Inequality in Latin America: Learning from matched employer-employee data*

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Abstract

Inequality in Latin America fell substantially in the early 2000s. In this paper, we take advantage of administrative matched employee-employed data in Brazil, Chile and Ecuador to examine whether these inequality trends held in the formal sector, as well. We document a significant decrease in the log variance of earnings in Brazil and Ecuador in the early 2000s, whereas inequality in Chile between 2008 and 2015 remained largely flat. In this context, we find that inequality among salaried workers is largely a between-firm phenomenon across these three countries. We expand on our descriptive analysis and estimate an additive worker and firm fixed effects model to understand the driving factors behind inequality in the region. We find a significant decline in between-firm inequality in Brazil and a modest one in Chile. We last focus our attention on the commodities and manufacturing sectors, which were directly exposed to two large external shocks, the commodity-boom and the "China Shock". We find an increase in inequality in the former sector accompanied by an reduction in inequality in the latter across the region.

JEL-Codes: D22, E24, J08, J31.
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1 Introduction

Latin America has historically faced high levels of income inequality, going back as far as the mid-19th century [see Williamson, 2010]. In this context, the decline in inequality in the past two decades has received extensive attention in the literature [Lustig et al., 2013, Cornia, 2014]. For the region as a whole, the Gini coefficient declined from an average of 0.550 in the early 2000s to 0.496 in 2012, and out of 18 countries with available and comparable data, 16 experienced a decline in this indicator during this period [Lustig et al., 2016] .

The evidence suggests that most of the recent reduction has been driven by lower inequality in labor earnings [see Alejo et al., 2014, Azevedo et al., 2013], a fall in the returns to education, and larger and more progressive public transfers [see Lustig et al., 2013].[1] Nonetheless, the majority of this analysis has been carried out using household surveys, which may fail to accurately measure earnings and thus potentially mismeasure the importance of labor income to the reduction in inequality.

In this paper, we complement the existing literature on inequality in Latin America by taking advantage of matched employee-employer administrative data covering the universe of formal sector workers in Brazil, Chile and Ecuador. As previously highlighted by Meyer and Mittag [2015], these data sources allow to accurately observe earnings with less measurement error, thereby allowing a more precise description of inequality trends. To this end, we first present a descriptive analysis of formal sector earnings inequality across the three countries since the mid-2000s, decomposing it into within- and between- firm components. While the data sources cover different time periods across the three countries, limiting the comparability of our analysis, we first establish whether the reduction of income inequality observed in household surveys is replicated using administrative data sources.[2]

To extend our descriptive analysis, we follow Abowd et al. [1999a] and estimate empirical models

[1] de la Torre et al. [2012] and Guerra-salas [2016] suggest that the boom in commodity prices induced, through the appreciation of the real exchange rate a substantial reallocation of resources from non-commodity tradeable sectors to nontradeable sectors reducing the skill premium. For the analysis of main driving forces also see Azevedo et al. [2013], Cord et al. [2016], Maurizio and Vázquez [2016], and Messina and Silva [2018].

[2] In Brazil, Ferreira et al. [2014] and Komatsu and Menezes [2015], and Engbom and Moser [2018] have found that rising minimum wages contribute to declining inequality over 2002-2012. Meanwhile, Contreras and Ffrench-davis [2012] found that a reduction in labor income inequality can explain the reduction in inequality in Chile during the early 2000s and in Ecuador, Ponce and Vos [2014] argues that the fall in income inequality in Ecuador is mainly associated with a recovery from the country's deep crisis of the late 1990s.

with additive worker and firm fixed effects. This strategy allows us to quantify the contributions of firm- and worker-specific factors towards explaining changes in inequality in the region.[3] As these models can only be estimated using matched employee-employer data, we provide an important contribution to the literature. While due to data limitations in Ecuador, we implement the general model for only Brazil and Chile, this is one of the first papers to estimate such models across two developing countries[4] and the first one using Chile. In fact, the existing literature on this topic has largely focused its attention on developed countries, with extensive work analyzing inequality decompositions in the United States, Germany, Portugal, Italy and Denmark, among others [Bloom et al., 2015, Barth et al., 2016, Card et al., 2013, Håkanson et al., 2015, Iranzo et al., 2008].

Our descriptive analysis shows a sizable decline in wage inequality, measured as the variance of the log of real wages for formal sector workers, in Brazil and Ecuador between 2004 and 2012, confirming the existing evidence from household surveys. On the other hand, formal sector inequality in Chile has remained flat from 2008 through 2015. In fact, the reduction in inequality in Brazil is largely explained by increasing wages for workers in the lowest decile of the income distribution, whereas in Ecuador, there has been a compression at both the top and the bottom of the distribution. We take further advantage of these three administrative data sources to analyze whether inequality is a between- or a within-firm phenomenon in the region. Across these three countries, we find that that income inequality in the formal sector is largely a between-firm phenomenon in the region, which replicates previous findings in the developed country literature and a recent paper for Brazil [Alvarez et al., 2018]. In fact, the decrease in inequality in Brazil and Ecuador can be largely explained by a decline in the variance of wages between firms.

We complement the descriptive analysis with evidence from the additive worker and firm fixed effects model in Brazil and Chile. Our AKM-model results indicate that the reduction in between-firm inequality can explain 78 percent of the decline in the log variance of wages in Brazil, while both between- and within-firm inequality have remained largely flat in Chile from 2008 through 2015. In both countries, there is a fall in the variance of the firm premiums but the size of this decline in Brazil is more than six times larger than in Chile and thereby accounts for 42% of the

[3] As is common in this literature, we refer to this model as the "AKM" model throughout the text.

[4] In a work simultaneous to ours, Messina and Silva [2018] estimate AKM models for Brazil and Costa Rica. Although closely related, they focus on the role of demand conditions in Latin America and show that the variance of firm premiums drive the changes over time for these two countries.

decline in inequality in the former.

We note that during our time period of analysis, Latin American countries have concurrently faced two large aggregate shocks: the boom in commodity prices and China's entry into the World Trade Organization. As these shocks have affected growth and inequality in the region [Benguria et al., 2017], and more specifically, affected employment in the commodities and manufacturing sectors [Costa et al., 2016], the AKM-estimates help to examine how these concurrent shocks have affected inequality across and within sectors, and to understand the driving forces behind the changing inequality patterns. With this goal in mind, we contribute to the literature by analyzing the evolution of inequality within two directly exposed industries in Chile and Brazil, manufacturing and commodities. In Brazil, we find a significant decrease in inequality within the manufacturing sector, while inequality in commodities has only increased slightly, and both changes are driven by changes in between firm inequality[5]. While our analysis for Chile focuses on a later time period (2008-2015), we find similar patterns as in Brazil, with a slight decline in within-manufacturing inequality and a significant increase in within-commodities-sector inequality. This paper therefore contributes to the literature exploring the drivers of the recent decline in inequality in Latin America, particularly focusing in Brazil, Chile and Ecuador. Furthermore, given the recent focus by policymakers on implementing policies aimed at reducing inequality, our paper contributes by establishing baseline facts about inequality in formal sector earnings in the region, which can serve as a guide for future policymaking aimed at reducing inequality in Latin America.

The rest of the paper is organized as follows. Section 2 describes our data sources. In Section 3, we present descriptive statistics on inequality trends in the region and present a variance decomposition of labor income inequality in Brazil, Chile, and Ecuador. Section 4 describes our econometric methodology and presents our main results. In Section 5, we describe the aggregate shocks affecting Latin American countries and present our sectoral results. Lastly, in Section 6 we present conclusions and final remarks.

[5]The fall in manufacturing is also documented by Alvarez et al. [2018].

2 Data Sources

In this section we provide a description of the administrative matched employer-employee data sets and sample selection used in Brazil, Chile and Ecuador. We note that while the data sources across these countries include different variables and cover different time periods, we harmonize the earnings variables to ensure comparability in our analysis.

Brazil. We analyze the Relacao Anual de Informaes Sociais (RAIS) database, which contains matched employee-employer information from a mandatory annual survey filled by all registered firms in the formal sector. As a result, RAIS covers the universe of formal sector workers, but provides no information on earnings outcomes for informal sector workers. In this paper, we use RAIS data for the country's 27 states for 2004 through 2012. As the Ministry of Labor has been known to levy fines on inaccurate reports, firms tend to hire specialized accountants to ensure the correct completion of the RAIS survey, resulting in highly accurate data. RAIS includes unique, time-invariant person identifiers, which allows us to construct a panel of formal sector workers in the period of interest. Moreover, the dataset includes individual-level characteristics such as age, gender, educational attainment, nationality and state of residence, which allows us to restrict our analysis to workers aged 18-65, as is common in this literature.

For each job held by every formal sector worker, we observe the number of total days employed in each year, including the month of entry and exit (aggregated to construct a variable of total months worked). The dataset includes earnings information on the average monthly compensation received by each worker, which includes regular salary payments, holiday bonuses, performance-based and commission bonuses, tips, and profit-sharing agreements. Throughout our analysis, we focus on a worker's primary employer, defined as the one in which the worker earns the highest total earnings in a year, which we deflate using the national consumer price index from the Instituto Brazileiro de Geografia and Estatística (IBGE). RAIS also includes a unique establishment-level identifier, which allows us to construct a longitudinal panel representing the universe of establishments and firms in Brazil over the 2004-2012 period. Lastly, we combine the employee and employer panels to track worker flows across establishments and firms representing the largest connected set of worker mobility through firms, a requirement of the fixed effects model introduced by Abowd et al. [1999a]. Nonetheless, as shown in Panel A in Table 1, the largest connected set in Brazil covers the vast

majority of workers and firms present in RAIS from 2004 through 2012, and similar patterns arise in Chile and Ecuador, shown in Panels B and C, respectively.

Chile. Our data comes from the country's the Unemployment Insurance (UI, *Seguro de Cesantía*) database, which contains matched employee-employer data for all formal sector employment contracts. Chile implemented its UI program in October 2002, at which point it became mandatory for workers under new employment contracts to register in the program, but entry remained voluntary for workers with existing contracts. As a result, as has been previously noted by Sehnbruch and Carranza [2015], the UI database does not become representative of the formal sector labor force until 2007. As a result, we restrict our empirical analysis to the 2008-2015 period.

The Unemployment Insurance database provides information on workers' monthly earnings, sector of employment, commune of residence, and observable characteristics, such as educational attainment, gender and age, and, as in Brazil, we restrict our analysis to workers aged 18-65. We similarly deflate monthly earnings using the Consumer Price Index obtained from the Central Bank of Chile. For every job held by every worker, we observe her month of entry and exit, which we use to construct a measure of months worked in each year, and we restrict our attention to a worker's primary employer, also defined as the one in which the worker earns the highest total earnings in a year. UI data therefore allows us to construct a panel of all formal sector workers in Chile from 2008 through 2015. Furthermore, as UI includes a unique establishment-level identifier, we also construct a longitudinal panel of the universe of firms in Chile. Upon combining the worker and firm panels, we are able to track worker flows across establishments. Panel B in Table 1 presents summary statistics for the selected sample in Chile and also provides information on the largest connected set of firms through which workers in our sample move from 2008 to 2015.

Ecuador. We use administrative data from the Ecuadorian Social Security Institute (IESS) from 2004 through 2012, which includes a unique worker and employer identifier, monthly earnings, days worked per month and information on the firm's economic sector for workers aged 18-65. On the other hand, this dataset does not include demographic information, which, as discussed below, leads us to exclude it from the estimation of the general AKM-models.

As in Brazil and Chile, we focus on a worker's main employer, defined as the one in which the worker earns the highest total earnings in a year. Moreover, monthly earnings are similarly deflated using the national Consumer Price Index from the National Institute of Statistics and Census of

Ecuador. Panel C in Table 1 provides summary statistics for Ecuador for our chosen sample as well as for the largest set of connected firms, showing the two samples are largely similar in terms of the number of firms and workers included. We next describe descriptive statistics on inequality trends in the region using the three data sources described above.

3 Descriptive Statistics

As discussed above, the reduction in income inequality across the region has been largely documented using household survey data [for a comprehensive summary of these trends, see Lustig et al., 2013]. In this section, we first evaluate whether these trends have also been observed in the formal sector. We then follow Bloom et al. [2015] and Barth et al. [2016] to decompose the variance of the log of real wages into variance within firm and variance between firms as follows:

$$Var(ln\ w_{ijt}) = Var(\overline{ln\ w_{jt}}) + \sum_{j=1}^{J} \frac{N_j}{N} Var(lnw_{ijt}|i \in j) \tag{1}$$

where $ln\ w_{ijt}$ represents log wages for worker i in firm j in year t. N is the total formal sector employment, N_j the employment at firm j, and J the total number of firms in the formal sector. Equation (1) allows us to quantify the extent to which inequality can be explained by inequality across firms, which in its extreme would imply that all workers within a firm earn the same wages and all differences are driven by firms, or, instead, by differences in wages within firms. We estimate equation (1) separately across the three countries in our sample.

Figure 1 presents trends in income inequality for Brazil. In particular, its Panel A shows the variance of log earnings in Brazil from 2004 through 2012 using RAIS data for formal sector earnings. This figure confirms the decline in inequality found in the existing literature [Alejo et al., 2014, Alvarez et al., 2018, Azevedo et al., 2013, Battistón et al., 2014, Ferreira et al., 2014, Komatsu and Menezes, 2015, Maurizio and Vázquez, 2016], as the the variance of log earnings in Brazil decreased by 11 log points between 2004 and 2012. Our results fit in with previous analysis by Alvarez et al. [2018], who restrict their attention to males aged 18-49, but who similarly find a decrease in the variance of log earnings of 10 log points over the same time period, and of Messina and Silva [2018] who focus on males aged 20-60. Following equation (1), we present the decomposition of the

variance of wages into the between and within firm components in Panel B of Figure 1. We first find that in 2004, the majority of the variance in log earnings could be explained by the between-firm component of earnings. Nonetheless, there was a significant decline in between-firm inequality from 2004 through 2012, declining by 9 log points over this time period, thus accounting for over 80 percent of the decline in the aggregate variance of log earnings from 2004 through 2012. On the other hand, within-firm inequality remained largely flat, having gone from 0.22 in 2004 to 0.21 in 2012. We also note the share of the within-firm variance of earnings is lower than previously found in developed countries [Lazear and Shaw, 2009]. Given the large reduction in inequality over this time period, we further examine its evolution across different percentiles of the income distribution in Panel C of Figure 1. We find a decline in the 50/10, 90/50 and 90/10 ratios, with the largest reduction appearing in the 90/10 ratio, which indicates a catch up of earnings from workers in the bottom decile of the distribution relative to the median real wage for formal sector workers.

Panel A in Figure 2 shows the variance of log earnings in Chile from 2008 through 2015 using data for formal sector earnings from the Unemployment Insurance database. Throughout this time period, the variance of the log of real wages has remained largely flat, going from 0.768 in 2008 to 0.771 in 2015. While papers using household survey data had shown a reduction in income inequality in the early 2000s [Alejo et al., 2014, Azevedo et al., 2013, Battistón et al., 2014, Contreras and Gallegos, 2011, Contreras and Ffrench-davis, 2012, Maurizio and Vázquez, 2016], the Gini coefficient flattened out as early as 2009, resembling our results. We note that our analysis only examines formal sector earnings, which may differ from other measures of labor income inequality, as these measures often include earnings from the informal sector.

In Panel B, we present the variance decomposition of Chile's within- and between-firm income inequality. As in Brazil, we find that the between-firm component of inequality is higher than the within-firm component, but here the difference is less pronounced. Furthermore, both measures have remained largely constant during our period of interest, as between-firm inequality has increased from 0.401 to 0.414 and within-firm inequality has fallen slightly, from 0.367 in 2008 to 0.357 in 2015. In Panel C, we examine the evolution in inequality across different log percentile ratios. We find an increase in the 90/10 ratio between 2008 and 2015, accompanied with smaller increases of the 50/10 and 90/50 earnings ratios.

Figure 3 presents our results for Ecuador. Panel A depicts the evolution in the variance of the

log of earnings from 2004 through 2012. As in Brazil, we find a significant decline in the variance of earnings in this time period, falling from 0.58 in 2004 to 0.37 in 2012. While the decline in inequality may seem large, our results fit in with previous analysis by Battistón et al. [2014], who found that Ecuador had the largest decrease in its Gini coefficient in the early 2000s, relative to its Latin American counterparts. In Panel B, we present the within- and between-firm decomposition, where we find that between-firm variance accounts for a majority of earnings inequality in 2004. Nonetheless, as in Brazil, inequality between firms fell by 17 log points between 2004 and 2012, which explains for almost 80 percent of the total reduction in inequality in this time period. In Panel C, we present various wage inequality ratios and find that Ecuador saw a generalized compression in formal sector earnings, given the significant reduction in the 90/10 and the 50/10 ratios.

4 Empirical Framework

Our previous findings suggest firms in Brazil, Chile and Ecuador are prominent factors shaping the dynamics of income inequality. To further explore this, we introduce an econometric model which allows us to control not only for unobserved worker characteristics but, more importantly, firm heterogeneity. More precisely, following the seminal work of Abowd et al. [1999b] for the French labor market, we specify a model for the log of real earnings which includes additive effects for workers and firms as follows:

$$lnw_{it} = \alpha_i + \psi_{J(i,t)} + X'_{it}\beta + \epsilon_{it}, \tag{2}$$

where X_{it} represents a vector of time varying controls, which includes year effects and workers' age. The term α_i is a "person effect" capturing the time-invariant, portable component of earnings ability which can include skills and other factors valued in the labor market. The term $\psi_{J(i,t)}$, associated to firm j represents "firm effects", or firm-specific relative pay premiums of employer j to all its employees at time t, which can represent rent-sharing, an efficiency wage premium, or strategic wage posting behavior. Finally, ϵ_{it} denotes an unobserved mean zero error capturing transitory shocks to human capital, person-specific job match effects, and other factors. The model assumes that the assignment of workers to firms obeys a strict exogeneity condition with respect

to ϵ_{it}, such that:

$$E[\epsilon_{it}|\alpha_i, \psi_{J(i,t)}, X_{it}] = 0$$

Moreover, and following Card et al. [2013], we further allow the person effects and firm effects to vary over time by dividing the sample into different overlapping intervals of five years and estimating the model using the data from each interval separately. For Brazil, we focus on the 2004-2008 and 2008-2012 periods and for Chile, we focus our attention on 2008-2012 and 2012-2015. Data limitations prevent us from implementing the model in Ecuador. However, the results from the other two countries might shed some light on Ecuador's income inequality.

Model (2) is estimated for each of the country-intervals by using an iterative algorithm described in Guimaraes and Portugal [2010], and implemented in Stata by Correia [2014]. Given that firm and person effects are only identified within a set of linked firms through worker mobility [see Abowd et al., 2002], we restrict our analysis to the largest connected set of firms in each interval. Following estimation of equation (2), we decompose the variance of log earnings in each period into the variance of the firm component, the worker component, time-varying observables, as well as the covariance between the firm-worker component, the worker and time-varying observables component, the firm and the observables component, and the variance of the residual as follows:

$$\begin{aligned} Var(lnw_{it}) &= Var(\alpha_i) + Var(\psi_{J(i,t)}) + Var(X_{it}) \\ &\quad +2\,Cov(\alpha_i, \psi_{J(i,t)}) + 2\,Cov(\alpha_i, X_{it}) + 2\,Cov(\psi_{J(i,t)}, X_{it}) + Var(\epsilon_{it}) \end{aligned}$$

This decomposition allows us to explore whether changes in inequality are driven by worker characteristics, firm characteristics, or an interaction of both [for further details see Card et al., 2013]. Furthermore, in order to confirm our descriptive analysis of the decomposition of inequality into within- and between-firm components, we apply the decomposition using equation (1) to each country in each sub-period.

4.1 Caveats

As discussed in Card et al. [2016], the person effects and the time varying controls X_{it} in equation (2) are not separately identified when X_{it} includes both year effects and a linear age term. We overcome this issue by restricting the age profile to be flat at the age of 40 years old by including the square and cube of $age - 40$, and year dummies in the cases of Brazil and Chile.[6]

In addition, while the two-way fixed effects model presented in equation (2) have been widely used in the inequality literature in recent years, the additive fixed effect structure has been previously criticized by Eeckhout and Kircher [2011]. As a result, in our empirical analysis, we check the validity of the exogenous mobility assumption of the additive fixed effects model following diagnostics presented by Card et al. [2013] and Card et al. [2016]. The first of these diagnostics divides firms according to their earnings premium quartile and explores whether the earnings gains for workers moving from low- to high-paying firms are symmetric to the losses of workers making the opposite movers, which provides suggestive evidence as to whether there exists exogenous mobility. In the second diagnostic, we plot the mean residuals from equation (2) by the estimated decile of the worker's fixed effect and the decile of the firm effect and examine whether these vary systematically across the 100 cells, which would imply a rejection of the additive structure of the fixed effects terms. We next present our results for Brazil and Chile and examine whether our estimates support the assumptions of the AKM model.

5 Main Results

The first two columns of Table 2 present the parameter estimates from the equation (2) in Brazil. We examine the standard deviations of the person effects, the firm effects and the time-varying covariates, and, as in the existing literature, we find that the standard deviations of the person effects are twice as large as those of the firm effects [Card et al., 2016]. Moreover, we find that the correlation between the firm and person effects is positive and large, which implies that there is positive assortative matching between high-skilled workers and high-paying firms, again confirming results previously found in the literature [Card et al., 2016, Alvarez et al., 2018].

[6]The same restriction is applied in Card et al. [2016] with Portuguese data following the idea that this is a good approximation to the shape of the age-earnings profile.

Table 3 presents the estimation results of the AKM model for Brazil for 2004-2008 and 2008-2012. Consistent with previous results from AKM models, we find that worker heterogeneity is the most important component for explaining the variance in earnings in each of the two sub-periods, accounting for 58 percent of the total variance of log earnings in 2004-2008, subsequently increasing to 60 percent in 2008-2012 (see Panel A). This relative increase is partly explained by the decline in the variance of log earnings from the first sub-period to the second. On the other hand, firm effects do not account for a major share of earnings inequality, as they only explain 17 percent of the variance of log earnings in 2004-2008, though the share falls to 14 percent in the 2008-2012 period. The covariance between worker and firm effects, which again indicates positive assortative matching between high-ability workers and high-paying firms, remains largely flat across time periods, accounting for about one-sixth of the total variance. We additionally note that the variance in time-varying observable characteristics is small across both time periods and so is the covariance between observable characteristics, and worker and firm effects.

The second decomposition (Panel B in Table 3) shows the contribution of between- and within-firm components to the variance of log earnings in Brazil from our AKM estimation. We confirm our descriptive analysis, as the between-firm component accounts for 60 percent of earnings inequality in 2004-2012. Moreover, we also find that the between-firm component explains 78.5 percent of the reduction in inequality from 2004-2008 to 2008-2012.

To explore whether the underlying assumption behind the additive fixed effects model holds in Brazil, we examine the earnings of workers who switch firms, from two years prior through two years following the switch, separately for each sub-period. We present the results in panels C and D of Figure 4. As noted above, we classify switchers by the firm effect quartile of their pre- and post-transition employers. The results show that the gains of workers who switch up the premium-ladder contrast the losses of those moving down the ladder, a result which is consistent with the AKM specification of additive worker and firm fixed effects. Panels A and B present the average estimated residual by decile of worker and firm effects for each period. The residuals across most combinations are close to zero, though as in Card et al. [2016] and Alvarez et al. [2018], there is some evidence that the worker and firm fixed effects may not be additive for the bottom decile of the worker's estimated effects and both at highest and lowest paying firms. Nonetheless, as the residuals remain small in magnitude, and given the results from the first diagnostic, the additive

fixed effect specification still holds in Brazil.

For Chile, the last two columns of Table 2 present the estimates from equation (2) for 2008-2012 and 2012-2015, respectively. We find that the magnitude of the standard deviation of the person effects are similar to those found in Brazil, but the estimated standard deviation of the firm effects are larger than in Brazil. As a result, the person effects are just 1.5 times larger than the firm effects. In terms of the relationship between the firm and person effects, we find a positive and large correlation, which, as in Brazil, confirms positive assortative matching between high-skilled workers and high-paying firms. Table 4 presents the estimation results of the AKM model for Chile for 2008-2012 and 2012-2015, including the two decompositions described above (Panels A and B, respectively). Again, as for Brazil, we find that worker heterogeneity is the single largest determinant of income inequality in Chile, accounting for 45 percent of the total variance of log earnings across both sub-periods of interest. We find that firm heterogeneity accounts for a 22 percent of the variance of earnings, a larger share than in Brazil, and this result holds across 2008-2012 and 2012-2015. Moreover, the covariance between worker and firm effects is also positive and large, but it accounts for just 17 percent of the variance of log earnings across both sub-periods, similar to Brazil. We also find that the variance in time-varying observables is small and the same holds true for the covariance between observables and worker and firm effects, respectively. Lastly, our decomposition of between- and within-firm inequality confirms our descriptive statistics, with between-firm inequality accounting for a majority of the variance in log earnings across both sub-periods in Chile.

The exogenous mobility assumption diagnostic in Chile are presented in Figure 5. Panels C and D show the change in the earnings of workers who switch firms up to two years before the switch and two years following the switch for each sub-period in Chile. As in Brazil, the fact that the gains for workers moving up the ladder are similar to those of workers switching to lower-paying firms confirms the additive worker- and fixed-effect AKM specification. Panels A and B present the average estimated residual by decile of worker and firm effects for each period. The residuals across most combinations are close to zero, though as in Brazil, and in Card et al. [2016] and Alvarez et al. [2018], there is some evidence that the fixed effects may not be additive for the bottom decile of the worker's estimated effects and both at highest and lowest paying firms. While the magnitudes of these residuals are larger than those found in Brazil, the combination of the two diagnostics

suggest that the additive fixed effect specification is valid in the Chilean context.

6 Sectoral Analysis

While most Latin American countries have historically pursued active policies to promote industrialization, the region has remained heavily dependent on exports of primary goods as a major driver of economic growth. As a result, an extensive literature has argued that the rapid increase in global commodity prices partly explained the region's sustained economic success in the first decade of the 2000s [Yu, 2011, Lustig et al., 2013]. For instance, per capita GDP in Brazil grew at an annual rate of 3.4 percent between 2002 and 2006 and 4.5 percent over the 2006-2010 period, accompanied by a 138 percent increase in export prices between 2002 and 2008 [Benguria et al., 2017]. Similarly, Chile's economic growth during the early 2000s was largely driven by the four-fold increase in copper prices between 2003 and 2011, as copper accounts for 60 percent of Chile's total goods exports [Pellandra, 2015].

At the same time, China's continued economic expansion during the early 2000s directly affected Latin American countries, in part through China's accession to the World Trade Organization in 2001, which gave China access to most-favored nation status among the 157 WTO members [see Pierce and Schott, 2016, for an analysis of the implications of China's accession to the WTO on the US economy]. As a result, while in 2000, China accounted for 3.4 percent of world imports and 4 percent of total exports, by 2012, these values had increased to 9.8 percent and 11.4 percent, respectively. While China's entry into the world economy has resulted in an increase in manufacturing imports for developed countries, in Latin America, trade with China has taken the shape of commodities-for-manufactures relationship, where Latin American countries export primary goods to China and import manufactured products. Costa et al. [2016] have examined the impact of this trade relationship on Brazil and found that local labor markets affected by manufacturing competition from China experienced slower growth in wages between 2000 and 2010, whereas regions which were faced increased Chinese demand for primary goods experienced faster wage increases. For Chile, Pellandra [2015] documents that the increase in commodity prices, largely driven by increased demand from China, resulted in an increase in unskilled workers' wages and a re-allocation in employment towards the copper sector. Nonetheless, the existing literature has not yet explored

how the concurrent commodity-boom and China shock affected inequality in these two countries. We thus take advantage of our administrative data sources and examine the evolution of inequality in within two directly exposed industries in Chile and Brazil, manufacturing and commodities.

In our empirical analysis, we re-estimate the AKM model specified in equation (2) separately for each sector across each of the two sub-periods defined above. We present our results for Brazil in Table 5, where we first find that baseline inequality in the manufacturing sector is larger than in the commodities sector, along with a slight increase in the log variance of wages in the commodities sector from 2004-2008 to 2008-2012 and a large decrease in inequality in the manufacturing sector across these two sub-periods. The increase in inequality in the commodities sector is fully driven by an increase in between-firm inequality. The fall in inequality in the manufacturing sector is also explained by significant fall in between-firm inequality, as this component explains over 92 percent of the decrease in the log variance of earnings in manufacturing in Brazil. Our results fit in with previous findings by Alvarez et al. [2018], who document a significant decrease in the variance of log earnings in the manufacturing sector from 2000 through 2012.

We present our results for Chile in Table 6, where we find similar results as in Brazil. Despite the different time period, there is an increase in the log variance of earnings in the commodities sector from 2008-2012 to 2012-2015, which is fully driven a significant increase in between firm inequality. On the other hand, we find a slight decrease in inequality in the manufacturing sector across these two sub-periods, with no significant changes in between- and within-firm components. Since the sectoral analysis across the manufacturing and commodities sectors indicate that inequality changes were largely driven by changes between firms, we note that a potential channel through which external shocks affect inequality is through firm entry and exit. For instance, Benguria et al. [2017] find that an increase in the commodity price index has a sizable positive effect on the probability that a firm becomes active. As a result, it possible that both the China shock and the commodities boom result in a widening dispersion of firm quality in the commodities sector, as both high- and low-quality firms may have been able to take advantage of external tailwinds. Meanwhile, on the manufacturing side, which was negatively affected by these shocks, between-firm inequality may have fallen as low-quality firms exited. While further work is needed to understand the role of these proposed mechanisms, our results shed light on the potential effects that these two major shocks may have had on inequality at the industry level in Latin America. Nonetheless, our sectoral

analysis brings to light the importance of considering how external shocks may affect aggregate as well as sector-specific inequality. In particular, understanding how these shocks affect inequality through changing assortative matching and by affecting firms' entry and exit decisions may help policymakers better understand how to design strategies aimed at confronting these shocks.

7 Conclusion

Latin America has historically had one of the highest levels of income inequality in the world. Nonetheless, the sustained economic boom experienced in the region during the early 2000s was accompanied by a substantial reduction in inequality. As discussed above, most of the research on inequality in Latin America has been carried out with household survey data, which is subject to significant measurement error. We therefore contribute to the inequality literature by assessing whether the reported trends hold true in administrative data in three countries in the region, Brazil, Chile and Ecuador, making our paper the first to compare these trends across more than two countries using administrative data. Our descriptive analysis confirms inequality decreases in Ecuador and Brazil, but we find that inequality largely stayed flat in Chile's formal sector. More importantly, we document that income inequality in the formal sector in Latin America is largely a between-firm phenomenon, though the recent decrease in Brazil and Ecuador was mostly explained by a decrease in between-firm inequality. We expand upon our descriptive analysis by estimating an econometric model which accounts for workers' mobility across firms. As this model requires matched employee-employer data, we implement it in two countries in our sample, Brazil and Chile. We find that the worker heterogeneity component is the largest single determinant of the log variance of earnings in both countries, but that firm effects and the covariance of worker and firm effects are significant contributors to income inequality. Given the importance of assortative matching between workers and firms to aggregate wage inequality in the region, we note that policies aimed at improving workers' skills and education should be complemented with actions aimed at enhancing workers' capacities to find employment at higher-paying firms. That combination may be better suited for reducing wage inequality in Latin America.

Finally, we go beyond our aggregate analysis and focus on two important economic sectors in the region, manufacturing and commodities, both of which were directly affected by the large

commodity-boom and the China shock. As we find an increase in inequality within the commodities sector along with a decrease in the manufacturing sector, a result which is largely driven by between-firm components, we posit that firm entry and exit decisions may be behind the observe patterns. While further work is needed to identify the causal mechanisms of these two shocks, we have provided baseline evidence on the effects of these two large shocks on inequality in two important sectors in Latin America.

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Tables and Figures

Table 1: Summary Statistics

Panel A. Brazil

	Worker-year	Workers	Mean	SD
2004-2008 (all observations)	208,814,855	61,316,341	2.241	0.752
2004-2008 (largest connected set)	204,966,333	59,964,631	2.250	0.754
2008-2012 (all observations)	262,059,313	75,341,143	2.379	0.720
2008-2012 (largest connected set)	258,261,115	74,012,779	2.385	0.722

Panel B. Chile

	Worker-year	Workers	Mean	SD
2008-2012 (all observations)	23,513,373	6,677,932	8.156	0.888
2008-2012 (largest connected set)	23,125,911	6,538,116	8.167	0.887
2012-2015 (all observations)	22,276,814	7,183,734	8.354	0.886
2012-2015 (largest connected set)	21,772,546	6,993,861	8.369	0.884

Panel C. Ecuador

	Worker-year	Workers	Mean	SD
2004-2008 (all observations)	5,450,284	1,925,044	1.523	0.707
2004-2008 (largest connected set)	5,342,213	1,875,096	1.534	0.706
2008-2012 (all observations)	8,661,694	2,938,152	1.639	0.656
2008-2012 (largest connected set)	8,529,971	2,870,974	1.646	0.657

Note: Statistics computed for workers of age 18-65. Source: RAIS, Chilean Unemployment Insurance Database, and Ecuadorian Social Security Institute (IESS)

Table 2: Estimation Results Across Countries

	Brazil		Chile	
	2004-2008	2008-2012	2008-2012	2012-2015
Person and firm parameters				
Number of worker effects	58,152,543	71,908,673	6,677,931	7,183,734
Number firm effects	1,702,937	2,097,216	515,396	531,006
Summary of parameter estimates				
SD of α_i	0.582	0.567	0.597	0.618
SD of ψ_j	0.296	0.264	0.416	0.409
SD of $T_t\beta$	0.090	0.093	0.097	0.056
Corr(α_i, ψ_j)	0.323	0.345	0.274	0.268
Corr$(\alpha_i, T_t\beta)$	-0.072	-0.073	-0.042	-0.016
Corr$(\psi_j, T_t\beta)$	-0.012	-0.013	0.035	-0.002
RMSE of AKM residual	0.247	0.232	0.402	0.376
Adjusted R^2	0.895	0.899	0.795	0.820
Sample size	192,710,218	243,300,786	23,513,373	22,276,814

Source: RAIS, and Chilean Unemployment Insurance Database

Table 3: Variance Decomposition for Brazil

	2004-2008	Share	2008-2012	Share	Change	Share
Panel A. AKM Decomposition						
Variance of log earnings	0.569	1.000	0.521	1.000	-0.048	1.000
Variance of worker effects	0.328	0.576	0.311	0.597	-0.017	0.354
Variance of firm effects	0.094	0.165	0.074	0.142	-0.020	0.417
Variance of year effects	0.008	0.014	0.008	0.015	0.000	0.000
2×Cov. worker and firm effects	0.105	0.185	0.099	0.190	-0.006	0.125
2×Cov. worker and year effects	-0.007	-0.012	-0.007	-0.013	0.000	0.000
2×Cov. firm and year effects	-0.001	-0.002	-0.001	-0.002	0.000	0.000
Variance of residual	0.042	0.074	0.037	0.071	-0.005	0.104
Panel B. Firm components						
Between Firms	0.339	0.596	0.302	0.580	-0.037	0.771
Within Firms	0.230	0.404	0.220	0.422	-0.010	0.208

Note: Variance decomposition consists of
$Var(lnw_{it}) = Var(\alpha_i) + Var(\psi_{J(i,t)}) + Var(X_{it}) + 2\,Cov(\alpha_i, \psi_{J(i,t)}) + 2\,Cov(\alpha_i, X_{it}) + 2\,Cov(\psi_{J(i,t)}, X_{it}) + Var(\epsilon_{it})$
Source: RAIS

Table 4: Variance Decomposition for Chile

	2008-2012	Share	2012-2015	Share	Change	Share
Panel A. AKM Decomposition						
Variance of log earnings	0.787	1.000	0.781	1.000	-0.006	1.000
Variance of worker effects	0.357	0.453	0.381	0.488	0.024	-3.845
Variance of firm effects	0.173	0.219	0.167	0.214	-0.006	0.905
Variance of year effects	0.009	0.012	0.003	0.004	-0.006	1.014
2×Cov. worker and firm effects	0.136	0.173	0.136	0.174	0.000	-0.016
2×Cov. worker and year effects	-0.005	-0.006	-0.001	-0.001	0.004	-0.616
2×Cov. firm and year effects	0.003	0.004	0.000	0.000	-0.003	0.445
Variance of residual	0.115	0.145	0.095	0.122	-0.020	3.094
Panel B. Firm components						
Between Firms	0.415	0.527	0.419	0.536	0.004	-0.634
Within Firms	0.372	0.473	0.362	0.464	-0.010	1.615

Note: Variance decomposition consists of
$Var(lnw_{it}) = Var(\alpha_i) + Var(\psi_{J(i,t)}) + Var(X_{it}) + 2\,Cov(\alpha_i, \psi_{J(i,t)}) + 2\,Cov(\alpha_i, X_{it}) + 2\,Cov(\psi_{J(i,t)}, X_{it}) + Var(\epsilon_{it})$
Source: Chilean Unemployment Insurance Database

Table 5: Variance Decomposition by Sector in Brazil

	Commodities						Manufacturing					
	2004-2008	Share	2008-2012	Share	Change	Share	2004-2008	Share	2008-2012	Share	Change	Share
Panel A. AKM Decomposition												
Variance of log earnings	0.429	1.000	0.444	1.000	0.015	1.000	0.540	1.000	0.488	1.000	-0.052	1.000
Variance of worker effects	0.247	0.576	0.258	0.581	0.011	0.733	0.319	0.591	0.304	0.623	-0.015	0.288
Variance of firm effects	0.093	0.217	0.086	0.194	-0.007	-0.467	0.092	0.170	0.068	0.139	-0.024	0.462
Variance of year effects	0.010	0.023	0.008	0.018	-0.002	-0.133	0.008	0.015	0.007	0.014	-0.001	0.019
2×Cov. worker and firm effects	0.046	0.107	0.068	0.153	0.022	1.467	0.102	0.189	0.091	0.186	-0.011	0.212
2×Cov. worker and year effects	-0.001	-0.002	-0.002	-0.005	-0.001	-0.067	-0.007	-0.013	-0.007	-0.014	0.000	0.000
2×Cov. firm and year effects	-0.001	-0.002	-0.001	-0.002	0.000	0.000	-0.001	-0.002	-0.001	-0.002	0.000	0.000
Variance of residual	0.033	0.077	0.026	0.059	-0.007	-0.467	0.028	0.052	0.024	0.049	-0.004	0.077
Panel B. Firm components												
Between Firms	0.257	0.599	0.280	0.631	0.023	1.533	0.318	0.589	0.269	0.551	-0.049	0.942
Within Firms	0.172	0.401	0.164	0.369	-0.008	-0.533	0.222	0.411	0.219	0.449	-0.003	0.058

Note: Variance decomposition consists of $Var(lnw_{it}) = Var(\alpha_i) + Var(\psi_{J(i,t)}) + Var(X_{it}) + 2\,Cov(\alpha_i, \psi_{J(i,t)}) + 2\,Cov(\alpha_i, X_{it}) + 2\,Cov(\psi_{J(i,t)}, X_{it}) + Var(\epsilon_{it})$

Source: RAIS

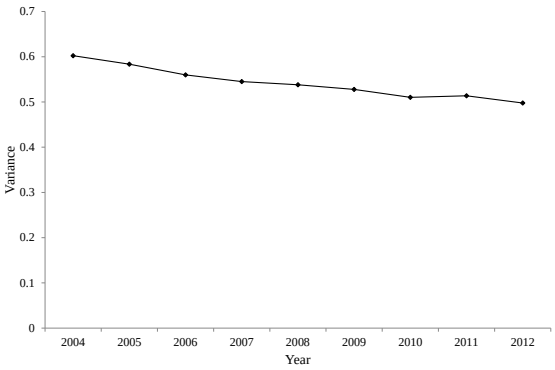
Table 6: Variance Decomposition by Sector in Chile

	Commodities						Manufacturing					
	2008-2012	Share	2012-2015	Share	Change	Share	2008-2012	Share	2012-2015	Share	Change	Share
Panel A. AKM Decomposition												
Variance of log earnings	1.083	1.000	1.218	1.000	0.135	1.000	0.784	1.000	0.787	1.000	0.003	1.000
Variance of worker effects	0.424	0.392	0.454	0.373	0.030	0.222	0.460	0.587	0.493	0.626	0.033	11.000
Variance of firm effects	0.362	0.334	0.456	0.374	0.094	0.696	0.152	0.194	0.148	0.188	-0.004	-1.333
Variance of year effects	0.005	0.005	0.003	0.002	-0.002	-0.015	0.006	0.008	0.002	0.003	-0.004	-1.333
2×Cov. worker and firm effects	0.164	0.151	0.204	0.167	0.040	0.296	0.075	0.096	0.063	0.080	-0.012	-4.000
2×Cov. worker and year effects	0.000	0.000	-0.001	-0.001	-0.001	-0.007	-0.002	-0.003	0.001	0.001	0.003	1.000
2×Cov. firm and year effects	-0.001	-0.001	-0.001	-0.001	0.000	0.000	-0.001	-0.001	-0.001	-0.001	0.000	0.000
Variance of residual	0.125	0.115	0.103	0.085	-0.022	-0.163	0.092	0.117	0.078	0.099	-0.014	-4.667
Panel B. Firm components												
Between Firms	0.602	0.556	0.747	0.613	0.145	1.074	0.315	0.402	0.319	0.405	0.004	1.333
Within Firms	0.480	0.443	0.470	0.386	-0.010	-0.074	0.469	0.598	0.467	0.593	-0.002	-0.667

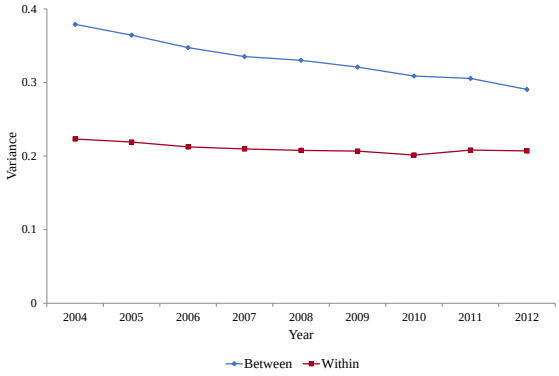
Note: Variance decomposition consists of $Var(lnw_{it}) = Var(\alpha_i) + Var(\psi_{J(i,t)}) + Var(X_{it}) + 2\,Cov(\alpha_i, \psi_{J(i,t)}) + 2\,Cov(\alpha_i, X_{it}) + 2\,Cov(\psi_{J(i,t)}, X_{it}) + Var(\epsilon_{it})$

Source: Chilean Unemployment Insurance Database

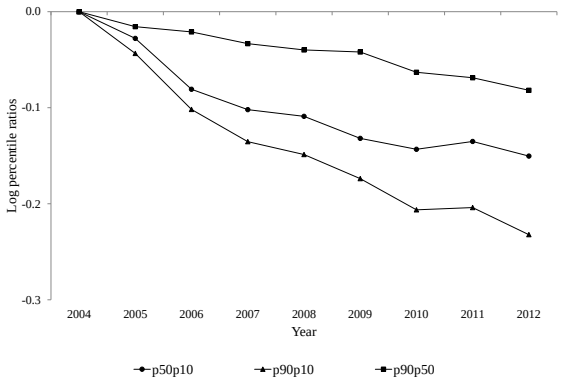
Figure 1: Descriptive Statistics for Brazil



(a) Variance of Log of Real Wages



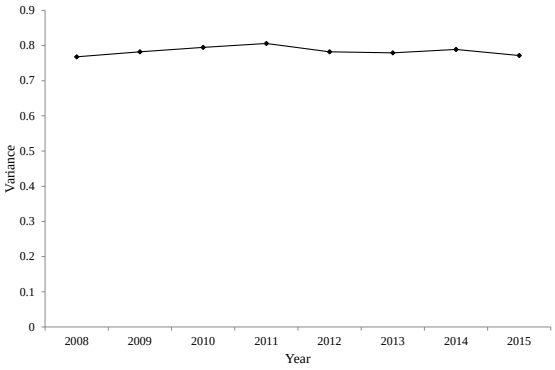
(b) Variance Decomposition of Log of Real Wages



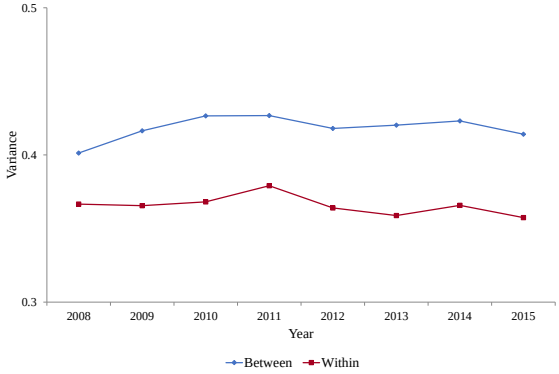
(c) Changes in Log Percentile Ratios

Note: Statistics computed for workers of age 18-65.
Source: RAIS

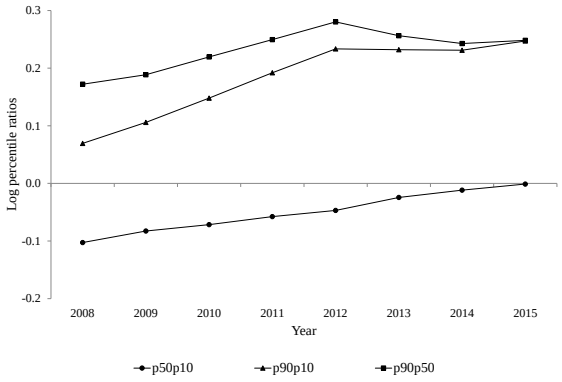
Figure 2: Descriptive Statistics for Chile



(a) Variance of Log of Real Wages



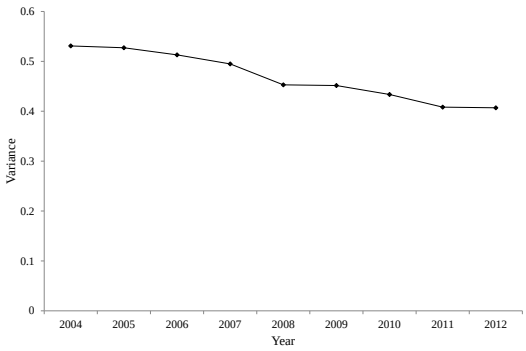
(b) Variance Decomposition of Log of Real Wages



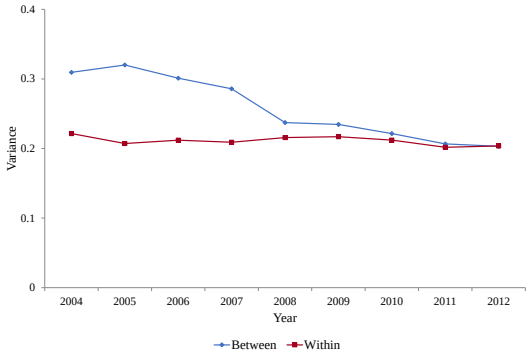
(c) Changes in Log Percentile Ratios

Note: Statistics computed for workers of age 18-65.
Source: Chilean Unemployment Insurance Database

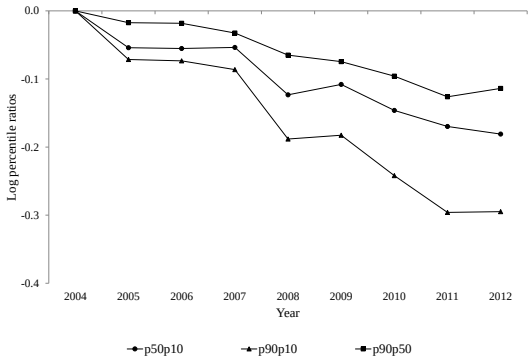
Figure 3: Descriptive Statistics for Ecuador



(a) Variance of Log of Real Wages



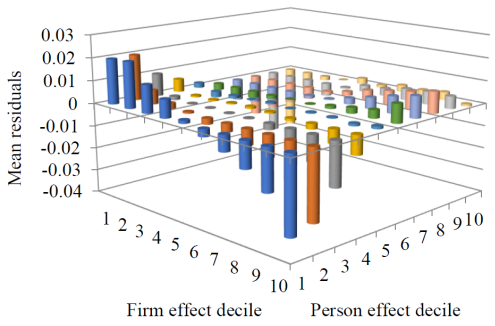
(b) Variance Decomposition of Log of Real Wages



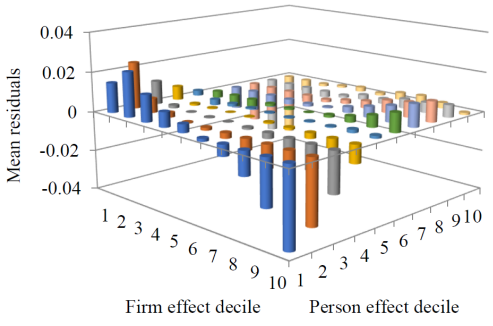
(c) Changes in Log Percentile Ratios

Note: Statistics computed for workers of age 18-65.
Source: Ecuadorian Social Security Institute (IESS)

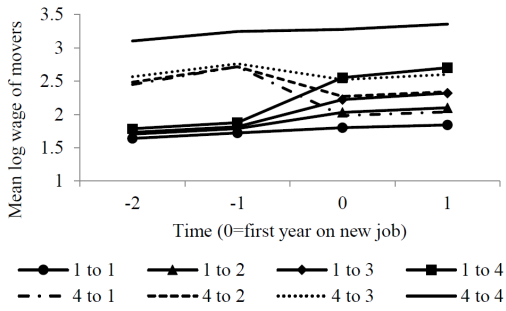
Figure 4: Exogenous Mobility Tests for Brazil



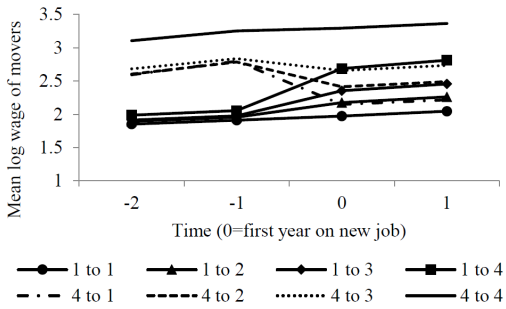
(a) AKM Residuals (2004-2008)



(b) AKM Residuals (2008-2012



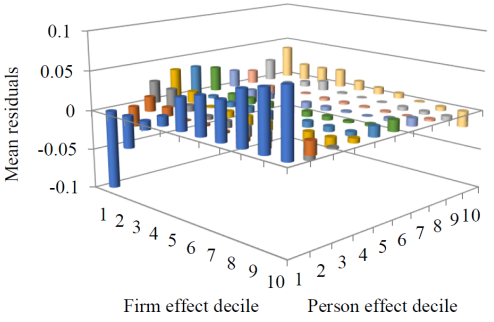
(c) Gains and Loses from Job Mobility (2004-2008)



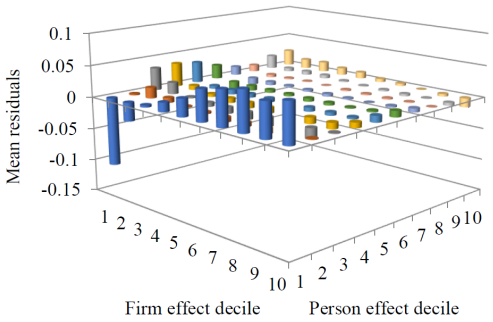
(d) Gains and Loses from Job Mobility (2008-2012)

Note: Statistics computed for workers of age 18-65.
Source: RAIS

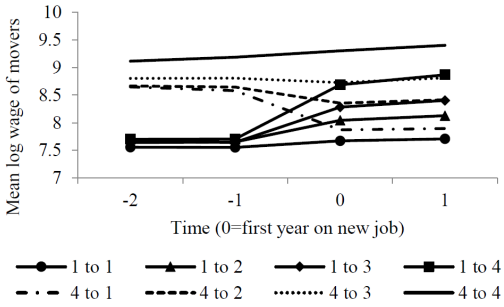
Figure 5: Exogenous Mobility Tests for Chile



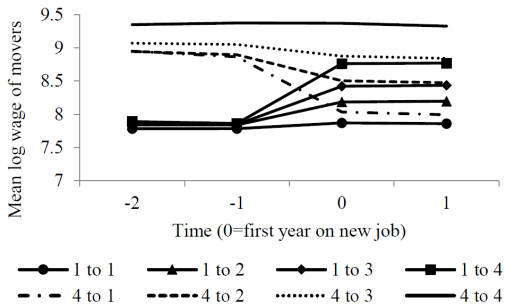
(a) AKM Residuals (2008-2012)



(b) AKM Residuals (2012-2015)



(c) Gains and Loses from Job Mobility (2008-2012)



(d) Gains and Loses from Job Mobility (2012-2015)

Note: Statistics computed for workers of age 18-65.
Source: Chilean Unemployment Insurance Database