The commodity price boom and regional workers in Chile: a natural resources *blessing*? (PRELIMINARY DRAFT)

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Abstract. This paper uses variation among Chilean regions in the exposure to a largely exogenous price shock to examine the effects of the growth of a geographically concentrated export sector on local labor markets using data from 2003 and 2011. We find that a region exposed to a 10% increase in regional prices experienced a 2.1% wage increase relatively to other regions. Since the price increase was highly correlated with the increase in export values, such wage gains can also be expressed in terms of the regional export increase, and we show that in regions that experienced a 10% exogenous increase in exports due to the price shock, workers' wages increased by 1.8%. Both of these effects were largely due to gains in the salaries of the least educated workers. Additionally, we use estimates of a spatial relative demand and supply model to show that relative demand for college graduates decreased faster in regions that experienced higher price increases, and that such relative demand shift was largely responsible for the observed reduction in educational wage premia. Even though interregional migration was not large, we posit that due to differential migration patterns across skill groups the overall decrease in wage inequality would have been even higher in absence of the equalizing migration effect.

1 Introduction

The field of development economics has traditionally been concerned with understanding the causes of income inequalities across countries, and identifying the policies that could allow poorer countries to "catch up" with richer ones. However, each country is made up of regions that vastly differ in their performance and growth rate, and the analysis of the differences across localities within the same country is receiving growing attention. As pointed out in a recent OECD report (OECD

(2013)), "each job is local", and local labor markets are characterized by huge disparities in terms of factors' productivity, firms' innovation and workers' employment and wages. In 10 OECD countries, more than 40% of the increase in unemployment over the past five years was concentrated in just one region, with regional disparities in youth unemployment growing even wider. Addressing the specific labor market conditions of these regions and responding with policies that incorporate local solutions is therefore a key element in the debate over national economic development.

In this paper, we exploit the variation in industry mix across Chilean regions to examine the effect of regional exposure to price changes on changing patterns of wage premia and employment across local labor markets. Among OECD countries Chile is as unequal as any, and regional disparities and its dependence on a few sectors concentrated in limited regions are probably the greatest challenge that can hamper its progress towards the achievement of developed country status. Territorial inequalities among regions in Chile are the second highest of all OECD countries, with the richest region generating over eight times the regional output per capita of the poorest one[1]. Figure 1 shows the GDP per capita in 2005 PPP constant thousands of dollars of Chilean macro-regions in 2003 and 2011, whilst as a reference, figure 2 compares 2011 GDPs per capita of some regions with those of other world countries. As can be clearly seen, the per capita GDP of the poorest Chilean region, Araucania, is lower than that of Egypt, while the one of the richest region, Antofagasta, is higher than Switzerland. The GDP of the Santiago region, by far the largest in terms of population, approximates the Chilean average and is comparable to the former Yugoslav Republic of Croatia.

The issue of the localization of economic activity and its effects on regional prosperity and workers' welfare has intrigued urban economists for decades, and the main explanation for the reason why firms tend to cluster in particular areas has been found in the existence of agglomeration economies that generate productivity increases. However, the Chilean economy is characterized by an extremely high dependence on natural resources, and as a consequence it is quite clear that output would be generated in the areas where such resources are located. In fact, the three regions with the highest GDP per capita, Antofagasta, Tarapaca, and Atacama, are also the regions where the largest deposits of copper – by far Chile's main produced and exported commodity - are located. Therefore, due to the large, exogenous increase in world prices experienced by copper in the past decade, Chile

[1] These are huge differences: by comparison, the GDP per capita of Delaware, the richest state in the United States - a country also characterized by strong territorial inequalities - is just over twice that of Missisippi, the poorest state.

arguably represents an excellent example of how the growth of a geographically concentrated sector can affect local labor markets and regional economic development.

In our empirical analysis, we exploit the variation in the industry mix of employment across regions combined with the differential price changes across industries at the national level to identify the effect of regional price shocks on wages at the local level. Our results show that in local labor markets where employment was more concentrated in industries which presented larger price increases workers' wages benefited the most, with regions facing a 10% increase in regional prices experiencing a 2.1% wage increase relatively to other regions. Such wage gains can also be expressed in terms of the increase in exports, as we show that in regions that experienced a 10% exogenous increase in exports due to the price effect, workers' wages increased by 1.8%. However, quite interestingly all of the benefits in terms of higher wages accrued to less educated workers, while our analysis indicates that the increase in regional prices and exports had no effect on the wages of college educated workers. Our estimates of implied relative demand shifts for college graduates as compared high school graduates, calculated using a spatial relative supply and demand model, confirm that relative demand for college graduates decreased faster in regions that experienced higher price increases, and that such relative demand shift was largely responsible for the observed reduction in educational wage premia. We also show that the low migration rates implied that relative supply did not match the relative demand shift, but due to differential migration patterns across skill groups the overall decrease in wage inequality was lower than it would have been in absence of interregional mobility.

The rest of the paper is organized as follows. In section 2, we begin by reviewing the recent empirical literature, starting from the popular and ubiquitous one on the "natural resourse course" that has nevertheless proved to be quite elusive to sound empirical evidence. In section 3, we introduce a short description of the importance of the copper sector in Chile, and present evidence of the role played by Chinese demand in stimulating the stunning boom in world prices experienced by the commodity in the first decade of this century. Section 4 introduces the theoretical model, which adapts Jones and Marjit (2003)'s 4x3 specific factors model to allow for a spatial dimention, to include a nontraded sector and to consider two types of mobile labor, and which we use to guide our empirical analysis. In section 5, we describe the data, and introduce some descriptive statistics to show the evolution of the economic structure and of average wages across Chilean regions. In section 6a, we use average regional price changes to estimate the effect of the regional price shock on normalized regional wage premia, calculated from Mincerian wage regressions, while section 6b uses a similar approach to estimate the impact of an increase in regional exports on local wages; section 6c completes the analysis examining the migration patterns of workers of different educational levels. In section 7, we extend the analysis to calculate regional wage gaps between college educated workers and high school graduates, using regional prices and export changes as variables that may affect the skilled wage premium through changes in the relative labor demand, and estimate the relative contribution of demand and supply factors on the change in the skilled wage premium across regions. In section 8, we examine employment effects. Finally, section 9 concludes.

2 Literature review

This paper is related to a number of different literatures that examine the effect of natural resources endowments on economic development, and the differential transmission of price shocks in the economy to local labor markets. A first strand of literature, mainly concerned with countries' "product space" and the desirability of different export baskets, has examined the relative performance of resource-rich countries and countries specialized in the production of industrial goods, with largely inconclusive results on the existence of the so-called "natural resource curse". Indeed, trade theory dating back to Ricardo states that countries maximize their welfare when they specialize in goods which they can produce relatively cheaply; and yet, the idea that mining is a bad use of labor and capital and should therefore be discouraged goes back as far as Adam Smith (1776), who argued that natural resources are associated with lower human and physical capital accumulation, productivity growth, and spillovers[2]. In Latin America, this thought was popularized at the end of the 1950s by Raul Prebisch (1959), who argued that natural resource industries had fewer possibilities for technological progress and that Latin American countries were condemned to decreasing terms of trade on their exports. These ideas were at the core of the subsequent import substitution industrialization (ISI) policy experiment which strongly modified national productive structures in many

[2] In The Wealth of Nations he wrote: "*When any person undertakes to work a new mine in Peru, he is universally looked upon as a man destined to bankruptcy and ruin, and is upon that account shunned and avoided by everybody. Mining, it seems, is considered there in the same light as here, as a lottery, in which the prizes do not compensate the blanks, though the greatness of some tempts many adventurers to throw away their fortunes in such unprosperous projects.*"

countries. The most widely known empirical test of the "natural resource curse" was undertaken by Sachs and Warner (1999), who find a negative correlation between natural resources exports as a share of GDP and growth in a cross section of countres between 1970 and 1990. However, several authors have challenged the statistical soundness of this article's results, which are not robust to the inclusion of other explanatory variables and to different measures of natural resource intensity (Sala-i-Martin, Doppelhofer and Miller (2004)). As witnessed by the successful experiences of many resource-rich countries such as Norway, Sweden, Canada and Australia (and even 19th century's United States), the drag on growth rather seems to be an issue of limited diversification possibilities within commodites (Auty (2000)), and scarce human capital in developing countries which may prevent their ability to take advantage of the technological spillovers generated by resource-intensive sectors[3].

As the above cited studies use country level aggregate data, they offer little insight about the local economic effects of resource abundance; another strand of literature identifies instead a specific exogenous shock and attempts to estimate its local effects within a country. One of the first studies in an emerging literature exploiting within-country variation to analyze the effect of resource booms was the paper by Black, McKinnish and Sanders (2005), who exploit the exogenous increase in the price of coal in the 1970s to estimate the impact of the employment shocks in the coal industry on a number of economic outcomes in the eastern United States. They find that the coal boom generated positive spillovers in the local goods sector, while at the same time there were no negative spillovers in the other traded sectors: overall, the shock increased wages and reduced poverty in counties with substantial coal reserves, suggesting that the local population experienced an economic benefit from the boom. Caselli and Michaels (2013) utilize variation in oil output across municipalities following the oil discoveries in Brazil at the end of the 20th century to study the effect of the fiscal windfall from oil royalties on government behavior. Even though oil producing municipalities report higher levels of income and spending, they find that the resource windfalls have no significant effects on local household income, pubic goods provision, and overall living standards. On the other hand, Aragon and Rud (2013) exploit a change in the

[3]In fact, one of the most important tranformative technologies of the 19th century, the steam engine, arose as a learning spillover from the mining industry in Scotland. In Sweden, the car manufacturers Saab and Volvo emerged from truck producers serving the forestry industry, while in Finland the telecom giant Nokia arose from what was originally a forestry company (Lederman and Maloney (2012)).

procurement policy of the Yanacocha gold mine in the city of Cajamarca, Peru, which gave priority to local suppliers and workers in competitive bids and encouraged suppliers to hire local workers, to estimate the effect of the increased demand for local inputs on living standards using households' survey data for the period 1997 to 2006. They find that the local shock increases nominal and real income and household consumption and reduces local poverty, and they identify backward linkages as a mechanism for this occurrence. Another closely related literature examines the effects of geographically concentrated demand shocks on local labor markets. Topalova (2010) exploits the variation in industrial composition across Indian districts to study the impact of the 1991 Indian trade liberalization on regional poverty, and finds that districts with a higher concentration of the sectors most exposed to liberalization experienced slower poverty declines and lower consumption growth. Using a similar approach, Kovak (2013) develops a specific-factors model of regional economies, and applies it to the context of the Brazilian trade liberalization of the early 1990s to show that in local labor markets where employment was concentrated in industries facing the largest tariff cuts (and therefore where goods' prices decreased the most) workers experienced the highest wage declines. A recent set of articles by Autor, Dorn and Hansen (2013) also exploit differential local labor markets exposure to separately examine the impact of technological advances and of Chinese import competition on U.S. employment between 1990 and 2007. They find that labor markets specializing in routine task-intensive activities experienced significant occupational *polarization* (gains in the share of employment in relatively high education, abstract-task intensive occupations and relatively low education, manual-task intensive occupations at the expense of the employment of middle-skill, routine-task intensive workers whose tasks can easily be performed by machines) but no overall employment declines; on the other hand, local labor markets more exposed to Chinese import competition (those with an industrial mix initially concentrated in the production of labor intensive goods for which China has a comparative advantage) experienced substantial differential declines in wages and local employment, especially for workers without college education, and a corresponding increase in unemployment, retirement and disability benefits.

Finally, this study is related to a growing literature that includes local labor markets heterogeneity as an additional variable in the traditional study of earnings inequality (for an excellent review of the latter literature, see Acemoglu and Autor (2011)). Black, Kolesnikova and Taylor (2014) provide a simple theoretical model to evaluate changes in inequality when workers live in local labor markets with substantial cost of living differences. These authors make the very important point that by focusing on national inequality measures that ignore spatial variation, researchers may well be overestimating the increase in U.S. wage inequality of the past decades. In fact, if preferences are homothetic, the evolution of within-location skill premia will be the same across all regions, but national trends will crucially depend on migration patterns: if most workers relocate from low price cities to high price ones, the increase in real inequality will be far lower than that in nominal inequality. This point is closely related to the finding of the same authors (Black, Kolesnikova and Taylor (2009)) that when the assumption of homothetic preferences is relaxed, returns to education vary by location, and are lower in high price, high-amenities cities. The same issue is also carefully explored by Moretti (2013) who uses housing prices to construct city-specific CPIs, and shows that since the 1980s college graduates have increasingly concentrated in cities with higher cost of living. Since his data shows that such relocation was mainly due to city-specific relative demand shocks, he concludes that the increase in utility differences between skilled and unskilled workers is smaller than that indicated by the change in their relative wages.

3 The copper sector in Chile and the commodity price boom

Chile has traditionally been a mining country, since the early days of the 19the century when it was the world's largest producer of nitrates. With the discovery of synthetic nitrates and the ensuing crisis in the beginning of the 20th century, the country began incentivating foreign investment in full scale copper projects, and copper production was almos exclusively guaranteed by U.S. owned companies until 1970. In 1971, the government of Salvador Allende nationalized Chilean copper, a decision which was not reversed by the Pinochet government that followed the military coup in 1973. The state-owned CODELCO (*Corporación Nacional del Cobre de Chile*) was created in 1976, to comprise the mines previously owned by the nationalized foreign owned companies. Additionally, a Foreign Investiment Statute (D.L. 600) was approved to establish rules that would guarantee the rights of foreign investors in order to lure back FDI in mining; however, it was not until the return to democracy in the 1990s that large scale investments in new copper mines from a number of foreign companies materialized. As a result, copper production in Chile today is dominated by nine large companies operating 23 major mines in different regions of the country; CODELCO accounts for about one third of total production and is currently the biggest copper producing company in the world. Table 1 shows a detail of the production and employment of the main companies operating in the country in 2003 and 2011.

Despite the Government's effort to try to diversify its economic structure and increase export revenues for non-traditional sectors, Chile's export structure still remains heavily geared towards commodities. In fact, if we include the manufacturing sector linked to the processing of these natural resources, about 80% of Chile's export revenues are generated by just four commodities: copper, fruit, fish, and wood. As shown in figure 3, Chile is by far the largest producer of copper in the world, accounting in 2011 for over 32% of global production, and also holds around the same percentage of known world reserves. Copper is also Chile's main exported commodity, representing around 60% of its total goods exports; copper exports experienced a spectacular increase in the period under analysis, with a nearly 25% average yearly growth (see figures 4 and 5).

Soaring world prices were by far the main factor in the increasing revenues from copper exports. The impact of the commodity price boom that began at the end of 2002 on the huge increase in export earnings and economic growth in many primary products-exporting countries, especially in South America, has been extensively analyzed, and the role of growing Chinese demand as key factor in stimulating prices is widely established (Yu (2011)). A number of factors simultaneously appearing at the beginning of the century, including the stunning rate of Chinese economic growth which greatly increased its per capita consumption, China's access to the WTO, which made it more integrated in world markets, and its shift in industrial structure towards capital intensive and energy intensive industries, which increased its appetite for metal, have been proposed as drivers of such a rapid demand increase. Clearly, the impact of China on commodity prices has not been the same in all commodities, as these are also affected by other demand factors such as the price of substitutes, and supply factors, including input costs. However, nowhere more than in copper has China's role been linked more clearly to the rise in prices: China's copper consumption increased from 20% of the world total in 2003 to 40% in 2011, accounting for the whole growth in world consumption in this time period (see figure 6), while its share of world imports rose from 10% in 2000 to almost 40% in 2010. Copper mining is a sector where demand shocks can have a particularly immediate impact on prices, as supply is inelastic and slow to respond due to the high investment cost necessary to increase production; Jenkins (2011) estimated that the world price for copper in

2007 was between 50 and 120 per cent higher than it would have been without the "China effect". Copper prices increased fourfold between 2003 and 2011: figure 7 presents the increase in the world price of copper, compared with Chile's Producer Price Index for the same commodity for the period under analysis, while figure 8 shows the evolution of Chinese Total Imports from the world in quantities, plotted against the increase in Chilean export revenues for the same commodity. There is a clear correlation between the two series, witnessing how closely the value of Chilean exports has tracked Chinese demand. As mining is a highly capital-intensive sector, it employs a small fraction of workers as compared other sectors in the economy and its overall participation in total GDP. While copper accounts for about 13% of Chilean GDP, the sector only employs about 3.5 % of salaried workers at the national level. However, the national average masks large differences at the regional level, whereby in two macro-regions the copper sector employs 20% of workers, with the percentage raising to almost 40% in selected micro-regions. The map in figure 9 visually represents such regional variation.

4 Theoretical framework

The theoretical framework borrows Jones and Marjit (2003)'s 4x3 specific factors model, modifying it to allow n regions, to include a nontraded sector and to consider two types of mobile labor working in the same sector. The model is closely related to the simple 3x2 specific factor structure introduced by Jones (1971); in order to simplify treatment, it utilizes the so called *linear neighborhood production structure,* first introduced by Jones and Kierkowski (1986), by means of which each productive activity employes exactly two inputs, and each of the mobile inputs is used in exactly two activities. Figure 10 provides a visual representation of the linear neighborhood production structure. Each region is characterized by three productive activities: a primary sector (A), a non-tradable service sector (N), and a manufacturing sector (M). There are two specific factors, each of which is used in just one productive activity: T - which can be thought of as land, natural resources, or capital specific to mining -, is used in the primary sector A, and K - which can be thought of as specific capital for advanced manufacturing, or entrepreneurship -, is used in the manufacturing sector M. Additionally, there are also two mobile factors, unskilled labor, L_U and skilled labor, L_S, which are employed together in the service sector N, but can also have alternative occupations in another activity, the primary sector, A, for unskilled labor, and manufacturing, M, for skilled labor. Production in each of the three sectors uses exactly two inputs, the regional supply of unskilled and skilled labor is assumed to be perfectly inelastic, and all factors are fully employed within each region. Labor is immobile within regions in the short run; however, it may migrate across regions in the long run. All regions have access to the same technology, so production functions do not differ across regions within each industry, and goods and factor markets are perfectly competitive. Finally, production exhibits constant returns to scale, and all regions face the same goods prices for the tradable goods, p_i, which are exogenously given by world markets. Nontradables prices are endogenously determined within each region. This setting generates the following relationship between changes in goods prices and unskilled ($\hat{w}_U$) and skilled ($\hat{w}_S$) wage changes (all theoretical results are derived in Appendix a.1):

$$\hat{w}_U = (\theta_{SN}/\Delta)\left[\lambda_{SN}\lambda_{UA}\sigma_{UA}\hat{p}_A - \lambda_{UN}\lambda_{SM}\sigma_{SM}\hat{p}_M\right] + \left[\lambda_{UN}\left(\lambda_{SM}\sigma_{SM} + \lambda_{SN}\sigma_N\right)/\triangle\right]\hat{p}_N + (\theta_{SN}/\Delta)\left[\lambda_{UN}\left(\hat{L}_S - \lambda_{SM}\hat{K}\right) - \lambda_{SN}\left(\hat{L}_U - \lambda_{UA}\hat{T}\right)\right] \quad (1)$$

$$\hat{w}_S = (\theta_{UN}/\Delta)\left[\lambda_{UN}\lambda_{SM}\sigma_{SM}\hat{p}_M - \lambda_{SN}\lambda_{UA}\sigma_{UA}\hat{p}_A\right] + \left[\lambda_{SN}\left(\lambda_{UA}\sigma_{UA} + \lambda_{UN}\sigma_N\right)/\triangle\right]\hat{p}_N + (\theta_{UN}/\Delta)\left[\lambda_{SN}\left(\hat{L}_U - \lambda_{UA}\hat{T}\right) - \lambda_{UN}\left(\hat{L}_S - \lambda_{SM}\hat{K}\right)\right] \quad (2)$$

where λ_{ij} denotes the fraction of the mobile factor i used in industry j, θ_{ij} represents factor i's distributive shares in industry j, and σ_{UA} and σ_{SM} are the elasticities of substitution between specific and mobile factor in industries A and M. Equations (1) and (2) provide the link between regional changes in the return to the two mobile factors and changes in commodity prices. If price increases in the primary sector, A, as (1) shows, the unskilled labor wage increases, but by a smaller percentage amount than the price change. This happens because an increase in the price of a commodity leads to a matching increase in average cost due to the zero profit condition following from the assumption of perfectly competitive markets, and therefore to an increase in the return to the specific factor T and of the marginal product of unskilled labor in sector A. However, the return to unskilled labor is constrained by its additional employment in another sector, which has not benefited by the price increase, while the return to the specific factor is not constrained in this way. As consequence, the unskilled wage rate cannot increase relatively as much as p_A, so that the return to the specific factor employed in sector A has to increase by a more than proportional amount to ensure that the increase in unit costs matches the increase in price. As far as the return to skilled labor is concerned, equation (2) shows that its wage rate decreases when commodity A's price increases, which follows directly from the increase in the unskilled wage rate and the zero profit condition equation in sector N, so that - if all other prices are unchanged - to any change in the unskilled wage $\hat{w}_U$ corresponds a change in the skilled wage equal to $\hat{w}_S = -\hat{w}_U \left(\frac{\theta_{UN}}{\theta_{SN}}\right)$.

Figure 11 presents a graphical treatment of the model. In each panel, the horizontal length of the diagram represents the labor endowment, the total amount of labor available for use in the region, while the vertical axis plots the wage and the value of the marginal product of labor (VMPL). In the top panels. the VMPL line for commodity A slopes down from the left, while the VMPL line for commodity N is flipped and drawn with respect to its origin sloping down from the right. Every point along the horizontal axis corresponds to an allocation of labor between the two industries satisfying the full employment condition. The point in the diagram where the two VMPL lines intersect determines the unique equilibrium unskilled wage rate in each region using all the available labor L_U. Consider now an exogenous increase in the price of commodity A. The immediate effect will be to raise the value of the marginal product of primary products, shifting up the VMPL line from $p_A MP_A$ to $p'_A MP_A$ and increasing the equilibrium wage in both regions. However, since region 2 allocates a large fraction of total employment to commodity A, the impact of the price increase on wages will be higher in that region, so that $w'^*_{U2} > w'^*_{U1}$. At the new equilibrium, labor allocated to production of commodity A will have risen while labor used in industry N will have fallen in both regions as workers will be attracted to the sector that benefited from the price increase. Due to the competitive profit condition in sector N, the increase in the marginal productivity of unskilled labor has to cause a decrease in the skilled labor wage rate; skilled workers in sector N will therefore be attracted to the manufacturing sector M, causing a decrease in the marginal productivity of labor in the manufacturing sector until it eventually matches the marginal productivity in the service sector and a new regional equilibrium skilled wage is reached. As shown in the bottom panels of figure 11, skilled wage decreases in both regions, however the overall impact will be higher in region 2, as a higher decrease in skilled wages is necessary to maintain the zero profit condition in the nontradable sector, so that $w'^{*}_{S1} > w'^{*}_{S2}$. Figure 12 repeats the analysis allowing for migration between regions. In this case, when the price of commodity A increases, unskilled workers in region 1 have an incentive to migrate to region 2, increasing the labor endowment and decreasing the marginal product of labor in both sectors there. This is represented graphically by a leftwards shift in the axis, showing that the endowment of unskilled workers in region 1 becomes lower than the one in region 2, which causes the marginal product of labor in region 1 to increase in both sectors. Therefore, unskilled wages will increase in region 1 and decrease in region 2, until the marginal products of labor are equalized, and, assuming perfect migration, the wage rate is equalized nationally. As shown in the bottom panel, in the case of skilled labor, the opposite process happens. Skilled workers will now have an incentive to migrate to region 1: skilled wages will increase in region 1 and decrease in region 2, until the marginal products of labor are equalized, and, assuming perfect migration, the skilled wage rate is equalized nationally as well.

5 Data and descriptive statistics

The main sources of data are the 2003 and 2011 rounds of the Chilean Government's Encuesta de Caracterización Socioeconómica Nacional (CASEN), a repeated cross section household survey on detailed social and economic characteristics of the population, which include information on wages and employment by 4-digit ISIC sector and micro-region both at the individual and household level. Monthly Producer Price Indexes (PPIs) at the 4-digit ISIC level were obtained from the Chilean National Statistical Institute (INE) for the time period 2003-2011[4]. Chile's local administration is organized in three tiers: *regiones, provincias and comunas.* In 2011, there were 15 regiones, 54 provincias and 346 comunas. Data are disaggregated down to the *comunas* level: however comunas are too small to represent a local labor market. For instance, the Santiago Metropolitan Area is composed of 37 comunas, 32 of which belong to the Santiago province (*provincia*). Using provinces seem therefore to be the most realistic approximation to local labor markets. Since a reorganization was undertaken between 2003 and 2011 with the creation of new *provincias*, and a shifts of comunas among existing provincias, we recode the 2003 data to reflect the 2011 administrative division. We restrict the sample to salaried workers aged 18 to 65 working full time who report receiving positive

[4]The INE only began reporting PPIs in 2003, hence the choice of the start year for our paper; quite conveniently that almost perfectly coincided with the beginning of the commodity price boom.

wages.

Table 2 shows the evolution of Chile's economic structure between 2003 and 2011 by presenting the percentage of salaried workers employed in each main sector in both years, disasaggregated by macro geographical region. It is immediately apparent how a substantial structural change is under way, with the traditional agricultural and manufacturing sectors losing a considerable share of total employment at the national level, to the benefit of mining and services. It can also be noted that the importance of the service sector share shifted quite considerably from the activities traditionally more relatively high skilled intensive (finance, insurance, real estate, education, health care, and the public sector) to those relatively low skilled intensive (construction, retail, transport, and domestic services). Additionally, while mining does not absorb a high percentage of workers at a national level, its relevance greatly varies at the regional level, with the sector representing a substantial share of total employment in the Northern regions, where there is a marked increase in the period under study. Table 3 shows average log wages earned by workers in the main economic sectors. The most striking element in the table is the vast premium earned by workers in the mining sectors, regardless of skill level[5]. Tables 4 and 5 show the average wages earned by low skilled workers and high skill workers, respectively, by sector and macro geographical area. While the higher wages commanded by low skilled workers living in the North in 2003 was in great part a reflection of their higher percent employment in the high paying mining sectors, table 4 shows that Northern workers in 2011 earned higher mean salaries than their counterparts in other regions in *every* main sector; on the other hand, high skilled workers in the Santiago Metropolitan region remained the most highly paid across all sectors in both periods.

6 Empirical Methodology

6.1 Regional Price Changes and Wages

According to the theoretical model, an increase in price in the primary sector should generate an increase in the wage of unskilled workers in the regions most exposed to the price shock, and a corresponding decrease in the wage of skilled workers. However, since unskilled workers represent over 70 per cent of the Chilean workforce, we would expect an increase in average wages in the

[5]See Data Appendix for exact definitions of skilled and unskiled workers.

most affected regions; in order to test the theory, we begin our empirical analysis by considering the wages of all workers, and subsequently extend it to account for heterogeneous workers. To calculate regional wage changes, we first estimate for each year a Mincerian wage regression defined as:

$$lnw_i = \alpha + \beta X_i + \sum_{r=2}^{R} \gamma_r d_{ir} + \epsilon_i \tag{3}$$

where the log hourly real wage is being explained by a vector X which includes demographic characteristics such as a quadratic function of age, and full dummies for years of education, marital status, sex, and rural residence, and industry fixed effects, and d_{ir} is a binary variable the equals 1 if the i-th worker is employed in region r, and 0 otherwise. The parameters of interest are the regional coefficients γ_r, which we subsequently normalize as deviations from the employment share-weighted average wage premia, calculating their exact associated standard errors using Haisken-DeNew and Schmidt (1997)'s method. These normalized regional wage premia can therefore be interpreted as the interregional percentage deviations from the (employment share-weighted) average region for workers with the same observable characteristics. The changes in the normalized wage coefficients between 2003 and 2011 by geographical region are visually represented in figure 13, with the range varying from a 24% decrease to a 23% increase. There is a clear visual resemblance to the copper employment map, with the Northern regions that seem to have benefited the most in the time period under analysis.

Next, we calculate the price level regional producers face at different time periods, as the weighted average of the yearly producer price index of the production sectors operating in that region, assigning to each sector j a weight equal to the number of workers in that sector as a share of the total workers in the region at the beginning of the period. The regional price changes for each region r betwen time t and $t+1$ are therefore computed as follows:

$$\Delta P_r = \frac{\sum \triangle P_j L_{rj}}{L_r} \tag{4}$$

where $\triangle P_j$s are calculated as log differences. Since we assume the price change in the non-traded sector to be equal to zero, the regional price change will depend both on the different employment concentration between tradable and non-tradable sectors, and on the different industrial composition among regions, which induces dissimilar exposure to price changes. The results of this calculation are represented visually in figure 14. As can visually be appreciated, there is a wide variation in the region-level price changes, with the range going from a minimum of 8% to a maximum of 54%.

Our empirical estimates of the region-level changes in prices and wages lead to the second stage equation of the effect of changes in prices on wages. Since the wage changes are estimates, we estimate the equation in Weighted Least Squares with weights equal to the inverse of the standard error of the first stage Haisken-DeNew and Schmidt's coefficients in order to place higher weight to more precisely estimated coefficients. The equation is defined as:

$$\Delta ln(w_r) = \beta_0 + \beta_1 \triangle ln(p_r) + \varepsilon_r \tag{5}$$

The first column of table 6 presents the results of the regression in its main specification[6]. It is important to note that the coefficient measures the relative effect of regional price changes on regions experiencing higher or lower price variation. Therefore, the coefficient on regional price change, significant at the 1% level, shows that a region facing a 10% increase in regional prices experienced a 2.1% wage increase relatively to other regions. This means that the increase in price caused a relative wage increase of 4.5% in a region experiencing the average price increase of 22 percent, and a relative wage increase of 12% in the region experiencing the highest price increase of 54%. A scatterplot of the regional observations is shown in figure 15, where the size of the bubbles is proportional to the weight each observation is given in the regression[7]. In order to avoid reverse causality and rule out possible regional wage dynamics that may affect producer prices and therefore bias the coefficients, we additionally calculate regional price changes as in equation (2) using world prices instead of Chilean producer prices, and subsequently perform 2SLS using these fictitious regional price changes as instruments for the actual regional price changes so as to isolate demand shifts.[8]. The result of the instrumental variable estimation is presented in column 2 of table

[6]If regional time-variant factors were present at the regional level such as regional minimum wage laws that changed in the period under analysis, it would be necessary to include regional fixed effects as controls in the main regression. However, the Chilean political system is very centralized, as regions have very little fiscal and legislative autonomy, and until 2014 regional representatives were even appointed directly from the Central Government. We have therefore little concern that regional specificities could confound the price effect.

[7]As a robustness test, we drop the Santiago region from the main specification, and the results are qualitatively unchanged.

[8]Supply and demand changes in a large, open country can affect world prices, but the Chilean economy is most likely too small for this to happen, with the sole possible exception of copper. To rule out this possibility, we run pass-through fixed-effects regressions of world prices to Chilean producer prices for 24 macro-sectors for the whole

6. World prices prove to be a very strong instrument for producer prices - as would be expected in the case of a very open economy such as Chile's - yielding a coefficient on regional price change of 18%, significant at the 5% level, a result that reinforces the hypothesis of a causal effect of price changes on regional wages[9].

Next, we perform the same analysis undertaken above separately for each educational group. We consider the case where there are two types of workers: Skilled (h), corresponding to college graduates-equivalent workers, and Unskilled (l), corresponding to high school graduates-equivalent workers. Estimation results for the effects of regional price changes using both OLS and 2SLS are presented in table 7. As shown in the right-hand side panel, as expected the effects for the unskilled group are even stronger than the main result from table 6: in regions facing a 10% increase in regional prices, unskilled workers experience a 2.9% wage increase (2.6% when using the instrumental variable approach) relatively to other regions. Additionally, as shown in the left hand side panel of table 7, the coefficients of regional price changes on regional wage changes for the skilled labor group are not statistically different from zero. Our empirical results are therefore reflective of the predictions of the empirical model.

It is important to note that these regression estimates serve as a test of the hypothesis of perfect factor mobility: if workers reallocated across regions in response to wage and price changes, the estimated effect of price changes on wages would be zero. Therefore, the difference in the effects across educational groups and especially the insignificant effect for skilled labor could also imply a higher mobility of skilled workers towards regions that experienced higher price changes. We will return to the role played by migration across regions in Chilean labor markets in section 6c.

6.2 Regional exports and wages

We now want to establish how much of this price increase transmitted to the labor market through an expansion of the exporting sector. A number of studies have documented a well-established empirical link between industry exports and wages, and three main theories have been proposed

2003-2011 period, using change in total China trade as instrument for world prices. The IV pass-through coefficient for mining is .73, significant at the 1 percent confidence level. These results are available upon request. The world price series is constructed using information from the IMF, UNCTAD and World Bank WDI for commodities, and the U.S. Bureau of Labor Statistics for manufactures and some agricultural products.

[9] Our endogeneity concern is confirmed by the direction of the bias between IV and OLS estimations. A Hausman test on endogeneity of Chilean Producer Prices rejects exogeneity of this variable at the 5% confidence level.

to explain it. The first argues that exporting firms (particularly in developing countries) need to upgrade the quality of their products to satisfy the demand of more sophisticated foreign customers, and therefore need to pay higher wages to attract a more skilled worforce (**?**). The second claims that the act of exporting *per se* requires activities (not necessarily connected to production or product quality) that are skill intensive, and therefore exporting firms will demand higher skills and pay higher wages (**?**). The third theory is connected with the fair wages hypothesis: as exporting firms are more profitable, profits are shared with their workers through higher wages (**?**). We therefore estimate the following:

$$dln(w_r) = \beta_0 + \beta_1 \left(\frac{\triangle XW_r}{L_r} \right) + \epsilon_r; \tag{6}$$

where we calculate the change in regional exports $\triangle XW_r$ by apportioning each industry's change in national exports to the world between 2003 and 2011 to regions according to their share in national employment (similarly to the method used by Autor, Dorn and Hansen (2013) to calculate regional Chinese import penetration). The change in exports in region r is therefore given by:

$$\triangle XW_r = \sum_j \frac{L_{rj}}{L_j} \triangle X_j \tag{7}$$

However, the change in the regional export index in (7) may arguably be endogenous, as its increase may be caused by regional shocks that could concurrently also affect wages. For instance, since more productive firms tend to pay higher wages and self select in the export market, if firms in a specific region were to receive a productivity shock this would cause a positive correlation between the change in exports and the error term, biasing upwards the parameter estimates obtained by OLS. Additionally, another possible source of endogeneity stems from the fact that wage changes could affect export growth, as a rise in average wages in a region may limit firms' ability to expand exports. In this case, the change in exports would be negatively correlated with the error term in (6), and OLS coefficient estimates would be biased downwards. Therefore, since what we are really interested in is establishing the effect of the portion of the exports change which was due to the exogenous change in regional price, we estimate equation (6) in 2SLS, instrumenting the regional export change per worker with the regional price change, and with the fictitious regional price changes calculated as in the previous section using world prices instead of Chilean Producer

Prices. Our first stage regression will therefore be:

$$\left(\frac{\triangle XW_r}{L_r}\right) = \beta_0 + \beta_1 dln(p_r) + \epsilon_r \tag{8}$$

The regression results are reported in table 8. The first thing that can be noted is that regional price changes have a very high power in predicting changes in regional exports. If the increase in exports had not occurred in regions with employment intensive in industries that experienced high price changes, the first stage regression would have very low predicting power. However, it was precisely the regions with employment concentrated in industries with growing exports that experienced the price increase, and some of exogenous increase in exports due to the price effect transmitted to wages: the second stage regression in both specifications yield quite similar results, and show that in a region facing a 10 U.S. dollars exogenous increase in regional exports per workers due to the price effect, workers benefited from a 1.8% increase in wages.

Table 9 repeats the analysis with heterogeneous workers, and just as in the previous section, effects are stronger for the unskilled workers group: the point estimate is 0.0024, meaning that in a region facing a 10 U.S. dollars increase in regional exports per worker due to the price effect, unskilled workers experienced respectively an increase in wages of 2.4 percentage points. On the other hand, the coefficient of regional export changes per worker on regional wage changes for the skilled labor group is not statistically different from zero, and point estimates are also quite negligible.

6.3 Interregional Migration

It is important to note that our results thus far have reflected quite well the predictions of the model in absence of migration. In a sense, these regressions already served as a test of the hypothesis of perfect factor mobility: as already illustrated in the theoretical section, if workers had reallocated across regions in response to wage and price changes, wages would have equalized nationally and the estimated effect of price changes on wages would have been zero. Therefore, the difference in effects between unskilled and skilled workers and especially the insignificant effect for skilled labor do not necessarily reflect a lower demand shift for skilled workers, but could also imply a higher mobility of skilled workers across regions. For this reason, it is important to analyze migration patterns, and in this sense the direction of mobility is especially crucial: if more educated workers responded to the demand shock by moving to regions most impacted by price changes, that would mean that skilled wages would have increased in these regions in absence of migration, contrary to the model's predictions. However, if skilled workers moved *away* from regions where prices increased the most, that would have actually moderated the wage decline predicted by the model and would therefore agree with the model's expectations.

It is indeed widely known that in most developed countries mobility rates differ by educational level, and that college graduates have a much higher propensity to move than high school graduates or high school dropouts[10]. This differences in willingness to move may reflect different preferences across educational groups in the value workers attribute to staying close to their family and friends, but they could also be caused by a lack of information about opportunities elsewhere, or by financial constraints as less educated workers - due to limited savings and lower access to credit - may lack the ability to come up with the investment needed to cover the costs of a move. Either way, empirical evidence indicates that the job market for skilled workers tends to be a national one, while the job market for unskilled positions is usually much more local. Is this the case for Chile as well? The 2011 survey includes a question on whether a person has changed residence in the previous five years, and if so, the *comuna* of origin is reported in the survey. In this way, we are also able to determine whether a person has moved *provincia* in the previous five years, and we use that information to code each observation as "mover" or "stayer".

Table 10 presents interregional migration rates by educational level. The overall proportion of individuals that in 2011 reported living in a different province five years earlier is just over 7 per cent. As shown in the table, such proportion is almost double for college educated as compared to high school graduates, as unskilled workers seem to have a very low overall migration rate. Additionally, as shown in the table, migration rates also display a great deal of variation across provinces. Of course, there could be other variables correlated to college education that are responsible for such differences across locations and educational level. To control for this, we estimate a logit model where the dependent variable is a 0-1 dummy coded as 1 for movers and 0 for stayers. Results on the

[10] In an interesting study that exploits a huge dataset of individual work histories from the U.S. economic census, Wozniak (2010) matched workers in their late twenties to the economic conditions of the State they lived in when they were eighteen and about to enter the labor market. He shows that among the young workers that entered the job market when the economy was weak, a large portion of college graduates relocated to States with stronger economies, while most unskilled workers did not move.

educational dummies (low skilled is the excluded category) are presented in table 11 with 2 different specifications: (1) without controls, and (2) with demographic controls (a quadratic in age, and sex and rural residence dummies), and a full set of province fixed effects. As reported in table 11, in both specifications there is still a higher probability of moving for high skill individuals. Calculating the marginal effects at the multivariate means, the coefficients imply that a high skill individual has a 4.3% and a 3.4% higher probability of moving (in the two specifications, respectively) as compared a low skill individual.

Although interregional migration rates are overall relatively low, they could have nevertheless had an equalizing effect on wages across locations, as long as migration were directed according to the model's predictions. Table 12 shows results from regressing the net regional migration inflow on the change in regional prices. The results are quite surprising, as there is a positive and significant relationship between changes in regional prices and net migration flows only for unskilled workers: provinces that experienced a 10 per cent price increase received a 0.6% higher rate of net migrants between 2006 and 2011. On the other hand, even though the estimate fall just shy of the 10 per cent significance threshold, high skill workers exhibit a negative coefficient, implying that high skill workers actually moved *away* from the regions that received the larger price shocks, just as predicted in the theoretical section. Even though the migration rate of unkilled workers is not high enough to suppose any large effect on equalizing interregional wages, this suggests that gains in unskilled workers' wages would have even been larger in absence of migration, whilst skilled workers mitigated their wage loss by moving to regions less impacted by the price shock.

7 An analysis of wage differentials

So far, we have first estimated regional wage effects for the whole workforce, and then separately by skill level. In this section, we now turn to analyzing what has happened to local wage differentials between skilled and unskilled workers.

In order to estimate wage premia, we use coefficient estimates from the split-sample Mincerian log wage equations as in (3.1) ran separately for the high skilled (superscript h) and low skilled (superscript l) workers for each year, and predict log wages for each region at the mean characteristics vector $\bar{x}$ of all workers in the sample (across all regions)[11]. Our wage gaps estimates are therefore computed as:

$$\hat{\delta}_r = (\hat{\gamma}_r^h - \hat{\gamma}_r^l) + (\hat{\alpha}^h - \hat{\alpha}^l) + \bar{x}(\hat{\beta}^h - \hat{\beta}^l) \quad (9)$$

The estimated wage differentials are presented graphically in figure 16 in the same way as in the earlier analysis for labor supply. As in the previous graphs, we can see a wide variation across locations in the educational premia, ranging from 0.71 to 1.18 in 2003, and from 0.39 to 1.06 in 2011. Moreover, as can be noticed by the regression line, which lies on the bottom right of the graph below the 45-degrees line, there is a clear decreasing pattern of wage premia between 2003 and 2011: low skill workers have therefore gained relatively to the more educated group over time in almost every region across the country[12].

In order to break down the geographical change in inequality in further detail, table 10 shows mean log wages for each province in both periods, expressed in differences from the 2003 average national wage of low skilled workers which is normalized to zero for ease of analysis. Looking first at low skill wages, table 10 shows a very interesting pattern: in the 2003 base year, the highest wages for low skilled workers could be found in the province of Cordillera, that had wages 6 percentage points higher than the Chilean average low skill wage, while the lowest low skill wages were in the provinces of Linares, Capitan Prat, and General Carrera, where they averaged 7 percent points below the national mean. Therefore, the log skill wage in 2003 was very homogeneous at the national level, and a low skilled worker could expect to earn a very similar wage regardless of his or her location, with a maximum difference of 0.13 log points between the best and worst paid locations. In 2011, a very distinct pattern appeared, with considerable variance across regions where the Antofagasta province exhibits the highest salaries for low skilled workers at 0.54 log points, while in the province of Cauquenes low skilled workers earned an average salary 5 percentage point lower than even the 2003 national low skilled average in real terms. Therefore, in 2011 location made a huge difference for how much low skilled workers could earned with almost a 60 percentage points difference between the highest and lowest paid province. Also, quite interestingly, in 2011 the high mining employment

[11] Regional wages could also have been predicted at the mean vector of regional characteristics $\bar{x}_r$, however we choose to adopt a mean vector across all regions in order to have a regional wage gap that does not vary with the mean characteristics of the workers in each region.

[12] The decrease in inequality in Chile in the first decade of the 2000s perfectly reflects the falling education earnings premia observed all across Latin America and the Caribbean in the same period. For an extensive review, see Aedo and Walker (2012).

provinces of Antofagasta, El Loa, and Copiapo occupied the first, second, and third position in the ranking of low skill wages; these provinces also showed three of the highest four increases in low skill wages between the two periods. Looking at high skill wages, the pattern is quite different: in 2003, the highest wages were commanded by workers living in the Southern region of Coyhauque, with 1.13 points over the national low skill average, while the lowest wages were earned by workers in the Capitan Prat province, at 0.65 normalized points. In 2011, Santiago led the ranking, with an average high skilled salary of 1.21, while the Tamarugal exhibitest the lowest, at 0.68 normalized ponts. In general, some of the northern mining provinces still have wages higher than the national average, especially in 2011, but by no means they are the highest in the country, as the ranking is led by some smaller Southern regions and the Santiago Metropolitan Region; these diverging elements combine to make most northern regions those with the lowest wage premia in the country. Finally, looking at wage changes between 2003 and 2011, high skill wages increased 0.07 log points on average, while low skill wages increased 0.24 points; therefore this detailed analysis confirms wage inequality decreased in Chile, with the wage gap decreasing from 0.97 to 0.79. Most importantly, the wage gap decreased in almost all of the provinces, with only one out of the 51 total exhibiting an increase in inequality. This same information is reported graphically in figure 3.17, where for each province the triangle represents the change in low skill wages between 2003 and 2011, while the square represents the change in high skill wages in the same period; therefore, the height of the bars corresponds to the decrease (or increase) in the log wage diffferentials in each province. Figure 17 highlights the point that the reduction in the wage gap is most of all a factor of an increase in the wages of low skilled workers, which have gained in practically every province. On the other hand, high skill wages exhibit a much more erratic pattern, with a greater variance in the wage change between the two periods, and a considerable number of provinces where real wages have actually *decreased*. In the figure, provinces are ordered right to left by the percent of mining employment. The picture emphasizes that four out of the ten provinces with the highest concentration of workers in the mining sector were among the top five gainers nationally in terms of low skill wage increases; since just two of these ten provinces exhibited significant gains in the wages of high skill workers, this translated in considerable decreases in wage gaps for many mining regions.

We are now at the point where we can finally add the last piece of the puzzle, and estimate what were the relative contributions of demand and supply factors to the reduction of the wage differential in Chile in the past decade. As a measure of labor supply, we calculate region-level values of the skilled and unskilled workers' hours shares for 2011 and 2003, and plot them on the vertical and horizontal axis respectively in figure 18, where the size of the bubbles is proportional to the number of workers in the region and relevant skill group in 2003. The figure shows two main phenomena. First, it is clear that there are very sizable spatial disparities in the relative education supplies. For instance, the high school graduates-equivalent hours share in 2011 varies from around .69 in the Santiago Metropolitan Region to .92 in the province of Linares, in the Maule region, while the college graduates-equivalent share varies from .08 to around .31. Second, the movement of the observations show a very stable pattern in the educational shares between the two periods, with the observations clustering around the 45-degrees line. While there are a roughly equal number of provinces which increase and decrease their shares of college educated workers, on average the supply shares of college and high school graduates are practically unchanged. Next, we use the canonical Katz and Murphy (1992) supply-demand model to calculate the relative implied labor demand of unskilled to skilled workers in a residual fashion from the wage equation[13] as:

$$D_{it} = ln\left(\frac{H_{rt}}{L_{rt}}\right) + \sigma ln\left(\frac{w_{Hrt}}{w_{Lrt}}\right) \tag{10}$$

In order to calculate relative labor demand, we need an estimate of the elasticity of substitution between skilled and unskilled labor σ. Most studies in the literature report estimates between 1 and

[13] The seminal work of Katz and Murphy (1992) provides a simple and useful framework to attempt to establish the relative contribution of demand and supply factors to the change in the regional wage premia. Using their canonical model of relative labor supply and demand for two different skill groups performing two different and imperfectly substitutable tasks, and augmenting it to allowing a spatial dimension, the production function for the aggregate economy is therefore defined as:

$$Y_{it} = [(A_{Lrt}L_{rt})^{\rho} + (A_{Hrt}H_{rt})^{\rho}]^{1/\rho}$$

where H_{rt} and L_{rt} are the total supply of high skilled and low skilled labor in region i at time t, $\sigma = \frac{1}{1-\rho}$ is the constant elasticity of substitution between skilled and unskilled labor, A_{Lrt} , A_{Hrt} are factor–augmenting technology terms. Equating wages to the marginal products of each skill group yields:

$$\frac{w_{Hrt}}{w_{Lrt}} = \frac{A_{Hrt}}{A_{Lrt}}\left(\frac{L_{rt}}{H_{rt}}\right)^{1-\rho}$$

Taking logs, the relative wage equation can be expressed as:

$$ln\left(\frac{w_{Hrt}}{w_{Lrt}}\right) = \frac{1}{\sigma}\left[D_{rt} - ln\left(\frac{H_{rt}}{L_{rt}}\right)\right]$$

where:

$$D_{it} = (\sigma - 1)ln\left[\frac{A_{Hrt}}{A_{Lrt}}\right]$$

is the relative demand shift which depends on the technology parameters for the two types of labor.

2. However, in his analysis of skill premia in Chile, Gallego (2012), using cointegration techniques for a panel from 1960 to 2000, obtains an estimate of 1.50. We therefore use this value, together with our previous estimates of the relative supplies and relative wages to calculate the implied spatial demand shifts for the college/high school educational groups. For ease of analysis, our calculated measures are once again presented graphically in figure 3.19. The regression line, which is calculated weighting by the 2011 employment by province and lies below the 45 degree line, shows a clear shift in demand towards the low educated group, with over 80 per cent of the provinces increasing the demand for unskilled workers over time.

In the Katz and Murphy's framework there is no unambiguous indicator for labor demand, and the empirical literature has therefore usually obviated to this problem by including a time trend as a proxy for the relative demand shifts. From equations (1) and (2), we can obtain the theoretical relationship connecting relative output price changes and labor supply changes with the change in the regional wage premia as:

$$(\hat{w}_S - \hat{w}_U)\,\Delta = \left[(\lambda_{UN}\lambda_{SM}\hat{K} - \lambda_{SN}\lambda_{UA}\hat{T}) - (\lambda_{UN}\hat{L}_S - \lambda_{SN}\hat{L}_U)\right] - \\ [\lambda_{SN}\lambda_{UA}\sigma_{UA}\hat{p}_A - \lambda_{UN}\lambda_{SM}\sigma_{SM}\hat{p}_M] + \hat{p}_N\,[\lambda_{SN}\lambda_{UA}\sigma_{UA} - \lambda_{UN}\lambda_{SM}\sigma_{SM}] \quad (11)$$

Equation (11) states that the skilled wage premium is inversely proportional to the change in the relative supply of skilled to unskilled workers, and to the change in price of the good that employs unskilled labor relative to the change in price of the good that only employs skilled labor. Additionally, whether an increase in the price of the nontraded good will increase or decrease the skill premium will depend on the relative elasticities of the mobile labor with respect to the fixed factors, and on the relative shares of skilled and unskilled labor used in the nontraded industry: the more skilled labor intensive the production of nontradables, the higher effect will an increase in nontraded prices will have on the skilled wage premia. Therefore, a proxy for the change in the relative labor demand is provided by the regional price change (or alternavely, by the regional export change per worker), so that the regression for the skilled wage premium takes the following form:

$$dln\left(\frac{\hat{w_{Hr}}}{\hat{w_{Lr}}}\right) = \alpha + \beta dln\left(\frac{H_r}{L_r}\right) + dln(p_r) + \epsilon_r \quad (12)$$

Regression estimates are reported in table 14. In, column 1 we include regional price change as a proxy for relative demand change and OLS results show that in regions experiencing a 10 per cent price increase, wage gaps between skilled and unskilled workers decreased by 4.5%, while changes in relative supply had no effect on the wage gap. In column 2, we include in the regression regional export changes per worker as the relative demand change proxy, and estimate the regression in 2SLS like in our previous analysis. In this specification, the demand coefficient implies that in regions where exports per worker increased by 10 U.S. dollars, wage gaps decreased 4.3%, while estimates for relative supply changes are still statistically insignificant. Therefore, demand factors favoring unskilled workers were clearly a dominant factor over changes in relative labor supply for explaining the reduction in wage gaps.

8 Employment Effects

In the theoretical section, we have shown how a shock to an industry which causes the price of its goods to increase relatively to other industries' goods will induce a reallocation of labor from unaffected sectors to the sector that benefited from the price increase. In absence of market frictions and under the assumptions of perfectly inelastic labor supply, regional full employment, and no interregional migration, the increase in jobs in a local labor market due to the expansion of the industry experiencing the price increase should be exactly offset by the decrease in employment in other sectors within the same labor market. However, with labor market imperfections and an upwards sloping labor supply, it is plausible that regions exposed to higher price shocks would experience a total job gain. An additional general equilibrium channel could operate through aggregate demand effects; by way of Keynesian-type multipliers, higher regional wages and increased employment due to positive net migration would increase consumption and investment in the local economy, expanding overall regional employment gains to sectors not directly affected by the price shock. Therefore, in order to calculate the differential effect of regional price changes on regional employment in each main sector, we empirically estimate the following models for changes in regional employment-to-population rates separately by educational level:

$$\Delta(E_{rk}) = \beta_0 + \beta_1 \triangle ln(p_r) + \varepsilon_{rk} \tag{13}$$

where $\triangle(p_r)$ are the regional price changes as in (5), and $\Delta(E_{rk})$ equals 100 times the change in sector k's ratio of employment to working-age population in region r, with k representing each of the four mutually exclusive macro-sectors: Agriculture (A), Mining (M), Nontradables (N), and Manufacturing (I).

The regression estimates for unskilled employment, reported in table 15, are very in much in line with the theoretical model's prediction: a region exposed to a 10% price increase experiences a 1% increase in the ratio of unskilled workers to population for mining employment, while the percentage of unskilled workers employed in the nontraded sector decreases by 1.1%. Additionally, there is a 0.3% expansion in the ratio of employment to population for unskilled workers in the manufacturing sector, possibly because manufacturing suppliers of inputs to the copper sector also expand in mining regions. As the positive coefficients in mining and manufacturing is almost exactly offset by the negative coefficient on nontradables, it would appear that aggregate demand effects are not playing any relevant role in the overall job adjustments to the price shock. It is however important to note that our approach focusing on local labor markets cannot capture any possible national component that aggregate demand effects may have; therefore, our estimates should be considered a lower bound on the aggregate total impact of the commodity price shock on national employment[14]. The results for skilled employment, reported in table 16, are consistent with our previous wage estimates that showed no effect of the price shock on skilled workers' wages. In fact, there does not appear to be much labor reallocation across sectors, as except for a modest increase in mining employment (a 0.1% increase in the employment-to-population ratio in regions exposed to a 10% increase in regional price), point estimates in other sectors are very close to zero and all statistically insignificant.

As in the previous sections, we repeat the analysis to estimate the changes in the regional employment composition as a function of the increase in exports, once again instrumented using regional price changes. The estimating equations are:

$$\Delta(E_{rk}) = \beta_0 + \beta_1 \triangle \left(\frac{\triangle XW_r}{L_r} \right) + \varepsilon_{rk} \tag{14}$$

[14]For instance, additional income in the regional economy will increase demand for non-tradable goods that are by definition offered locally. However, demand may also increase for tradable goods produced in other regions, which would cause employment in industries producing these goods to increase at the national level. Since these effects may be common across locations, they will not be captured by our approach which focuses on variations across local labor markets.

Results for unskilled employment, reported in table 17 closely mirror estimates obtained in the regional price regressions: in a region exposed to a 10 dollars increase in exports per worker, the employment to population ratio increases by 1.1 per cent in mining and by 0.3 per cent in manufacturing, while it decreases by 1.2 per cent in the nontraded sector. For skilled employment, a 10 dollars increase in regional exports per worker increases the mining employment-to-population ratio by 0.2%, while there is no effect in employment for other sectors (see table 18).

9 Conclusion

This paper documented the short term effects of a large increase in commodity prices on regional employment and wages in the context of Chile, a resource abundant country that has often been pointed out as a success story due to its market friendly policies that allowed it to achieve high levels of growth and avoid the natural resource curse. We exploit the natural experiment provided by the large, exogenous differential price changes experienced by industries at the national level combined with the wide degree of variation existing in the industry mix of employment across regions to identify the effect of regional price shocks on wages at the local level, and our results show that in regions whose output faced a 10 percent price increase wage gaps between unskilled and skilled workers declined 8%. These results suggest that unskilled workers in regions well endowed with natural resources obtained a large benefit, and that their gains contributed to the reduction in the skilled wage gap experienced by the country in the period under study. In a country such as Chile, where the reduction of the still persistent high levels of income inequality has been declared a national priority, that should certainly be seen as a positive outcome. However, a few considerations with nontrivial implications in terms of policy can be added with a view to the long-term future.

First, while the good news is that Chile still has copper reserves expected to last for a few more decades and demand will most likely stay strong, prices are expected to level off as supply catches up with demand (Gauvin and Revillard, 2014). In fact, copper prices already subsided in the past couple of years, which caused mining companies to scale down previously planned investments. The completion of large mining development projects could potentially have important implications in terms of labor demand, as mines transition from the construction phase – highly intensive in unskilled labor – to the less labor intensive operational phase. The surge in demand for unskilled labor could therefore prove to be short lived. Additionally, even though as we mentioned above a reduction in relative inequality can certainly be considered positive, it would have clearly been better if such effect had been obtained within a context of rising wages for both groups of workers. It is instead quite worrisome that skilled workers' real wages actually declined in so many regions. Since we traced back the decline in earnings premia to relative demand rather than supply factors, this suggests that labor demand may be accommodating to the type of skills available in the market: if that was the case, the relative decline in the demand for skilled workers may have been a response to the quality of skills. This could point to a skill mismatch between demand and supply of skilled labor, whereby the Chilean educational system would not be producing the types of skills needed by the labor market. This would happen, for instance, if there was an overproduction of traditional college degrees such as law, medicine and business at the expense of the degrees in higher demand in today's knowledge economy such as information technology and computer engineering. There are signs that this may actually be the case especially in the mining sectors, where a recent report (Fundaccion Chile, 2011) has identified substantial skill shortages both in terms of quantity and quality for the 2011-2020 period in a number of occupations that are key to mining operations. With the move towards automation, mechanization, and data analytics, there is an increasing level of sophistication in the operations of mining projects, and the report points out that the skills currently provided by the educational system are not in line with those required by the industry. In particular, the main shortages are identified for fixed and mobile equipment operators, maintenance supervisors, and processing and extraction professionals. Additionally, the sector is currently viewed as an unattractive career option for young graduates and there are a number of college degrees for which it competes as an employer with other sectors of the economy: the extent of the problem is compounded by the high rates of employee turnover in the sector and by the long time it takes to fill jobs at middle and senior management. Unless the attractiveness of the industry can be improved, harsh competition for talent within the sector is therefore set to result in additional in-house training needs for candidates who are not quite as skilled as the job requirements. At the overall economy level, there is evidence that the skill set currently available in Chile may represent a serious constraint to the economy's long term growth, and in this sense the government's effort to pursue a comprehensive reform of the educational system are certainly to be seen favorably.

Secondly, the high dependence on just one single commodity makes both the national and the regional economies alike very vulnerable, and the resources generated by the commodities bonanza should be invested in efforts towards economic diversification. To some extent, Chile already recognized that natural resources windfalls can be used for long term economic development by creating in 2005 the National Council on Innovation and Competitiveness, with the role of implementing a national innovation strategy that would put in place a set of horizontal and vertical policies with the goal of increasing economic diversification. A new royalty tax on mining[15] came into effect in January 2006 to finance the newly created Innovation for Competitiveness Fund (FIC), a key instrument to support these policies. However, the implementation of the strategy for innovation and competitiveness has faced several challenges and had mixed results. In particular, it appears that most of the funds raised by the 2006 royalty tax have not been spent on special innovative programs as it had originally been planned, and – contrary to promises – less than 10 per cent of the total were allocated to the Northern regions that are the largest contributors to the Fund. Additionally, while the number of both export markets and exported products have increased slightly, the diversification process has stagnated in the past decade, and as stated above important gaps in terms of human capital still remain. An adequate long term development strategy for Chile would be to deepen its static and dynamic competitive advantage in natural resources, creating clusters in competitive sectors with high potential for growth[16]. Since the different types of natural resources are concentrated in specific regions, this would also constitute a mechanism to achieve regional development. In the case of clusters in the copper sector, the strategy should be oriented towards increasing the downward linkages of the copper export activities. Large mining companies require inputs and services of high quality, and many different firms have emerged to produce such inputs and services locally; these firms have the potential to turn into exporters themselves, as they are gradually forced to acquire experience and *know how* that could also make it competitive in

[15]Under tax stability agreements, large mining companies pay a flat 4 or 5 per cent rate, which is due to increase in 2017 (when the 12-year tax invariability clause will expire) to a new Specific Tax on Mining established in 2010. This will be charged at a progressive rate based on their sales and operating income, resulting in a máximum effective rate of 14%. CODELCO makes larger contributions to the country's coffers through higher royalties and by distributing all dividends to the government. It is estimated that CODELCO accounts for around 20 per cent of total fiscal revenues in Chile, and that its contributions since its onset have been higher than the corporate income tax paid by all Chilean companies combined.

[16]The National Council on Innovation and Competitiveness had originally identified seven clusters in which Chile has competitive advantage: aquiculture, fruit cultivation, mining, aviculture, global services, specialty tourism and health foods. However, the cluster development strategy has stalled, and the Chilean Economic Development Agency (CORFO) has been focusing on subsidizing horizontal innovation efforts through its Innova Chile program, which had the effect of mainly generating software development firms.

international markets. The mining sector constitutes therefore a great internal market that could become the base to develop an export sector of mining inputs and engineering services for mining. In addition, the creation of the mining cluster would be the perfect way to generate innovation and increase productivity in the whole copper value chain. Given that long run growth depends on the rate of technological change, the idea that countries with high endowments of natural resources are destined to lower growth crucially depends on the assumption that all technological innovation is created in the industrial sector. However, the mining sector is an important user of modern technology, and there is no reason why it could not generate itself knowledge that could then spill over to other sectors. In Chile, mining is indeed a leading sector in the utilization of modern technology, such as satellite communication, robotics, nuclear sensors, computational modeling, software to increase the efficiency of the production and management processes, and platforms for the worldwide purchase of mining inputs. Nevertheless, mining generates very little innovation, and there is very little diffusion of the technology it utilizes. A first step in the right direction towords the solution of the problem of the creation and dissemination of technological innovation has been the creation by BHP Billiton and CODELCO of the World Class Suppliers Program (*Programa Proveedores Clase Mundial*), a shared strategy that could generate benefits for both mining companies and suppliers. Under this program, if the mining firm has a problem that is unable to solve in house, a contract is signed to guarantee that the intellectual property of the solution belongs to the supplier; if the solution is effective, the supplier can sell it to other firms. In this fashion, the mining firm obtains the solution to a concrete problem, while the suppliers have the insurance that the innovation they generate will be applied to a customer, and the opportunity to expand their business. The goal of the program is to create 250 world class suppliers that in 2020 sold to foreign markets one third of their output. In 2012, 55 firms had already managed to grow and start exporting, and to improve their security, labor and environmental protection norms. The *Programa Proveedores Clase Mundial* has the potential to develop a continuous process of generation of technological innovation; in this scenario, copper could move from being a "cash cow", simply used to generate fiscal revenues and foreign reserves, to a more dynamic role of generating technological innovation with an incorporated mechanism for its dissemination.

Finally, an analysis of the regional impact of the commodity boom in Chile cannot be considered complete without taking into consideration the social and environmental consequences of the expansion of mining activities. Even though a lot of progress has been made in reducing the accident rate, mining unions regulary stage strikes demanding better work conditions for miners. Additionally, recent data from various social surveys show that mining regions have higher average drug use and crime rates, and lower health, education and housing quality indicators than non-mining ones. Part of this problem may be made worse by the highly centralized system of Government present in Chile: paradoxically, public spending is lower in those areas that are generating the highest contribution to fiscal revenues, as social spending is allocated according to historical budget patterns, without considering the influx of workers to the booming areas. On the environmental front, mining is creating a huge pressure on water reserves, in addition to pollution and the acceleration of glaciers destruction. While our analysis only focused on economic outcomes, future research could therefore examine the impact of the commodity price boom on social indicators; such work would importantly complement our results and would paint a more complete picture of the complex consequences of a natural resource windfall on the quality of life in affected regions.

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3.a Appendix

a.1 Data Appendix

1. Basic processing of the CASEN household survey data

We use the 2003 and 2011 CASEN surveys, which contain data on a sample of 68,153 and 86,854 households respectively. We perform the analysis at the single individual level, and use *comunas* sampling weights in all calculations. We restrict the sample to *salaried* employees - all wage earners employed in the public or private sector, formal or informal - aged 18 to 65 who worked at least 20 hours a week and reported positive salary in the previous month. For all individuals in the sample, we construct a measure of hourly earnings, obtained as the logarithm of total monthly adjusted income (including bonuses and overtime) from the principal occupation divided by hours worked last month. Since in the 2011 survey only hours worked in the previous week are available, we multiply the value by 4.33 to obtain monthly hours. The 2003 wages are expressed in real terms and adjusted to 2011 *pesos* using the Chilean CPI. From the obtained sample, we further drop individuals whose wages were below half of the minimum wage at survey time, and those whose wages were above 20 times the median wage. The analysis is performed at the *provincia* level: since an administrative reorganization was undertaken between 2003 and 2011 with the creation of new *provincias*, and a shifts of comunas among existing provincias, the 2003 data are recoded to reflect the 2011 administrative division. Out of the 54 *provincias* existing in 2011, we drop Easter Island, Chilean Antarctica, and Palena from all of our analysis as they contain no observations in at least one of the two surveys.

2. Coding of the Education Categories and Construction of the Relative Wages Series

To construct consistent educational categories, we define as low-skilled individuals who did not complete primary school (less than eight years of education), primary school graduates (eight years of education), high school dropouts (those with fewer than twelve years of education), high school graduates (twelve years of education), and college dropouts (individuals with thirteen years of education). High skilled individuals are defined as some college attendees (those with at least fourteen years of schooling but less than sixteen), college only graduates (those with sixteen or seventeen years of completed schooling), and postgraduates (eighteen years or more years of schooling). The main reason why we choose to adopt fourteen years of schooling as our threshold is that in the Chilean education system, post-high school higher education comprises colleges and technical schools: colleges award four or five years' Bachelors' degrees and two years' Associates degrees, while technical schools award two or three years Higher-Level Technician degrees. A minimum of two years of schooling after high school is therefore necessary to obtain a higher level certification.

In order to calculate relative wage differentials, we estimate log hourly wage equations separately for low skilled and high skilled workers in each year, using the same controls as in our main wage regression (a quadratic in age, years of education, dummies for marital status, sex, and rural residence, and industry fixed effects). The mean log wage for each skill group in each province is the predicted log wage from these regressions evaluated at the mean characteristics vector of all workers in the sample.

3. Construction of Relative Supply Measures

In order to obtain measures of labor supply for high skill and low skill employees, we first form a labor quantity sample for each year equal to total hours worked by all employed workers (including those in self-employment) in 8 education categories: primary school dropouts, primary school graduates, high school dropouts, high school graduates, college dropouts, some college attendees, college graduates, and postgraduate; then, for each education category, we calculate real full-time average wages for each year. The aggregate labor supply of high skill workers in efficiency units is calculated as the sum of college graduates labor supply plus the labor supply of the postgraduate and college attendees groups re-weighted by their wage relative to the wage of those who have precisely completed college. For example, if those with a postgraduate degree earn on average 40 percent more than college graduates, their hours worked count as 1.4 times those of a college graduate in the aggregate high skill labor supply. Similarly, the aggregate labor supply of low skill workers in efficiency units is calculated as the sum of high school graduates labor supply plus the labor supply of the college dropouts, high school dropouts, primary school graduates, and primary school dropouts groups re-weighted by their wage relative to the wage of those who have precisely completed high school. Therefore, workers with less than high school education are included in the low skill group with their labor supply weighted by their wage relative to those having completed high school.

a.2 Formal exposition of the specific factor model with three goods and four factors

We model each region as a 4x3 specific factors economy similarly to Jones and Marjit (2003). Each region is characterized by three productive activities: a primary sector (A), a service sector (N), and a manufacturing sector (M). There are two specific factors, each of which is used in just one productive activity: T - which can be thought of as land, natural resources, or capital specific to mining -, is used in the primary sector A, and K - which can be thought of as specific capital for advanced manufacturing, or entrepreneurship -, is used in the manufacturing sector M. Additionally, there are also two mobile factors, unskilled labor, L_U and skilled labor, L_S, which are employed together in the service sector N, but can also have alternative occupations in another activity, the primary sector, A, for unskilled labor, and manufacturing, M, for skilled labor.

Denoting a_{ij} the input-output coefficients representing the quantity of factor i used per unit of output in the j-th industry, the full employment equations of the two mobile factors in any particular region r (we henceforth drop the regional subscript on all terms) can be written as:

$$\begin{cases} a_{UA}Y_A + a_{UN}Y_N = L_U \\ a_{SN}Y_N + a_{SM}Y_M = L_S \end{cases} \tag{15}$$

We assume that there is sufficient flexibility in technology to allow the two specific factors to also be fully employed at positive factor prices:

$$\begin{cases} a_{TA}Y_A = T \\ a_{KM}Y_M = K \end{cases} \tag{16}$$

Assuming perfect competition, the competitive profit conditions are met in all three industries so that output price equal total cost. Denoting p_j the price of commodity j, and w_i, r_j the factor payments, we have:

$$\begin{cases} a_{UA}w_U + a_{TA}r_T = p_A \\ a_{UN}w_U + a_{SN}w_S = p_N \\ a_{SM}w_S + a_{KM}r_K = p_M \end{cases} \tag{17}$$

Letting hats represent proportional changes, it follows from the Wong-Viner envelope theorem that costs are minimized along the unit isoquants so that any small change in the input-output coefficient will not change unit costs. Therefore, cost minimization implies:

$$\begin{cases} \theta_{TA}\hat{a}_{TA} + \theta_{UA}\hat{a}_{UA} = 0 \\ \theta_{UN}\hat{a}_{UN} + \theta_{SN}\hat{a}_{SN} = 0 \\ \theta_{SM}\hat{a}_{SM} + \theta_{KM}\hat{a}_{KM} = 0 \end{cases} \tag{18}$$

where the θ_{ij} represent factor i's distributive shares in industry j. Making use of these equations and differentiating the competitive profit conditions, it follows that:

$$\begin{cases} \theta_{UA}\hat{w}_U + \theta_{TA}\hat{r}_T = \hat{p}_A \\ \theta_{UN}\hat{w}_U + \theta_{SN}\hat{w}_S = \hat{p}_N \\ \theta_{SM}\hat{w}_S + \theta_{KM}\hat{r}_K = \hat{p}_M \end{cases} \tag{19}$$

Returning to the full employment conditions, output changes are obtained differentiating (16):

$$\begin{cases} \hat{Y}_A = \hat{T} - \hat{a}_{TA} \\ \hat{Y}_M = \hat{K} - \hat{a}_{KM} \end{cases} \tag{20}$$

and substituting into the differentiated form of equations (15) yields:

$$\begin{cases} \lambda_{UA}(\hat{a}_{UA} + \hat{Y}_A) + \lambda_{UN}(\hat{a}_{UN} + \hat{Y}_N) = \hat{L}_U \\ \lambda_{SN}(\hat{a}_{SN} + \hat{Y}_N) + \lambda_{SM}(\hat{a}_{SM} + \hat{Y}_M) = \hat{L}_S \end{cases} \tag{21}$$

where λ_{ij} denotes the fraction of the mobile factor i used in industry j. Multiplying the first equation in (21) by λ_{SN} and the second by λ_{UN}, subtracting and substituting for output changes in (20), we obtain:

$$\lambda_{SN}\lambda_{UN}(\hat{a}_{UN} - \hat{a}_{SN}) + \lambda_{SN}\lambda_{UA}(\hat{a}_{UA} - \hat{a}_{TA}) - \lambda_{UN}\lambda_{SM}(\hat{a}_{SM} - \hat{a}_{KM}) = \lambda_{SN}(\hat{L}_U - \lambda_{UA}\hat{T}) - \lambda_{UN}(\hat{L}_S - \lambda_{SM}\hat{K}) \quad (22)$$

We now need to link the change in factor intensities to the elasticities of substitution between specific and mobile factor in industries A and M, and between the two mobile factors in industry N:

$$\begin{cases} \sigma_{UA} = \frac{(\hat{a}_{UA} - \hat{a}_{TA})}{\hat{p}_A - \hat{w}_U} \\ \sigma_{SM} = \frac{(\hat{a}_{SM} - \hat{a}_{KM})}{(\hat{p}_M - \hat{w}_S)} \\ \sigma_N = \frac{(\hat{a}_{UN} - \hat{a}_{SN})}{(\hat{w}_S - \hat{w}_U)} \end{cases} \quad (23)$$

Substituting for the change in factor intensities in (22), we obtain:

$$\lambda_{SN}(\lambda_{UA}\sigma_{UA} + \lambda_{UN}\sigma_N)\hat{w}_U - \lambda_{UN}(\lambda_{SN}\sigma_N + \lambda_{SM}\sigma_{SM})\hat{w}_S = \lambda_{SN}\lambda_{UA}\sigma_{UA}\hat{p}_A - \lambda_{UN}\lambda_{SM}\sigma_{SM}\hat{p}_M - \lambda_{SN}(\hat{L}_U - \lambda_{UA}\hat{T}) + \lambda_{UN}(\hat{L}_S - \lambda_{SM}\hat{K}) \quad (24)$$

Equation (24) is the first of a system of two equations connecting changes in the returns to the two mobile factors to changes in commodity prices; the second one is just the competitive profit condition of change for the N sector from (19). Solving the system for the returns of the two mobile factors yields:

$$\hat{w}_U = (\theta_{SN}/\Delta)\left[\lambda_{SN}\lambda_{UA}\sigma_{UA}\hat{p}_A - \lambda_{UN}\lambda_{SM}\sigma_{SM}\hat{p}_M\right] + \left[\lambda_{UN}\left(\lambda_{SM}\sigma_{SM} + \lambda_{SN}\sigma_N\right)/\triangle\right]\hat{p}_N + (\theta_{SN}/\Delta)\left[\lambda_{UN}\left(\hat{L}_S - \lambda_{SM}\hat{K}\right) - \lambda_{SN}\left(\hat{L}_U - \lambda_{UA}\hat{T}\right)\right] \quad (25)$$

$$\hat{w}_S = (\theta_{UN}/\Delta)\left[\lambda_{UN}\lambda_{SM}\sigma_{SM}\hat{p}_M - \lambda_{SN}\lambda_{UA}\sigma_{UA}\hat{p}_A\right] + \left[\lambda_{SN}\left(\lambda_{UA}\sigma_{UA} + \lambda_{UN}\sigma_N\right)/\triangle\right]\hat{p}_N + (\theta_{UN}/\Delta)\left[\lambda_{SN}\left(\hat{L}_U - \lambda_{UA}\hat{T}\right) - \lambda_{UN}\left(\hat{L}_S - \lambda_{SM}\hat{K}\right)\right] \quad (26)$$

where $\Delta = \theta_{SN}\lambda_{SN}\lambda_{UA}\sigma_{UA} + \theta_{UN}\lambda_{UN}\lambda_{SM}\sigma_{SM} + \lambda_{UN}\lambda_{SN} + \sigma_N$. Let's now consider a price increase in the primary sector, A. As (25) shows, the unskilled labor wage increases, but by a smaller percentage amount than the price change[17]. This happens because an increase in the price of a commodity must lead to a matching increase in average cost, and therefore an increase in the marginal product of unskilled labor in sector A . However, since unskilled labor is also employed in another sector, workers there will be attracted to the sector that benefited from the price increase, causing an increase in the marginal productivity in the service sector until it eventually matches the marginal productivity in the primary sector, which is driven down by an equal amount[18]. The extent to which the unskilled wage responds to the price increase in industry A depends upon the share of the total unskilled labor in the region absorbed by that industry as indicated by λ_{UA}, and the elasticity of demand for unskilled labor with respect to a given amount of specific capital in industry A, σ_{UA} (as the graphical treatment in section 3.4 makes clear, the more elastic is labor demand, the higher the proportion of the price increase that gets transmitted to wages).

We now turn to examine what happens to the return to skilled labor. Equation (26) shows that its wage rate decreases when commodity A's price increases, which follows directly from the increase in the unskilled wage rate and the competitive profit equation of change in sector N. However, since commodity N is assumed to be a nontradable, in order to determine the final direction of changes in both wage rates we need to determine what happens to nontradable prices p_N. As shown in equations (25) and (26), in absence of changes in nontradable prices, an increase in the price of either traded good would generate opposite symmetric changes in the wages of skilled and unskilled

[17] As a result, unskilled *real* wage could actually decrease if the nominal wage rate increase is lower than the increase in cost of living, which will be the case if commodity A takes a high share of workers's total consumption. However, Ruffin and Jones (1977) showed that in the case of a price increase of exportables the improvement in the terms of trade will always increase the real wage rate as long as exports are "typical" in terms of labor intensity and elasticity of demand for labor by sector.

[18] The competitive profit equation of change ensures that the owners of the specific factor employed in the A sector are net winners, as they enjoy a proportional increase in the factor return higher than the increase in the commodity price.

workers, so that to any change in the unskilled wage $\hat{w}_U$ corresponds a change in the skilled wage equal to $\hat{w}_S = -\hat{w}_U \left(\frac{\theta_{UN}}{\theta_{SN}}\right)$. Therefore, an increase in the price of primary good A would raise the return to specific factor T by a magnified amount, raise the wage rate of unskilled workers, but proportionately by less than the price of primary goods, and lower the skilled wage by an amount proportional to the unskilled wage increase and the distributive share of unskilled labor in the nontradable sector N. Skilled workers in sector N will then be attracted to the manufacturing sector M, and this alternative employment opportunity will serve to mitigate the regional fall in skilled wages. With the price of M assumed constant, the fall in the skilled wage rate allows an increase in the return for the owners of specific capital K.

Summarizing, a price increase in the primary sector (assumed to be the same in all regions) will increase unskilled wages in every region, with the relative magnitude of such changes depending on the regional factor distribution across industries. Clearly, if in a given region labor is more heavily distributed in the sector experiencing the price increase, then - assuming no migration across regions is allowed - that region's wages will benefit as compared other regions. On the other hand, while the primary sector price increase will have the direct effect of decreasing skilled wages everywhere, the relative decrease in each region will be inversally proportional to the distributive share of skilled labor in sector N. What happens if migration is allowed instead? As explained above, the change in commodity prices will create wage differences across regions that will affect workers' incentives to locate in different regions. Workers will therefore have an incentive to move from regions whose wages have relatively decreased towards regions whose wages have relatively increased: migration will therefore tend to minimize the impact of the price change across regions and reduce interregional wage differences. This effect of migration could be examined by analyzing the impact of an increase in a region's labor endowment on wages while holding commodity prices constant. Equations (25) and (26) show that an increase in the endowment of unskilled labor L_U causes w_S to increase and w_U to fall, while an increase in the endowment of skilled labor L_S causes w_U to increase and w_S to fall. Note that if the increases in L_U and L_S were accompanied by an increase of λ_{UA} times of the endowment of commodity A's specific factor, and of λ_{SM} times of the endowment of commodity M's specific factor, respectively, there would be no change in factor returns. In this case, the endowment change would exactly match the factor proportions used in the production of commodities A and M, so that a new equilibrium would be found at a higher output level without changes in factor prices.

a.3 Tables and Figures

Table 1: Chile's main copper mining operations

Mine	Company	Country	Province	Prod. (03)	Prod. (11)	Empl. (03)	Empl. (11)
Mantos Blancos	Anglo American Chile	UK	Antofagasta	86.9	78.6	2,410	1,815
Mantoverde	Anglo American Chile	UK	Chanaral	60.2	61.1	556	419
Los Bronces	Anglo American Chile	UK	Santiago	207.8	221.4	3,486	2,758
El Soldado	Anglo American Chile	UK	Quillota	70.5	40.4	3,792	3,258
Fundicion Chagres	Anglo American Chile	UK	Quillota	n.a.	n.a.	754	500
Michilla	Antofagasta Minerals	Chile	Antofagasta	52.7	41.6	700	1,968
Los Pelambres	Antofagasta Minerals	Chile	Choaca	337.8	426.1	3,796	5,133
El Tesoro	Antofagasta Minerals	Chile	Antofagasta	92.4	97.1	1,091	2,179
Esperanza	Antofagasta Minerals	Chile	Antofagasta	-	96.6	738	3,126
Zaldivar	Barrick Gold	Canada	Antofagasta	150.5	132.3	1,239	2,181
Minera Escondida	BHP Billiton	Australia	Antofagasta	994.7	817.7	7,659	10,648
Spence	BHP Billiton	Australia	Antofagasta	-	181	1,695	4,377
Cerro Colorado	BHP Billiton	Australia	Tamarugal	131.5	94.3	883	2,727
El Teniente	Codelco	Chile	Cachapoal	339.4	400.3	14,555	16,175
Chuquicamata	Codelco	Chile	El Loa	601.1	443.4	14,402	14,143
Radomiro Tomic	Codelco	Chile	El Loa	306.1	470.1	5,334	5,672
Ministro Hales	Codelco	Chile	El Loa	-	-	-	1,110
El Salvador	Codelco	Chile	Chanaral	80.1	69	4,791	6,389
Andina	Codelco	Chile	Los Andes	235.8	234.4	3,429	8,436
Ventanas	Codelco	Chile	Los Andes	-	-	-	2,070
Gaby	Codelco	Chile	Antofagasta	-	118	-	438
La Candelaria	Freeport-MacMoran	U.S.A.	Chanaral	212.7	148.4	1,390	2,444
El Abra	Freeport-MacMoran	U.S.A.	El Loa	226.6	123.4	1,793	2,672
Carmen de Andacollo	Teck	Canada	Elqui	22.1	72	674	1,970
Quebrada Blanca	Teck	Canada	Tamarugal	73.8	63.4	593	2,198
Dona Ines de Collahuasi	Glencore	Switzerland	Tamarugal	394.7	453.3	4,246	10,635

Note: Employment includes workers and contractors. Production in thousands of metric tons.

Sources: Author, based on information from various years of the following publications: Consejo Minero Annual Report, Cochilco Copper and Other Minerals Yearbook, Sernageomin Chilean Mining Yearbook, Codelco and Antofagasta Minerals Sustainabilty Reports.

Table 2: Chile's Sector Shares of Employment, 2003 and 2011

	Agriculture		Mining		Manufacturing		L/S Services		H/S Services	
	2003	2011	2003	2011	2003	2011	2003	2011	2003	2011
North	5.6	2.8	12.8	19.8	8.9	5.9	44.4	43.1	28.4	28.4
Centre	19.3	15.5	2.1	4.2	12.6	8.3	38.3	45.1	27.6	27.0
South	18.2	15.2	0.5	0.8	12.1	9.6	39.3	44.1	29.9	30.3
Santiago M.R.	4.1	2.9	0.5	1.0	17.2	14.3	42.0	48.5	36.2	33.4
CHILE TOTAL	**11.0**	**8.9**	**1.9**	**3.6**	**14.5**	**10.9**	**40.6**	**46.3**	**32.0**	**30.3**

Source: Author's calculations based on CASEN household survey

Table 3: Mean log wages, by sector

	Low Skilled		High Skilled	
	2003	2011	2003	2011
Agriculture	6.66	6.93	7.77	7.74
Mining	7.46	7.58	8.39	8.29
Manufacturing	6.98	7.16	7.80	7.85
Low Skill Services	6.93	7.08	7.61	7.74
High Skill Services	6.93	7.19	7.94	8.01

Source: Author's calculations based on CASEN household survey

Table 4: Mean log wages, by sector and geographical area, low skilled workers

	North		Centre		South		Santiago R.M.	
	2003	2011	2003	2011	2003	2011	2003	2011
Agriculture	6.77	7.13	6.62	6.91	6.69	6.95	6.75	6.97
Mining	7.59	7.69	7.38	7.52	6.91	7.51	7.37	7.43
Manufacturing	7.09	7.33	6.91	7.13	6.78	7.07	7.04	7.17
Low Skill Services	6.93	7.23	6.76	7.01	6.74	6.97	6.97	7.15
High Skill Services	7.00	7.26	6.95	7.10	6.99	7.11	7.12	7.25
TOTAL	7.02	7.33	6.79	7.04	6.79	7.01	7.01	7.17

Source: Author's calculations based on CASEN household survey

Table 5: Mean log wages, by sector and geographical area, high skilled workers

	North		Centre		South		Santiago R.M.	
	2003	2011	2003	2011	2003	2011	2003	2011
Agriculture	7.47	7.70	7.46	7.60	7.84	7.88	8.24	7.89
Mining	8.42	8.20	8.14	8.12	8.57	8.37	8.67	8.75
Manufacturing	7.71	7.80	7.61	7.78	7.71	7.83	7.94	7.89
Low Skill Services	7.34	7.82	7.47	7.60	7.58	7.59	7.73	7.84
High Skill Services	7.76	7.93	7.79	7.85	7.88	7.96	8.06	8.14
TOTAL	7.75	7.94	7.68	7.78	7.80	7.87	7.97	8.03

Source: Author's calculations based on CASEN household survey

Table 6: Effect of producer price changes on regional wages

	OLS	IV
Regional Price Change	0.206***	0.172**
	(0.069)	(0.075)
R - squared	0.136	0.132
Observations	51	51
First stage		
Regional World Price Change		0.927***
		(0.030)
F-test of excluded instrument		920.14
p-value		0.000

Note: Coefficient estimates from a regression of log change in regional prices on regional wage changes. Both regressions are weighted by the inverse of the standard error of the estimated change in the first stage Haisken-DeNew and Smith's log provincial wage coefficients. Instrumental variable regression uses fictitious regional price changes calculated using world prices instead of Chilean Producer Prices as instruments for the actual regional price changes. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Robust Standard Errors are in parenthesis.

Table 7: Effect of producer price changes on regional wages, by education

	High Skilled		Low Skilled	
	OLS	IV	OLS	IV
Regional Price Change	0.058	0.024	0.293***	0.260***
	(0.103)	(0.129)	(0.0941)	(0.081)
R - squared	0.004	0.004	0.214	0.212
Observations	51	51	51	51
First stage				
Regional World Price Change		0.906***		0.929***
		(0.029)		(0.031)
F-test of excluded instrument		965.01		885.84
p-value		0.000		0.000

Note: Coefficient estimates from a regression of log change in regional prices on regional wage changes. All regressions are weighted by the inverse of the standard error of the estimated change in the first stage Haisken-DeNew and Smith's log provincial wage coefficients. Instrumental variable regressions use fictitious regional price changes calculated using world prices instead of Chilean Producer Prices as instruments for the actual regional price changes. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Robust Standard Errors are in parenthesis.

Table 8: Effect of change in regional exports per worker on regional wage changes

	IV1	IV2
Unit export change per worker	0.0018**	0.0015**
	(0.0007)	(0.0007)
Observations	51	51
First stage		
Regional price change	116.50***	102.47***
	(23.79)	(23.42)
Observations	51	51
F-test of excluded instrument	23.99	19.15
p-value	0.000	0.000

Note: Coefficient estimates from a 2SLS regression of log change in regional exports per worker on regional wage changes. Regressions are weighted by the inverse of the standard error of the estimated change in the first stage Haisken-DeNew and Smith's log provincial wage coefficients. The first column uses regional prices changes calculated using Chilean Producer Prices as an instrument for unit export changes; the second column uses fictitious regional price changes calculated using world prices as an instrument for unit export changes. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Robust Standard Errors are in parenthesis.

Table 9: Effect of change in regional exports per worker on regional wage changes, by education

	High Skilled		Low Skilled	
	IV1	IV2	IV1	IV2
Unit export change per worker	0.0005	0.0002	0.0024***	0.0023**
	(0.0011)	(0.0011)	(0.0009)	(0.0009)
Observations	51	51	51	51
First stage				
Regional price change	111.44***	97.74***	120.72***	107.26***
	(20.67)	(20.11)	(25.01)	(24.63)
Observations	51	51	51	51
F-test of excluded instrument	30.63	23.63	23.30	18.96
p-value	0.000	0.000	0.000	0.000

Note: Coefficient estimates from 2SLS regressions of log change in regional exports per worker on regional wage changes. Regressions are weighted by the inverse of the standard error of the estimated change in the first stage Haisken-DeNew and Smith's log provincial wage coefficients. The first column of each group uses regional prices changes calculated using Chilean Producer Prices as an instrument for unit export changes; the second column uses fictitious regional price changes calculated using world prices as an instrument for unit export changes. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Robust Standard Errors are in parenthesis.

Table 10: Percent migration by province and educational level

Province	High Skilled			Low Skilled		
	In-Migration	Out-Migration	Net Flow	In-Migration	Out-Migration	Net Flow
Iquique	10.5%	10.8%	-0.3%	13.0%	3.0%	10.0%
Tamarugal	26.9%	1.9%	25.0%	10.8%	2.4%	8.5%
Antofagasta	9.3%	13.5%	-4.2%	6.2%	3.9%	2.3%
El Loa	8.0%	10.2%	-2.3%	7.5%	5.6%	1.9%
Tocopilla	9.1%	16.7%	-7.6%	10.4%	5.2%	5.2%
Copiapo	8.9%	15.7%	-6.8%	6.5%	3.3%	3.3%
Chanaral	45.9%	18.2%	27.7%	20.5%	7.8%	12.7%
Huasco	12.3%	6.4%	5.9%	6.8%	7.1%	-0.3%
Elqui	10.8%	13.1%	-2.2%	6.6%	3.4%	3.2%
Choapa	6.7%	37.0%	-30.3%	7.4%	4.4%	3.0%
Limari	16.2%	35.6%	-19.3%	3.0%	8.8%	-5.8%
Valparaiso	13.5%	20.2%	-6.6%	7.9%	8.5%	-0.6%
Los Andes	9.1%	5.7%	3.5%	6.5%	2.1%	4.5%
Petorca	3.6%	15.9%	-12.3%	2.8%	7.9%	-5.2%
Quillota	3.9%	10.7%	-6.8%	3.8%	2.9%	0.9%
San Antonio	12.1%	8.4%	3.7%	4.6%	2.2%	2.4%
San Felipe de Aconcagua	5.5%	5.1%	0.5%	2.0%	4.6%	-2.6%
Marga Marga	16.8%	9.2%	7.6%	6.3%	5.4%	0.9%
Cachapoal	8.3%	6.4%	1.9%	3.8%	2.3%	1.5%
Cardenal Caro	22.5%	73.5%	-51.0%	2.5%	4.8%	-2.4%
Colchagua	4.6%	14.9%	-10.2%	4.2%	2.5%	1.6%
Talca	13.4%	17.5%	-4.1%	3.5%	2.3%	1.2%
Cauquenes	26.1%	5.1%	21.0%	6.0%	7.6%	-1.6%
Curico	10.2%	11.5%	-1.3%	4.8%	2.9%	1.9%
Linares	7.0%	6.2%	0.8%	3.4%	1.5%	2.0%
Concepcion	5.3%	12.0%	-6.7%	3.5%	3.8%	-0.3%
Arauco	0.0%	33.3%	-33.3%	1.6%	9.7%	-8.2%
Biobio	7.5%	13.7%	-6.3%	3.3%	3.1%	0.3%
Nuble	9.4%	13.5%	-4.1%	3.3%	7.6%	-4.3%
Cautin	8.9%	20.6%	-11.6%	4.1%	6.2%	-2.2%
Malleco	15.1%	14.7%	0.5%	9.4%	5.4%	4.0%
Llanquihue	13.0%	9.3%	3.7%	3.2%	4.3%	-1.1%
Chiloe	13.3%	16.7%	-3.4%	3.0%	4.8%	-1.8%
Osorno	7.1%	7.1%	0.0%	8.9%	4.9%	4.0%
Coyhaique	22.4%	3.7%	18.7%	8.5%	6.7%	1.8%
Aisen	19.3%	45.8%	-26.5%	6.2%	6.5%	-0.4%
Capitan Prat	36.0%	23.7%	12.3%	16.0%	17.6%	-1.6%
General Carrera	21.1%	0.0%	21.1%	5.7%	3.2%	2.5%
Magallanes	7.1%	8.7%	-1.6%	3.6%	3.6%	0.0%
Tierra del Fuego	8.6%	31.6%	-23.0%	14.0%	5.7%	8.3%
Ultima Esperanza	14.3%	11.4%	3.0%	2.7%	2.5%	0.1%
Santiago	8.2%	5.2%	3.0%	3.8%	3.8%	0.0%
Cordillera	14.5%	16.6%	-2.1%	7.7%	5.5%	2.1%
Chacabuco	19.7%	6.4%	13.3%	7.4%	3.1%	4.3%
Maipo	9.1%	8.3%	0.8%	8.8%	9.4%	-0.6%
Melipilla	4.1%	3.6%	0.4%	4.7%	2.5%	2.3%
Talagante	4.0%	7.1%	-3.1%	4.6%	3.5%	1.1%
Valdivia	16.5%	10.5%	6.0%	4.1%	6.6%	-2.5%
Ranco	9.0%	6.1%	2.9%	5.1%	17.2%	-12.1%
Arica	10.9%	13.3%	-2.5%	4.2%	5.9%	-1.6%
Parinacota	83.3%	0.0%	83.3%	0.0%	9.3%	-9.3%
TOTAL			**9.8%**			**4.5%**

Note: the table shows the percent workers that in the 2011 survey reported living in a different province five years earlier.

Table 11: Probability of Cross-Province Migration 2006-2011: Logit Estimates

	(1)	(2)
Skilled	0.689***	0.610***
	(0.067)	(0.075)
Pseudo R - squared	0.013	0.044
Observations	65,711	65,711

Note: Both columns report coefficient estimates of a dummy for skilled workers from a logit model where the dependent variable is a 0-1 dummy coded 1 for workers that in 2011 reported changing their province of residence since 2006. The first column does not include additional controls, while the second column include a full set of controls for a quadratic in age, sex and rural residence dummies, and province fixed effects. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Standard Errors are in parenthesis.

Table 12: Effect of regional price changes on 2006-2011 net interregional migration flows

	High Skill	Low Skill
Regional Price Change	-0.201	0.059**
	(0.122)	(0.028)
R - squared	0.064	0.044
Observations	51	51

Note: Coefficient estimates from a regression of chabge in regional price on net regional in-migration rates, for skilled and unskilled workers separately. Regression is weighted by 2011 provinces' employment. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Robust Standard Errors are in parenthesis.

Table 13: Real Regional Wages Relative to Average 2003 Low Skill Wages

	2003			2011			2003-2011		
Province	HS wage	LS wage	GAP	HS wage	LS wage	GAP	HS wage	LS wage	GAP
CHILE	1.81	0.00	1.81	1.64	0.17	1.46	-0.17	0.17	-0.35
Iquique	1.59	0.11	1.49	1.58	0.33	1.25	-0.01	0.22	-0.23
Tamarugal	1.34	0.00	1.34	1.25	0.22	1.03	-0.09	0.22	-0.31
Antofagasta	1.63	0.15	1.47	1.77	0.50	1.27	0.14	0.35	-0.21
El Loa	1.83	0.22	1.61	1.69	0.46	1.23	-0.14	0.25	-0.39
Tocopilla	1.58	0.13	1.45	1.44	0.32	1.12	-0.14	0.19	-0.33
Copiapo	1.68	-0.08	1.76	1.54	0.34	1.20	-0.14	0.42	-0.56
Chanaral	1.64	0.02	1.63	1.59	0.30	1.28	-0.05	0.29	-0.34
Huasco	1.76	0.02	1.74	1.46	0.20	1.26	-0.30	0.18	-0.48
Elqui	1.85	-0.08	1.93	1.46	0.13	1.33	-0.39	0.20	-0.59
Choapa	1.59	-0.19	1.78	1.42	0.09	1.33	-0.17	0.28	-0.45
Limari	1.47	-0.10	1.57	1.49	0.07	1.42	0.02	0.17	-0.15
Valparaiso	1.59	-0.02	1.60	1.54	0.12	1.42	-0.04	0.14	-0.18
Los Andes	1.76	-0.11	1.87	1.57	0.19	1.38	-0.19	0.30	-0.48
Petorca	1.63	-0.14	1.76	1.22	0.02	1.20	-0.41	0.16	-0.57
Quillota	1.57	-0.02	1.59	1.36	0.09	1.28	-0.21	0.11	-0.31
San Antonio	1.70	-0.03	1.73	1.48	0.13	1.35	-0.23	0.16	-0.39
San Felipe de Aconcagua	1.49	-0.14	1.63	1.40	0.06	1.34	-0.08	0.20	-0.29
Marga Marga	1.62	0.02	1.59	1.47	0.15	1.32	-0.15	0.13	-0.28
Cachapoal	1.61	0.01	1.60	1.45	0.18	1.27	-0.15	0.17	-0.33
Cardenal Caro	1.88	-0.06	1.94	1.35	0.12	1.23	-0.53	0.18	-0.71
Colchagua	1.57	-0.15	1.72	1.43	0.00	1.43	-0.14	0.15	-0.28
Talca	1.70	-0.11	1.81	1.56	0.11	1.44	-0.14	0.22	-0.36
Cauquenes	1.74	-0.17	1.91	1.46	-0.15	1.61	-0.28	0.02	-0.29
Curico	1.54	-0.11	1.65	1.48	0.06	1.43	-0.05	0.17	-0.22
Linares	1.56	-0.17	1.73	1.31	-0.10	1.41	-0.24	0.08	-0.32
Concepcion	1.69	-0.11	1.80	1.61	0.17	1.44	-0.08	0.28	-0.36
Arauco	1.59	-0.12	1.71	1.33	-0.04	1.38	-0.26	0.08	-0.34
Biobio	1.51	-0.17	1.68	1.53	0.08	1.44	0.01	0.25	-0.23
Nuble	1.55	-0.22	1.77	1.40	-0.04	1.44	-0.15	0.18	-0.33
Cautin	1.73	-0.24	1.98	1.66	0.03	1.63	-0.07	0.27	-0.35
Malleco	1.62	-0.27	1.89	1.40	-0.07	1.46	-0.22	0.20	-0.42
Llanquihue	1.85	0.05	1.80	1.69	0.13	1.56	-0.16	0.08	-0.24
Chiloe	1.79	0.12	1.67	1.58	0.19	1.39	-0.21	0.07	-0.28
Osorno	1.87	-0.18	2.05	1.47	0.01	1.46	-0.41	0.19	-0.59
Coyhaique	2.07	0.14	1.94	1.91	0.33	1.58	-0.16	0.20	-0.36
Aisen	1.81	0.17	1.64	1.91	0.35	1.56	0.10	0.18	-0.07
Capitan Prat	1.78	0.25	1.53	1.68	0.44	1.24	-0.10	0.19	-0.29
General Carrera	1.81	0.06	1.75	1.67	0.41	1.26	-0.14	0.35	-0.49
Magallanes	1.89	0.21	1.68	1.73	0.32	1.41	-0.16	0.11	-0.27
Tierra del Fuego	1.97	0.18	1.79	1.85	0.40	1.45	-0.12	0.22	-0.34
Ultima Esperanza	1.83	0.05	1.78	1.73	0.17	1.56	-0.10	0.11	-0.22
Santiago	1.95	0.11	1.84	1.76	0.24	1.53	-0.19	0.12	-0.31
Cordillera	1.85	0.13	1.72	1.41	0.29	1.13	-0.43	0.16	-0.60
Chacabuco	1.72	0.03	1.69	1.49	0.20	1.29	-0.23	0.17	-0.40
Maipo	1.81	0.00	1.82	1.51	0.13	1.38	-0.30	0.13	-0.44
Melipilla	1.73	-0.02	1.75	1.49	0.13	1.36	-0.24	0.15	-0.39
Talagante	1.69	0.01	1.68	1.67	0.19	1.47	-0.02	0.18	-0.20
Valdivia	1.78	-0.12	1.90	1.58	0.11	1.47	-0.20	0.23	-0.43
Ranco	1.54	-0.29	1.83	1.58	0.05	1.53	0.03	0.34	-0.30
Arica	1.46	-0.04	1.50	1.48	0.28	1.20	0.03	0.32	-0.30

Note: Real wages shown are the predicted log wages for each province at the mean characteristics vector of all observations in the sample from log hourly wage equations estimated separately for each skill group in each year, with controls for a quadratic in age, years of education, dummies for marital status, sex, rural residence, and industry fixed effects. The 2003 average log wage of the low skill group for the whole country is normalized to zero.

Table 14: Effect of regional relative supply changes and regional price changes on changes in college wage premia

Dep. var: Regional wage premium changes	(2)	(3)
Regional Relative Supply Change	0.573	0.475
	(0.620)	(0.730)
Regional Price Change	-0.453*	-
	(0.262)	
Unit Export Change per Worker	-	-0.0043**
		(0.0020)
Instrument	-	Reg. Price Ch.
First stage		
Regional price change	-	105.34***
		(24.59)
F-test of excluded instrument	-	9.64
p-value	-	0.000
R - squared	0.118	0.287
Observations	51	51

Note: The first column reports coefficient estimates from a regression of shifts in regional relative college/high school equicalent workers' labor supply and regional prices changes on changes in predicted regional log wage premia. The second column reports coefficient estimates from a 2SLS regression of shifts in regional relative college/high school equicalent workers' labor supply and changes in regional exports per worker (instrumente with changes in Chilean Producer Prices) on predicted regional log wage premia changes. All regressions weighted by 2011 provinces' employment. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Robust Standard Errors are in parenthesis.

Table 15: Estimates of effects of regional price changes on regional unskilled employment-to-population ratios, by sector

	Agriculture	Mining	Nontraded	Manufacturing
Regional Price Change	-0.042	0.096 ***	-0.113 ***	0.028**
	(0.040)	(0.010)	(0.038)	(0.010)
R - squared	0.034	0.672	0.189	0.038
Observations	51	51	51	51

Note: Coefficient estimates regressions of changes in regional prices on regional employment-to working population ratios. Regressions are weighted by the 2011 regional population. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Robust Standard Errors are in parenthesis.

Table 16: Estimates of effects of regional price changes on regional skilled employment-to-population ratios, by sector

	Agriculture	Mining	Nontraded	Manufacturing
Regional Price Change	0.002	0.013 **	0.023	0.005
	(0.003)	(0.006)	(0.032)	(0.005)
R - squared	0.007	0.204	0.007	0.007
Observations	51	51	51	51

Note: Coefficient estimates regressions of changes in regional prices on regional employment-to working population ratios. Regressions are weighted by the 2011 regional population. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Robust Standard Errors are in parenthesis.

Table 17: Estimates of effects of regional export changes on regional unskilled employment-to-population ratios, by sector

	Agriculture	Mining	Nontraded	Manufacturing
Regional Export Change	-0.0004	0.0011 ***	-0.0012 **	0.0003***
	(0.0004)	(0.0002)	(0.0005)	(0.0001)
Observations	51	51	51	51
First stage				
Regional Price Change	89.25**	89.88 ***	89.25**	89.25**
	(23.74)	(24.00)	(23.74)	(23.74)
F-test of excluded instrument	14.13	14.02	14.13	14.13
p-value	0.000	0.000	0.000	0.000

Note: Coefficient estimates regressions of changes in regional exports per worker on regional employment-to working population ratios. Regressions are weighted by the 2011 regional population. Instrumental variable regression uses regional prices changes as an instrument for unit export changes. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Robust Standard Errors are in parenthesis.

Table 18: Estimates of effects of regional export changes on regional skilled employment-to-population ratios, by sector

	Agriculture	Mining	Nontraded	Manufacturing
Regional Export Change	0.0002	0.0002 *	0.0001	0.0005
	(0.0003)	(0.0001)	(0.0001)	(0.0006)
Observations	51	51	51	51
First stage				
Regional Price Change	89.25**	89.88 ***	89.25**	89.25**
	(23.74)	(24.00)	(23.74)	(23.74)
F-test of excluded instrument	14.13	14.02	14.13	14.13
p-value	0.000	0.000	0.000	0.000

Note: Coefficient estimates regressions of changes in regional exports per worker on regional employment-to working population ratios. Regressions are weighted by the 2011 regional population. Instrumental variable regression uses regional prices changes as an instrument for unit export changes. *** denotes t-test significance at the 1% level, ** at the 5% level, * at the 10% level. Robust Standard Errors are in parenthesis.

Figure 1: GDP per capita, Chilean macro-regions, 2003 and 2011

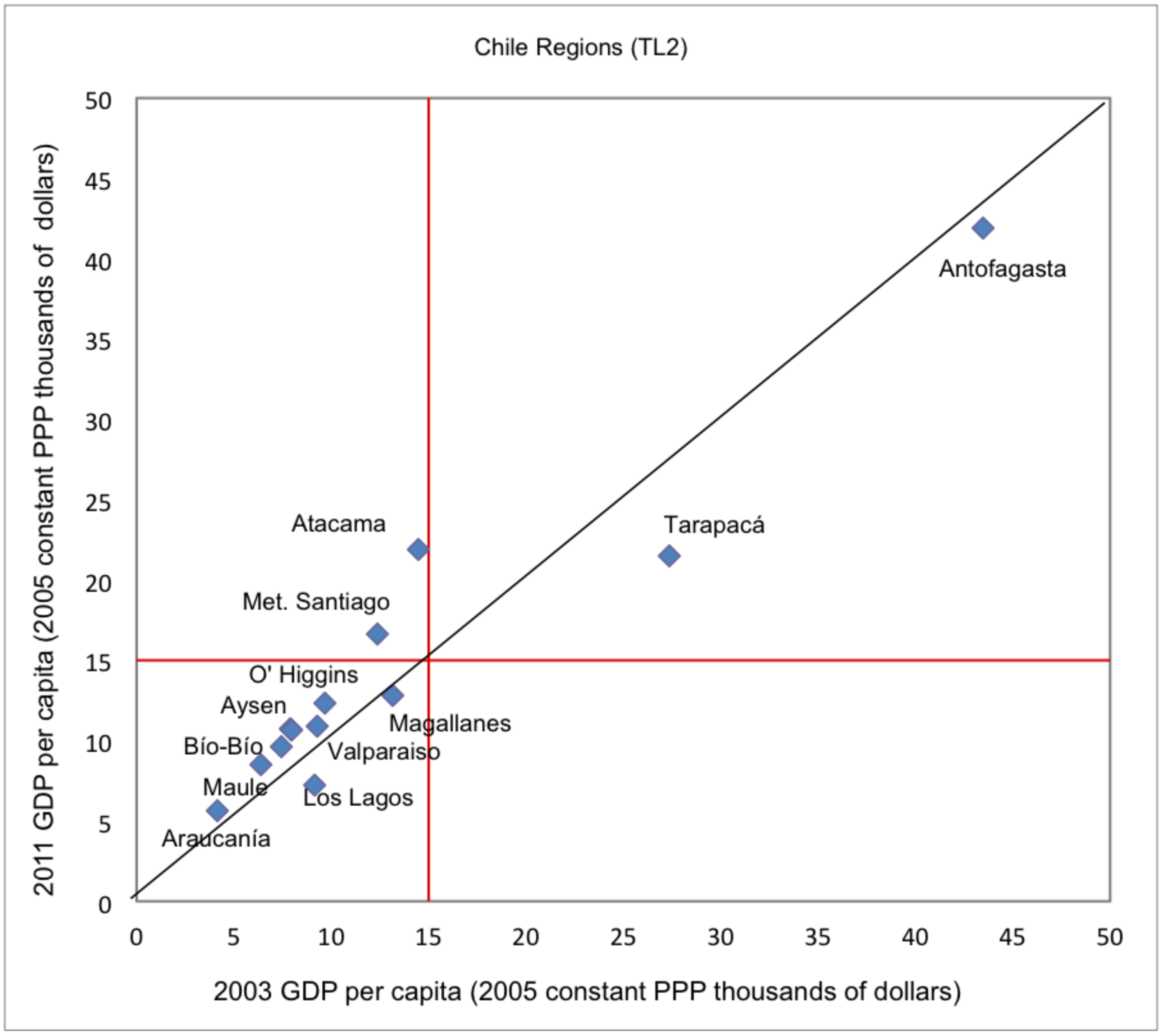


Figure 2: GDP per capita (US dollars), selected Chilean macro-regions and world countries, 2011

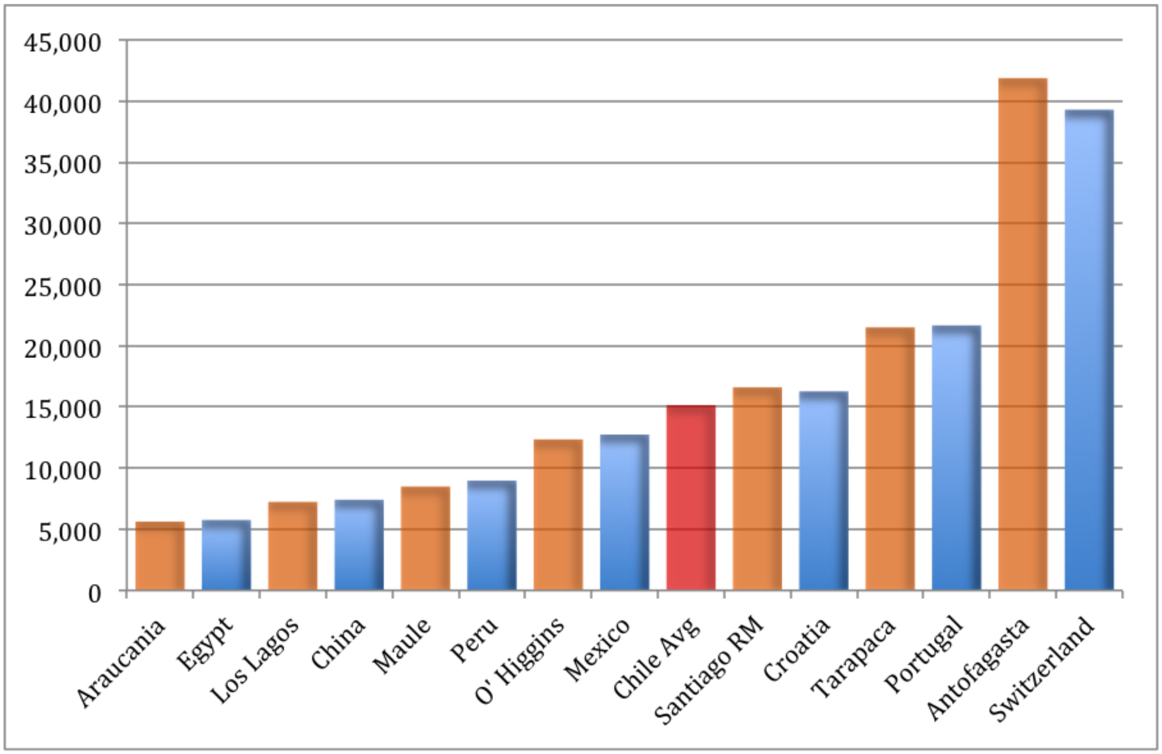


Figure 3: Copper production in thousands of metric tons, by country, 2003 and 2011

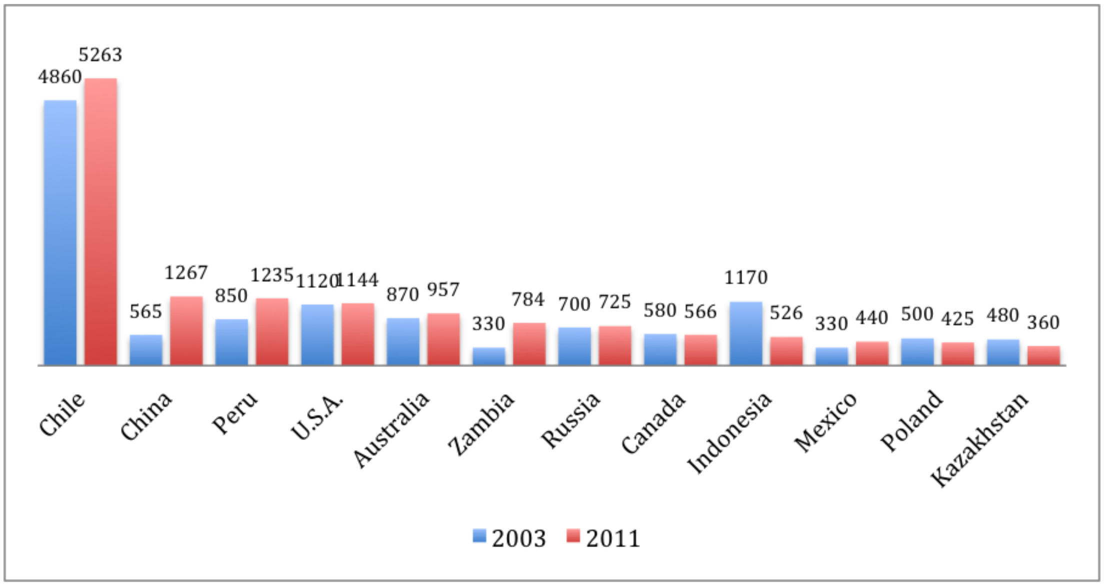


Figure 4: Chilean exports of copper 2003-11, thousands of US dollars

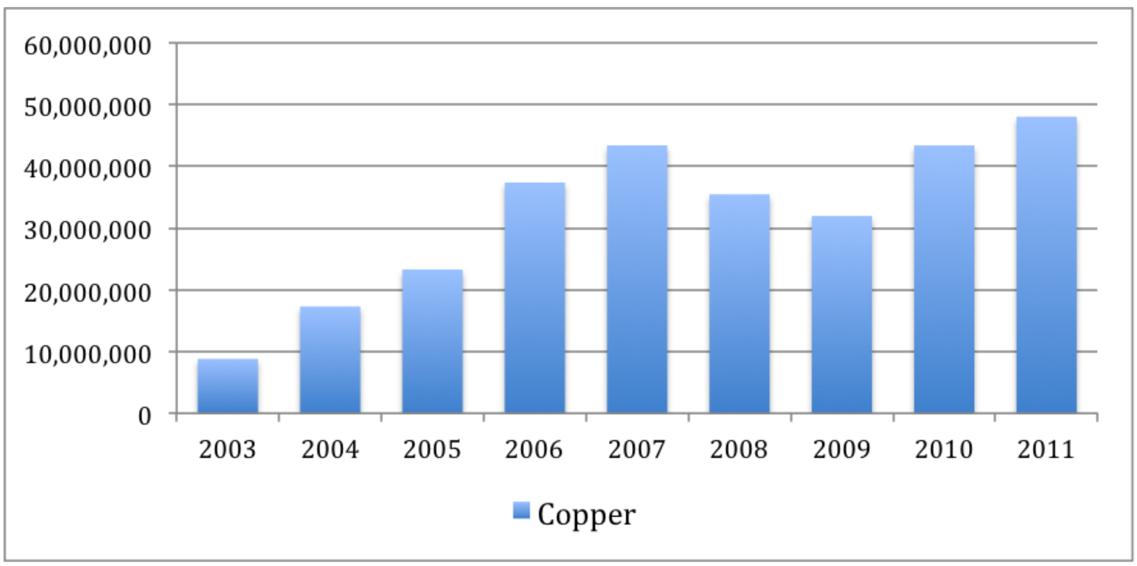


Figure 5: World copper consumption by country, 2010

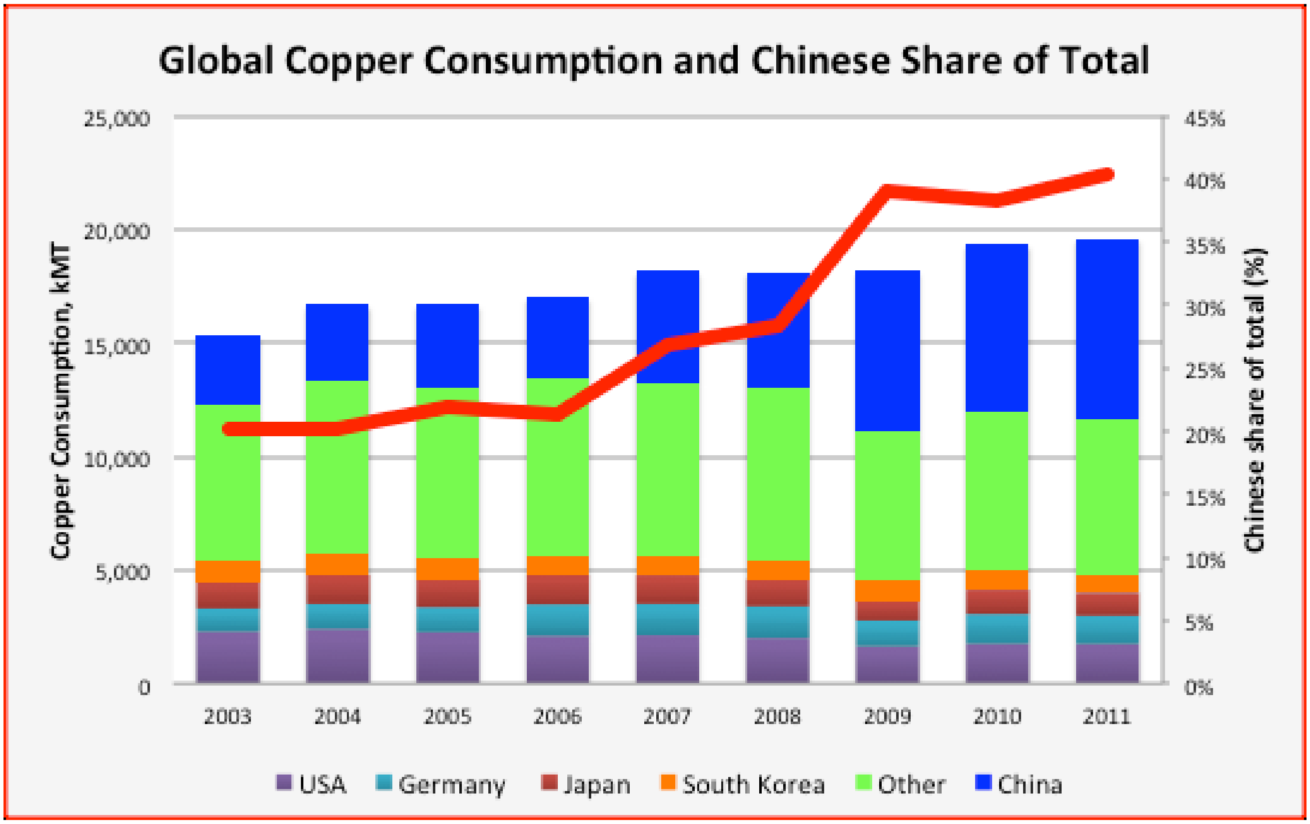


Figure 6: Chilean exports of copper 2003-11, as percent of total exports

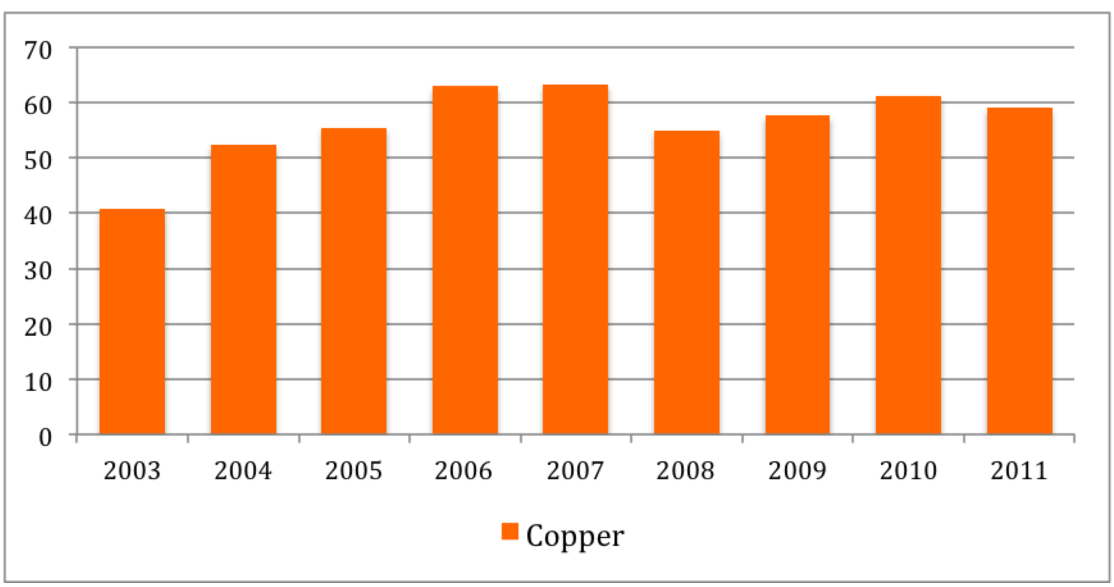


Figure 7: World price and Chile's PPI, copper

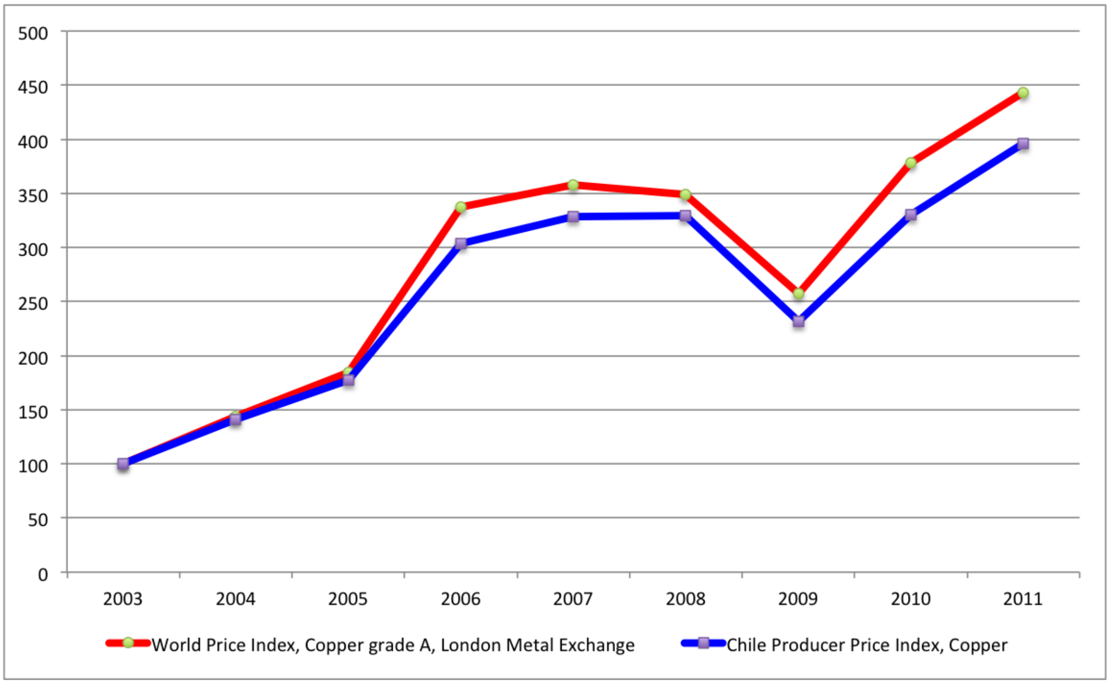


Figure 8: China's total world imports and Chile's export revenues, copper

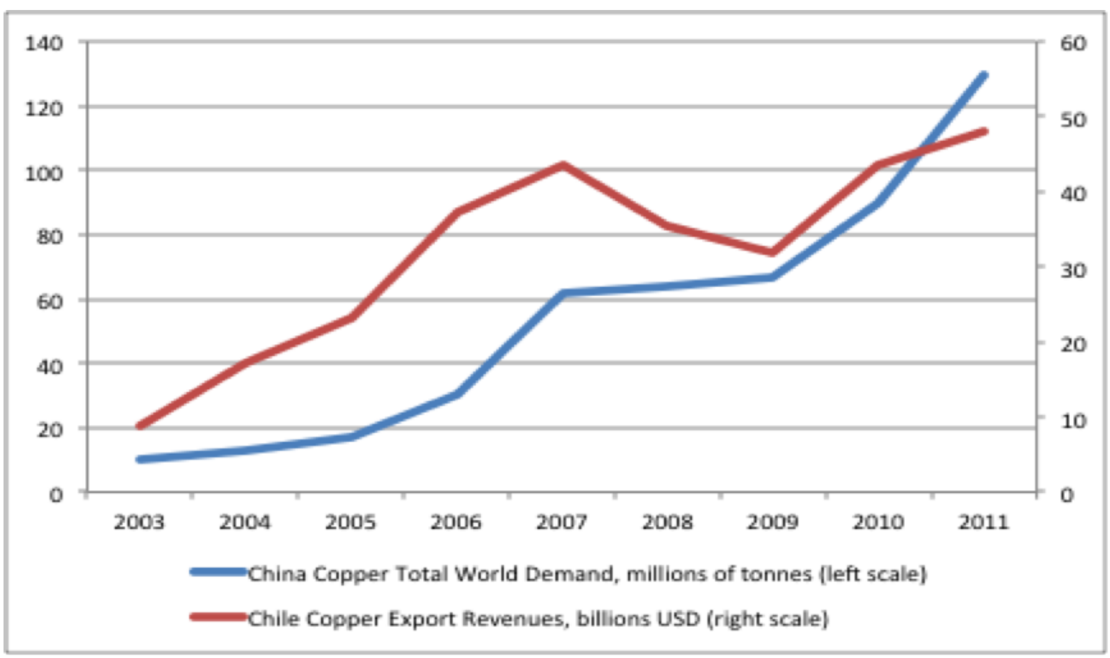


Figure 9: Region level copper sector employment

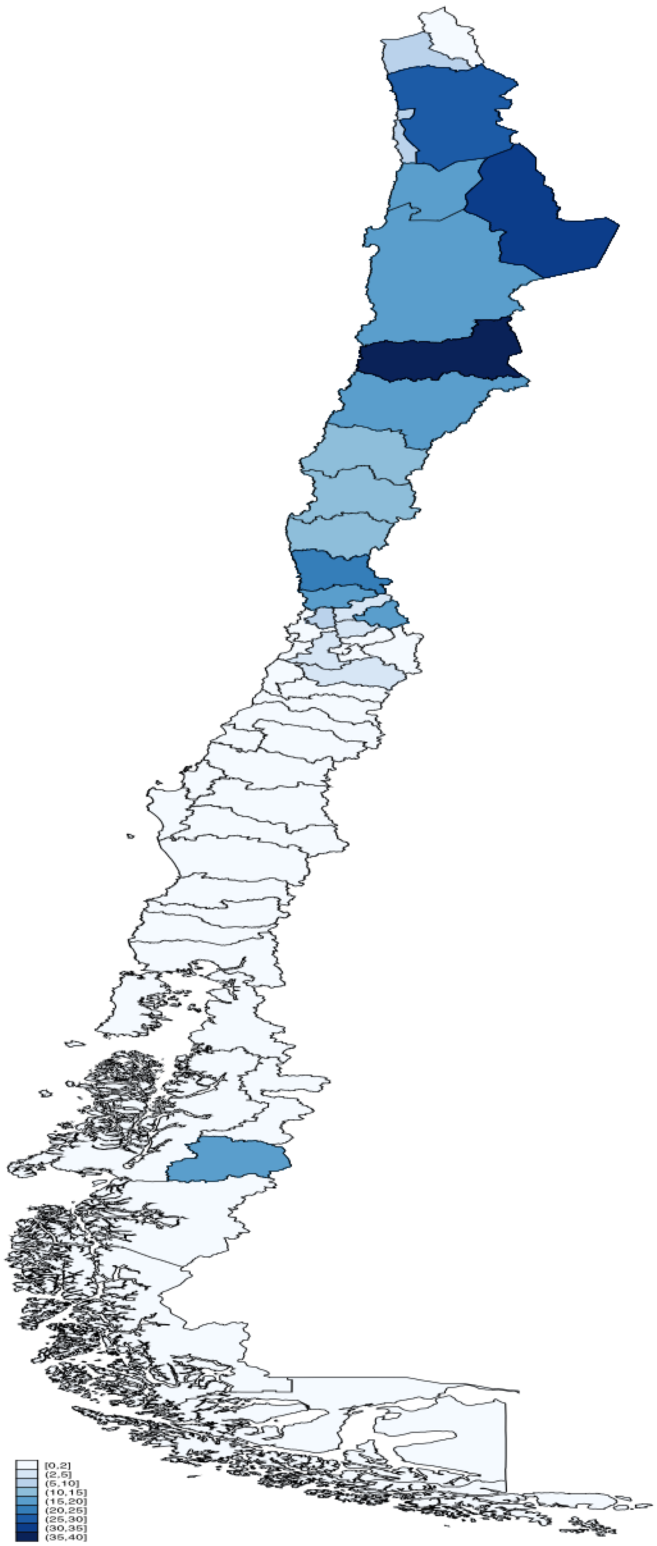


Figure 10: The linear 4x3 neighborhood production structure

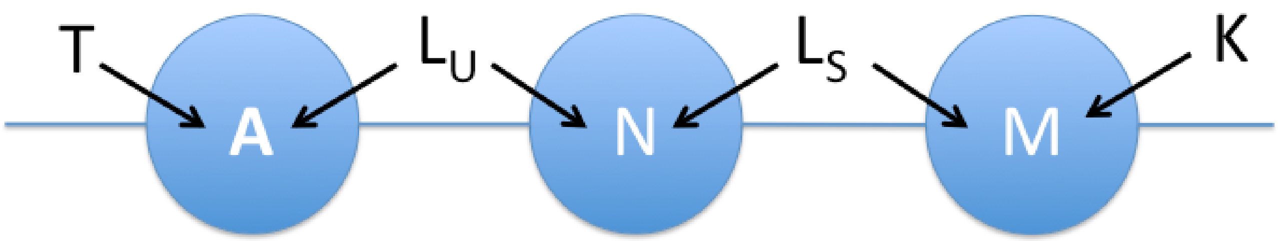


Figure 11: Two region graphical representation of specific factor model with two mobile factors, without interregional migration

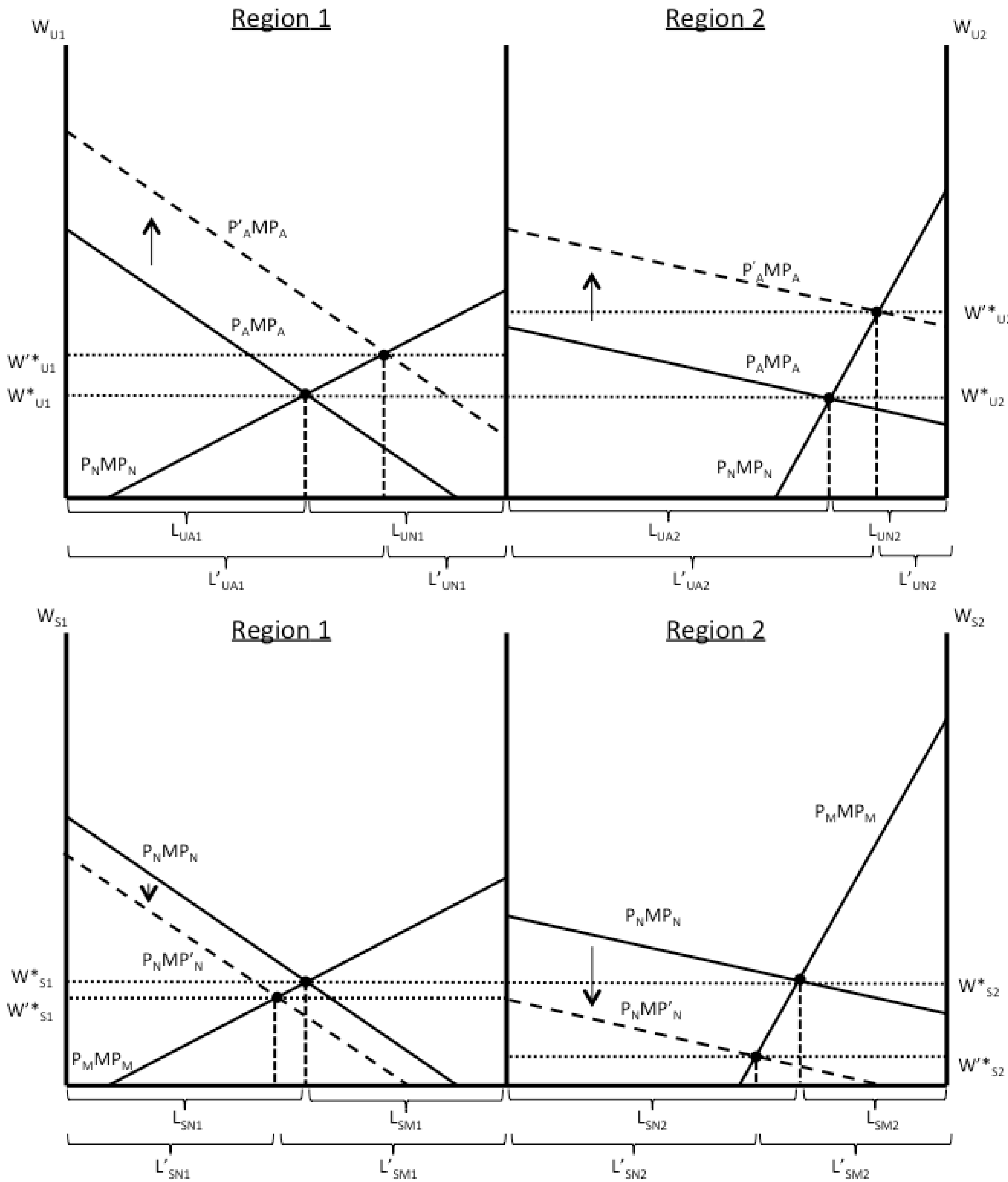


Figure 12: Two region graphical representation of specific factor model with two mobile factors, with interregional migration

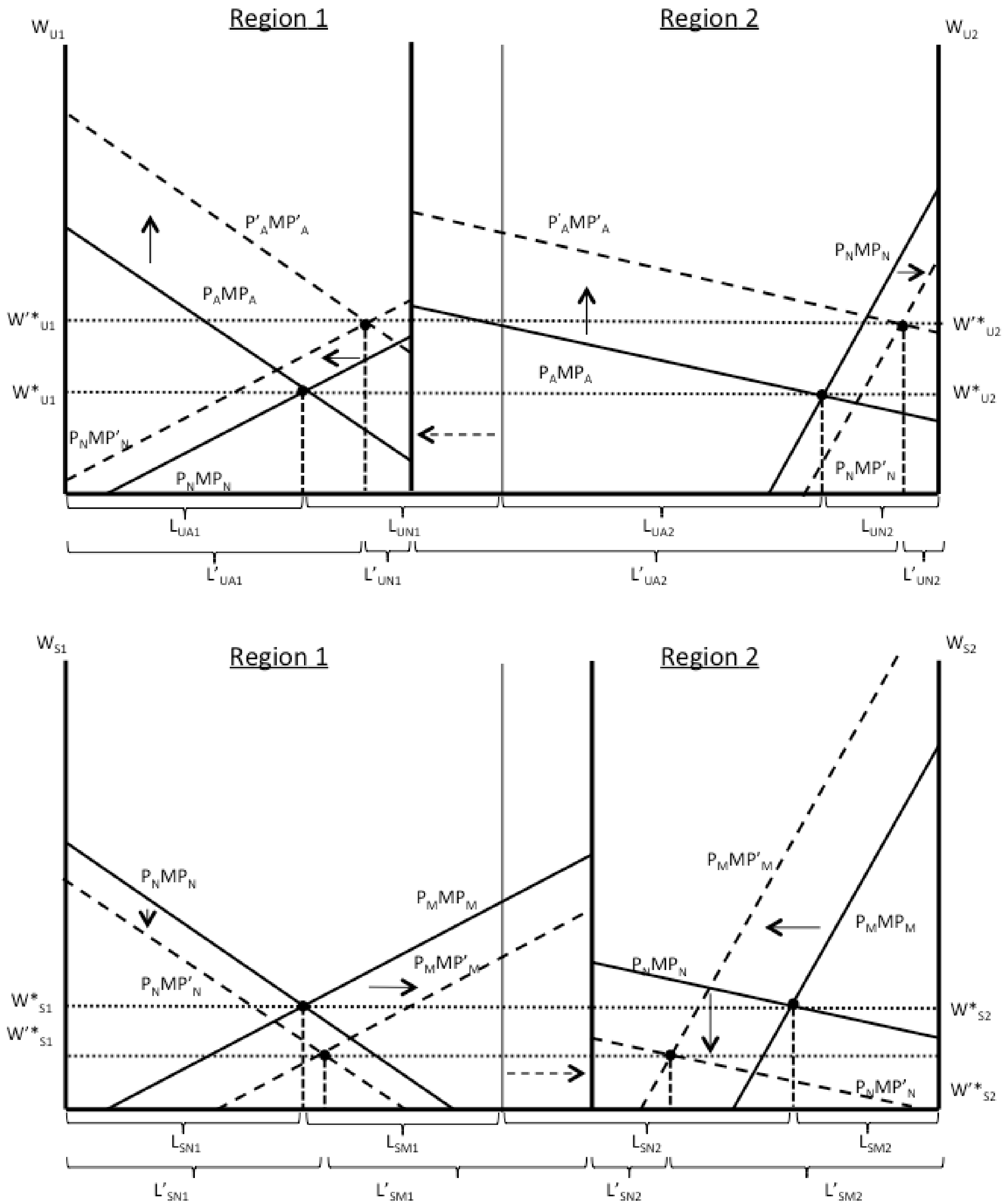
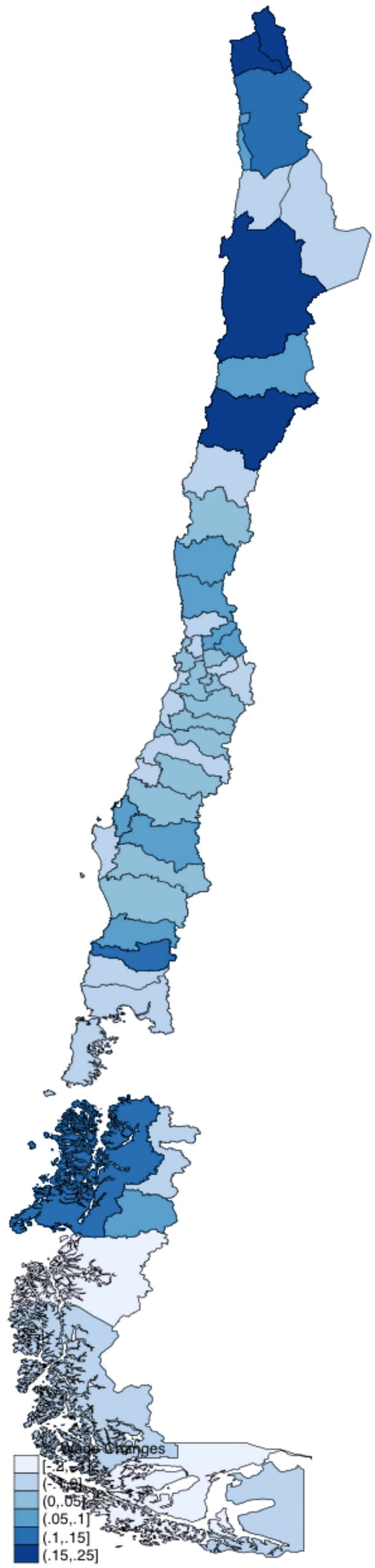
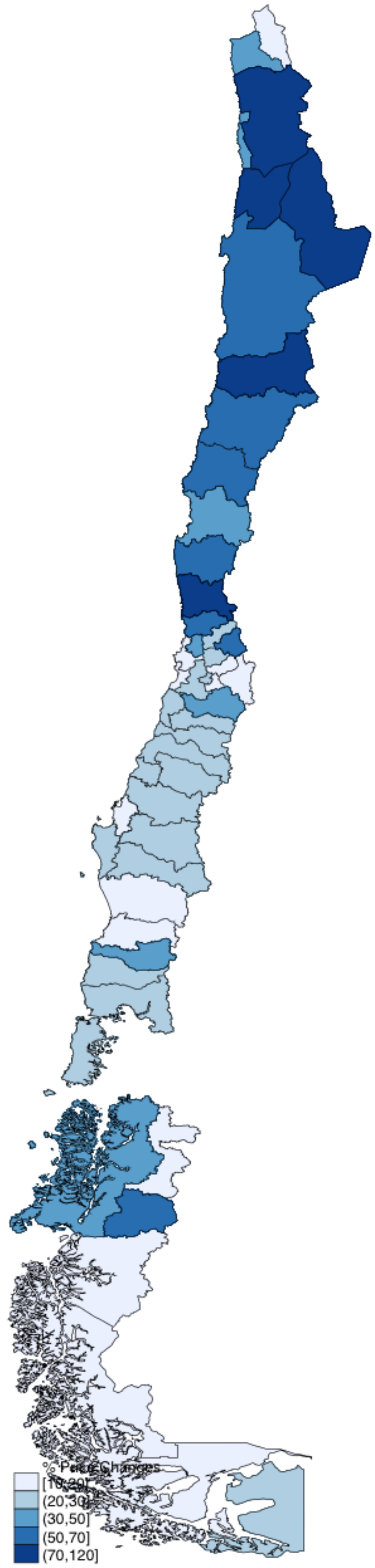


Figure 13: Normalized regional wage changes



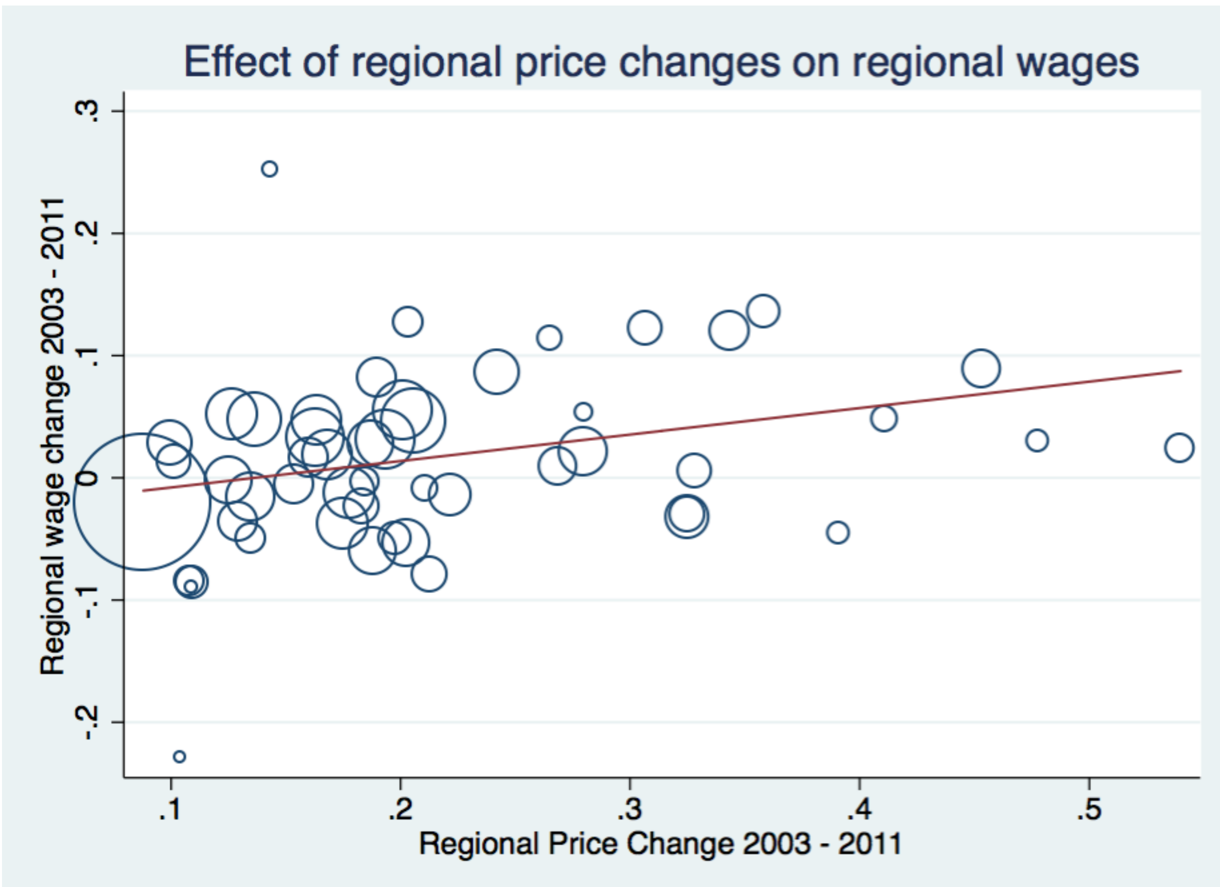
Note: changes in normalized regional fixed effects coefficients from Mincerian wage regressions

Figure 14: Regional price changes 2003-2011



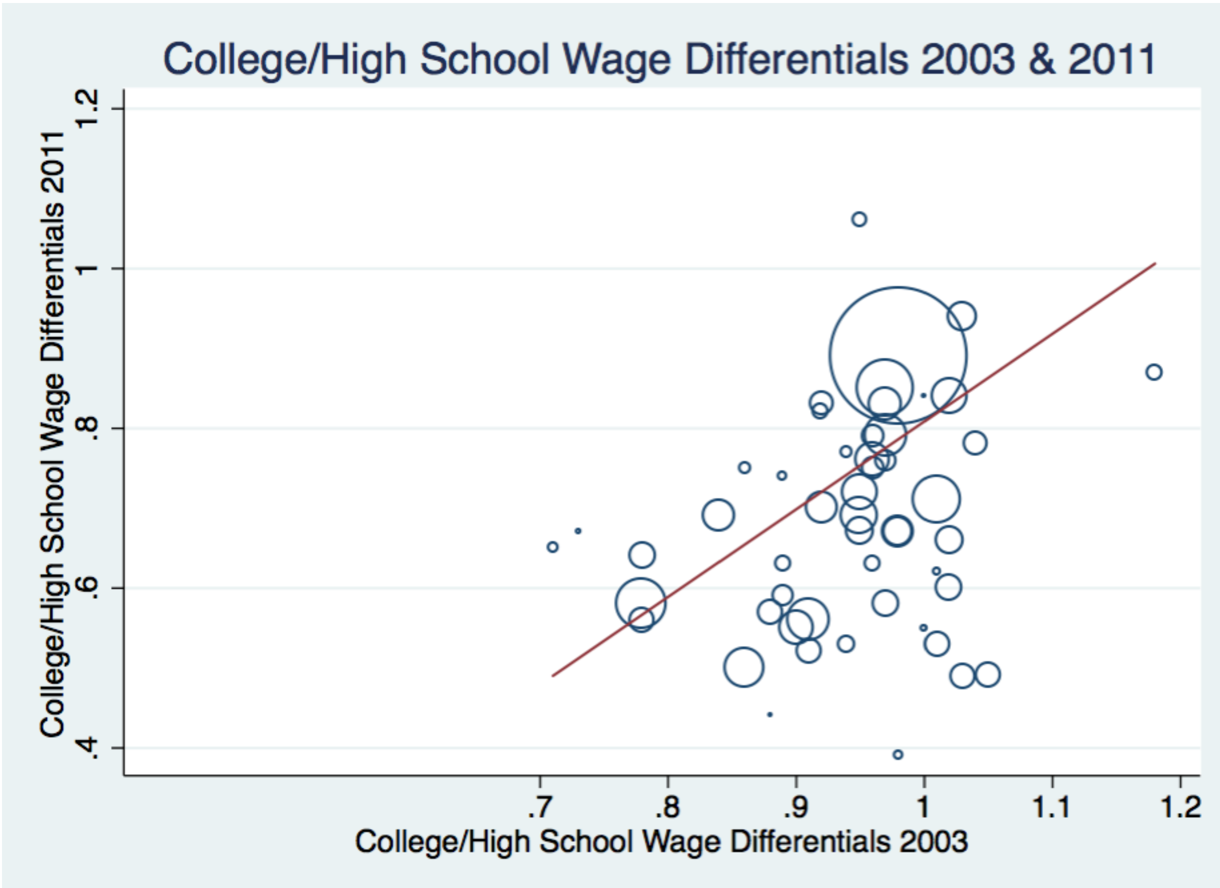
Note: weighted average of producer price changes

Figure 15: Scatterplot of regional price and wage changes



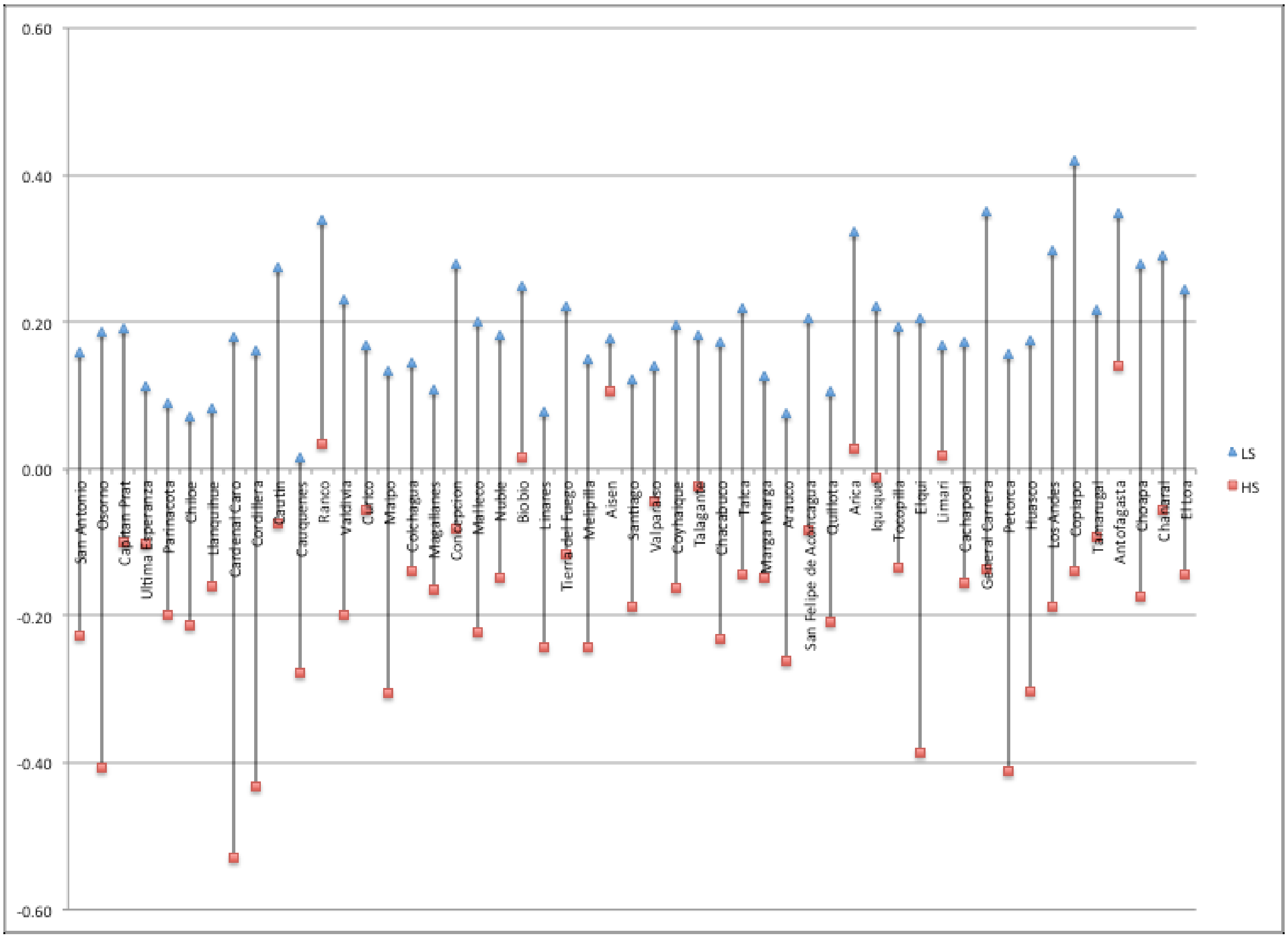
Note: the panel plots estimates of regional prices changes between 2003 and 2011 against the changes in normalized regional wages in the same period. The size of the bubbles is proportional to the inverse of the standard errors of the wage changes estimates.

Figure 16: Regional College/High School Wage Differentials, 2003 to 2011



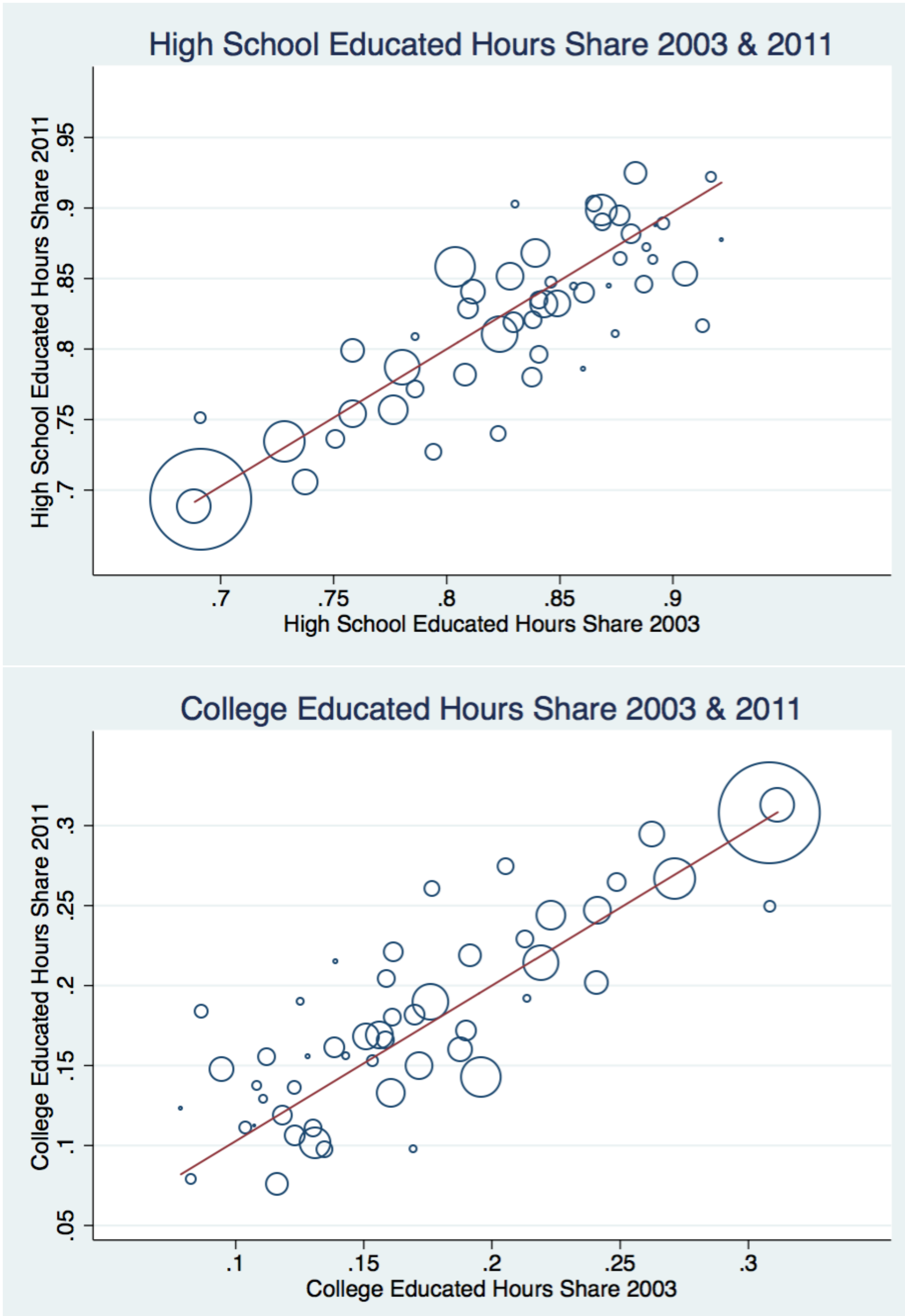
Note: the panel plots 2003 regional college/high school wage differentials against 2011 regional college/high school wage differentials derived from predicted wages from log wage regressions estimated separately for each province. The estimated slope of the regression line is weighted by each province's employment in 2011.

Figure 17: Wages growth for High School and College Educated Workers, 2003 to 2011



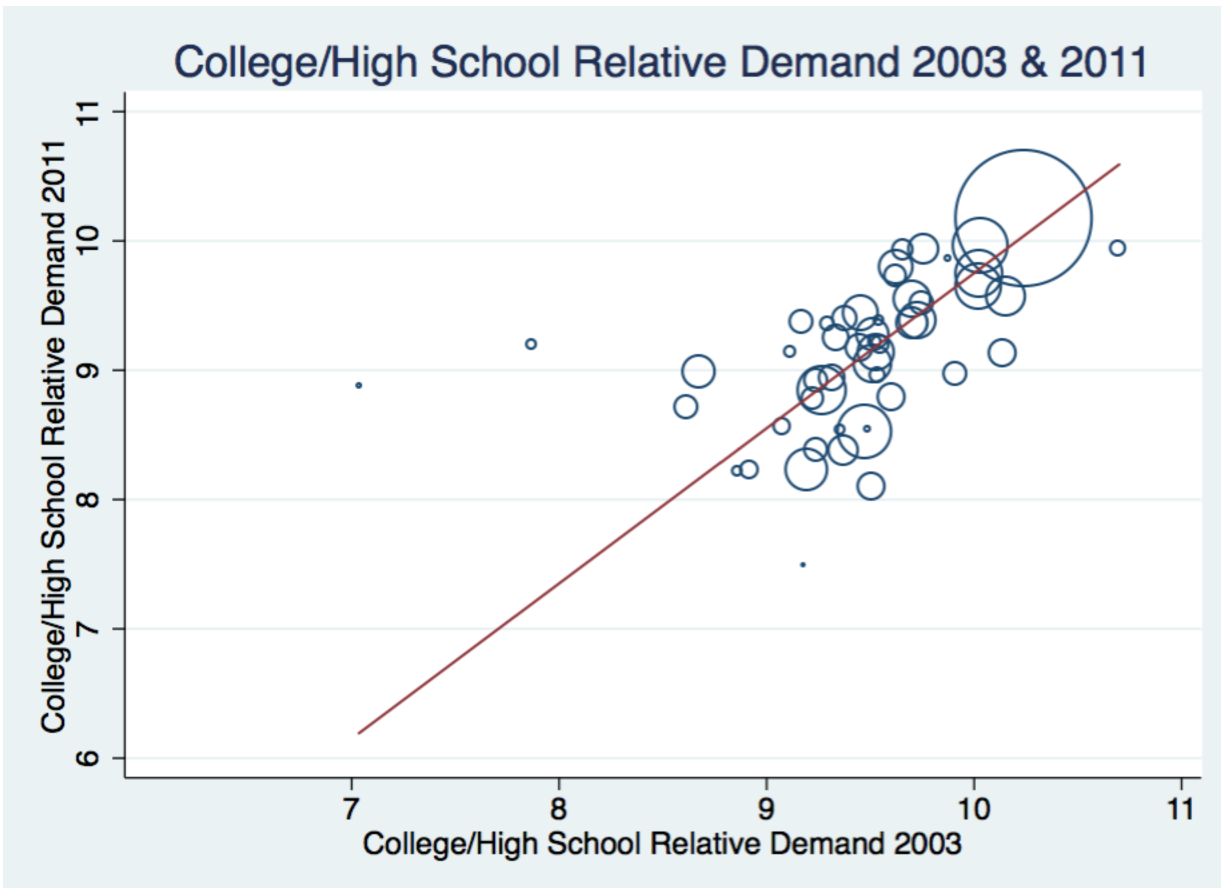
Note: for each province, the triangle corresponds to the change in wages for high school graduates, while the square corresponds to the change in wages for college graduates.

Figure 18: Regional High School and College Equivalent Hours shares, 2003 and 2011



Note: each panel plots high school and college equivalent hours shares in 2003 against high school and college equivalent hours shares in 2011, respectively, by province. The size of the bubbles is proportional to the employment in the relevant province in 2011. For definitions of high school and college equivalents see the Data Appendix.

Figure 19: College educated/high school educated relative local demand shifts, 2003 and 2011



Note: the panel plots 2003 regional college/high school caluclated relative demand against 2011 regional college/high school calculated relative demand. The estimated slope of the regression line is weighted by each province's employment in 2011.