The Dynamics of Labour Market Polarization in Chile: An Analysis of the Link Between Technical Change and Informality*

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Abstract

In spite of the growing literature on polarization, relatively little is known about the individual-level patterns underlying the decline of routine occupations and its links with informal employment. To shed light on this, we examine the flows of formal and informal workers into and out of routine and non-routine occupations over the period 1980-2015 in Chile. Using rich longitudinal data from the Social Protection Survey of Chile, we first reconstruct individuals' occupational trajectories by classifying individuals into different states at a monthly frequency. We then use a series of multilevel competing risk event history models and a decomposition flow approach to study the flows underlying the decline of routine occupations. Our results suggest a process of displacement and occupational downgrading for routine manual workers: workers in routine manual formal employment become increasingly unemployed or use informality as a buffer against job loss, and workers in routine manual informal employment become unemployed or transit to non-routine manual informal occupations. By contrast, the cognitive component of tasks performed by routine cognitive workers seems to offer relatively more protection against job displacement and occupational downgrading. Lastly, we find that the decrease in the share of routine occupations in Chile is mostly due to an increase in the outflows transition rates to unemployment and informality and a decrease in the inflow transition rate from unemployment.

Keywords: occupations, tasks, routinization, labour market displacement, unemployment, informality.
JEL classification: E24, E26, J21, J23, J24, O30.

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1 Introduction

Over recent decades, labour markets have become increasingly polarized: in many countries, the employment and income shares of routine occupations have declined, while the shares in abstract and manual occupations have increased (Autor, Levy and Murnane 2003; Autor, Katz and Kearney 2006; Autor and Dorn 2009; Acemoglu and Autor 2011; Goos and Manning 2007; Spitz-Oener 2006; Dustmann, Ludsteck and Schonberg 2009; Goos, Manning and Salomons 2009; Goose, Manning and Salomons 2014; Ariza and Raymond Bara 2020; Lewandowski, Park and Schotte 2020; Peña and Siegel 2021). The literature has been attributing this phenomenon to the introduction of new technologies able to perform structured and repetitive tasks (Autor, Levy and Murnane 2003; Acemoglu and Autor 2011). Indeed, routine tasks follow well-defined rules and therefore can become codifiable and performed by a computer or robot. By contrast, manual tasks require basic skills and adaptability to different environments and situations, while abstract tasks entail complex decision-making process, intuition, creativity, and communication ability and can only be performed by workers with high analytical capacity and adaptability.

While this process of technical change and occupational substitution has been well documented in the literature, still little is known about the individual-level patterns underlying the decline of routine employment. Furthermore, this process is likely to disrupt individuals' professional careers, as it pushes some workers to adapt by moving to other types of jobs (Autor 2019). However, a relatively low number of studies have examined the occupational mobility patterns of workers switching out of routine jobs (Cortes 2016; Cortes et al. 2017, 2020; Smith 2013; Foote and Ryan 2014). Among these studies, Smith (2013) finds that the decline in the share of workers in middle-skill jobs in the US is due both to a decline in inflows (from non-employment and for younger workers) and to a rise in outflows (to non-employment and to other jobs). Similarly, Cortes et al. (2020) find that the decline in employment in middle-wage routine occupations in the US can be primarily accounted for by changes in transitions rates from non-participation and unemployment to routine employment. Yet, due to data limitations, a limited number of states were considered, and job-to-job transitions were not investigated.

Furthermore, these studies have focused on high-income countries; thus, less is known about the labour market changes associated with the decline of routine jobs in low- and middle-income countries. Yet, we expect to find additional insights for a number of reasons. First, these countries differ in task endowments (De la Rica et al. 2020; Marcolin et al. 2018; Lewandowski et al. 2019). Jobs in low- and middle-income countries are more routine intensive than in high-income countries (Lo Bello, Sanchez Puerta and Winkler 2019; Peña and Siegel 2021). Besides, there are key differences in terms of whether and how polarization is taking place (Das and Hilgenstock 2018; Maloney and Molina 2016; Messina, Pica and Oviedo 2016; Gasparini et al. 2021). In the last two decades, the shift away from routine work and towards non-routine work in low- and middle-income countries was much slower than in high-income countries (Lewandowski, Park and Schotte 2020; Peña and

Siegel 2021). Last, labour markets in low- and middle-income countries are characterised by a substantial share of the population working in informal employment. Yet, to the best of our knowledge, no studies have examined empirically the link between routine biased technical change and informality.[1] Previous studies have analysed the worker flows between formal employment, informal employment, unemployment, and non-participation (Bosch and Maloney 2008; Albertini et al. 2020). For instance, Bosch and Maloney (2008) show that job separations of informal employment is the most important driver for the unemployment rate dynamic in Brazil and Mexico, while movements in formal employment are largely accounted for by changes in the formal job finding probabilities from all other states. Similarly, Albertini et al. (2020) document that the ins and outs of informal employment are key drivers of labour market fluctuations in Argentina. However, despite documenting important stylized facts on worker flows in Latin America, these studies do not examine the links with technical change.

In this paper, we examine the labour market changes in the flows of formal and informal workers into and out of routine and non-routine occupations. Our aim is to answer two questions: i) what are the main labour market changes that underlie the disappearance in middle-wage routine jobs? and ii) what are the links between routine biased technical change and informality? We focus on the case of Chile which has been experiencing a decline in routine employment over the last decades (Falcone et al. 2022). We use rich longitudinal data from the Social Protection Survey of Chile which contains retrospective biographical information on individuals' employment history going back to January 1980 until July 2016. This allows us to observe individual-level transitions across labour market states at a monthly frequency. We classify individuals in each month according to their labour market status (employed, unemployed, or not in the labour force), their current occupational group (employed in non-routine cognitive (NRC) occupations, in routine cognitive (RC) occupations, in routine manual (RM) occupations or in non-routine manual (NRM) occupations), and their informality status (formal or informal worker).

We begin by analysing individuals' transitions in and out of different occupations over time using a series of multistate competing risks event history models. We compare the relative risks for individuals to move to different states. In this respect, we are especially interested in investigating where do routine formal and informal workers move to when they are being substituted for. Nonetheless, we also explore transitions from other occupations, from unemployment as well as from non-participation. Second, we examine how these relative risks of transiting to different states have changed over time since the 1980s. This allows us to provide a better understanding of the labour market displacement effects of the process of technical change and its links with informal employment. We then investigate to which extent the type of transitions that individuals do vary by gender and age group. This allows us to identify which demographic groups are the most affected by the process of technical change. Lastly, we use a modified version of the flows approach adopted

[1] From a theoretical perspective, Gomez (2021) shows that job polarization, driven by routine-biased technological change, increases the size of the informal sector.

in Cortes et al. (2020) to study the flows underlying the decline of formal and informal routine occupations. This allows us to identify the key changes in transition rates that can account for the decline in routine employment.

Our results suggest that the decline in the share of routine occupations is mostly driven by a decrease in the share of routine manual occupations which is observed both in the formal and informal labour markets. This implies that the process of technical change not only affects formal workers, but it also has displacement effects among informal workers. Furthermore, our results suggest a process of occupational downgrading for routine manual workers: formal workers employed in routine manual occupations are increasingly more likely to go out of the labour market or to start to work in the informal sector. This is suggesting that informality is used as a buffer against job loss for individuals working in routine occupations. Workers in routine manual informal employment are more likely to become unemployed or to transit to non-routine manual informal occupations.

By contrast, the cognitive component of tasks performed by routine cognitive workers seems to offer relatively more protection against job displacement and occupational downgrading. Furthermore, we find clear differences by gender and age group. For instance, regarding workers in RM formal occupations, men are more likely to transit to RM informal occupations whereas women are more likely to become unemployed or inactive. Similarly, among individuals who work in RM informal occupations, women are more likely to become inactive compared to men. We also find that the decrease in the share of routine occupations in Chile is mostly due to an increase in the outflows transition rates of routine manual workers to unemployment and informality as well as a decrease in the inflow transition rate from unemployment.

Our paper contributes to the literature in the following ways. First, a relatively low number of studies have examined the occupational mobility patterns of workers switching out of routine jobs (Cortes 2016; Cortes et al. 2017, 2020; Smith 2013; Foote and Ryan 2014) and all have focused on developped economies. To the best of our knowledge, this is the first study that examines the labour market changes in the flows of workers into and out of routine and non-routine occupations in a middle-income country context. Our rich longitudinal data from Chile enables us to consider many labour market states and to investigate job-to-job transitions. Besides, this is the first study to empirically investigate the link between the process of technical change and informality. Our findings provide new insights into the micro-level mechanisms and worker-level adjustments underlying the process of technical change. Furthermore, we document different job reallocation across genders. These findings highlight the potential effect of the process of technical change in creating or exacerbating inequalities between different demographic groups.

Our paper proceeds as follows. In Section 2, we present our data. Section 3 presents a descriptive analysis of the transitions into and out of different occupations in the formal and informal labour markets. In Section 4, we conduct counterfactual exercises to identify the key changes in the transition rates that can account for the decline in routine employment. Lastly, Section 5 concludes.

2 Data

We use rich longitudinal data from the Social Protection Survey of Chile. Since 2002, the survey has followed a large sample of individuals to have a representative sample of the Chilean population. This survey includes demographic and socioeconomic information at the individual and household levels. More importantly for our purpose, it contains information on individuals' employment histories spanning January 1980 to July 2016. This allows us to observe individual-level transitions across labour market states at a monthly frequency. Furthermore, it allows us to observe changes over a relatively long period (1980-2016) where the process of technical change has been taking place.[2]

Following the recent literature, we consider four broad occupational groups based on the tasks performed on the job: i) non-routine cognitive (NRC) occupations, ii) routine cognitive (RC) occupations, iii) routine manual (RM) occupations, and iv) non-routine manual (NRM) occupations. The distinction between routine and non-routine occupations is based on the definition provided by previous studies (Autor and Dorn 2013; Autor, Levy and Murnane 2003; Cortes et al. 2020). More specifically, routine occupations are occupations whose tasks involved are a set of specific activities accomplished by following well-defined instructions and procedures. Conversely, an occupation is considered non-routine if the job involves a variety of tasks requiring flexibility, problem-solving, or human interaction skills.

We aggregate detailed occupational codes based on the ISCO-1 digit classification into these four occupational groups. Specifically, NRC occupations are Professional, Managerial and Technical Occupations; RC occupations are Sales and Clerical Occupations; RM occupations are Production, Craft and Repair Occupations, Operators, and Transportation and Material Moving Occupations; and NRM occupations are service occupations. Regarding informality, our measure comprises unregistered workers without access to social security benefits, workers with no explicit written contracts of employment, workers in temporary jobs, and low-skilled self-employment, in line with the International Labour Organization's guidelines on measuring informality (ILO 2013) and following previous studies (Berniell et al. 2021).

Given our occupational categories and also by taking into account the informality status of individuals, we can classify individuals into one of the ten following categories: i) employed formally in NRC occupations, ii) employed formally in RC occupations, iii) employed formally in RM occupations, iv) employed formally in NRM occupations, v) employed informally in NRC occupations, vi) employed informally in RC occupations, vii) employed informally in RM occupations, viii) employed informally in NRM occupations, ix) unemployed, or x) inactive.[3] By proceeding this way, we obtain individual-level transitions across labour market states at a monthly frequency. We restrict our sample to individuals aged 15 to 65 observed between January 1980 and December 2015.

[2] See Appendix A for a description of the database.

[3] For individuals who have gaps in their employment history, we impute the last available month's status.

Table 1 presents descriptive statistics for the full sample. There is clear heterogeneity across occupations in terms of gender composition: workers in RC occupations are predominantly women (59% of women compared to 41% of men) whereas RM occupations are predominantly composed of men (88% of men compared to only 12% of women). There is also a larger proportion of formal workers in RC and NRC occupations compared to in RM and NRM occupations.

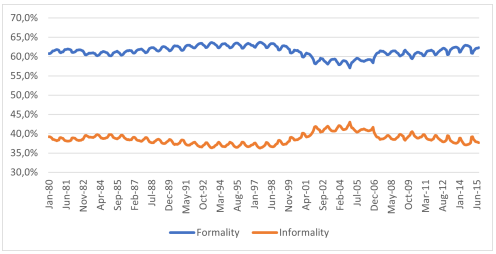
Table 1. Descriptive statistics (%)

	All	NRC	RC	RM	NRM	Unemp.	Inactive
Male	50	65	41	88	54	42	27
Female	50	46	59	12	46	58	73
Average age	36	38	35	38	38	35	34
Formal	61	75	72	55	48		
Permanent job	82	92	90	77	72		
Contract signed	84	91	86	85	73		
Contributing to social security	73	81	79	69	68		
Self-employee	23	26	15	31	15		
Employee	77	74	85	69	85		
N	27,109	6,808	11,709	10,773	9,960	11,410	20,991

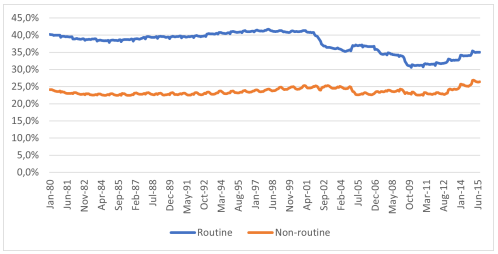
Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The sample is restricted to individuals aged 15 to 65.

In addition, Figure 1 displays the monthly time series of employment in formality/informality, in routine and non-routine occupations as well as in each occupational group as a share of the total working-age population. Figure 1a shows that informal employment represents around 40% of the total working-age population in Chile. Figure 1b illustrates the decline in routine employment. This decrease starts to take place around the beginning of the 2000s. This is in line with what has been found in previous studies for Chile (Falcone et al. 2022). Lastly, Figure 1c shows that the decline in routine occupations is mostly driven by a decrease in routine manual occupations, which started since the beginning of the series. By contrast, routine cognitive occupations have remained more or less stable along the period. This is different from what has been documented in Cortes et al. (2020) for the US, since they have found that the share of routine cognitive occupations in total employment has decreased since the beginning of the 2000s. In the next section, we start to delve deeper into these trends by using a series of multilevel competing risk event history models.

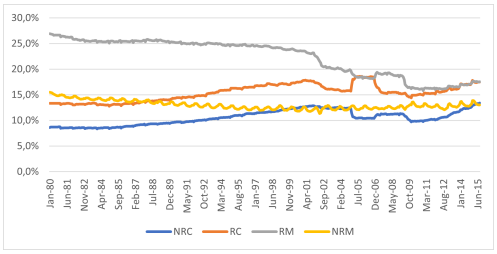
Figure 1. Monthly time series of employment (January 1980 - December 2015)



(a) Formal and informal employment



(b) Routine and non-routine employment



(c) Employment in NRC, RC, RM, NRM occupations

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: These figures present the monthly time series of employment in formality/informality (Figure 1a), in routine and non-routine occupations (Figure 1b) as well as in each occupational group (Figure 1c) as a share of the total working-age population for the period January 1980 to December 2015.

3 Workers' labour market transitions

In this section, our objective is to gain a better understanding of the direction of the flows within employment statuses to have a first approximation of the main labour market changes that underlie the disappearance of middle-wage routine jobs. Therefore, we study individuals' transitions over time using a series of multistate competing risks event history models. We compare the relative risks for individuals to move to different states. We are especially interested in investigating where do routine formal and informal workers move to when they are being substituted for. Nonetheless, we also explore transitions from other occupations, from unemployment as well as from non-participation. Lastly, we explore to which extent the type of transitions that individuals do vary by gender and age group.

3.1 Multilevel multistate event history models

To study changes in the employment status of individuals over time, we estimate multilevel multi-state event history models. These models are an extension of conventional event history models: rather than analysing a single employment transition, individuals can move to different states. We start by observing all individuals from January 1980. When individuals are in employment, they can either switch between occupations, or go out of employment as unemployed or inactive. Similarly, when individuals are out of employment (as unemployed or inactive), they can either return to employment or become unemployed (if inactive) or inactive (if unemployed).

To understand the link between the decline in routine employment and formal/informal employment, we estimate nine sets of multilevel competing-risks event history models for the outcomes of: 1) individuals employed in RM formal occupations, 2) individuals employed in RC formal occupations, 3) individuals employed in NRM formal occupations, 4) individuals employed in NRC formal occupations, 5) individuals employed in RM informal occupations, 6) individuals employed in RC informal occupations, 7) individuals employed in NRM informal occupations, 8) individuals employed in NRC informal occupations, and lastly 9) individuals who are out of employment (either as unemployed or inactive). We focus on these outcomes to get a sense of which labour market state routine workers are more likely to transit to over the last 35 years.

We estimate multilevel models because of the fact that each individual can experience several changes in their employment statuses along their careers. Besides, individuals can change their employment status at different points in time. We extend the conventional competing-risks model by conducting simultaneous analysis of changing to different employment statuses. The risk of a change in the employment status is thus expressed by:

$$ln\mu_{im}^{k}(t) = ln\mu_0(t) + \sum_j \alpha_j x_{ij} + \sum_l \beta_l w_{il}(t) + \gamma z_i \tag{1}$$

where $\mu_{im}^{k}(t)$ denotes the hazard of transiting to the employment status of type k of order m (first and subsequent order) for individual i. For all individuals, this refers to the risk of becoming employed in another occupation or to become unemployed or inactive. $ln\mu_0(t)$ denotes the baseline log-hazard, which is specified as piecewise constant. The baseline is time (in months) since the first observation, when the individuals entered into the panel. For most individuals, this is January of the year 1980.

x_{ij} and w_{il} represent time-constant and time-varying characteristics that influence individuals' propensities to change their employment status. We include gender, age and time since the individual started being in the initial state. z_i denotes an interaction term between the period and the type of employment transition and γ is the parameter to measure its effect. The model assumes a common baseline for transitions to all employment types and the same effect of covariates, but the employment levels by type of employment statuses can vary by period. These models are fitted using extended data in which each individual has k records, where k corresponds to the number of categories in the employment status variable.

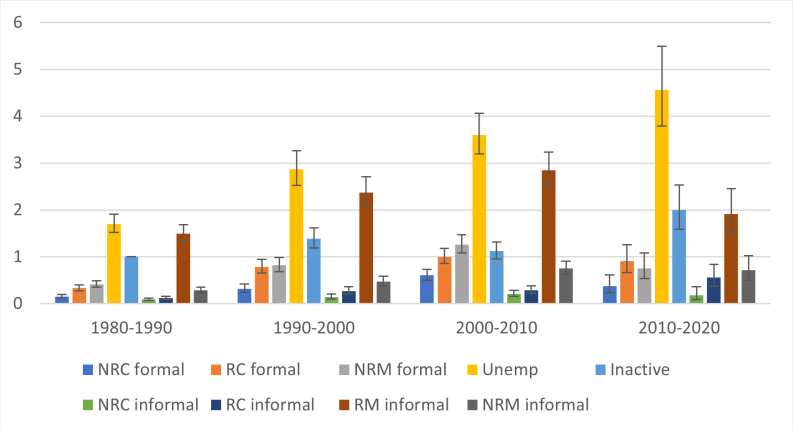
3.2 Main results

We summarise our results for the outcomes of individuals employed formally and informally in RM, RC, NRM, NRC occupations as well as for individuals who are out of employment. Alternatively, the results of the full models are available in Appendix B Tables B.1 to B.9.

We start by examining the outcomes of individuals who are employed in RM formal occupations (Figure 2). These individuals are at risk of transiting to any other occupation

as a formal or informal worker or to go out of employment as unemployed or inactive. The reference category is the risk of transiting to inactivity in the 1980s. The results displayed in Figure 2 show that in the 1980s, individuals that were employed in RM formal occupations were more likely to become unemployed or to become employed informally in RM occupations. These relative risks have increased significantly over the years. In the 2010 decade, becoming unemployed or transiting to RM informal occupations remain the most likely outcomes. Having in mind the automation process that the Chilean economy is going through (Falcone et al. 2022), our results suggest that the displacement of routine manual formal workers can cause the enlargement of informal employment.

Figure 2. Relative risks of a transition by type of transition over time for RM formal workers

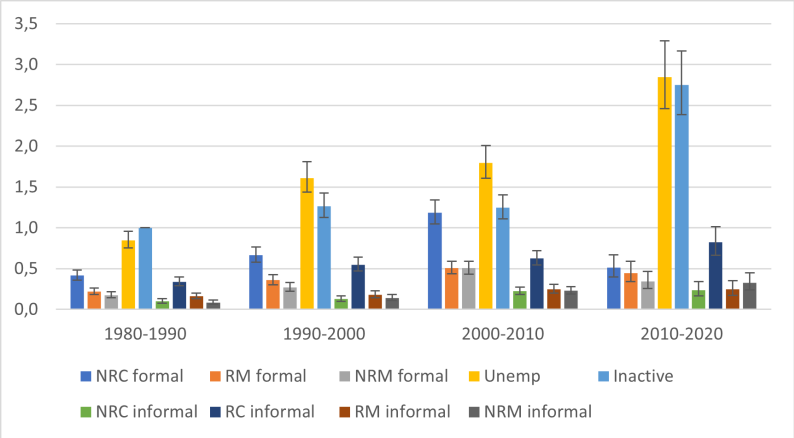


Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition by type of transition over time for RM formal workers. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported.

Individuals employed in RC formal occupations (Figure 3) were more likely to become inactive or unemployed in the 1980s. This remained the same the following decades. Yet, the relative risks have increased significantly over the years: in the 2010 decade, individuals that were employed in RC occupations are almost three times more likely to move to unemployment or inactivity compared to in the 1980s. If they remain employed, workers in RC formal occupations are more likely to transit to NRC formal and RC informal occupations. Therefore, while workers in RC formal occupations also transit to informality, the cognitive component of this occupation allows them to have the alternative of transiting to NRC formal occupations.

Individuals employed in NRM formal occupations (Figure 4) were more likely to become unemployed, inactive or to transit to RM formal or NRM informal occupations in the 1980s. These transitions remained the most likely throughout all decades. Lastly, individuals employed in NRC formal occupations (Figure 5) were more likely to become inactive in the 1980s. Yet, over the years, the likelihood of transiting to RC formal occupations has increased. It is the most likely outcome in the 1990s and 2000s. However, in the 2010 decade, this likelihood goes down. Individuals that are employed in NRC occupations in the 2010s are now more likely to go out of employment. They are also slightly more likely

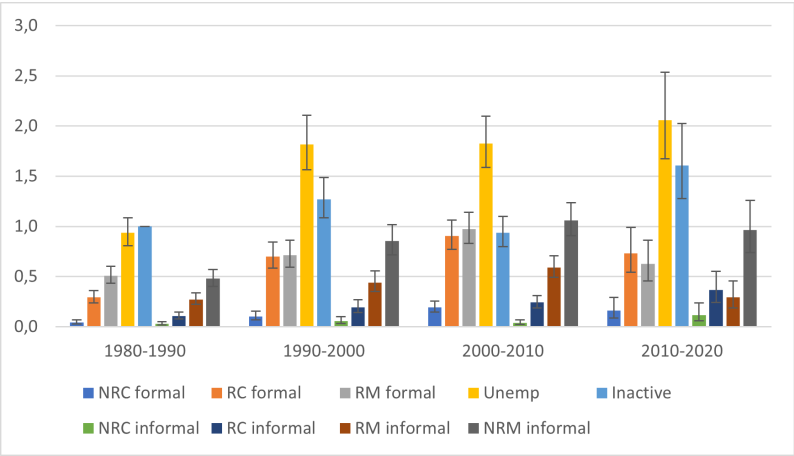
Figure 3. Relative risks of a transition by type of transition over time for RC formal workers



Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition by type of transition over time for RC formal workers. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported.

to transit to NRC informal occupations. In other words, the cognitive component of RC and NRC formal occupations allow workers to make more transitions within formal labour markets compared to RM and NRM formal occupations, whose workers tend to transit more to informality by contrast.

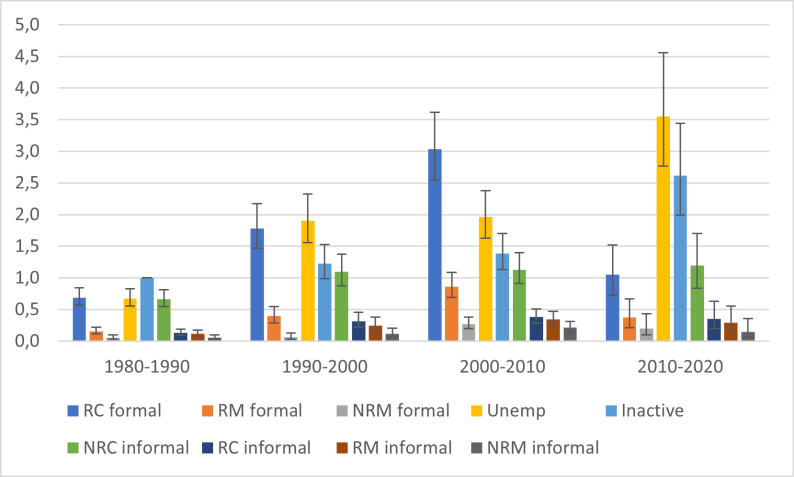
Figure 4. Relative risks of a transition by type of transition over time for NRM formal workers



Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition by type of transition over time for NRM formal workers. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported.

We now examine the outcomes of informal workers. Individuals who are employed in RM informal occupations (Figure 6) are first more likely to become unemployed in the 1980s. They also are more likely to become inactive or to become employed in RM formal occupations in the 1980s. In the 2010 decade, they are much more likely to become unemployed. Along the period, the likelihood of transiting to NRM informal occupations has grown steadily and it is close to surpass the likelihood of transiting to RM formal

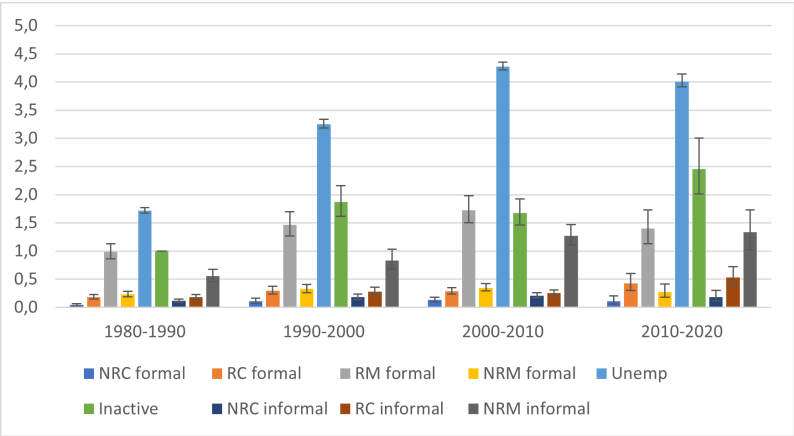
Figure 5. Relative risks of a transition by type of transition over time for NRC formal workers



Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition by type of transition over time for NRC formal workers. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported.

occupations in the 2010 decade. This finding is also suggesting that automation might be modifying the set of opportunities that RM informal workers have when being replaced by technology able to perform the same tasks.

Figure 6. Relative risks of a transition by type of transition over time for RM informal workers

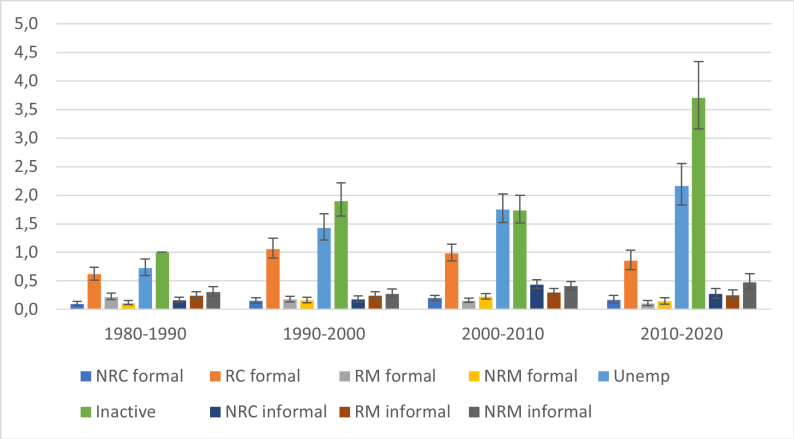


Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition by type of transition over time for RM informal workers. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported.

Individuals employed in RC informal occupations (Figure 7) are more likely to become inactive in the 1980s. This remains the case throughout all decades. However, we document also in informality that RC workers do not experience the same impact from automation as RM workers. Indeed, RC informal workers have a higher probability of transiting to the formal labour market (to RC formal) than to remain in informality (to NRM informal). This is consistent with our finding that the cognitive content of tasks is

associated with workers having a higher likelihood of being in formal employment compared to workers whose jobs involve more predominantly manual tasks.

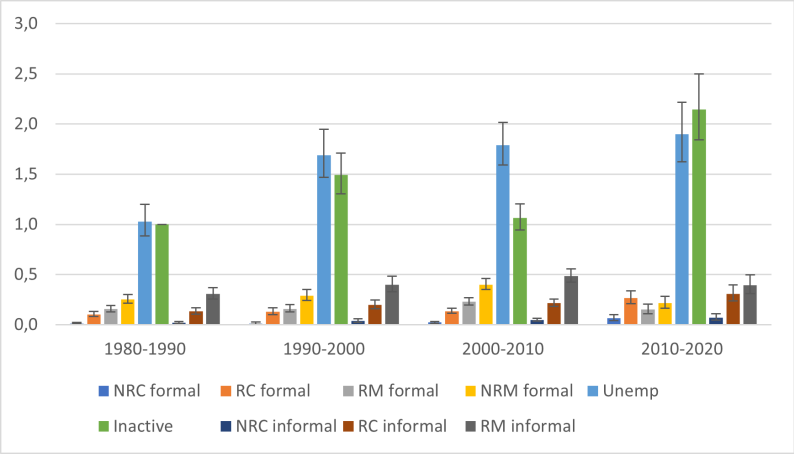
Figure 7. Relative risks of a transition by type of transition over time for RC informal workers



Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition by type of transition over time for RC informal workers. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported.

Individuals employed in NRM informal occupations (Figure 8) are much more likely to go out of the labour market as unemployed or inactive. Similarly, individuals employed in NRC informal occupations (Figure 9) are much more likely to become unemployed or inactive. However, compared to other informal workers, NRC workers are the ones that have the highest likelihood of transiting to formal employment either in the same occupation (NRC formal) or to RC formal occupations.

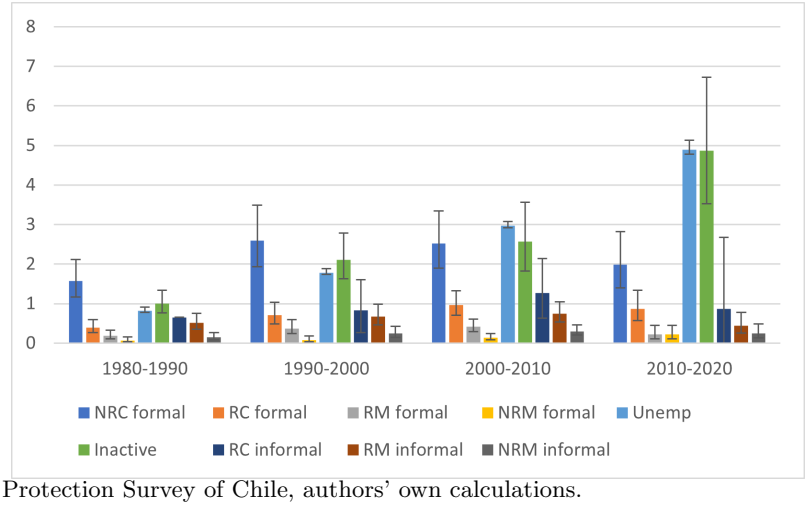
Figure 8. Relative risks of a transition by type of transition over time for NRM informal workers



Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition by type of transition over time for NRM informal workers. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported.

We conclude this quick investigation by examining the outcomes of individuals who are out of employment (either as unemployed or inactive). We examine the relative risks of

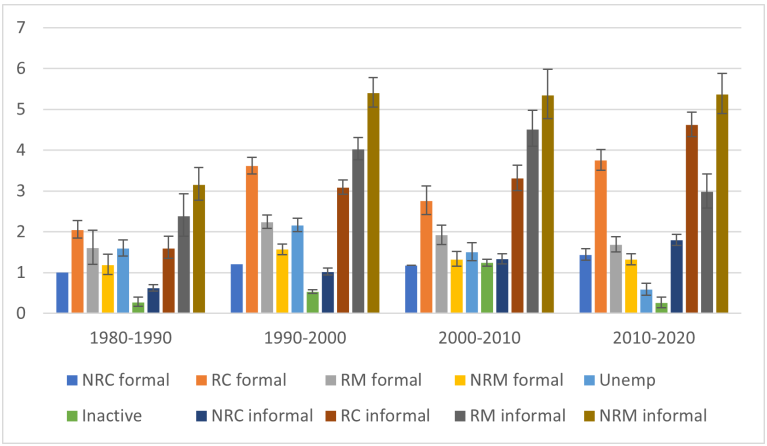
Figure 9. Relative risks of a transition by type of transition over time for NRC informal workers



Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition by type of transition over time for NRC informal workers. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported.

transiting to the other categories. The reference category is the risk of transiting to NRC formal occupations in the 1980s. The results displayed in Figure 10 show that informality is the most likely outcome for individuals to transit to - more precisely to NRM, RC and RM informal occupations. In the 1980s, individuals that were out of employment were more likely to start to work informally in NRM occupations. This relative risk has increased significantly over the years. The most likely outcome in the formal labour market is to be employed in RC formal occupations. By contrast, individuals who are out of employment have a lower relative risk of starting to work in RM occupations in the 2010 decade compared to in the 1990s for instance.

Figure 10. Relative risks of a transition by type of transition over time for individuals who are out of employment



Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition by type of transition over time for individuals who are out of employment. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to NRC formal occupations in the 1980s. 95% confidence intervals are also reported.

To summarise, our results highlight two key take away points: i) the work opportunities of routine manual workers, irrespective of whether they are formal or informal workers, have been narrowing over time to occupations in the informal market (RM informal and NRM informal occupations), suggesting a process of occupational downgrading, ii) routine cognitive workers, irrespective of whether they are formal or informal workers, are being relatively less affected by this process of automation, as their probability to transit into formality is still the highest probability among all the possible transitions into employment.

3.3 Heterogeneity across demographic groups

So far, we have focused on aggregate transitions rates. Yet, it is well known that labour market transition rates vary significantly across demographic groups. For instance, young individuals often experience more frequent transitions compared to those who are older. Men and women also often have very different labour market trajectories. Thus, we explore to which extent the type of transitions that individuals do vary by gender and age group. The results discussed here are reported in Appendix B Figures B.1 to B.9.

Regarding individuals who work in RM formal occupations (Appendix B Figure B.1), men are much more likely to transit to RM informal occupations whereas women are more likely to become unemployed or inactive. There is no clear pattern among age groups. Among individuals who work in RC formal occupations (Appendix B Figure B.2), men and women have relatively similar propensities to become unemployed or inactive. Yet, the younger individuals are more likely to make a transition. For individuals working in NRM formal occupations (Appendix B Figure B.3), while men are much more likely to become unemployed, women have a higher likelihood of becoming inactive. Younger individuals are again more likely to experience a change in their employment status. Lastly, among individuals who work in NRC formal occupations (Appendix B Figure B.4), there is no clear difference by gender nor age group.

Among individuals who work in RM informal occupations (Appendix B Figure B.5), women are much more likely to become inactive than men. There is no clear difference by gender among individuals who work in RC informal occupations (Appendix B Figure B.6). Women are again much more likely to become inactive compared to men among individuals who work in NRM informal occupations (Appendix B Figure B.7). We do not see significant differences between men and women among individuals who work in NRC informal occupations (Appendix B Figure B.8). Lastly, among individuals who are out of employment (Appendix B Figure B.9), men are much more likely to transit to RM informal occupations compared to women. By contrast, women are more likely to transit to RC formal occupations than men, it is the third most likely transition for women. Younger individuals are also more likely to transit to RC formal occupations or to RC informal occupations compared to older individuals.

4 Transition Rates and Counterfactual Analysis

In the previous section, we have documented that routine manual workers become increasingly unemployed or use informality as a buffer against job loss. In this section, we aim to gain a deeper understanding of the dynamics behind these trends and the decline of routine occupations. More specifically, we want to understand the role of the transition rates in and out of our ten employment states in explaining these trends. To do so, we use a modified version of the flows approach adopted in Cortes et al. (2020) and conduct counterfactual analyses to unveil the relative importance of inflows and outflows in explaining the trends identified previously. This approach is described in detail in this section.

4.1 Construction of Transition Rates

We start by constructing monthly transition rates across the ten labour market states. The transitions rates from labour market status i to labour market status j at date t ($\gamma_{ij,t}$) are defined as follows:

$$\gamma_{ij,t} = \frac{\sum \tau_{ij,t}}{\sum \tau_{ii,t} - \sum \tau_{il,t} + \sum \tau_{ei,t}} \tag{2}$$

where $\tau_{ij,t}$ is the transition from status i at date t to status j at date $t+1$, $\tau_{ii,t}$ is the transition from status i at date t to status i at date $t+1$ (stayers), $\tau_{il,t}$ represents workers in status i at month t that have left the panel the next month $t+1$, and $\tau_{ei,t}$ represents individuals that have entered the panel and move to status i at date $t+1$. For example, if we focus on the transition rate from NRC formal at date t (denoted by 1) to RC formal at date $t+1$ (denoted by 2) (transition codified as 12), then the formula above is equal to:

$$\gamma_{12,t} = \frac{\sum \tau_{12,t}}{\sum \tau_{11,t} - \sum \tau_{1l,t} + \sum \tau_{e1,t}} \tag{3}$$

We aim to obtain a mathematical expression that mimics the evolution of the stocks of our employment statuses. To do so, we use the following law of motion to recover the monthly stock evolution of our ten labour market statuses:

$$stocks_{t+1} = inflows_{t+1} - outflows_{t+1} \tag{4}$$

where $stocks_{t+1}$, $inflows_{t+1}$, $outflows_{t+1}$ are 10x1 matrices. The matrix $inflows_{t+1}$ is then computed as:

$$inflows_{t+1} = stocks_t * \alpha_t \tag{5}$$

We define α_t as a 10x10 matrix that is composed by sub-matrices as follows:

$$\alpha_t = \begin{bmatrix} \omega_t^{F-F} & \omega_t^{F-N} & \omega_t^{F-I} \\ \omega_t^{N-F} & \omega_t^{N-N} & \omega_t^{N-I} \\ \omega_t^{I-F} & \omega_t^{I-N} & \omega_t^{I-I} \end{bmatrix} \tag{6}$$

where: ω_t^{F-F} is a 4x4 matrix of transition rates from formality to formality in each of our four occupational groups, ω_t^{F-N} is a 4x2 matrix of transitions rates from formality to either unemployment or inactivity, ω_t^{F-I} is a 4x4 matrix of transitions rates from formality to informality in each occupation, ω_t^{N-F} is a 2x4 matrix of transitions rates from either unemployment or inactivity to formality in each occupation, ω_t^{N-N} is a 2x2 matrix of transitions rates from either unemployment or inactivity to either unemployment or inactivity, ω_t^{N-I} is a 2x4 matrix of transition rates from either unemployment or inactivity to informality, ω_t^{I-F} is a 4x4 matrix of transition rates from informality to formality in each occupation, ω_t^{I-N} is a 4x2 matrix of transition rates from informality to either unemployment or inactivity, ω_t^{I-I} is a 4x4 matrix of transition rates from informality to informality in each occupation. The matrix $stocks_t$ is then given by:

$$stocks_t = [NRC^F, RC^F, RM^F, NRM^F, U, I, NRC^I, RC^I, RM^I, NRM^I] \tag{7}$$

where the superscript F stands for formal, the superscript I stands for informal, U refers to unemployment and I to inactivity. The outflows are given by:

$$outflows_{t+1} = \beta_t * stocks_t^T \tag{8}$$

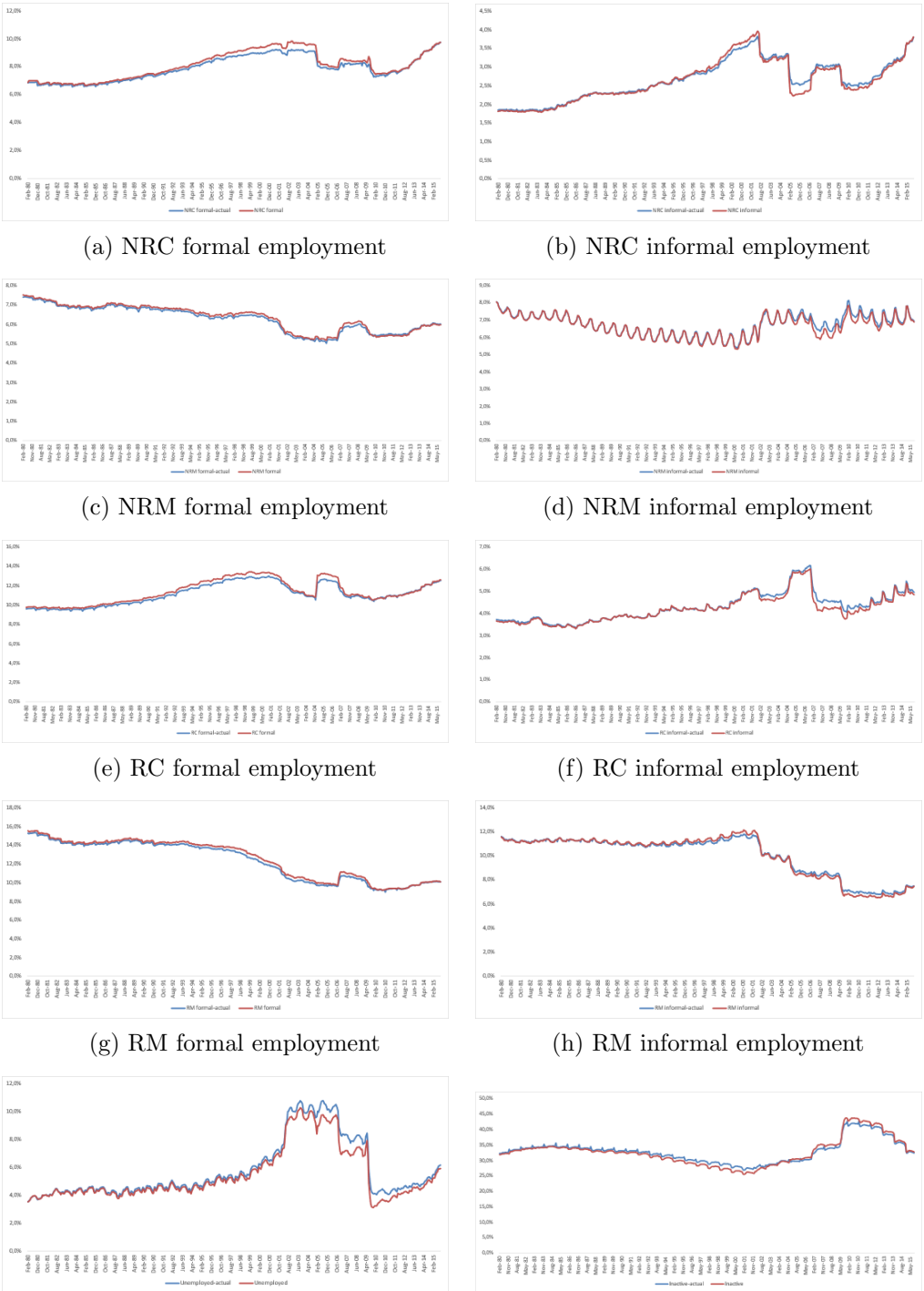
where matrix β_t is matrix α_t but with zeros in the main diagonal and $stocks_t^T$ (the transpose of $stocks_t$) is a column vector (10x1) in which each position has the same order as the row vector $stocks_t$. Equipped with our law of motion, the next step is to test its capacity to mimic the monthly evolution of the stocks in each occupation. In this case, by using the transition rates, we should be able to iterate forward in order to reconstruct the observed series of our ten employment statuses.

Figure 11 plots employment in each occupation, unemployment and inactivity from 1980:1 to 2015:12. The stocks based on the full sample are the blue lines while the estimates based on the law of motion (Equation 4) are the red lines. The figure displays some interesting patterns. While the stocks of NRC occupations (both formal and informal) display ups and downs during the period, there is a positive growth between the end and the beginning of the series (Figures 11a and 11b). The share of NRM occupations has been more or less stable during the period, displaying a slight decrease in the formality share at the end of the series (Figure 11c and 11d).

Regarding routine occupations, RC occupations have increased in participation in the total stocks (Figures 11e and 11f) whereas RM occupations display a clear negative trend (Figures 11g and 11h). Furthermore, it is interesting to note that the decline in RM

formal stocks starts since the beginning of the series, while the decline in RM informal stocks occurs as recently as the beginning of the 2000s. In other words, the displacement of routine workers due to automation is not a phenomenon that is exclusively happening in formal labour markets since RM informal workers are also affected by this process.

Figure 11. Labour market stocks from full sample and based on law of motion



(a) NRC formal employment

(b) NRC informal employment

(c) NRM formal employment

(d) NRM informal employment

(e) RC formal employment

(f) RC informal employment

(g) RM formal employment

(h) RM informal employment

(i) Unemployment

(j) Inactivity

Source: Social Protection Survey of Chile, authors' own calculations.

Notes: This figure presents the labour market stocks from the full sample and based on the law of motion (equation 4) from January 1980 to December 2015.

The general patterns observed in each occupation are in line with what has been documented in the literature for middle-income countries (Peña and Siegel 2021). However, by breaking down the occupational statuses by formal/informal employment, we are able to document that the decline of routine occupations in the case of a middle-income country such as Chile is localised in routine manual occupations, and that the process of automation in labour markets has also affected (although with a delay) workers in informality.

Finally, it is important to note that the law-of-motion described by Equation 4 does a good job in replicating the evolution of the observed stocks. This allows us to be confident in implementing the counterfactual analysis presented in the next subsection. In this counterfactual exercise, we want to disentangle the role of the transition rates (in and out) in explaining the evolution of the ten occupational stocks, with special emphasis on routine occupations (both formal and informal).

4.2 Aggregate Counterfactual

We now study the role of changes in aggregate transition rates into and out of our ten labour market states in accounting for the general patterns showed in the previous section. As Cortes et al. (2020), we would like to smooth the transition rates over the business cycle. Thus, we start by arbitrarily dividing the transition rates into the following phases: i) 1980-1985, ii) 1986-1990, iii) 1991-1995, iv) 1996-2000, v) 2001-2005, vi) 2006-2010 and vii) 2011-2015. For each period, we calculate the average transition rates in each of the ten statuses.

Using this information, we construct Table 2 which presents the ratio of the average transition rates between 2011-2015 and 1980-1985. The table shows that job-to-job mobility has increased over the last 35 years for both inflows and outflows. If we consider the outflows (rows in Table 2 - the averages are in the last column), the statuses that, on average, have seen the highest increase in their transition rates compared to in the 1980-1985 period are the NRC formal, RM formal, NRM formal and NRM informal occupations. On the inflows side (columns in Table 2 - the averages are reported in the last row), the statuses that have experienced the largest increase in their inflows transition rates are the NRC formal, RC formal, NRC informal, and RC informal occupations. Importantly, the table also shows that the inflows from unemployment to RM formal and informal occupations are among the few transition rates that have decreased along the period.

We proceed by using our average transition rates for the seven periods in our law-of-motion (Equation 4). These "stocks based on average rates" are plotted in Figure 12 alongside the observed monthly stocks. As Cortes et al. (2020), we find that the average period-specific transition rates do a good job in replicating the general patterns observed in the data, in addition to providing smooth series not affected by the Chilean business cycle. Particularly, the stocks based on average transitions also depict the underlying pattern observed in routine manual occupations in the formal and informal labour markets.

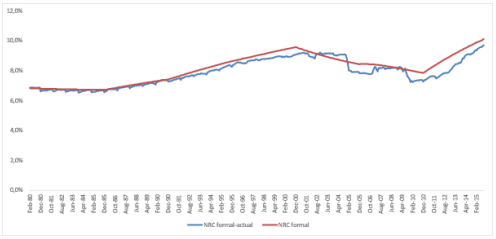
Table 2. Ratio of average transition rates between 2011-2015 and 1980-1985

		NRC^F	RC^F	RM^F	NRM^F	Unemp.	Ina.	NRC^I	RC^I	RM^I	NRM^I	Averages
		1	2	3	4	5	6	7	8	9	10	
NRC^F	1	0.999	4.638	6.195	6.415	3.490	2.257	2.449	2.295	14.410	5.062	4.821
RC^F	2	3.682	0.999	2.033	3.388	3.520	2.843	3.130	3.933	1.455	3.079	2.806
RM^F	3	6.547	3.358	0.999	2.192	2.269	1.632	2.963	6.367	2.111	2.156	3.059
NRM^F	4	9.235	4.865	1.929	0.998	1.974	1.654	2.753	4.344	1.342	2.629	3.172
Unemployed	5	2.668	2.520	0.952	1.408	0.997	1.579	6.180	2.931	0.851	1.228	2.131
Inactive	6	2.501	2.431	1.297	1.641	0.984	0.994	3.964	4.539	1.276	2.178	2.180
NRC^I	7	2.172	3.776	2.393	5.152	3.280	3.892	0.998	3.626	1.529	2.656	2.947
RC^I	8	4.598	1.918	0.858	3.306	2.882	3.368	4.442	0.997	1.641	1.785	2.580
RM^I	9	6.223	2.938	2.063	1.630	1.598	2.100	3.370	2.960	0.997	3.157	2.704
NRM^I	10	4.558	3.997	1.755	1.908	1.553	1.758	12.205	2.895	1.453	0.995	3.308
Averages		4.318	3.144	2.047	2.804	2.255	2.208	4.245	3.489	2.706	2.493	

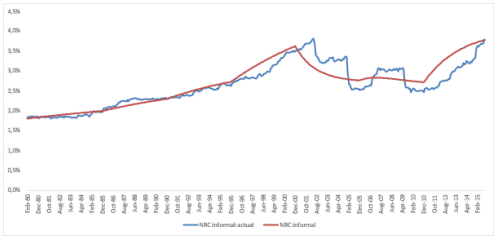
Source: Social Protection Survey of Chile, authors' own calculations.

Notes: This table presents the ratios between the average transition rates from the period 2011-2015 to the period 1980-1985. The rows represent the outflows of each occupation and the columns represent the inflows.

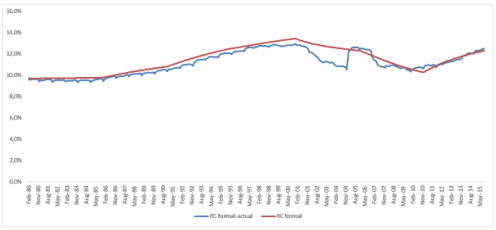
Figure 12. Employment stocks based on law of motion using monthly rates and phase averages



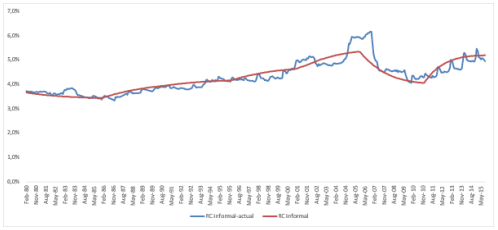
(a) NRC formal employment



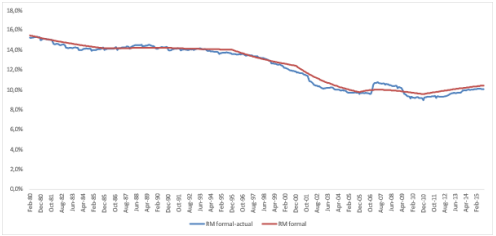
(b) NRC informal employment



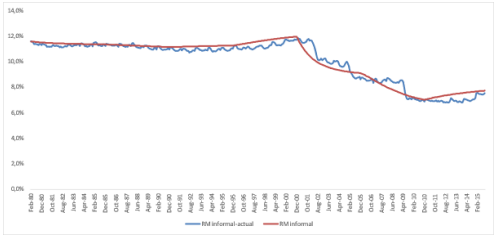
(c) RC formal employment



(d) RC informal employment

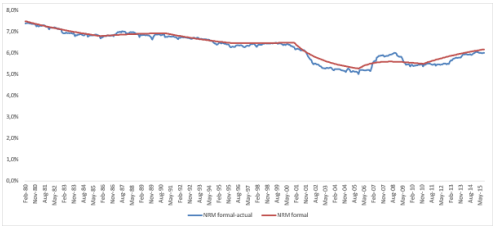


(e) RM formal employment

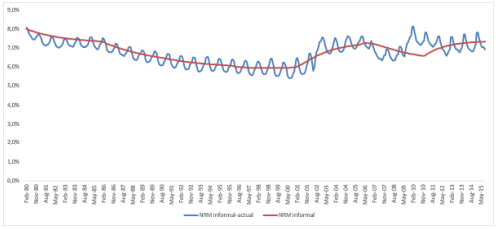


(f) RM informal employment

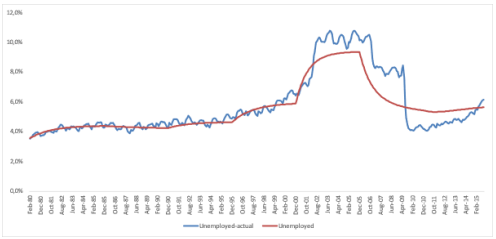
Figure 12. Employment stocks based on law of motion using monthly rates and phase averages (continued)



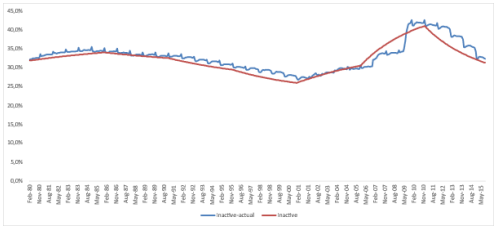
(g) NRM formal employment



(h) NRM informal employment



(i) Unemployment



(j) Inactivity

Source: Social Protection Survey of Chile, authors' own calculations.

Notes: This figure presents the labour market stocks from the full sample and based on the law of motion (eq. 4) and using the average transition rates per period, from January 1980 to December 2015.

As our objective lies in understanding the main drivers behind the decline of routine occupations and the links with informal employment, we conduct some counterfactual exercises in which we substitute one by one the period-specific average transition rates by the average transition rates observed in the pre-polarization period, i.e. in 1980-1985. This will allow us to unveil which type of flow (inflow or outflow) is the most important in explaining the patterns observed in the data for each status. To illustrate our exercise, we depart from Equation 4 and modify it as follows:

$$stocks_{t+1}^{cf} = inflows_{t+1}^{cf} - outflows_{t+1}^{cf} \tag{9}$$

In this equation, we observe for the initial period the following: $stocks_1^{cf} = stocks_1$, $inflows_1^{cf} = inflows_1$ and $outflows_1^{cf} = outflows_1$. Then,

$$inflows_{t+1}^{cf} = stocks_t^{cf} * \alpha_t^{cf} \tag{10}$$

$$outflows_{t+1}^{cf} = \beta_t^{cf} * stocks_t^{T,cf} \tag{11}$$

where α_t^{cf} and β_t^{cf} are the matrices for the counterfactual transition rates. We construct 100 matrices of counterfactual transition rates where we take one by one each labour market transition and we substitute the period-specific transition rates by the average transition rate of the period 1980-1985 (pre-polarization period).

When conducting this exercise, the total stocks or total number of workers in the

counterfactuals will be different to those obtained in the baseline because we modify the transition rates by holding them constant. Therefore, we use a rule to distribute this difference across the occupations for which the transition rate evolves as in the data. This difference is distributed by using as a weight the participation of the occupation in the total number of workers in those occupations for which the transition rate evolves as in the data in the previous month (see equations 12 and 13).

For example, if we are interested in the counterfactual scenario in which the inflow transition rate from unemployment to NRC formal employment is maintained constant, then the inflows and outflows of the occupations that are not affected by this transition rate are going to be adjusted following these expressions - we take as an example RC formal (where O is any other occupation not involved in this transition):

$$inflows^{RCF}_{t+1,cf,adjusted} = inflows^{RCF}_{t+1,cf} + \frac{inflows^{RCF}_{t,cf}}{\sum inflows^{O}_{t,cf}} * (inflows^{RCF}_{t+1} - inflows^{RCF}_{t+1,cf}) \tag{12}$$

$$outflows^{RCF}_{t+1,cf,adjusted} = outflows^{RCF}_{t+1,cf} + \frac{outflows^{RCF}_{t,cf}}{\sum outflows^{O}_{t,cf}} * (outflows^{RCF}_{t+1} - outflows^{RCF}_{t+1,cf}) \tag{13}$$

Using the expressions above, we adjust the inflows and outflows to match the total number of workers in the counterfactual scenario with the baseline scenario. We repeat this process 100 times, as we have 100 transition matrices.

Among the 10 statuses, we distinguish between those that follow a negative trend and those that follow a positive trend between 1980 and 2015. The statuses that depict a positive trend are: NRC formal, RC formal, unemployment, inactivity, NRC informal, and RC informal. Those displaying a negative trend are: RM formal, NRM formal, RM informal, and NRM informal. Later, we subtract from the first point of the series (January 1980) the last point of the series (December 2015) for the series with a positive trend whereas, we subtract from the last point of the series (December 2015) the first point of the series (January 1980) for the series with a negative trend. Mathematically, for the series going upwards, we have:

$$\Delta stock^{O} = stock^{O}_{t=1} - stock^{O}_{T} \tag{14}$$

$$\Delta stock^{O}_{cf} = stock^{O}_{cf,t=1} - stock^{O}_{cf,T} \tag{15}$$

and for the series going downwards, we have:

$$\Delta stock^{O} = stock^{O}_{T} - stock^{O}_{t=1} \tag{16}$$

$$\Delta stock^{O}_{cf} = stock^{O}_{cf,T} - stock^{O}_{cf,t=1} \tag{17}$$

where O represents our ten employment statuses. Finally, we compute the following expression:

$$1 - \frac{\Delta stock^{O}_{cf}}{\Delta stock^{O}} \tag{18}$$

The rationale of equation 18 is that, for the series going upwards, the counterfactual will tell us how much of this increase would have been lost (if the value is positive) or gained (if the value is negative) if the transition rate was the same as during the 1980-1985 period. Conversely, for the series going downwards, the counterfactual will tell us how much of this decrease would have been avoided (if the value is positive) or magnified (if the value is negative) if the transition rate was the same as during the 1980-1985 period. This exercise will allow us to identify which inflows and outflows are the most important to explain the decrease in routine occupations and its relationship with informality.

4.3 Results

We first present Table 3 which contains the percentage point difference between the last point and the first point of the series for each employment state when the series go upwards; and the difference between the first point and the last point of the series when the trend goes downwards. In addition, Table 4 depicts the counterfactual scenarios computed using equations 9 to 18 for our ten employment statuses. In this table, each of the employment statuses in the first rows has its inflow and outflow rates resulting from the counterfactual exercises in the corresponding columns. Each position in Table 4 represents the counterfactual value resulting from leaving the corresponding transition rate at the 1980-1985 value. When the information contained in Table 3 is combined with Table 4, we obtain several important insights.

First, we document that for NRC formal occupations, the slight decrease in the transition rate of stayers (see Table 2) has had an important effect. Indeed, if the transition rate would have remained at its value in the 1980-1985 period, the growth in the stocks would have been 163% higher, leaving everything else constant. Importantly, the inflows from RC formal occupations over the period would explain a significant part of the increment in NRC formal employment. Indeed, leaving the inflow rate from RC formal to NRC formal occupations at its 1980-1985 value would have mitigated the growth of NRC formal employment by 58%.

On the side of the outflows, our results indicate that the increase in the outflow rates over the period has not allowed a bigger increase in the participation of NRC formal occupations. In fact, the rates show that NRC formal workers tend to transit more to RC formal occupations, unemployment and inactivity. In net terms, the statuses that have contributed the most to the increase in NRC formal stocks are RC formal employment

and inactivity.

Table 3. Percentage point variation of employment stocks

Status	Value	Upward/downward
NRC formal	3.4%	Upward
RC formal	2.7%	Upward
RM formal	5.0%	Downard
NRM formal	1.3%	Downard
Unemployed	2.1%	Upward
Inactive	5.0%	Upward
NRC informal	2.0%	Upward
RC informal	1.8%	Upward
RM informal	4.2%	Downard
NRM informal	0.7%	Downard

Source: Social Protection Survey of Chile, authors' own calculations.

Table 4. Results from aggregate counterfactual exercises

	NRC^F		RC^F		RM^F		NRM^F		Unemployment	
	Inflows	Outflows	Inflows	Outflows	Inflows	Outflows	Inflows	Outflows	Inflows	Outflows
NRC_F		-1.63	0.32	-0.47	-0.07	0.08	-0.06	0.06	0.15	-0.13
RC_F	0.58	-0.39		-1.46	-0.11	0.12	-0.40	0.45	0.36	-0.27
RM_F	0.14	-0.13	0.18	-0.16		0.85	-0.34	0.37	0.18	0.01
NRM_F	0.06	-0.04	0.21	-0.18	-0.12	0.11		1.47	0.10	-0.05
Unemp.	0.28	-0.32	0.57	-0.79	0.00	0.34	-0.30	0.59		-0.45
Ina.	0.40	-0.26	0.83	-0.76	-0.08	0.13	-0.44	0.40	-0.08	-0.15
NRC_I	0.23	-0.15	0.09	-0.08	-0.02	0.02	-0.04	0.02	0.14	-0.14
RC_I	0.10	-0.05	0.25	-0.25	0.00	0.05	-0.17	0.12	0.25	-0.21
RM_I	0.05	-0.06	0.09	-0.05	-0.27	0.26	-0.14	0.13	0.15	0.06
NRM_I	-0.04	-0.03	0.15	-0.10	-0.08	0.00	-0.48	0.37	0.15	-0.09
	Inactivity		NRC^I		RC^I		RM^I		NRM^I	
	Inflows	Outflows	Inflows	Outflows	Inflows	Outflows	Inflows	Outflows	Inflows	Outflows
NRC_F	0.13	-0.07	0.11	-0.18	0.02	-0.07	0.00	0.00	-0.07	0.10
RC_F	0.25	-0.11	0.07	-0.09	0.21	-0.18	0.00	0.01	-0.25	0.39
RM_F	0.01	0.01	0.03	-0.03	0.07	0.00	-0.08	0.08	0.00	0.24
NRM_F	0.04	-0.02	0.01	-0.02	0.05	-0.06	0.00	0.00	-0.35	0.41
Unemp.	0.53	-0.09	0.36	-0.33	0.42	-0.49	0.00	0.13	-0.70	-0.97
Ina.		-5.08	0.61	-0.40	0.77	-1.01	-0.01	0.03	-2.25	1.00
NRC_I	0.22	-0.22		-0.37	0.06	-0.10	-0.02	0.00	-0.07	0.14
RC_I	0.51	-0.40	0.14	-0.07		-0.48	-0.02	0.04	-0.27	0.38
RM_I	0.24	0.04	0.04	-0.03	0.07	-0.05		0.29	-0.71	0.31
NRM_I	0.27	-0.27	0.06	-0.03	0.12	-0.08	0.00	0.10		1.00

Source: Social Protection Survey of Chile, authors' own calculations.

Notes: In this table, each occupation in the first row has its own counterfactual scenarios (inflows and outflows) in the second row. For example, if we take the NRC^F in the first row and we focus on the inflows coming from RC^F (value of 0.58), then the counterfactual exercise is performed by holding the inflow transition rate from RC^F to NRC^F at its 1980-1985 value, and the result of this exercise is that the stocks of NRC^F would be 58% smaller in this counterfactual, which alternatively means that the inflows from RC^F to NRC^F explain approximately 58% of the increase in NRC^F stocks, holding everything else constant. To interpret this table, it is important to know whether the series' stock is going upward or downward along the period (See Table 3). When the series is going upward, the inflows column (with a positive value) indicates by how much the increase would have been mitigated if the corresponding inflow rate would have remained at its 1980-1985 value. In the case of the outflows (with a negative value), it indicates how much bigger would have been the growth in the stocks if the outflows transition rate had remained at its pre-polarization value. When the series' stock is going downward, then the inflows column (with a negative value) tells us by how much the decrease would have been greater if the corresponding inflow rate had remained at its 1980-1985 value. The outflows (with a positive value) give an indication of how smaller would have been the decrease in the corresponding status if the transition rate had been equal to its value at the pre-polarization period.

In the case of RC formal employment, we observe that the inflows from unemployment and inactivity play an important role in explaining its increase during the period. Indeed,

the ratio of the average transition rates calculated in Table 2 shows a considerable increase of the inflows from out of employment categories to RC formal occupations. Regarding the outflows, we document that if the rates had remained the same as the ones in 1980-1985, then the increase in RC formal employment would have been higher, the most important statuses being the stayers, unemployment and inactivity.

Next, we analyse RM formal employment. The inflows column tells us that if the rates had been the same as in the 1980-1985 period (smaller inflow rates), the decrease in RM formal employment would have been greater. Interestingly, the inflows from RM informal employment have prevented a larger decrease in RM formal occupations. This has been also the case for NRM formal and RC formal employment.

An important point to notice is that the counterfactual exercise of leaving constant the inflows from unemployment to RM formal employment increases the stocks of RM formal occupations (the value is 0.001). This is due to the fact that the inflows from unemployment to RM formal have decreased along the period. Regarding the outflows, we document that the decrease in the transition rate of stayers alone explain 85% of the decrease in RM formal occupations, maintaining everything else constant. Overall, these results point out that the most important driver in the decrease of RM formal occupations are the increase in the outflow transition rates and the decrease in the inflow transition rate from unemployment.

When analysing in more detail the role of the outflows, we find that outflows to unemployment and RM informal occupations are the ones with the highest explanatory power for the decrease in RM formal employment. When we consider the net flows to explain the decrease in RM formal employment, the participation of RM informal employment becomes almost null and the participation of RC informal employment becomes positive. However, unemployment remains with a high explanatory power. This means, that in the short run, those that have lost their job due to automation in RM formal employment became unemployed or transited to informality.

Regarding NRM formal employment, our results show that leaving the inflow transition rates at their 1980-1985 values exacerbates the reduction in the NRM formal stocks along the period. This is especially true for inactivity and those coming from NRM informal occupations. In terms of the outflows, if the rate of stayers had been the same as in 1980-1985 (smaller transition rate), the participation of NRM formal employment would have grown instead of declining.

Regarding the unemployment category, our calculations show that RM formal and RM informal employment are the biggest net contributors to unemployment. In fact, the outflows column demonstrates that the growth in unemployment would have been smaller if the outflows transition rate to RM occupations had stayed at its 1980-1985 value. The reason for this is that the transition rates have decreased over time, as shown by Table 2. In other words, less workers are making the transition from unemployment to RM occupations as the automation process takes place. Overall, inactivity shows similar

patterns as for unemployment. However, for inactivity, the transition rate of stayers has by far the highest explanatory power. Indeed, if the transition rate of stayers had remained constant, the participation of inactivity would have grown by more than 500%.

Our findings for informality depict similar trends to what has been reported for our four occupational categories in the formal labour markets. The inflows from unemployment and inactivity to NRC informal employment explain an important part of the increase in this serie, inactivity being the most important one. The outflows show that if the transition rates had remained constant at their pre-polarization values, then in all the cases the increase in NRC informal employment would have been higher.

While there are quantitative differences, we observe qualitatively the same results for RC informal employment, as unemployment and inactivity constitute an important share of the inflows and outflows of this occupation. Nonetheless, when considering the net terms, flows from RM formal occupations have a positive impact in explaining the growth in RC informal employment. RM informal employment decreases along the period, and we document that this decrease is explained mostly by the decrease in the transition rate of stayers, which has had an impact of 29% in the reduction of RM informal employment. On the other hand, the decrease in this employment status would have been 8% higher had the inflows from RM formal employment remained at their pre-polarization values. Indeed, the increase in the inflows over the decades has prevented a greater decrease in the participation of RM informal occupations.

There are also net flows going to unemployment and NRM informal employment. This means that the automation process in the informal labour market has displaced workers: they have become either unemployed or employed in NRM informal occupations, which, on average, are occupations that are less productive and with lower wages. In addition, our results indicate that outflows are the biggest force behind the decrease in RM informal occupations. Finally, for NRM informal employment, the inflows suggest that with smaller transition rates (1980-1985 rates), the decrease in the series would have been higher. On the other hand, the outflows to inactivity and NRM formal employment play an important role in explaining the decrease in this series along the period.

To summarise, our results indicate that the increase in the outflows transition rates and the decrease in the inflow rate from unemployment are the most important driver in the decrease of routine occupations. For RM formal employment, the outflows towards unemployment have the highest explanatory power, while the outflows to RM informal employment is the second. For RM informal employment, we find that the outflows to unemployment and to NRM informal occupations are the most important ones. Finally, as we find that outflows to unemployment and informality and inflows from unemployment are an important contributer to the decrease in routine manual occupations, we would like to understand how they interact together.

One way to see this is to focus our attention on those routine workers transiting to unemployment to see where they go after being unemployed. Table 5 reports the

results for individuals who were employed in RM formal occupations and then become unemployed while Table 6 reports the results for individuals who were employed in RM informal occupations and then become unemployed.

The results reported in Table 5 show that, over time, a larger proportion among individuals who were employed formally in RM occupations and then lost their job go to informality. Conversely, a lower proportion of individuals go back to being employed in RM formal occupations, a fact that basically echoes with our result that inflows from unemployment to RM formal occupations have been gradually decreasing. Similarly, Table 6 shows that, among individuals who were employed informally in RM occupations and then became unemployed, a higher proportion become employed in other occupations in the informal labour market. In addition, less workers transit from unemployment to RM informal occupations.

Table 5. Proportion of individuals transiting to different occupations after being in RM formal employment then unemployed

	1980-1990	1991-2000	2001-2015
RM formal	56.17	49.47	38.40
RM informal	19.14	23.68	30.51
Other occupations - formal	14.20	16.66	14.38
Other occupations - informal	10.49	10.19	16.71

Source: Social Protection Survey of Chile, authors' own calculations.

Table 6. Proportion of individuals transiting to different occupations after being in RM informal employment then unemployed

	1980-1990	1991-2000	2001-2015
RM formal	12.66	10.44	10.01
RM informal	69.41	66.74	61.64
Other occupations - formal	6.75	9.20	6.34
Other occupations - informal	11.18	13.62	22.01

Source: Social Protection Survey of Chile, authors' own calculations.

To conclude, we observe that the process of automation has resulted in a displacement of routine workers who have become either unemployed or have experienced a downgrade in their occupational status. This downgrade occurs at a different level: while RM formal workers transit to informality in RM or RC occupations, RM workers already in informality tend to transit more within informal labour markets to NRM occupations.

Regarding NRC and RC occupations, it seems that the cognitive component is allowing these workers to transit more within the formal labour markets. Finally, it is important to mention that the results presented in this section complement and give us a better understanding of the probabilities computed in section 3. Indeed, the counterfactual scenarios allow us not just to disentangle the relative importance of inflows and outflows, but also to quantify the magnitude of their impact in the evolution of the occupational stocks.

5 Conclusions

The objective of this paper was to analyse the labour market changes that underlie the disappearance of routine employment and to explore the link between routine-biased technical change and informality in a middle-income country such as Chile. We first studied individuals' transitions over time using a series of multistate competing risks event history models. We compared the relative risks for individuals to move to different states. We then examined how these relative risks of transiting to different states have changed over time since the 1980s. This allowed us to provide a better understanding of the labour market displacement effects of the process of technological change and its links with informal employment. In the second part of the paper, we used a modified version of the flow approach adopted in Cortes et al. (2020) to study the flows underlying the decline of routine formal and informal occupations. This allowed us to shed light on which changes in transition rates are key in accounting for the decline in routine employment.

Our results show that the decline in routine occupations is mostly driven by a decrease in the share of RM occupations which is observed both in the formal and informal market. This implies that the process of technical change not only affects formal workers, but it also has displacement effects among informal workers. Formal workers employed in RM occupations are more likely to go out of the labour market or to start to work in the informal sector. This is suggesting that informality is used as a buffer against job loss for individuals working in routine occupations. Workers employed in RM informal occupations are more likely to become unemployed or to transit to NRM informal occupations. By contrast, the cognitive component of tasks performed by RC workers seems to offer relatively more protection against job displacement and occupational downgrading.

Furthermore, we find clear differences by gender. For instance, regarding workers in RM formal occupations, men are more likely to transit to RM informal occupations whereas women are more likely to become unemployed or inactive. Similarly, among individuals who work in RM informal occupations, women are more likely to become inactive than men. Our flow approach shows that the decrease in routine manual occupations can be explained mostly by an increase in outflows and a decrease in inflows from unemployment. Indeed, for formal routine manual occupations, outflows to unemployment and informality account for an important part of the decline. In the case of routine manual informal occupations, outflows to unemployment and to NRM informal occupations play an important role in the decrease of RM informal workers. These results suggest a process of displacement and occupational downgrading.

Our study contributes to shed light on the process by which routine employment is disappearing in a middle-income country context where the labour market is characterised by a higher prevalence of underemployment, informality and routine jobs. Our findings also help to better understand the changing labour market opportunities faced by different demographic groups and to identify vulnerable populations in order to better assist them in this fast changing job landscape.

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Appendix A. Construction of the Database

The data we use comes from the Social Protection Survey. This is a panel dataset currently comprised by six rounds starting in 2002/2003 up to 2015/2016 (see Table A.1). The first round of the survey is not representative of the Chilean population. However, the following rounds are representative of the Chilean population older than 18 years of age. The labour history section contains retrospective information on different labour market outcomes (employment status, occupational category, hours worked, and other) going back 1980. Indeed, workers are asked to recall their labour market history. This allows us to know the full labour market history of individuals since January 1980 to July 2016.

After cleaning each dataset round separately, we merge all rounds, except the round 2012.[4] During this merge, we detected several inconsistencies. We started by looking at inconsistencies between the starting date and the end dates of occupational statuses for each individual. We applied an iterative procedure to reduce these conflicts to zero. Generally, we identified the cases where the starting date of a status j_2 was earlier than the end date of the previous status j_1. In those cases, we substitute the starting date of status j_2 by the end date of status j_1. Then, we repeat the search for starting dates that are higher than end dates in the same observation. We ran 14 iterations until these conflicts disappear. In addition, when there is missing data between two occupational statuses, we impute the occupational status that is available in the last month before this missing information. We also make a distinction between formal and informal employment. Following Berniell et al. (2021), we define informal workers as: unregistered workers without access to social security benefits, workers with no explicit written contracts of employment, workers in temporary jobs, and low-skilled self-employment. Finally, we restrict our sample to individuals who are 15 to 65 years old. Our final database contains 27,359 observations spanning from January 1980 to July 2016.

[4] There were several problems with the sample design and fieldwork of the 2012 round (see Dirección de Estudios Previsionales (2012)) and the results are not representative of the Chilean population. Therefore we decided to exclude this round.

Table A.1. Description of the rounds of the panel

Round	Sample size	National representativeness	Number of observations	Recalling labour history since	Variables in labour history module used
2002/2003	17,246	No	76,061	(i) January 1980 (or since age 15)	(i) Start and end (month and year) of the corresponding employment status, (ii) Employment status, (iii) Occupation, (iv) Type of job, (v) Occupational category, (vi) Contractual relationship, (vi) Contributing to the pension system
2004/2005	16,727	Yes	29,896	(i) January 2002 if interviewed in 2002, (ii) January 1980 (or since age 15) if not interviewed in 2002 (new individuals entering the panel in 2004/05)	(i) Start and end (month and year) of the corresponding employment status, (ii) Employment status, (iii) Occupation, (iv) Type of job, (v) Occupational category, (vi) Contractual relationship, (vi) Contributing to the pension system
2006/2007	19,509	Yes	27,514	(i) January 2004 if interviewed in 2004/05 (ii) January 2002 if not interviewed in 2004/05	(i) Start and end (month and year) of the corresponding employment status, (ii) Employment status, (iii) Occupation, (iv) Type of job, (v) Occupational category, (vi) Contractual relationship, (vi) Contributing to the pension system
2008/2009	19,512	Yes	23,865	(i) January 2006	(i) Start and end (month and year) of the corresponding employment status, (ii) Employment status, (iii) Occupation, (iv) Type of job, (v) Occupational category, (vi) Contractual relationship, (vi) Contributing to the pension system
2012/2013	16,214	No	27,020	(i) January 2009	(i) Start and end (month and year) of the corresponding employment status, (ii) Employment status, (iii) Occupation, (iv) Type of job, (v) Occupational category, (vi) Contractual relationship, (vi) Contributing to the pension system
2015/2016	18,007	Yes	46,657	(i) January 2009 if individual belongs to the panel sample (ii) January 2001 (or since age 15) if individual belongs to the refreshed sample (new individuals entering the panel in 2015/16)	(i) Start and end (month and year) of the corresponding employment status, (ii) Employment status, (iii) Occupation, (iv) Type of job, (v) Occupational category, (vi) Contractual relationship, (vi) Contributing to the pension system

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: Based on information provided by Subsecretaría de Previsión Social of Chile and Berniell et al. (2021).

Appendix B. Additional Figures and Tables

Table B.1. Log-relative risks of transiting to different occupations for individuals employed in RM formal occupations

	No controls	With controls
Constant	0.001***	0.001***
Type x Period		
NRC formal x 1980-1990	0.154***	0.154***
NRC formal x 1990-2000	0.420***	0.320***
NRC formal x 2000-2010	0.797**	0.604***
NRC formal x 2010-2020	0.578***	0.379***
RC formal x 1980-1990	0.331***	0.331***
RC formal x 1990-2000	1.028	0.783***
RC formal x 2000-2010	1.322***	1.002
RC formal x 2010-2020	1.394**	0.913
NRM formal x 1980-1990	0.411***	0.411***
NRM formal x 1990-2000	1.074	0.817**
NRM formal x 2000-2010	1.663***	1.261***
NRM formal x 2010-2020	1.156	0.757
Unemployment x 1980-1990	1.702***	1.702***
Unemployment x 1990-2000	3.770***	2.871***
Unemployment x 2000-2010	4.751***	3.602***
Unemployment x 2010-2020	6.969***	4.565***
Inactivity x 1980-1990 (ref.)	1	1
Inactivity x 1990-2000	1.817***	1.384***
Inactivity x 2000-2010	1.478***	1.120
Inactivity x 2010-2020	3.059***	2.004***
NRC informal x 1980-1990	0.088***	0.088***
NRC informal x 1990-2000	0.181***	0.138***
NRC informal x 2000-2010	0.271***	0.206***
NRC informal x 2010-2020	0.272***	0.178***
RC informal x 1980-1990	0.117***	0.117***
RC informal x 1990-2000	0.356***	0.271***
RC informal x 2000-2010	0.381***	0.289***
RC informal x 2010-2020	0.850	0.557***
RM informal x 1980-1990	1.499***	1.499***
RM informal x 1990-2000	3.117***	2.374***
RM informal x 2000-2010	3.758***	2.849***
RM informal x 2010-2020	2.923***	1.915***
NRM informal x 1980-1990	0.285***	0.285***
NRM informal x 1990-2000	0.614***	0.468***
NRM informal x 2000-2010	0.999	0.757***
NRM informal x 2010-2020	1.088	0.713*
Gender		
Male (ref.)		1
Female		1.456***
Age group		
16-19 (ref.)		1
20-24		0.865***
25-29		0.697***
30-34		0.618***
35-39		0.617***
40-44		0.533***
45-49		0.476***
50-54		0.322***
55-59		0.297***
60+		0.074***
Time since in RM		
0-1 year (ref.)		1
1-3 years		1.272***
3-5 years		1.037
5-10 years		0.982
10+ years		1.419***
ln-L	-29080.62	-28649.426
N	345,078	345,087

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: this table presents the log-relative risks of transiting to different occupations for individuals employed in RM formal occupations.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.2. Log-relative risks of transiting to different occupations for individuals employed in RC formal occupations

	No controls	With controls
Constant	0.002***	0.003***
Type x Period		
NRC formal x 1980-1990	0.417***	0.417***
NRC formal x 1990-2000	0.878*	0.664***
NRC formal x 2000-2010	1.628***	1.185***
NRC formal x 2010-2020	0.787*	0.515***
RM formal x 1980-1990	0.217***	0.217***
RM formal x 1990-2000	0.474***	0.358***
RM formal x 2000-2010	0.696***	0.507***
RM formal x 2010-2020	0.684***	0.448***
NRM formal x 1980-1990	0.176***	0.176***
NRM formal x 1990-2000	0.360***	0.272***
NRM formal x 2000-2010	0.696***	0.507***
NRM formal x 2010-2020	0.525***	0.344***
Unemployment x 1980-1990	0.849***	0.849**
Unemployment x 1990-2000	2.130***	1.612***
Unemployment x 2000-2010	2.469***	1.797***
Unemployment x 2010-2020	4.345***	2.846***
Inactivity x 1980-1990 (ref.)	1	1
Inactivity x 1990-2000	1.673***	1.266***
Inactivity x 2000-2010	1.714***	1.248***
Inactivity x 2010-2020	4.197***	2.749***
NRC informal x 1980-1990	0.101***	0.101***
NRC informal x 1990-2000	0.169***	0.128***
NRC informal x 2000-2010	0.306***	0.223***
NRC informal x 2010-2020	0.365***	0.239***
RC informal x 1980-1990	0.340***	0.340***
RC informal x 1990-2000	0.726***	0.549***
RC informal x 2000-2010	0.860**	0.626***
RC informal x 2010-2020	1.254**	0.822*
RM informal x 1980-1990	0.162***	0.162***
RM informal x 1990-2000	0.238***	0.180***
RM informal x 2000-2010	0.341***	0.248***
RM informal x 2010-2020	0.376***	0.247***
NRM informal x 1980-1990	0.086***	0.086***
NRM informal x 1990-2000	0.186***	0.140***
NRM informal x 2000-2010	0.314***	0.229***
NRM informal x 2010-2020	0.502***	0.329***
Gender		
Male (ref.)		1
Female		0.933***
Age group		
16-19 (ref.)		1
20-24		0.894***
25-29		0.697***
30-34		0.606***
35-39		0.536***
40-44		0.477***
45-49		0.419***
50-54		0.314***
55-59		0.243***
60+		0.093***
Time since in RC		
0-1 year (ref.)		1
1-3 years		1.236***
3-5 years		1.038
5-10 years		0.965
10+ years		1.348***
ln-L	-34083.032	-33737.856
N	359,874	359,874

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: this table presents the log-relative risks of transiting to different occupations for individuals employed in RC formal occupations.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.3. Log-relative risks of transiting to different occupations for individuals employed in NRM formal occupations

	No controls	With controls
Constant	0.002***	0.004***
Type x Period		
NRC formal x 1980-1990	0.043***	0.043***
NRC formal x 1990-2000	0.141***	0.102***
NRC formal x 2000-2010	0.281***	0.192***
NRC formal x 2010-2020	0.279***	0.161***
RC formal x 1980-1990	0.291***	0.291***
RC formal x 1990-2000	0.966	0.701***
RC formal x 2000-2010	1.329***	0.905
RC formal x 2010-2020	1.268	0.730**
RM formal x 1980-1990	0.509***	0.509***
RM formal x 1990-2000	0.984	0.715***
RM formal x 2000-2010	1.426***	0.972
RM formal x 2010-2020	1.091	0.628***
Unemployment x 1980-1990	0.936	0.936
Unemployment x 1990-2000	2.500***	1.815***
Unemployment x 2000-2010	2.678***	1.824***
Unemployment x 2010-2020	3.576***	2.059***
Inactivity x 1980-1990 (ref.)	1	1
Inactivity x 1990-2000	1.748***	1.269***
Inactivity x 2000-2010	1.373***	0.935
Inactivity x 2010-2020	2.790***	1.606***
NRC informal x 1980-1990	0.028***	0.028***
NRC informal x 1990-2000	0.079***	0.058***
NRC informal x 2000-2010	0.053***	0.036***
NRC informal x 2010-2020	0.203***	0.117***
RC informal x 1980-1990	0.107***	0.107***
RC informal x 1990-2000	0.269***	0.195***
RC informal x 2000-2010	0.354***	0.241***
RC informal x 2010-2020	0.634***	0.365***
RM informal x 1980-1990	0.273***	0.273***
RM informal x 1990-2000	0.605***	0.439***
RM informal x 2000-2010	0.864	0.588***
RM informal x 2010-2020	0.507***	0.292***
NRM informal x 1980-1990	0.479***	0.479***
NRM informal x 1990-2000	1.173*	0.852*
NRM informal x 2000-2010	1.553***	1.057
NRM informal x 2010-2020	1.674***	0.964
Gender		
Male (ref.)		1
Female		0.965
Age group		
16-19 (ref.)		1
20-24		0.815***
25-29		0.605***
30-34		0.510***
35-39		0.503***
40-44		372***
45-49		0.399***
50-54		0.288***
55-59		0.194***
60+		0.61***
Time since in NRM		
0-1 year (ref.)		1
1-3 years		1.221***
3-5 years		0.960
5-10 years		0.877***
10+ years		1.343***
ln-L	-20319.964	-19936.021
N	203,742	203,742

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: this table presents the log-relative risks of transiting to different occupations for individuals employed in NRM formal occupations.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.4. Log-relative risks of transiting to different occupations for individuals employed in NRC formal occupations

	No controls	With controls
Constant	0.001***	0.001***
Type x Period		
RC formal x 1980-1990	0.690***	0.690***
RC formal x 1990-2000	2.211***	1.783***
RC formal x 2000-2010	3.897***	3.034***
RC formal x 2010-2020	1.481**	1.048
RM formal x 1980-1990	0.157***	0.157***
RM formal x 1990-2000	0.489***	0.394***
RM formal x 2000-2010	1.109	0.863
RM formal x 2010-2020	0.535**	0.378***
NRM formal x 1980-1990	0.055***	0.055***
NRM formal x 1990-2000	0.074***	0.060***
NRM formal x 2000-2010	0.348***	0.271***
NRM formal x 2010-2020	0.288***	0.204***
Unemployment x 1980-1990	0.675***	0.675***
Unemployment x 1990-2000	2.360***	1.903***
Unemployment x 2000-2010	2.524***	1.965***
Unemployment x 2010-2020	5.018***	3.551***
Inactivity x 1980-1990 (ref.)	1	1
Inactivity x 1990-2000	1.520***	1.226*
Inactivity x 2000-2010	1.779***	1.385***
Inactivity x 2010-2020	3.702***	2.620***
NRC informal x 1980-1990	0.667***	0.667***
NRC informal x 1990-2000	1.361***	1.098
NRC informal x 2000-2010	1.448***	1.127
NRC informal x 2010-2020	1.686***	1.193
RC informal x 1980-1990	0.133***	0.133***
RC informal x 1990-2000	0.393***	0.317***
RC informal x 2000-2010	0.488***	0.380***
RC informal x 2010-2020	0.494**	0.349***
RM informal x 1980-1990	0.118***	0.118***
RM informal x 1990-2000	0.308***	0.249***
RM informal x 2000-2010	0.439***	0.341***
RM informal x 2010-2020	0.411***	0.291***
NRM informal x 1980-1990	0.055***	0.055***
NRM informal x 1990-2000	0.149***	0.120***
NRM informal x 2000-2010	0.273***	0.213***
NRM informal x 2010-2020	0.206***	0.146***
Gender		
Male (ref.)		1
Female		0.921**
Age group		
16-19 (ref.)		1
20-24		0.923*
25-29		0.870**
30-34		0.866**
35-39		0.723***
40-44		0.680***
45-49		0.495***
50-54		0.509***
55-59		0.367***
60+		0.133***
Time since in NRC		
0-1 year (ref.)		1
1-3 years		1.492***
3-5 years		0.975
5-10 years		0.854**
10+ years		1.442***
ln-L	-14236.41	-14075.459
N	207,639	207,639

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: this table presents the log-relative risks of transiting to different occupations for individuals employed in NRC formal occupations.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.5. Log-relative risks of transiting to different occupations for individuals employed in RM informal occupations

	No controls	With controls
Constant	0.002***	0.006***
Type x Period		
NRC formal x 1980-1990	0.042***	0.042***
NRC formal x 1990-2000	0.184***	0.110***
NRC formal x 2000-2010	0.263***	0.131***
NRC formal x 2010-2020	0.307***	0.109***
RC formal x 1980-1990	0.179***	0.179***
RC formal x 1990-2000	0.489***	0.292***
RC formal x 2000-2010	0.571***	0.284***
RC formal x 2010-2020	1.199	0.426***
RM formal x 1980-1990	0.984	0.984
RM formal x 1990-2000	2.452***	1.462***
RM formal x 2000-2010	3.471***	1.724***
RM formal x 2010-2020	3.935***	1.397***
NRM formal x 1980-1990	0.230***	0.230***
NRM formal x 1990-2000	0.547***	0.326***
NRM formal x 2000-2010	0.701***	0.348***
NRM formal x 2010-2020	0.769	0.273***
Unemployment x 1980-1990	1.714***	1.714***
Unemployment x 1990-2000	5.451***	3.250***
Unemployment x 2000-2010	8.608***	4.275***
Unemployment x 2010-2020	11.283***	4.005***
Inactivity x 1980-1990 (ref.)	1	1
Inactivity x 1990-2000	3.131***	1.866***
Inactivity x 2000-2010	3.374***	1.676***
Inactivity x 2010-2020	6.917***	2.455***
NRC informal x 1980-1990	0.113***	0.113***
NRC informal x 1990-2000	0.300***	0.179***
NRC informal x 2000-2010	0.421***	0.209***
NRC informal x 2010-2020	0.523***	0.186***
RC informal x 1980-1990	0.179***	0.179***
RC informal x 1990-2000	0.474***	0.282***
RC informal x 2000-2010	0.506***	0.251***
RC informal x 2010-2020	1.506***	0.535***
NRM informal x 1980-1990	0.554***	0.554***
NRM informal x 1990-2000	1.400***	0.834***
NRM informal x 2000-2010	2.564***	1.273***
NRM informal x 2010-2020	3.751***	1.331**
Gender		
Male (ref.)		1
Female		1.756***
Age group		
16-19 (ref.)		1
20-24		0.811***
25-29		0.651***
30-34		0.602***
35-39		0.561***
40-44		0.527***
45-49		0.379***
50-54		0.312***
55-59		0.173***
60+		0.051***
Time since in RM		
0-1 year (ref.)		1
1-3 years		0.482***
3-5 years		0.317***
5-10 years		0.268***
10+ years		0.417***
ln-L	-44900.702	-42267.548
N	330,381	330,381

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: this table presents the log-relative risks of transiting to different occupations for individuals employed in RM informal occupations.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.6. Log-relative risks of transiting to different occupations for individuals employed in RC informal occupations

	No controls	With controls
Constant	0.003***	0.011***
Type x Period		
NRC formal x 1980-1990	0.096***	0.096***
NRC formal x 1990-2000	0.241***	0.148***
NRC formal x 2000-2010	0.368***	0.198***
NRC formal x 2010-2020	0.439***	0.171***
RC formal x 1980-1990	0.617***	0.617***
RC formal x 1990-2000	1.724***	1.058
RC formal x 2000-2010	1.820***	0.982
RC formal x 2010-2020	2.180***	0.982
RM formal x 1980-1990	0.220***	0.220***
RM formal x 1990-2000	0.282***	0.173***
RM formal x 2000-2010	0.284***	0.153***
RM formal x 2010-2020	0.258***	0.101***
NRM formal x 1980-1990	0.115***	0.115***
NRM formal x 1990-2000	0.262***	0.161***
NRM formal x 2000-2010	0.414***	0.224***
NRM formal x 2010-2020	0.361***	0.141***
Unemployment x 1980-1990	0.724***	0.724***
Unemployment x 1990-2000	2.319***	1.424***
Unemployment x 2000-2010	3.247***	1.752***
Unemployment x 2010-2020	5.522***	2.159***
Inactivity x 1980-1990 (ref.)	1	1
Inactivity x 1990-2000	3.094***	1.899***
Inactivity x 2000-2010	3.215***	1.735***
Inactivity x 2010-2020	9.470***	3.702***
NRC informal x 1980-1990	0.161***	0.161***
NRC informal x 1990-2000	0.292***	0.180***
NRC informal x 2000-2010	0.804**	0.434***
NRC informal x 2010-2020	0.697**	0.272***
RM informal x 1980-1990	0.242***	0.242***
RM informal x 1990-2000	0.390***	0.239***
RM informal x 2000-2010	0.555***	0.299***
RM informal x 2010-2020	0.645***	0.252***
NRM informal x 1980-1990	0.301***	0.301***
NRM informal x 1990-2000	0.452***	0.277***
NRM informal x 2000-2010	0.757***	0.409***
NRM informal x 2010-2020	1.213	0.474***
Gender		
Male (ref.)		1
Female		1.015
Age group		
16-19 (ref.)		1
20-24		0.728***
25-29		0.580***
30-34		0.460***
35-39		0.479***
40-44		0.395***
45-49		0.299***
50-54		0.214***
55-59		0.137***
60+		0.053***
Time since in RC		
0-1 year (ref.)		1
1-3 years		0.563***
3-5 years		0.435***
5-10 years		0.343***
10+ years		0.438***
ln-L	-31351.122	-30056.119
N	186,066	186,066

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: this table presents the log-relative risks of transiting to different occupations for individuals employed in RC informal occupations.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.7. Log-relative risks of transiting to different occupations for individuals employed in NRM informal occupations

	No controls	With controls
Constant	0.004***	0.017***
Type x Period		
NRC formal x 1980-1990	0.013***	0.013***
NRC formal x 1990-2000	0.019***	0.011***
NRC formal x 2000-2010	0.043***	0.022***
NRC formal x 2010-2020	0.182***	0.064***
RC formal x 1980-1990	0.104***	0.104***
RC formal x 1990-2000	0.229***	0.130***
RC formal x 2000-2010	0.260***	0.134***
RC formal x 2010-2020	0.756**	0.265***
RM formal x 1980-1990	0.157***	0.157***
RM formal x 1990-2000	0.281***	0.159***
RM formal x 2000-2010	0.441***	0.228***
RM formal x 2010-2020	0.431***	0.151***
NRM formal x 1980-1990	0.253***	0.253***
NRM formal x 1990-2000	0.513***	0.290***
NRM formal x 2000-2010	0.775***	0.400***
NRM formal x 2010-2020	0.613***	0.214***
Unemployment x 1980-1990	1.028	1.028
Unemployment x 1990-2000	2.987***	1.690***
Unemployment x 2000-2010	3.471***	1.790***
Unemployment x 2010-2020	5.418***	1.897***
Inactivity x 1980-1990 (ref.)	1	1
Inactivity x 1990-2000	2.635***	1.491***
Inactivity x 2000-2010	2.063***	1.064
Inactivity x 2010-2020	6.126***	2.145***
NRC informal x 1980-1990	0.020***	0.020***
NRC informal x 1990-2000	0.065***	0.037***
NRC informal x 2000-2010	0.090***	0.046***
NRC informal x 2010-2020	0.201***	0.070***
RC informal x 1980-1990	0.134***	0.134***
RC informal x 1990-2000	0.348***	0.197***
RC informal x 2000-2010	0.419***	0.216***
RC informal x 2010-2020	0.871	0.305***
RM informal x 1980-1990	0.308***	0.308***
RM informal x 1990-2000	0.703***	0.398***
RM informal x 2000-2010	0.938	0.484***
RM informal x 2010-2020	1.120	0.392***
Gender		
Male (ref.)		1
Female		1.167***
Age group		
16-19 (ref.)		1
20-24		0.740***
25-29		0.626***
30-34		0.633***
35-39		0.591***
40-44		0.513***
45-49		0.367***
50-54		0.255***
55-59		0.161***
60+		0.023***
Time since in NRM		
0-1 year (ref.)		1
1-3 years		0.432***
3-5 years		0.295***
5-10 years		0.217***
10+ years		0.277***
ln-L	-44669.118	-41820.392
N	269,379	269,379

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: this table presents the log-relative risks of transiting to different occupations for individuals employed in NRM informal occupations.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.8. Log-relative risks of transiting to different occupations for individuals employed in NRC informal occupations

	No controls	With controls
Constant	0.001***	0.004***
Type x Period		
NRC formal x 1980-1990	1.573***	1.573***
NRC formal x 1990-2000	3.840***	2.600***
NRC formal x 2000-2010	4.597***	2.516***
NRC formal x 2010-2020	4.894***	1.987***
RC formal x 1980-1990	0.393***	0.393***
RC formal x 1990-2000	1.040	0.704*
RC formal x 2000-2010	1.762***	0.964
RC formal x 2010-2020	2.141***	0.869
RM formal x 1980-1990	0.191***	0.191***
RM formal x 1990-2000	0.552**	0.373***
RM formal x 2000-2010	0.757	0.414***
RM formal x 2010-2020	0.551*	0.224***
NRM formal x 1980-1990	0.067***	0.067***
NRM formal x 1990-2000	0.106***	0.072***
NRM formal x 2000-2010	0.262***	0.143***
NRM formal x 2010-2020	0.551*	0.224***
Unemployment x 1980-1990	0.820	0.820
Unemployment x 1990-2000	2.631***	1.781***
Unemployment x 2000-2010	5.437***	2.976***
Unemployment x 2010-2020	12.052***	4.894***
Inactivity x 1980-1990 (ref.)	1	1
Inactivity x 1990-2000	3.119***	2.111***
Inactivity x 2000-2010	4.694***	2.569***
Inactivity x 2010-2020	11.990***	4.869***
RC informal x 1980-1990	0.652**	0.652**
RC informal x 1990-2000	1.230	0.833
RC informal x 2000-2010	2.326***	1.273
RC informal x 2010-2020	2.141***	0.869
RM informal x 1980-1990	0.517***	0.517***
RM informal x 1990-2000	0.997	0.675**
RM informal x 2000-2010	1.363*	0.746*
RM informal x 2010-2020	1.101	0.447***
NRM informal x 1980-1990	0.146***	0.146***
NRM informal x 1990-2000	0.361***	0.244***
NRM informal x 2000-2010	0.551***	0.301***
NRM informal x 2010-2020	0.612	0.248***
Gender		
Male (ref.)		1
Female		1.178***
Age group		
16-19 (ref.)		1
20-24		0.939
25-29		0.701***
30-34		0.526***
35-39		0.555***
40-44		0.470***
45-49		0.410***
50-54		0.337***
55-59		0.197***
60+		0.032***
Time since in NRC		
0-1 year (ref.)		1
1-3 years		0.626***
3-5 years		0.370***
5-10 years		0.336***
10+ years		0.638***
ln-L	-13122.985	-12685.088
N	97,506	97,506

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: this table presents the log-relative risks of transiting to different occupations for individuals employed in NRC informal occupations.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.9. Log-relative risks of transiting to different occupations for individuals who are out of employment

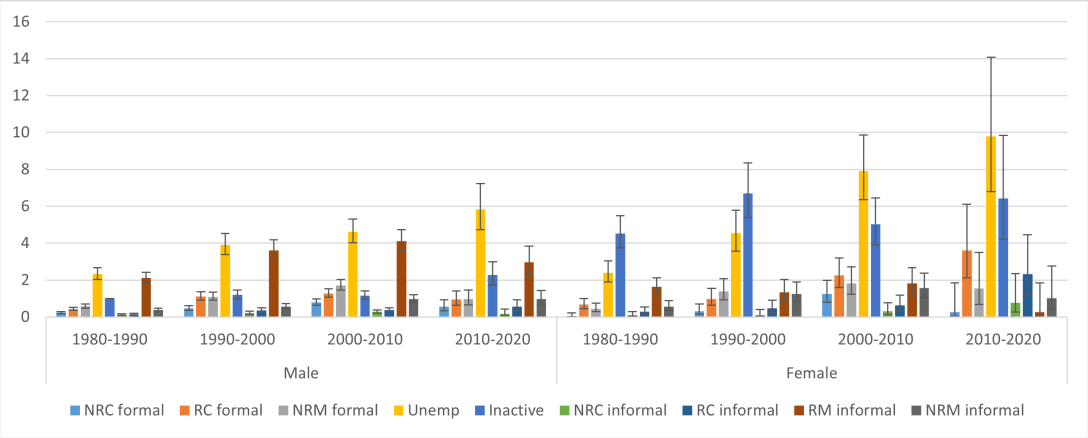
	No controls	With controls
Constant	0.001***	0.001***
Type x Period		
NRC formal x 1980-1990 (ref.)	1	1
NRC formal x 1990-2000	2.159***	1.209***
NRC formal x 2000-2010	2.312***	1.179***
NRC formal x 2010-2020	3.699***	1.436***
RC formal x 1980-1990	2.047***	2.047***
RC formal x 1990-2000	6.447***	3.611***
RC formal x 2000-2010	5.403***	2.755***
RC formal x 2010-2020	9.652***	3.747***
RM formal x 1980-1990	1.598***	1.598***
RM formal x 1990-2000	3.991***	2.236***
RM formal x 2000-2010	3.755***	1.914***
RM formal x 2010-2020	4.346***	1.687***
NRM formal x 1980-1990	1.184***	1.184***
NRM formal x 1990-2000	2.795***	1.566***
NRM formal x 2000-2010	2.600***	1.326***
NRM formal x 2010-2020	3.400***	1.320***
Unemployment x 1980-1990	1.591***	1.591***
Unemployment x 1990-2000	3.855***	2.160***
Unemployment x 2000-2010	2.943***	1.500***
Unemployment x 2010-2020	1.507***	0.585***
Inactivity x 1980-1990	0.270***	0.270***
Inactivity x 1990-2000	0.954	0.535***
Inactivity x 2000-2010	2.425***	1.236***
Inactivity x 2010-2020	0.673***	0.261***
NRC informal x 1980-1990	0.616***	0.616***
NRC informal x 1990-2000	1.815***	1.017
NRC informal x 2000-2010	2.608***	1.330***
NRC informal x 2010-2020	4.620***	1.794***
RC informal x 1980-1990	1.597***	1.597***
RC informal x 1990-2000	5.505***	3.084***
RC informal x 2000-2010	6.490***	3.308***
RC informal x 2010-2020	11.894***	4.617***
RM informal x 1980-1990	2.384***	2.384***
RM informal x 1990-2000	7.185***	4.025***
RM informal x 2000-2010	8.851***	4.512***
RM informal x 2010-2020	7.672***	2.978***
NRM informal x 1980-1990	3.148***	3.148***
NRM informal x 1990-2000	9.632***	5.396***
NRM informal x 2000-2010	10.491***	5.348***
NRM informal x 2010-2020	13.812***	5.362***
Gender		
Male (ref.)		1
Female		0.641***
Age group		
16-19 (ref.)		1
20-24		0.797***
25-29		0.775***
30-34		0.741***
35-39		0.589***
40-44		0.441***
45-49		0.308***
50-54		0.183***
55-59		0.090***
60+		0.017***
Time since out of employment		
0-1 year (ref.)		1
1-3 years		0.404***
3-5 years		0.446***
5-10 years		0.353***
10+ years		0.329***
ln-L	-184571.44	-174321.91
N	1,292,770	1,292,770

Source: Social Protection Survey of Chile, authors' own calculations.

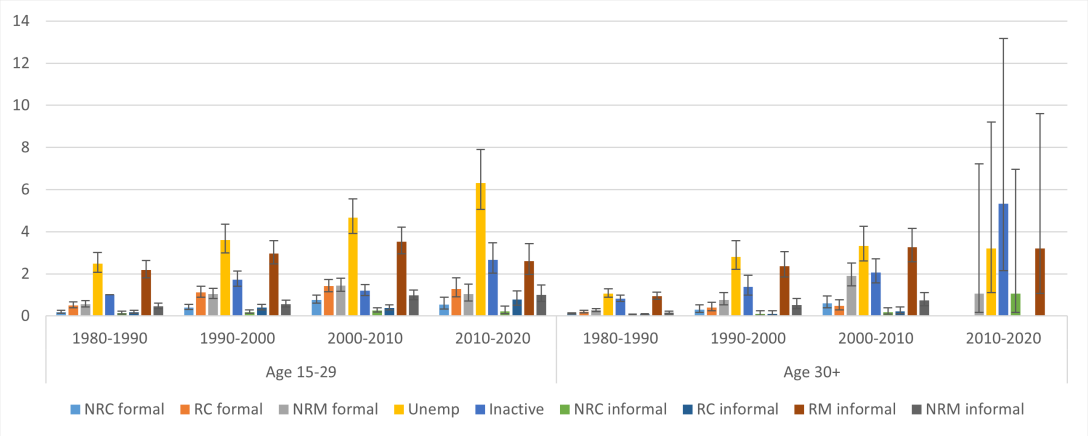
Notes: this table presents the log-relative risks of transiting to different occupations for individuals who are out of employment.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure B.1. Relative risks of a transition by type of transition over time for RM formal workers



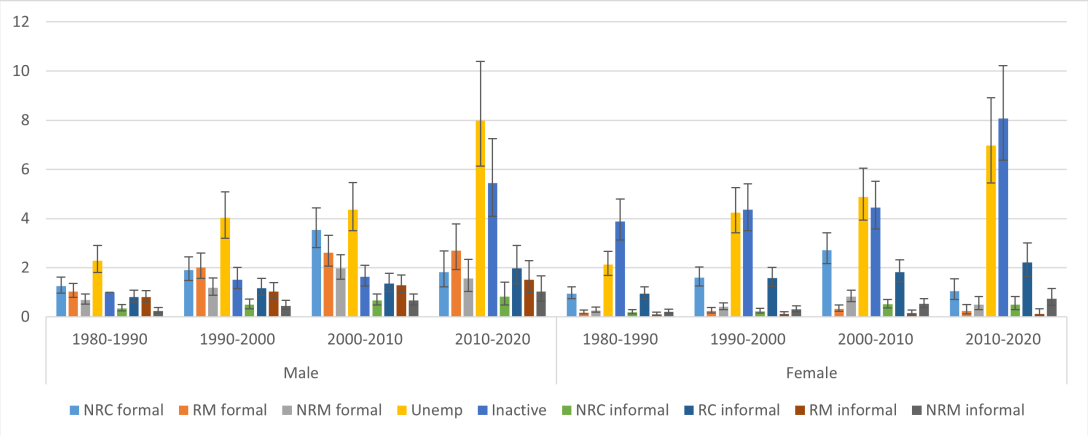
(a) By gender



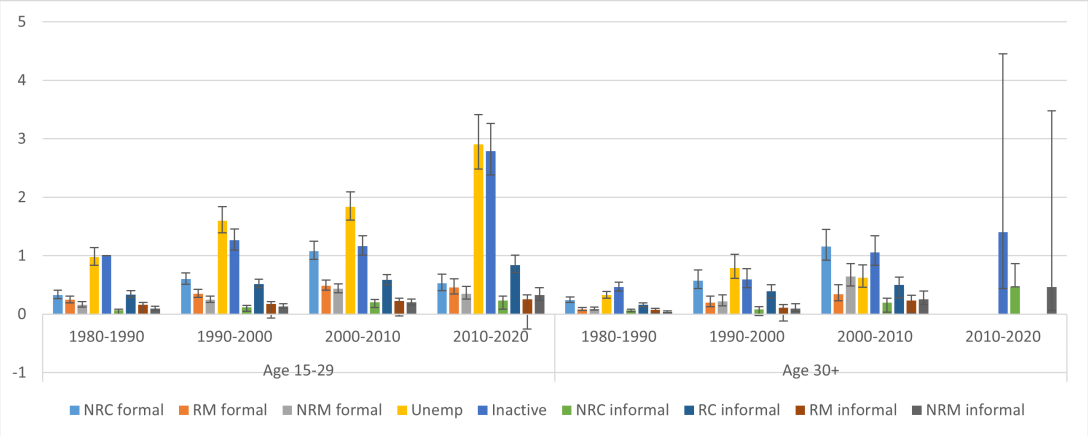
(b) By age group

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition over time for RM formal workers: a) by type of transition and gender, and b) by type of transition and age group. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported. Some categories may be missing due to limited sample size.

Figure B.2. Relative risks of a transition by type of transition over time for RC formal workers



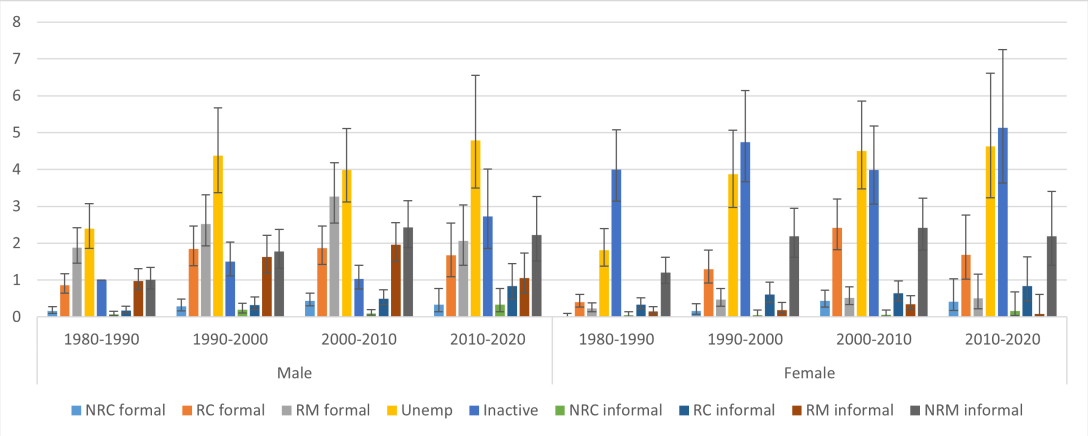
(a) By gender



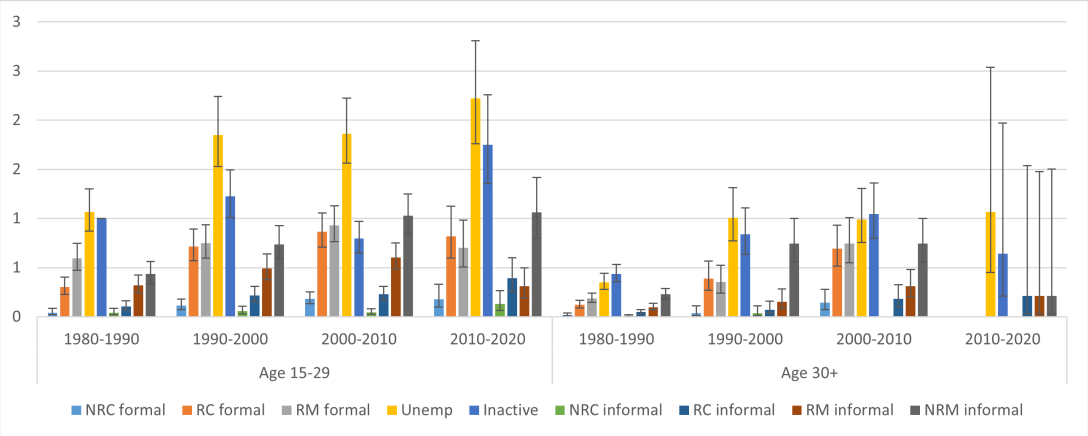
(b) By age group

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition over time for RC formal workers: a) by type of transition and gender, and b) by type of transition and age group. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported. Some categories may be missing due to limited sample size.

Figure B.3. Relative risks of a transition by type of transition over time for NRM formal workers



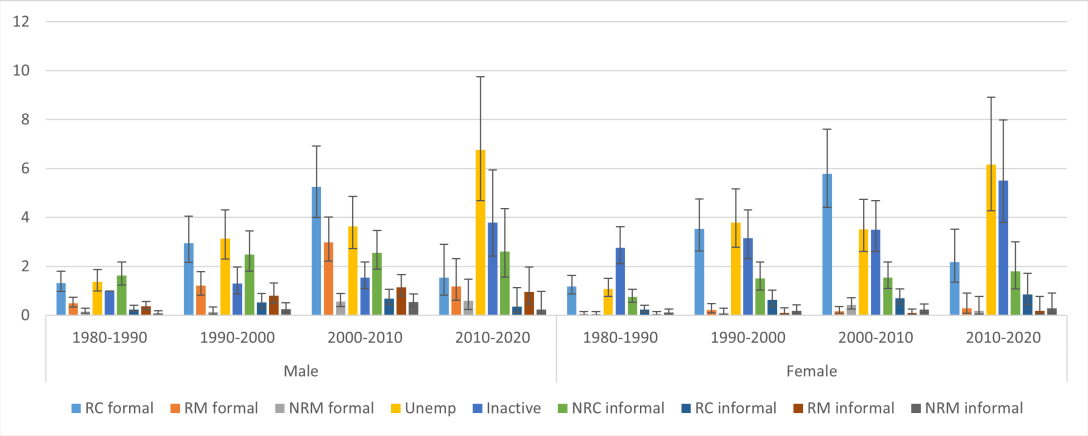
(a) By gender



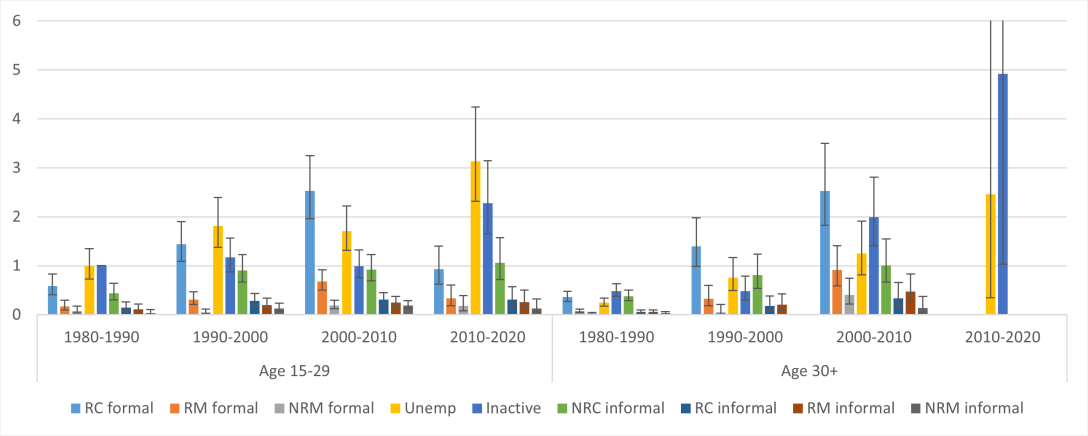
(b) By age group

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition over time for NRM formal workers: a) by type of transition and gender, and b) by type of transition and age group. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported. Some categories may be missing due to limited sample size.

Figure B.4. Relative risks of a transition by type of transition over time for formal NRC workers



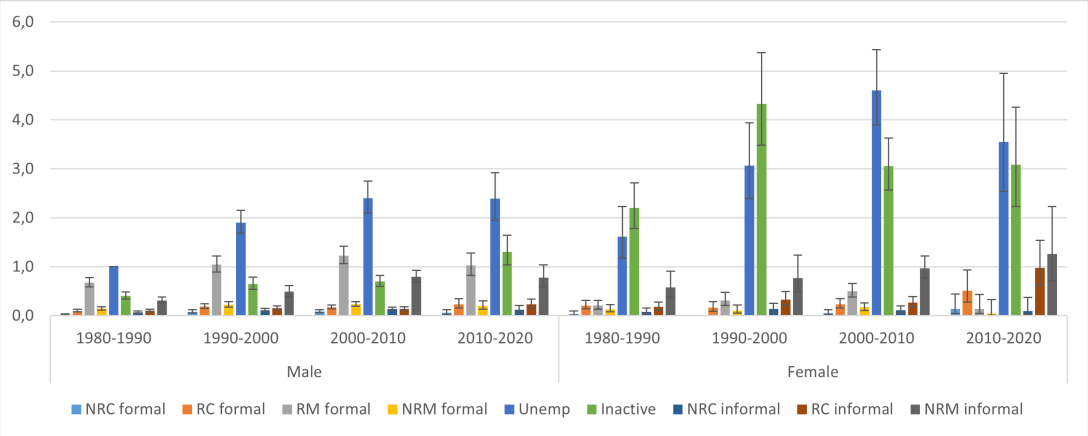
(a) By gender



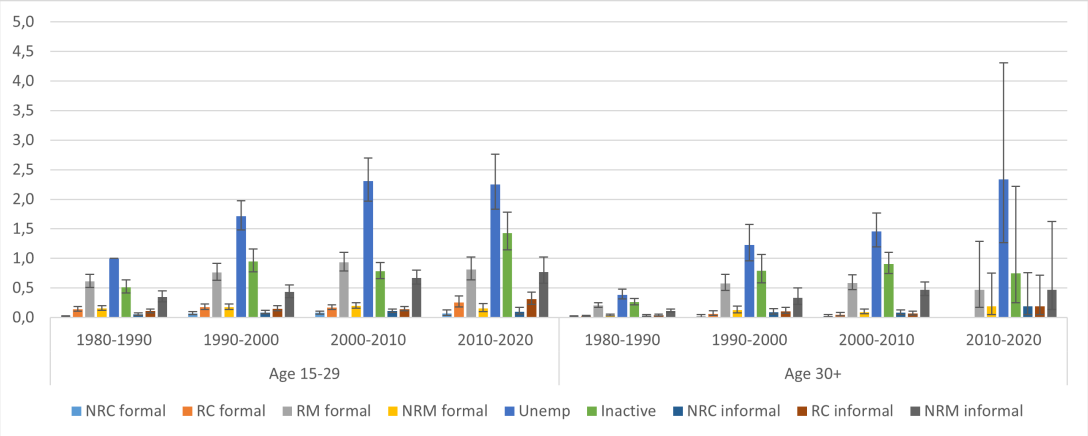
(b) By age group

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition over time for NRC formal workers: a) by type of transition and gender, and b) by type of transition and age group. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported. Some categories may be missing due to limited sample size.

Figure B.5. Relative risks of a transition by type of transition over time for RM informal workers



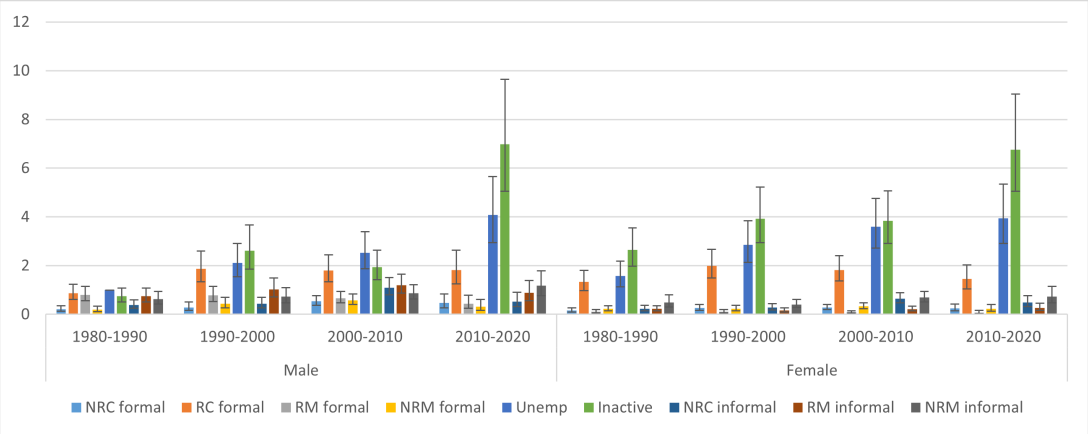
(a) By gender



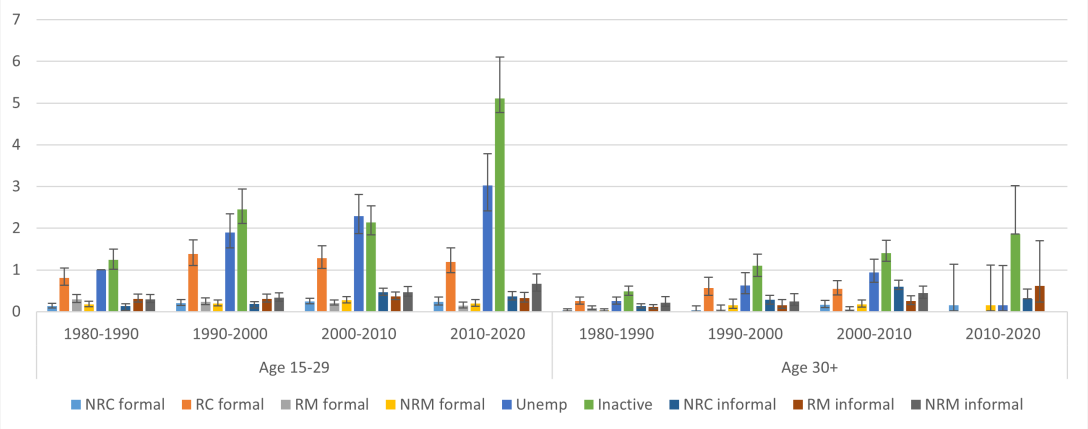
(b) By age group

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition over time for RM informal workers: a) by type of transition and gender, and b) by type of transition and age group. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported. Some categories may be missing due to limited sample size.

Figure B.6. Relative risks of a transition by type of transition over time for RC informal workers



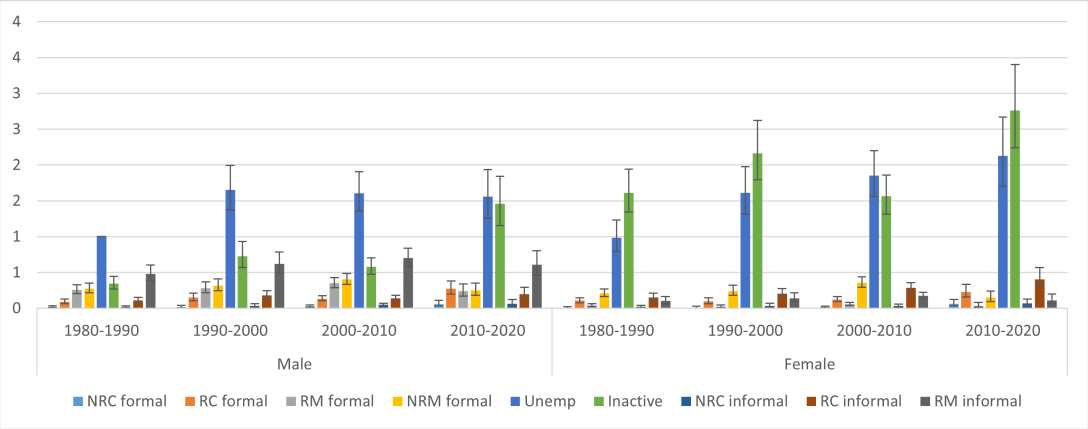
(a) By gender



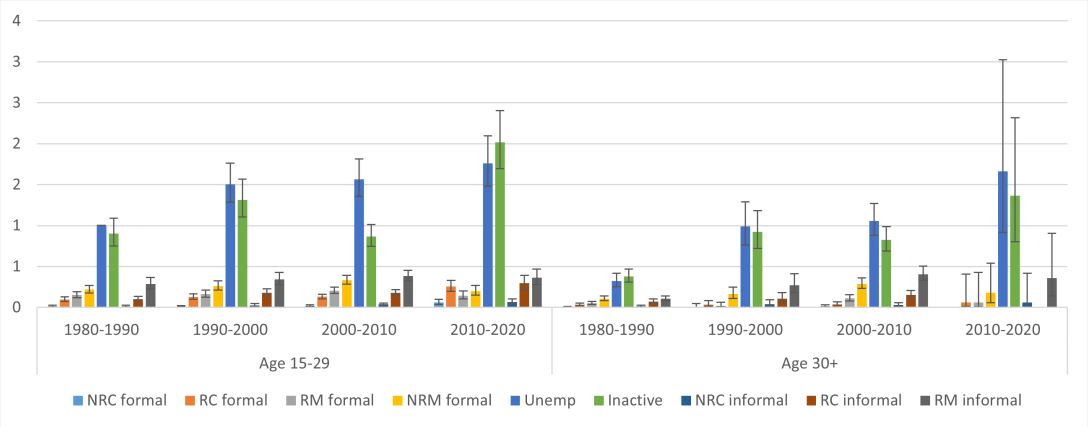
(b) By age group

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition over time for RC informal workers: a) by type of transition and gender, and b) by type of transition and age group. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported. Some categories may be missing due to limited sample size.

Figure B.7. Relative risks of a transition by type of transition over time for NRM informal workers



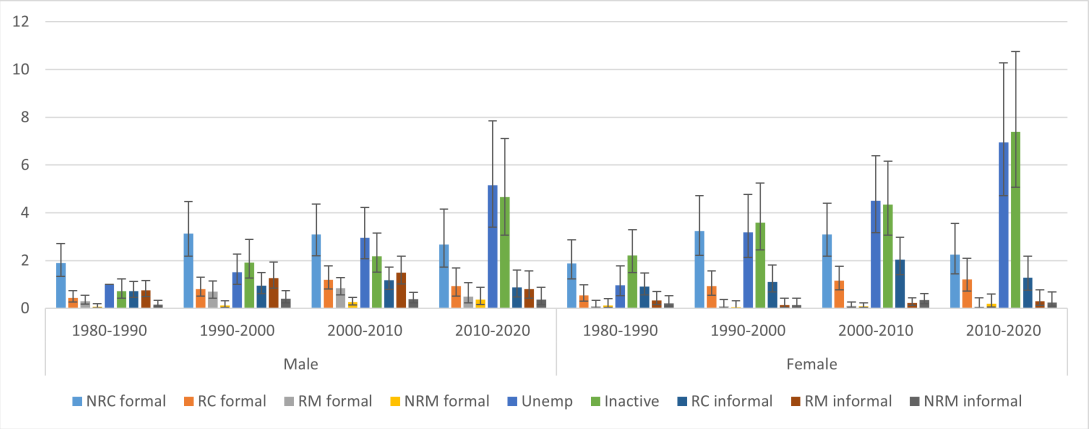
(a) By gender



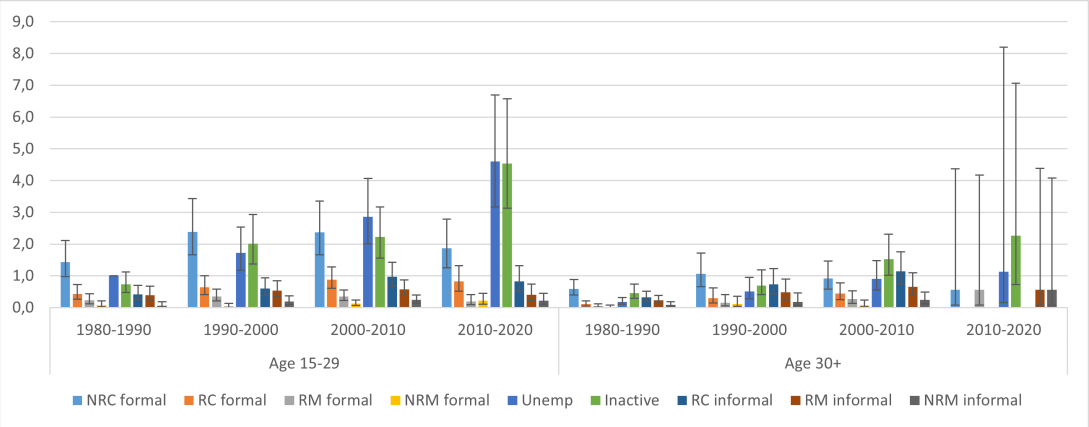
(b) By age group

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition over time for NRM informal workers: a) by type of transition and gender, and b) by type of transition and age group. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported. Some categories may be missing due to limited sample size.

Figure B.8. Relative risks of a transition by type of transition over time for NRC informal workers



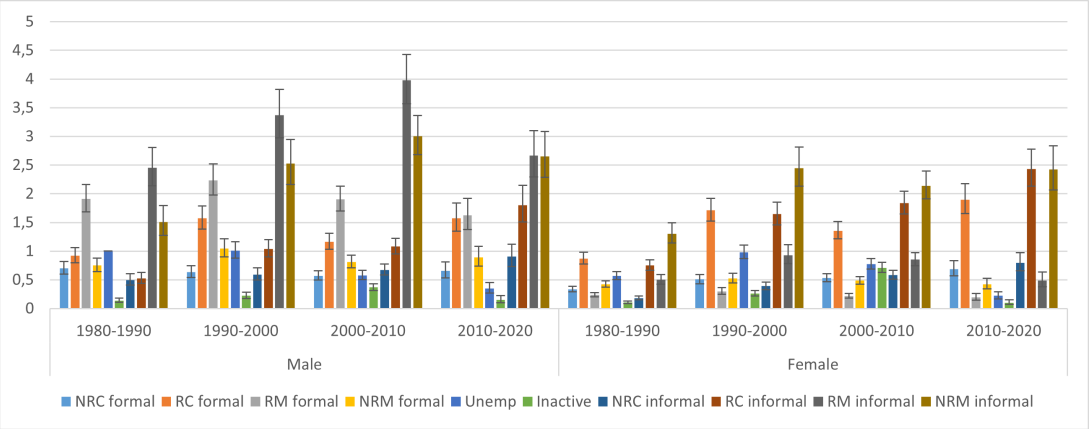
(a) By gender



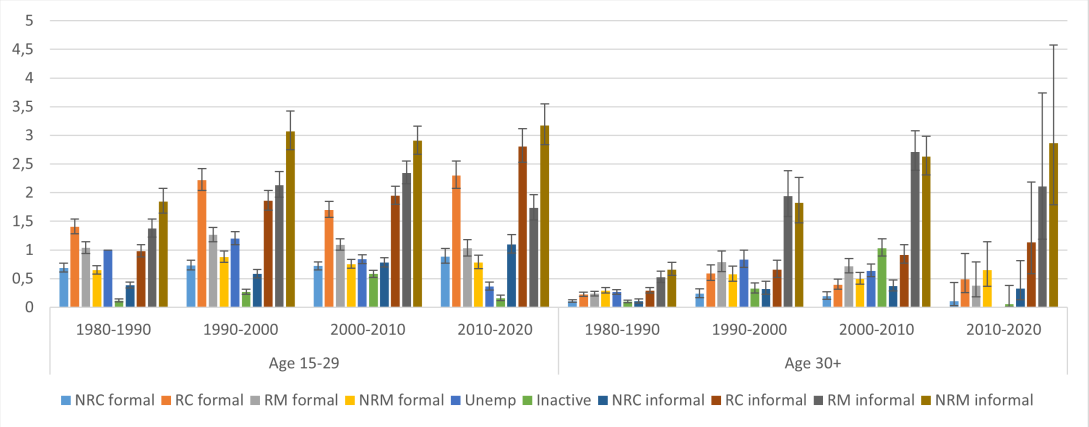
(b) By age group

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition over time for NRC informal workers: a) by type of transition and gender, and b) by type of transition and age group. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to inactivity in the 1980s. 95% confidence intervals are also reported. Some categories may be missing due to limited sample size.

Figure B.9. Relative risks of a transition by type of transition over time for individuals who are out of employment



(a) By gender



(b) By age group

Source: Social Protection Survey of Chile, authors' own calculations.
Notes: The figure presents the relative risks of a transition over time for individuals who are out of employment: a) by type of transition and gender, and b) by type of transition and age group. All the models are adjusted for gender, age, and time spent in the initial state. The reference category is transiting to NRC formal occupations in the 1980s. 95% confidence intervals are also reported. Some categories may be missing due to limited sample size.