



# Labor productivity and comparative advantage in mining: The copper industry in Chile

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Received 19 January 2001; received in revised form 1 April 2001; accepted 11 April 2001

## Abstract

Over the past two decades, the copper industry has enjoyed dramatic increases in labor productivity in both Chile and the United States. Recent research attributes most of the increase in the United States to innovation and technological change, rather than the exploitation of higher quality copper deposits due to the development of new mines and a shift in output from low to high productivity mines.

This article assesses the sources of productivity growth in Chile, where well over half of the copper now produced comes from new mines. While better copper deposits are more important in Chile than the United States, innovation and technological change have contributed substantially to the growth in labor productivity in Chile as well. These findings are important for companies and countries striving to maintain a comparative advantage in mining. © 2001 Elsevier Science Ltd. All rights reserved.

*Keywords:* Copper mining industry; Labor productivity; Comparative advantage

## Introduction

Chile accounts for almost 35% of the world's mine output of copper, and is the world's largest producer. During the 1970s and 1980s, as Fig. 1 shows, copper output in the country grew modestly but persistently, roughly doubling over these two decades. Then, in the 1990s the growth rate accelerated, causing output to double again in only the first seven years of this decade, a period when copper output in the rest of world was more or less stagnant.

While Chile is important for the global copper industry, the reverse is also true: the copper industry is important for Chile. Over the past decade, this industry has provided between 35 and 52% of the country's annual export earnings, and between 6 and 9% of its annual GDP (Comisión Chilena del Cobre, annual). Very

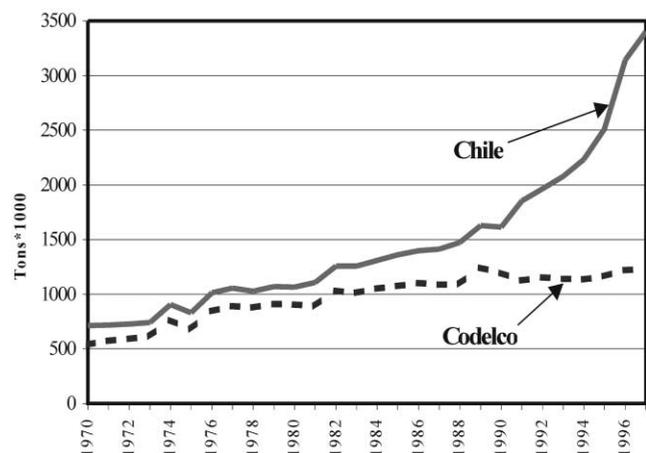


Fig. 1. Copper mine output for Chile and for Codelco, 1970–97 (thousands of tons of contained copper).

few countries are so dependent on one single commodity.

An important factor, perhaps the most important factor, behind the recent rise is the growth in labor pro-

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ductivity in the Chilean copper industry. As Fig. 2 shows, the tons of copper mined per employee of copper companies, increased at a brisk annual rate of 5.8% over the 1970–90 period, and then at an astonishing 22.3% per year over the 1990–97 period. This latter period coincides with a boom in foreign mining investment in Chile.

The recent surge in labor productivity shown in Fig. 2 is not merely an artifact of measuring labor productivity in terms of copper output per mining company employee. Over the past several decades and particularly during the 1990s, it is true that mining companies in Chile, as elsewhere, outsourced a variety of activities that their own employees once performed. Research we have reported on elsewhere (Garcia et al., 2000), however, indicates that the surge in labor productivity in the Chilean copper industry during the 1990s was real. The upward bias introduced by outsourcing, while substantial, was offset by a downward bias arising from a decline over time in the average number of hours that mining company employees worked annually.

This study attempts to identify the forces behind this spectacular rise in labor productivity. It covers the 1970–97 period, with particular attention on the two decades between 1978 and 1997. It examines two explanations or hypotheses, which are not necessarily mutually exclusive.

The first attributes the surge in labor productivity to changes over time in the quality of the mineral endowment or deposits being exploited, changes due to the development of Escondida, Candelaria, El Abra, Zaldívar, and other new mines. As Fig. 1 and Table 2 in Appendix A show, Corporación del Cobre de Chile (Codelco, the state mining company) accounted for almost all of Chile's copper mine output before 1990. Over the past decade, a number of new mines, owned and operated by private companies, have come on

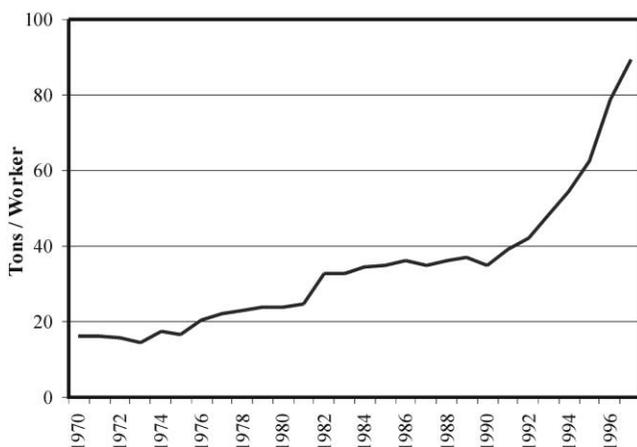


Fig. 2. Labor productivity in the Chilean copper industry, 1970–97 (tons of copper contained in mine output per copper company employee).

stream. As a result, Codelco today accounts for less than 40% of Chile's copper output.

New mines are widely assumed to enjoy higher labor productivity. Their ore grades are typically high during the early years of operation. They possess new equipment, which tends to be larger and to embody the latest technology. Haulage routes are often shorter. Material flows are more efficiently organized. Moreover, private companies, according to the conventional wisdom, are more efficient, in part because they are freer to concentrate solely on profit maximization.

The second possible explanation for the rise in labor productivity emphasizes the development and diffusion of new technologies and other innovations. Recent research on the US copper mining industry, as the next section notes, attributes most of the growth in labor productivity over the past several decades in that country to the introduction and diffusion of new innovations. Whether these findings hold for other copper mining countries, such as Chile, however, is an interesting question. The US copper mining industry, although the largest in the world after Chile, has in contrast to Chile experienced little new mine development in recent years. This raises the possibility that the forces behind productivity growth are quite different in the two countries.

The analysis is divided into four sections. The second section, which follows this introduction, reviews the recent research on labor productivity growth in the US copper mining industry in light of its possible relevance.

The third section returns the focus to Chile. It assesses how much of the growth in labor productivity between 1978 and 1997 for the entire Chilean copper industry is the result of productivity growth at individual mines, and how much is the result of the shift in output location from low to high productivity mines. If rising labor productivity is largely the result of new mines and an improvement in the quality of the mineral endowment being exploited (our first hypothesis), then shifts in mine output location should account for most of the improvement in labor productivity. If instead innovation is the primary driving force (our second hypothesis), then most of the improvement should come from rising labor productivity at the level of individual mines.

The final section, summarizes the findings, and looks at their implications.

### Copper mining in the United States

Throughout most of the 20th century, the United States mined more copper than Chile or any other country. By the late 1970s, however, its copper industry was in trouble. The country's share of western world output declined sharply, as imports rose. Many mines were not covering their cash (variable) costs let along their capital costs. Producers twice sought government protection

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