Resources Policy 35 (2010) 247–256

Contents lists available at ScienceDirect

Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

Good deposits are not enough: Mining labor productivity analysis in the copper industry in Chile and Peru 1992–2009

J. Joaquín Jara [a,*], Patricio Pérez [a,b], Pablo Villalobos [c]

[a] Chilean Copper Commission, Agustinas 1161, 4th Floor, Santiago, Chile
[b] Faculty of Business Administration, Universidad de Valparaiso, Viña del Mar, Chile
[c] Ministry of Economy, Santiago, Chile

ARTICLE INFO

Article history:
Received 16 March 2010
Received in revised form
20 July 2010
Accepted 2 August 2010

JEL classification:
C33
D24
L72

Keywords:
Labor productivity
Copper
Chile
Peru
Panel data
Production scale
Geological features

ABSTRACT

Chile and Peru produce almost 45% of world's mine copper output. This situation reflects their natural endowment and mining tradition, but is also the result of development processes undertaken over the last decades. As a result, both countries multiplied its mine copper production in more than 3 times in the last 20 years. Mining labor productivity played a central role achieving these amazing growth rates. Although there is a consensus about the relevance of this variable for the mining industry, the specific factors behind labor productivity changes are not completely understood.

In this paper we use a panel data approach to analyze labor productivity in the copper mining sector in Chile and Peru from 1992 to 2009. This technique is consistent with heterogeneity among mines and allows us to identify, describe and analyze all the different sources behind labor productivity changes.

The result of the analysis shows that better deposits and operational factors are important, but not enough to explain labor productivity improvements in the copper mining industry, and instead, company specific efforts and wide industry changes, such as technology and management innovations, are as important as the evolution of the reserve base or geological features of the operations.

Introduction

Chile and Peru are the leading copper producer countries, and together represent almost 45% of world's mine copper output, a situation which is expected to be maintained in the foreseeable future. This primary position reflects their natural endowment and the mining tradition of these countries, but is also the result of development processes undertaken over the last decades in both economies. In fact, in the last 40 years the annual average production growth was 5.6% in both countries, allowing production to double every 12 years. In spite of similarities among the observed rates, their growth patterns reveal some differences (Fig. 1).

In the case of Chile, since early 1970s and until late 1980s, the production increase was moderate and fairly stable. During this period only seven relevant mines were in operation and only few were developed. Nevertheless, country's output doubled for the first time in 1986. The increase carried out by Codelco[1] after the nationalization process contributed to this situation.

In contrast, in the 1990s Chile's performance was marked by an increasing foreign investment and an explosive production raise, reflected by the startup of 10 new world class mines and a growth rate averaging 11% annually, more than double than the previous decades (Table 1). Among the factors explaining the massive inflow of new production in were: the commodity price boom at the end of the 1980s; the new technology available across the industry; and the improved management practices in the mining sector. However, there were three critical elements in this particular process: first, an excellent project portfolio developed in the country since the middle of the 1950s; second, the policies to foster foreign investment and the changes in the mining regulations introduced in the previous decades; and finally, the enhanced political and socioeconomic conditions after the recovery of the democracy in the country.[2] These elements enabled the country to expand its production level from 1.6 million MT in 1990 to 5.4 million MT in 2009.

* Corresponding author. Tel.: +56 2 3828242.
E-mail addresses: jjara@cochilco.cl, jjara@uc.cl (J. Joaquín Jara), pperez@cochilco.cl (P. Pérez).

[1] National Copper Corporation, by its Spanish acronym.
[2] For details see Lagos (1997).

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doi:10.1016/j.resourpol.2010.08.001

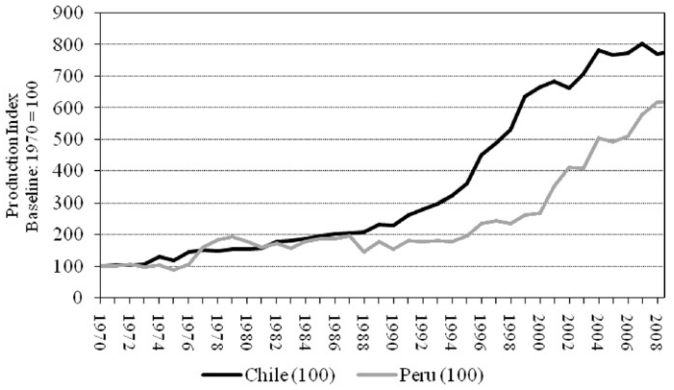

Fig. 1. Production growth in Chile and Peru 1970–2009. *Source*: Chilean Copper Commission.

Table 1
Rate of production growth by period 1971–2009.
Source: Chilean Copper Commission.

	Chile	Peru
1971–1979	5.3	8.9
1980–1989	4.3	0.1
1990–1999	10.8	4.4
2000–2009	2.2	9.5
1971–2009	**5.6**	**5.6**

Peru's case was a little different. Its production experienced a sharp increase during the second half of the 1970s, from 220 MT to almost 400 MT. This was mainly explained by the startup of only one operation, Cuajone mine in 1976. After that, output remained nearly steady until the mid 1990s, when Peru's copper industry followed a similar process to the one experienced by Chile. The political and economical changes introduced in the first half of the 1990s, joint with a whole new regulatory framework for the mining industry, allowed the country to increase the attraction of foreign investment to this sector. As a result, copper production start rising in the second half of the 1990s, but most importantly in the following decade. Peru's output increased more than 3 times between 1996 and 2009, from around 400 thousand MT to 1.25 million MT.

Mining labor productivity played a central role in these amazing production growth trends. There are strong evidence suggesting that labor productivity has been an essential driver for companies and countries in order to compete in the mining sector, to reach a sustainable level of output, and therefore to get a competitive industry (Darmstadter, 1997; Tilton and Landsberg, 1997; Aydin and Tilton, 2000; Tilton, 2001; García et al., 2001; among others).

Tilton and Landsberg (1997) reviewed the collapse and subsequent recovery of the US industry between 1970 and 1995. They concluded that jumps in productivity due to the development of new technologies and other innovations were essential to overcome the drop of competitiveness caused by the declining in mining conditions (in this case, the introduction of SX-EW technology played a central role). In other article, Aydin and Tilton (2000) noted that, in the case of US industry in the period 1975–1995, the impact of new production on labor productivity was just marginal. On the other hand, innovation, development and diffusion of technology were essential for meaningful and sustainable improvements over time. Furthermore, Tilton (2001) examined the relationship between labor productivity, costs and the survival of mines during a recession. He concluded that productivity level at the beginning of the downturn is less relevant to survive than the mine's ability to increase its productivity and reduce its costs through innovations and management changes during the recession. Also, the author suggests that those mines with higher reserves have stronger incentives to invest in technology and management improvements and increase productivity than those mines with less endowments and a shorter life.

In the case of Chile and Peru, there are also attempts to explore the link between labor productivity and the mining booms. García et al. (2001) studied the source of productivity growth between 1978 and 1997 in the Chilean copper industry. The authors found that over 50% of the raise in production during the period came from new operations, affecting the productivity trend. They conclude that, unlike the US situation during the previous decades, in the case of Chile the new mines were the main responsible for the increase in labor productivity, although the contribution of innovation and technological change were also relevant. In the case of Peru, Glave and Kuramoto (2007) indicate that, between 2001 and 2004, the average productivity of the mining sector rose on average by 77%. According to the authors, new mines and investments in technology improvements was behind this relevant increase.

Although there is a consensus about the relevance of labor productivity in the mining industry, analyzing its sources of growth is not an easy work. Deposits vary in size, shape, ore type, grades and location, which makes technology to exploit them differ greatly across operations. Mines are either open pit or underground (discounting underground exploitation methods), and processing facilities could be traditional concentration plants or hydrometallurgical systems (Lix-SX-EW). Moreover, each mine could be located in the mountain or desert, isolated of communities or close to them, which not only affect mining and processing techniques, but also extraction design, equipment characteristics, working conditions, number of employees, management strategies, stakeholders relationships, among other issues. Additionally, country specific factors, such as labor and environmental regulations, workforce qualifications and cultural aspects also affect labor productivity patterns. Therefore, each deposit and each country has special features that differ from one to another.

As a result, when labor productivity trends are analyzed, it is important to take into account heterogeneity across mines. In order to deal with this issue, we use a panel data approach. We also model labor productivity separately by countries and exploitation methods (open pit or underground), including time effects to capture group-wide productivity changes. An important progress of our model is the inclusion of specific geological features at each mine.

Given the actual and future relevance of the Andean countries for the copper industry, the motivation of our work is to study the observed labor productivity changes on the Chilean and Peruvian copper industry from 1992 through 2009.

The rest of this paper is organized as follows. The next section describes the estimation methodology, the data and the variables used in this work. The section after this presents the econometric results and their analysis. The final section presents the findings and concluding remarks.

Data and methodology

The model

Following the approach from Ellerman et al. (1998) and Stoker et al. (2005), we estimate the labor productivity for the copper mining sector, using a model which allows us to separate this productivity into different effects. The basic model we use is

$$\ln\left(\frac{Q_{it}}{L_{it}}\right) = \alpha + \beta X_{it} + \mu_{it}, \quad (1)$$