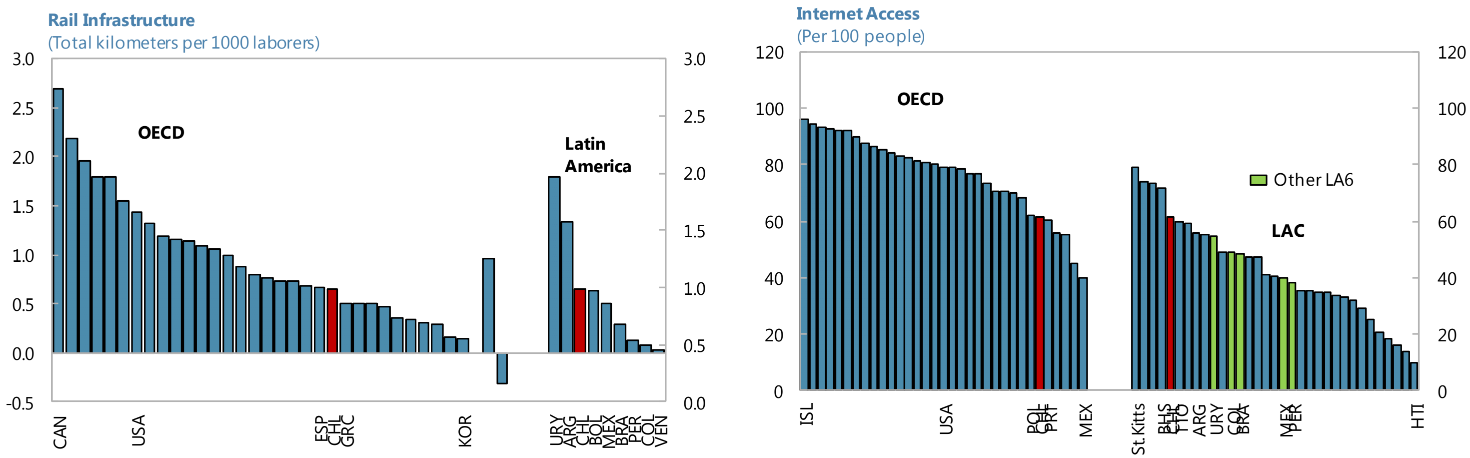
inefficiencies in as few key network industries. Staff estimates shows that removing these gaps has the potential for a sharp improvement in the level of GDP. Despite the large range of uncertainty on the quantification of the reform agenda, model simulations shows that the negative impact on GDP from higher taxes on capital income is likely to be minor and soon offset but the positive effects of the structural reforms on productivity. But badly designed reforms that remove only a very small fraction of the gaps, at a slow speed, and with little credibility can greatly reduce the positive impact on GDP.

Figure 1. Infrastructure and Human Capital Gaps



Sources: World Development Indicators (2014), and Barro and Lee (2014).

Figure 2. Alternative Measures of Infrastructure



Source: World Development Indicators (2014).

Figure 3.a. Credible versus non credible policies

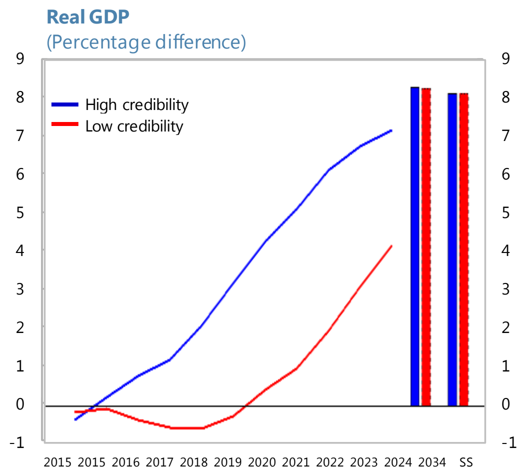


Figure 3.b. High speed versus low speed in implementation

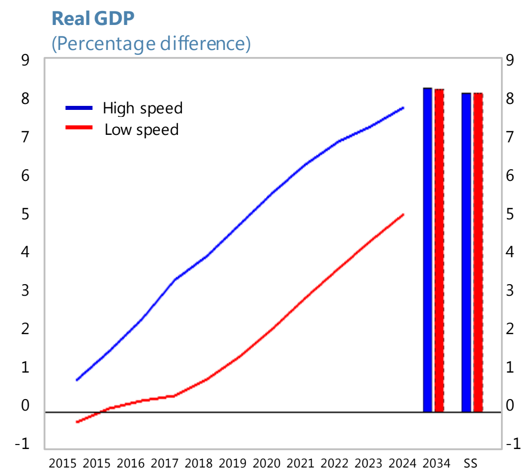
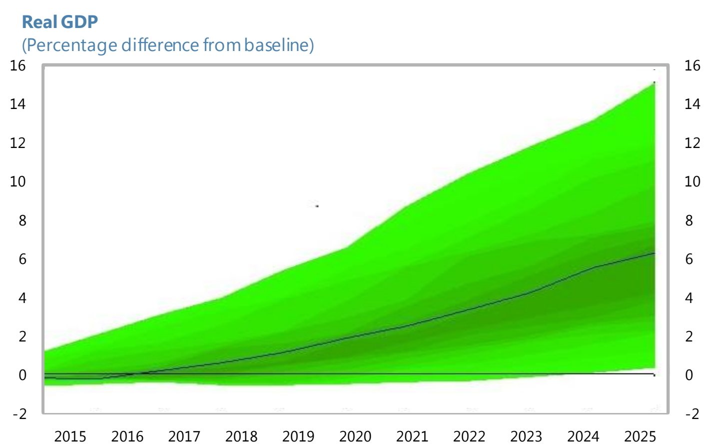


Figure 4. Impact of Reforms on Real GDP



Source: Fund staff calculations.

Box 1. Tax Reform: How Much Does it Affect Tax Rates on Capital Income?

Chile passed a comprehensive tax reform in September 2014, to help finance the agenda of structural reforms. The reform aims at raising 3 percent of GDP, half of which by introducing profound changes in the taxation of capital income. The previous system was characterized by full integration between corporate and personal income taxes, and dividends were taxed only when distributed. In broad terms, under the new regime firms can choose between two different tax systems:

- *An integrated system*, in which taxes on capital income are continued to be paid at the corporate level and fully credited at the personal shareholder level, but dividends are taxed on an accrual basis (that is, regardless of their distribution). The statutory corporate income tax rate is increased from 20 percent to 25 percent (by 2018), whereas the top marginal rate on personal income is reduced from 40 percent to 35 percent. De Gregorio (2014) shows that, under a few assumptions on intertemporal discount factors, firm profitability, and dividend policies, shareholders of non-distributing firms are likely to end up paying higher taxes under this system.[1]

Top Marginal Tax Rates on Capital Income

	Before	After	
		Integrated	Semi-integrated
Dividend	40%	35%	35%
Corporate	20%	25%	27%

- *A semi-integrated system*, where only 65 percent of the taxes paid on capital income are credited at the individual level. The statutory corporate income tax rate is increased from 20 to 27 percent (by 2018). At the personal level, dividends are taxed only when distributed, as in the old system. Given the partial deductibility of taxes paid on corporate profits, the top marginal rate on personal income increases to 44.45 percent, from 40 percent in the old system.[2]

Under the new regime, the average effective marginal tax rate on capital income is higher. To estimate the impact of the new two systems on the average effective capital income tax rate, Chile's *Servicio de Impuestos Internos (SII)* uses a detailed micro-simulation model on both households and firms. Households in the model are statistically representative of the demographic and economic characteristics of the population, while the sample of firms in the model is stratified depending on their dividend distribution policies. Given households characteristics and firms decisions, the micro-simulation model is able to account for many factors that determine the effective tax incidence on capital income (such as deductions, exemptions, and different taxation of returns on investment financed by debt or equity). The model suggests that the 1,000 largest firms, which do not normally distribute dividends or have small distribution rates, and are assumed to continue to do so, will choose the semi-integrated system, as this will allow their shareholders to continue to pay taxes on dividends only when they are distributed. By contrast, small firms (which tend to distribute large dividends) may have an incentive to adopt the fully integrated system, as this implies a lower top marginal tax rate (35 percent vs. 44.45 percent). Considering all these effects, the SII estimates that the average effective marginal tax rate on capital income will increase by 3 percentage points.

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[1] Jose De Gregorio, 2014, Notas Sobre la Reforma Tributaria, mimeo, University of Chile.

[2] The top marginal rate can be computed as follows: assuming that the distributed profits are $100, a firm pays corporate taxes equal to $27. At the personal level, the shareholder whose top marginal PIT rate is 35 percent pays 35%*$100-65%*$27=$17.45. The marginal rate on distributed profits is ($27+$17.45)/$100*100=44.45%.

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