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Social security schemes and labor supply in the formal and informal sectors

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Resumen

Este trabajo analiza cómo los cambios en el régimen de seguridad social afectan a la trayectoria de los trabajadores entre los sectores formal e informal. La elección entre sectores es completamente voluntaria, las personas construyen sus senderos de decisión en el mercado laboral en función del programa de pensiones y su dotación de capital humano. Se construye un modelo de decisión discreta en tiempo finito que es estimaron los datos del panel de hogares de Argentina en el período 1995-201, y se evalúan cambios en el comportamiento de los trabajadores cuando se cambia el esquema de pensiones. Entre los principales resultados, en primer lugar, si se fijan los parámetros a fin de replicar un sistema de reparto, hay una ligera reducción en los años de formalidad y en el porcentaje de trabajadores que obtienen una pensión completa. Por otra parte, si se aumenta la exigencia de obtener una pensión completa de 30 a 35 años de la formalidad, aumenta el porcentaje de trabajadores de más de 45 años en la formalidad y el número de los años de trabajo formal, pero disminuye la obtención de una pensión en todos los niveles educativos. La disminución de los requerimientos para obtener una pensión tiene un efecto sobre la reducción del número de años en la formalidad, aun para aquellos que no están directamente afectados (la parte alta de la distribución de la alta educada). Por último, si la edad mínima para lograr una pensión es ahora 67 en lugar de 65, existe un incremento importante en la formalidad y de aquellos que obtienen una pensión completa, especialmente en el caso de los trabajadores poco educados.

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Abstract

This paper analyzes how changes in the social security scheme affect the participation path of workers between the formal and the informal sectors. The choice between the formal and informal sectors is completely voluntary. In this framework, individuals, depending on the retirement program and their endowment of human capital, construct their decision paths in the labor market. I use Argentinean panel data from the period 1995-2011 to estimate a structural model, and this is used to evaluate changes in the workers' behavior when the pension scheme changes. Among the main results, if the parameters are fixed as in the PAYG, there is a slight reduction in the years of the formality and the percentage of workers who achieve a full pension. Moreover, the increase of the requirement to achieve a full pension to 35 years in the formality, increases the percentage of workers in formality over 45 and the number of the years working formally but it decreases the achievement of a pension at all educational levels. The decrease of that requirement has an effect on the reduction of the years in formality even for those who are not affected directly, the high part of the distribution of the high educated. Finally, if the minimum age to achieve a pension is now 67 instead of 65, there is an important increment in the formality and the full pension achievement especially for the low educated workers.

1. Introduction

Informality defined as the lack of social security contributions is one of the main characteristics of the labor markets in developing countries. This feature not only has an impact on the current situation of the workers not receiving benefits such as health insurance, unemployment insurance or extra payments, but it also affects access to the pension system for the elderly. This paper discusses the impact of retirement scheme changes in the labor path between informality and formality and the pension achievement. I will explore the changes in the main variables of the current system, that is: i) number of years of contributing to the system; and ii) the minimum age, which are both requirements to obtain a pension. Furthermore, this paper deals with the reform of the pension system, from a mixed system where two pillars coexist: a pay-as-you-go (PAYG) system and an individual capitalization system to a new system with only one of those pillars. In order to summarize the different systems I take the rate of replacement as the main characteristic of each scheme, and the different types of pensions (full, advanced age or survival) into consideration.

Over the last few decades, in many developing countries several reforms in the pension scheme have been implemented, aiming to cover the increasing deficit of the public budget triggered by the advance of demographic transition. In South America, in 1975, there were 12.8 working age people (15-64) per each old individual (65 or more); this number fell to 11.4 in 2000 and the estimation for the few next years is an important fall, estimate to be 6.7 for 2025 and 3.7 for 2050 (United-Nations, 1999). This pattern is provoked not only by the rise in the life expectancy and survival rates, but also by the fall in birth rates.

Argentina is a special and interesting case because, on the one hand, it is in an advanced stage of demographic transition reaching the same levels as developed countries[1] and, on the other, the system has been the subject of several reforms in the last 20 years. The reform which was established in 1993, transformed a public PAYG with persistent and increasing deficits into a mixed system (PAYG and individual capitalization) in the retirement program in which private and public institutions coexist. This reform was triggered by the need to make the system sustainable. This reform and its consequences were studied in depth by the academia and discussed in the political environments during the last decade, and finally it was reformed in December 2008 to return only to a publicly funded PAYG system[2]. Despite this reform, the requirements to access a pension are still relatively strict in comparison with the region. However, the government carried out a Moratorium in an attempt to impulse the universal pension's coverage.

This Moratorium was introduced in 2007 as part of the Pension Inclusion Program[3] to include mainly women and self employed workers who have eligibility difficulties in the pension system (Bosch and Guajardo (2012), Bosch and Manacorda (2012)). In these papers the Moratorium has no effect given that self employed men and women are no included in the estimation, the former because of the lack of measurement through the household survey and the latter because their situation has many ingredients such as fertility and home production which are not included here.

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[1] As is shown in the Figure A.1, Argentina present an advance stage of the demographic transition even in the middle of the past century, and in the projection for 2015 is much closer to the high income countries.

[2] This reform was motivated in part due to the financial crisis after September 2008.

[3] The details can be seen Arza (2009).

Country	Mean	Male	Female
Uruguay	20.3	13.0	17.7
Chile	23.6	16.6	24.6
Argentina	36.1	27.0	35.5
Colombia	42.7	36.6	38.4
Ecuador	52.0	48.2	45.3
Mexico	55.5	50.5	47.0

Source: CELADES

Table 1: Informality (lack of pension rights) among salaried workers in LatinAmerica (2009)

Additionally, pension achievement has been in the academic and political discussion in the last two decades. The work record allows the agencies to properly enforce the requirements to achieve the pension, by checking the years in formality (contribution history). At the same time, those workers who either enter and exit from the formality repeatedly or are in informality for many years have great difficulties in achieving a pension. These workers in the past, even when they did not meet the requirements, were able to easily cheat the agencies through (false) witnesses[4]. Recently in the region[5], there were some reforms in order to relax the requirements (reducing the years of contribution, computing, in the case of women, the number of offspring as years of contribution).

Country	Low education	Medium education	High education
Uruguay	27.0	11.0	3.3
Chile	31.8	18.6	12.6
Argentina	51.6	32.0	14.4
Colombia	62.9	30.1	8.2
Ecuador	74.9	47.5	21.6
Mexico	73.9	43,6	24.6

Source: CELADES

Table 2: Informality Rates Among Salaried Workers by schooling level in 2009

The Argentinean program severely punishes short contribution careers in comparison with other countries of the region (Forteza and Ourens, 2009). Conversely, the program also has a wide promotion of extraordinary programs to allow access to specials pensions, for those who do not have enough years to have the right to either the full or the advanced age pension. Additionally, there has also been an increment in the level of the minimal pension in the last few years (Rofman et al., 2010). These changes have led to the idea that the pension system is an essential factor in the formality path, because the workers can believe that even if they are in the informality the government commitment to maintaining some requirement to access a pension will be relaxed (Forteza et al., 2009). Moreover, if the requirements to access a pension are too strict and only a small share of the population can enjoy it, the government will be forced either to change the rules or to create new types of pensions.

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[4] Note the practices are not viewed as a crime in many countries neither by the citizens nor the government.
[5] For example, in Uruguay, Chile or Colombia.

Holzmann and Takayama (2009) focus on the specific effect of some social transfers such as non-contributory pension in the great mobility between formality and informality. Latin America is one of the regions where informality has been studied in depth. There are about 50% of salaried workers who are employed informally, informal workers being defined as those who are not covered by labor regulation, such as taxes, right to health system and right to pension income in retirement age (Portes et al. (1989), Schneider (2012)). In this research informal workers are identified as those who declare that their employer is not paying the necessary contribution to have the right to a pension in old age.

It is relevant to analyze the nature of the informality, in the past the existence of two segmented markets was a common assumption. These markets, formal and informal markets, have different rules which were associated with a high and a low productivity sector respectively. This concept has been discussed by the empirical literature using data from Mexico, Colombia, Argentina and Uruguay[6], where the empirical evidence goes towards the idea that the workers decide where to be, the workers decide which sector to be in based on their characteristics. A third idea proposes a moderate dualism, which is considered in most of the recent theoretical papers[7]. In my paper, I model this moderate dualism through a partial equilibrium model in which the workers decide to work either formally or informally, but being in each sector not only has a different wage function, but also the cost to entry, the cost to change and the probabilities of losing the job are different. This idea is a fundamental concept in this paper.

In the tradition of discrete choice models, Keane and Wolpin (1997) developed a seminal model which provided an estimation of the decision between home production, schooling, and occupational choice. Following this model, Van der Klaauw and Wolpin (2008) developed and estimated a model of labor supply and consumption in low income households with individuals in their fifties. In this model, the individual decides whether to work full or part time or not work at all, subject to the social security rules, limited borrowing, bequests, uncertain health and death. They analyzed single and married individuals separately, and found a lower response among married individuals when social security benefits are reduced by 25%, a reduction in labor supply for individuals below 62 and an increase of total hours for the individual over this age.

Furthermore, Bailey Jones and French (2010) estimate a retirement dynamic model which includes the decision of savings and medical expenses, with special attention paid to the different systems of medical expenses and the role of health insurance. They point out the relevance of Medicare eligibility in the labor decisions for individuals older than 60 years.

The labor supply behavior in context of informality was analyzed in some recent papers, Todd and Velez-Grajales (2008) and Joubert (2012) assess the behavior of individuals among the covered and uncovered sector[8] for Chile, changing the rules of the pension system. Theoretically, the main differences between these papers and my paper is the definition of informal workers that they are using. They consider as covered (formal) workers those who have a contract, while the uncovered are those do not have a contract and self employed workers. Additionally, Todd and Velez-Grajales (2008) estimate the model only with men and Joubert (2012) works with couples as a decision unit and he allows for savings in the model. Finally Otero (2013), using data for Chile, analyses the pension system changes in the formality performance with asymmetric bargaining power intra household.

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[6] Magnac (1991), Maloney (2004), Pratap and Quintin (2006) and Bucheli and Ceni (2010).

[7] Galiani and Weinschelbaum (2007), Amaral and Quintin (2006) , Ceni Gonzalez (2014).

[8] Covered workers are those who have a write contract. This definition try to capture some measure of the informality.

With respect to these last papers, I consider the pension system as a general provision system and not only as a saving system. This allows me to manage different pension schemes and compare them. From an empirical point of view, they are using data for Chile where the rate of uncovered workers is significantly lower than in Argentina. Furthermore, the recent reform in Argentina is a interesting point to study, because the economic volatility gives the role of saving which has a lot of obstacles in the traditional way, to the pension system.

An intertemporal utility maximization model for Brazil using a pseudo-panel is estimated by Robalino (2009). The individual decides where to work and how much to save given a set of social policies. This research has many shortcomings, the main one being the estimation using a pseudo-panel that triggers higher measurement errors. Finally, they do not take data about wages into account nor do they model the longitudinal transition of the workers.

My paper is structured as follows. Section 2 presents some facts from the data to contextualize the topic, Section 3 provides the main features of the Argentinean pension system, Section 4 provides the data which is used in the estimation, Section 5 presents the structural model, Section 6 presents the main results of the estimation, Section 7 the policy experiments, and finally, Section 8 contains the main conclusions.

2. Some facts from the data

Informality is present in all the countries of the region with different degrees depending on the level of development and the institutional framework. In Tables 1 and 2 the level of informality in six countries of Latin America is shown using the lack of contribution to achieve a pension in the future as the definition[9]. We can identify three groups: Argentina is in the middle one with more than 35% of the salaried workers in informality. These differences are due to the general development level of the countries and the institutional framework such as the quality of the benefits or the level of the government enforcement[10]. However, this problem is also present with relevant figures in the most advanced countries of the region: Chile and Uruguay[11]. In the countries with lower informality, there are greater differences between women and men than in countries with higher levels (Table 1). Furthermore, differences between educative levels is a feature which is present in all the countries (Table 2).

In order to analyze the mobility behavior among formality, informality and unemployment, I perform a multinomial logit with Argentinean data from the period 1995-2008. In Table 3 we can observe that the marginal effects, the age, the education and the tenure have a positive effect on the formality and a negative one on the informality. Being married and being the head of the household has a positive effect of being formal and a negative of being informal, meanwhile being single has a negative effect in both sectors. Being formal in the previous period has a relevant effect on remaining in formality in the current period. It is easier to enter in formality from unemployment than informality relatively to being informal in t-1, and it is easier to lose an informal job than a formal one.

Marginal effects 1995-2008			
	Unemployed	Formal	Informal
Unemployed(-1)	0.0748***	0.0466***	−0.1215***
	(0.0015)	(0.0032)	(0.003)
Formal (-1)	−0.0184***	0.3322***	−0.3138***
	(0.0014)	(0.0010)	(0.0014)
Age	0.0012***	0.0004***	−0.0016***
	(0.0001)	(0.0001)	(0.0001)
Education	−0.0036***	0.0706***	−0.067***
	(0.0011)	(0.0015)	(0.0017)
Married	−0.0095***	0.0273***	−0.0178***
	(0.0035)	(0.0045)	(0.0049)
Single	0.022***	−0.0153***	−0.0068
	(0.0037)	(0.0049)	(0.0056)
Head	−0.0213***	0.043***	−0.0217***
	(0.0020)	(0.0025)	(0.0028)
Tenure	−0.0350***	0.0539***	−0.0189***
	(0.0005)	(0.0008)	(0.0008)

Standard Errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Marginal effects based on the multinomial model. (only men)

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[9] Similar figures can be observed when other definitions such as health insurance or paid holidays are taken into consideration.
[10] These features are treated and discussed deeply in Ceni Gonzalez (2014).
[11] Chile leads almost all the rankings about economic performance and economic development in Latin America.

Based on the multinomial logit model, I predict the distribution in each sector by education, age and marital status. Firstly, the distribution by education is clear, the prediction shows that formality is increasing and informality and unemployment are decreasing by education level, as is shown in Table 4. The probability of being unemployed in the lower level of education (incomplete high school) is double in the highest one (college complete). Comparing the highest education with the lowest one, the probability of being formal is two times higher and the probability of being informal is four times lower. The change in the probabilities when the workers achieve a college degree is remarkable[12]. The probability of being unemployed decreases by more than 4 points, the probability of being formal increases by almost 20 points and being informal decreases by more than 15 points.

The data for age groups shows that the probabilities for the unemployed decreases until the fifties and then increases, the formality has the opposite behavior, increasing and then slightly decreasing. Meanwhile, informality decreases with age but the percentage remains stable after the age of 45. Being formal is 20 points more probable for those over 35 years old than the workers in their twenties, and being informal is 15 points less probable. Regarding the distribution by marital status, the single people have double the probability of being unemployed or 50% higher probability of being informal than those who are married or divorced. In general, the characteristics of formality, informality and unemployment are in line with the literature (Loayza et al. (2009), Hazans (2011)).

The transitions are studied through the multinomial model which was presented before. Figure A.2 in the Appendix shows the transitions yearly from the formality (first panel), and the informality (second panel). The formality is the sector where the workers remain (do not change) more, but those who change go more to other jobs in the informality rather than to unemployment. In the second panel, there are 30% of the informal workers who annually change sector; in 2003 there is an equal percentage when workers go to formality and to unemployment, and in the latest years the major percentage is for those who change to formality (rather than the unemployment).

In Figure A.3, the first panel shows the transition from unemployment and the second panel shows those workers who do not change from the sector who were working the year before (the stayers). The unemployed workers tend to change more to informality than to formality, it is easier for the unemployed to enter in the labor market through the informal sector[13]. Formal workers tend to remain in formality more than the informal workers do in informality and the unemployed in unemployment.

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[12] Medium education means completed high-school and high education completed college.
[13] This feature is also observed if smaller periods are consider, such as quarterly or biannual changes.

Distribution in each sector 1995-2008			
Education	**Unemployed**	**Formal**	**Informal**
Low Education	0.1137	0.4796	0.4067
Medium Education	0.0861	0.6594	0.2545
High Education	0.0423	0.8578	0.0999
Age group	**Unemployed**	**Formal**	**Informal**
23-28	0.1143	0.5157	0.3700
29-34	0.0767	0.6350	0.2883
35-44	0.0640	0.7048	0.2312
45-54	0.0652	0.7254	0.2094
55-65	0.0829	0.7091	0.2080
Marital status	**Unemployed**	**Formal**	**Informal**
Married	0.0629	0.6949	0.2422
Divorced-widow	0.0850	0.6372	0.2779
Single	0.1371	0.4875	0.3754
Total	**0.0894**	**0.6211**	**0.2895**

Table 4: Distribution in each sector by education, age group and marital status based in the multinomial model. (only men)

Additionally, these transitions are studied by other dimensions. Table 5 shows the probability of transitions of the active salaried workers. In the first block, in all the elements of the principal diagonal, there are the individuals who do not switch annually[14]. The rows in the table are the original sector where the workers have been in the previous year (t - 1), and the columns are the current sector (t). It is important to note that the formality is 20 points more stable than the informality, and about 38% of the unemployed remain in this condition for two consecutive years. At the same time, the informal sector appears more unstable than the formal sector, and it is easier to enter from unemployment (40% instead of 23%), this feature gives some attractiveness to this sector. Additionally, there are 20% of informal workers who annually move to the formality after, for example, gaining some experience or escaping from unemployment.

These changes can also be analyzed by the education level. In the second block, we can observe the transition from unemployment. The stayers in unemployment decrease slightly by educative levels (40%, 37% and 34% respectively); for those who change to the formality the percentages are quite low, but anyway the more educated workers have an almost three times lower probability of losing their job (4.2%, 2.6% and 1.4% from low to high educative level). In the case of the informal workers, they can lose their job with the same probability for all educative levels (about 11%).

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[14] In the whole period 1995-2008.

Probability of being in each sector			
	Unemployed	Formal	Informal
Unemployed (-1)	0.3797	0.2270	0.3934
Formal (-1)	0.0282	0.8916	0.0802
Informal (-1)	0.1123	0.2140	0.6737
Probability of being unemployed by education and sector of precedence			
Education	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.3947	0.0417	0.1121
Medium Education	0.3697	0.0266	0.1118
High Education	0.3429	0.0141	0.1154
Probability of being formal by education and sector of precedence			
Education	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.1758	0.8362	0.1704
Medium Education	0.2531	0.8984	0.2528
High Education	0.3834	0.9492	0.3920
Probability of being informal by education and sector of precedence			
Education	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.4295	0.1221	0.7175
Medium Education	0.3771	0.0751	0.6354
High Education	0.2737	0.0367	0.4926

Table 5: Probabilities of being in each sector, based on the multinomial model 1995-2008. (only men)

The third block of Table 5, shows the transitions to formality. It is shown that formality is remarkably more stable in the more educated individuals (10 points higher), and the educated workers who were in informality can change to the formality with much more probability than the low educated workers (22 points more). For the unemployed workers, the percentages are 17.6% for the low educated, 25.3% for the medium educated, and 38.3% for the higher ones. Formality has fewer barriers to entry for the high educated than for the other workers.

In the fourth block, the transitions to informality can be observed. Informality is more stable in the lower educative levels, 71.8% for the low educated and 49.3% for the high ones (almost 22 points of difference between the higher and the lower one). The less educated workers also present more probability to enter to work informally when they used to be unemployed than those with a high educative level (43% and 27% the lower and the higher educative levels respectively). The same pattern is presented for those who came from formality (12% and 4% the lower and the higher educative levels respectively).

The distribution of the wages is shown in Figure 1 in the Kernel simulations by educative level. The mean of the wages is always higher in formality than in informality in the different levels. However, the informal wages are definitely more volatile (higher standard deviations) than the formal ones, especially in the higher levels of education.
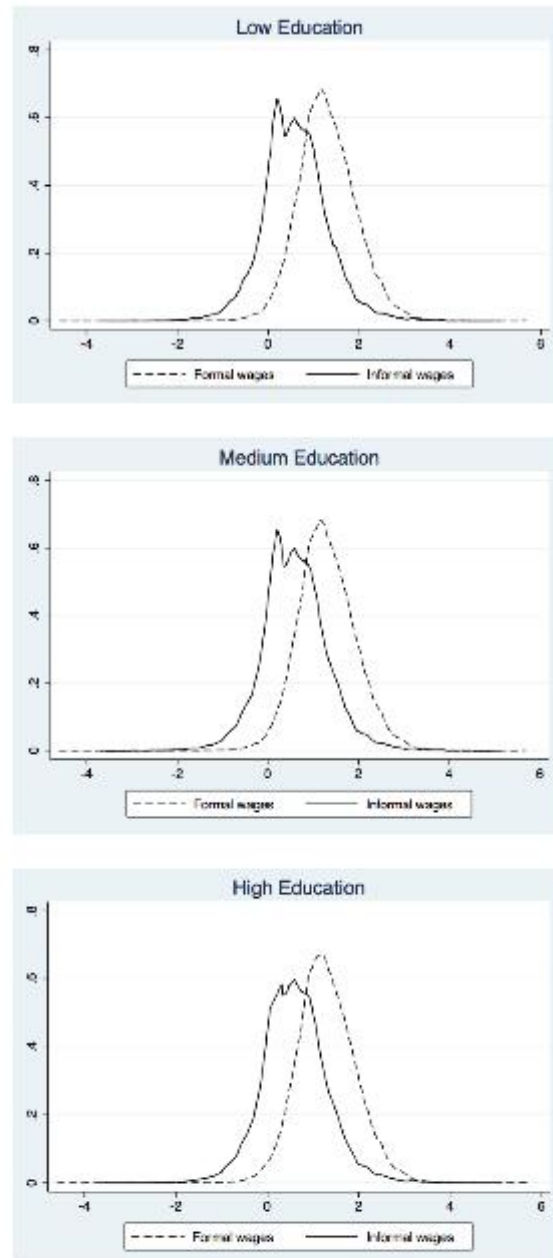

Figure 1: Distribution of wages 1995-2008 by education level

The share of elderly men who achieve some pension payment is shown in Table 6. In the data in 2001, most men achieved some pension payment after 75 years old. However, this data is only a photo in 2001 and these workers worked at a time prior to the existence of working records, and the pension requirements were confirmed only by witnesses. If we analyze the work histories (Forteza et al., 2009) in the pre 2008 pension scheme in Argentina the simulation shows that only 40% of men would achieve at least 30 years of contributions. Bosch and Guajardo (2012) show that the share of over 65 with a pension income decreases between 1992 and 2007 from about 85% to 65% among men. Principally, those men who have no pension coverage are mainly self-employed.

Coverage of the pension system

	65-69	70-74	75+
Contributive	64.18	81.8	84.52
Full pension	60.06	75.99	75.37
Advanced age	3.31	4.95	8.16
Non contributive pension	1.31	2.35	3.87

Table 6: Coverage of the pension system (only men). Source: Bertranou (2001)

3. The Argentinean background: pension system and savings

In Argentina, the pension system has changed drastically twice in the last twenty years. The system changed first in 1994, and a multipillar system based on a PAYG and individual capitalization was established. The first pillar was a PAYG scheme, which was financed by employer's contribution (16% of gross taxable income), and the workers would obtain a Universal Pension Benefit (UPB) with 30 years of contribution and at 60 or 65 years old for women and men respectively. The pension payment was a monthly at amount of about 28% of the average wage.

The second pillar was financed by employee contributions (11% of gross taxable income), which financed the PAYG or individual capitalization scheme. Private and public institutions participated in this scheme (Rofman, 2000). There were also employer and employee contributions for different funds to finance redistribution programs and the health system.

In December 2008, as a consequence of the global financial crisis and after more than a decade of criticism of the multipillar regime, the scheme changed again, returning to a single public pillar with a PAYG scheme. The pension is composed of the UPB and Compensatory Pension (CP), which is included to compensate the elimination of individual capitalization. This system is financed by current contributions and general taxes. The employee and employer contributions have not changed, only the administrator of the resources has changed. In the model estimation, I will consider the period 1995-2008 in order to capture the first scheme and the period 2008-2011 as the out of sample validation.

In this paper the different schemes are summarized by the rates of replacement. These figures were estimated taking the different schemes into consideration, and given the multiplillar scheme was only active for 14 years, there was no possibility to observe an entire generation in the system during the whole active life.

The severe financial crisis that Argentina suffered in 2001 deeply affected saving decisions, because many banks closed and the savers lost a lot of their money. Moreover, in the last two years many restrictions have been imposed to prevent private access to foreign currency which has traditionally been the main way for families to save. However, a pension system is related with the saving decision for the elderly, based on the events of the last decade I have decided not to take into account the saving decision in the model.

4. Data

I use the Permanent Household Survey (EPH in Spanish) carried out by the National Institute of Statistics and Census (INDEC in Spanish) for the period 1995 to 2011. The sample is restricted to the urban regions, covering 28 large urban centers where 70% of the urban population of Argentina live.[15]

Between 1995 and 2002 the survey was biannual[16], in 2003 it became quarterly. In the first period, the panel is rotative losing 25% of the cases every six months. In the second period, the rotation has the following characteristics: i) two consecutive quarters share 50% of the cases, ii) two quarters with one quarter in the middle, do not have any cases in common, and iii) two quarters with two quarters in the middle, share 25% of cases. Any quarter shares 25% of the cases with the same one in consecutive years. In the whole period it is possible to follow some individuals for one year and a half.

This survey has a socioeconomic purpose and it is crucial in identifying workers in different sectors of the economy. The identification of the formal workers is directly assessed asking if the employer pays the social contribution to have the right to access a pension payment in retirement. Unfortunately, the questionnaire does not ask anything about the contribution of the self employers. This is the main shortcoming of this survey, so my research only analyzes the dynamic of the salaried workers. This feature allows me to analyze the pure transitions form job to job without taking into consideration self-employment as a possible escape from unemployment.

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[15] Urban population accounts for the 90% of the total population of Argentina, so the survey gives a good representation of the country.
[16] First and third quarter.

5. Model

The model describes the decision problem of the individual in the subsequent periods after they leave the education system until they die. In each period the individuals choose between either working in the formal or informal sector or being unemployed. The individuals have an endowment of human capital which was acquired in the past and depends on the years of schooling, and also the experience that they acquire to work in formal and informal jobs. This latter point means that the employer ca not distinguish the sector where the experience of the workers has been gained. For instance, I assume that a young individual at 23 years old leaves the education system with a level of formal education between incomplete elementary school and university degree. They face a finite horizon decision and choose among the different options that they have as in the seminal paper of Keane and Wolpin (1997).

The worker's life is classified in three stages as is shown in Figure 2, the first one is the pure active life, where the worker can either work in formality or informality, or be unemployed. The second stage, is the elective retirement stage where those workers who are eligible for retirement can choose to retire, and those who are not eligible continue as in the pure active life stage. The third and final stage is the compulsory retirement stage where everyone is in retirement even if they are not eligible for a pension. In this last stage, everyone receive a pension.
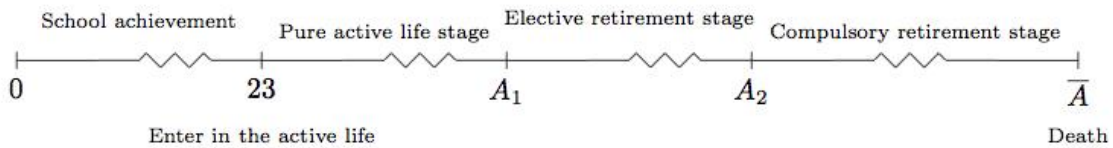
Figure 2: Timeline of the individual in the model

Firstly, Equation (1) shows the state space, that is: the time which determines the stage of the worker's life; the education level which introduces initial heterogeneity to the individuals, the experience in the labor market which is gained if the individuals are working either in formality or informality, the number of years in the formality which is accumulated with the experience in the formal sector giving the insight to achieve one of the requirements to access pension rights, the sector where the individual was in the previous period which determines the type of benefit to enjoy (i.e. the unemployment insurance if they choose unemployment after being formal), and the cost of entry to the formal sector (i.e. the cost from the unemployment is higher than from the informality), and a random shock in wages.

$$\Omega(t) = \left[a, S, X, a_F, \mathbf{I}_k^{t-1}, \epsilon(a)^j\right]$$
$$k = \left\{\text{Formal (F)}, \text{Informal (I)}, \text{Unemployed (U)}\right\} \quad (1)$$
$$j = \left\{\text{Formal (F)}, \text{Informal (I)}\right\}$$

There is a Mincer equation of working in each sector in Equation (2) where the reward depends on the education and the experience gained working (both in formality and informality), and benefits (B_1) in formal workers:

$$\ln\left(R^j(S, X)\right) = \alpha_0^j + \alpha_1^j S + \alpha_2^j X + \alpha_3^j \left(\frac{X}{10}\right)^2 + \epsilon(a)^j + B_1(S)$$

$$j = \left\{\text{Formal (F), Informal (I)}\right\} \qquad \epsilon^j \sim N\left(0, \Sigma\right) \quad \Sigma = \begin{pmatrix} \sigma^f & 0 \\ 0 & \sigma^i \end{pmatrix} \tag{2}$$

The reward of being unemployed is determined by the fact that the worker has the right to enjoy unemployment insurance or not, as is shown in Equation (3). If the worker works in formality in t, then the worker can enjoy the insurance in t + 1, which is fixed as a percentage (b_2) of the previous wage, and they also enjoy $B_2(X; S)$ which reflects leisure or home production.

$$R^U(a, X, S) = \begin{cases} b_2 \mathbf{E}\left[R^F(a-1)\right] + B_2(X, S) & \text{if } \mathbf{I}_F^{-1} = 1 \quad \text{with} \quad 0 \le b_2 \le 1 \\ B_2(X, S) & \text{otherwise} \end{cases} \tag{3}$$

The functional form of the home production-leisure function increases with the education and decreases with the experience in the job market as in Equation 4. The parameters b_{21} and b_{23} depend on the educational achievement.

$$B_2(X, S) = b_{21}(S)\left(b_{22} + \frac{b_{23}(S)}{X}\right) \tag{4}$$

The first stage of analysis is the pure active life until age A_1, the individual decides taking not only the current and the future value function, but also the transition probabilities into account. The transition probabilities are defined as $\varphi_f(S)$, which is the probability of formal job destruction (formality ! unemployment), $\varphi_i(S)$, which is the probability of informal job destruction (informality to unemployment), $\lambda_F(S)$ (unemployment to formal) which is the probability of finding a job in the formal sector, and $\lambda_I(S)$ (unemployment to informal) which is the probability of finding a job in the informal sector. The value function V_j in Equation (5) is the maximum among the value of being employed in the sector j, and V_U which is the value of being unemployed.

$$V(\Omega(t)) = max\left\{V^F, V^I, V^U\right\} \tag{5}$$

Equation (6) shows the value function of working in formality V_F (informally V_I) is defined with the formal (informal) Mincer equation, the cost of entering each sector, the cost of switching sectors and the expectation of the future depends on the probability (1- $\lambda_k(S)$) of being employed and the future realization of the wages, that is the expected discounted value of all the years of the first stage (pure active life), plus the value function of the second and the third stage. The cost of entering and switching sectors depends on the sector of the previous and the current period (see Equation 8).

$$V^j\Big(\Omega(a)\Big) = U\Big(R^j(a) - \mathbb{C}^{Fk}(a,S)\mathbf{I}^{-k}\Big)$$

$$+ \beta\Big[\lambda_j(S)\mathbf{E}_{\Omega(a+1)/\Omega(a)}V^U\Big(\Omega(a+1)\Big)$$

$$+ (1-\lambda_j(S))\mathbf{E}_{\Omega(a+1)/\Omega(a)}max\Big\{V^I\Big(\Omega(a+1)\Big), V^F\Big(\Omega(a+1)\Big)\Big\}\Big]$$

$$j = \Big\{\text{Formal (F)}, \text{Informal (I)}\Big\}$$

$$(6)$$

The cost of entry in formality (Equation 7) depends on the educational achievement, the age and where the worker was in the previous period (working informally or unemployed). The cost of entry in informality is fixed at zero.

$$\mathbb{C}^{Fj}(a,S,\mathbf{I}^{-k}) = \begin{cases} (\Pi-a)\phi_{11}(S) & \text{if } \mathbf{I}^{-k} = \text{informal} \\ (\Pi-a)\phi_{12}(S) & \text{if } \mathbf{I}^{-k} = \text{unemployed} \\ 0 & \text{if } \mathbf{I}^{-k} = \text{formal} \end{cases} \quad (7)$$

$$k = \Big\{\text{Formal (F), Informal (I), Unemployed (U)}\Big\}$$

$$\mathbf{I}^{-k} = \begin{cases} 1 & \text{if the individual being in } -k \text{ in the previous period} \\ 0 & \text{otherwise} \end{cases} \quad (8)$$

The value function for the unemployed worker depends on the current utility function, which is different if in the previous period the workers were in formality or in informality, and the expected utility function, as is shown in Equation 9.

$$V^U\Big(\Omega(a)\Big) = U\Big(R^U(a)\Big)$$

$$+ \beta\Big[\Big(1-\phi_F(S)-\phi_I(S)\Big)\mathbf{E}_{\Omega(a+1)/\Omega(a)}V^U\Big(\Omega(a+1)\Big)$$

$$+ \phi_F(S)\mathbf{E}_{\Omega(a+1)/\Omega(a)}max\Big\{V^U\Big(\Omega(a+1)\Big), V^F\Big(\Omega(a+1)\Big)\Big\}$$

$$+ \phi_I(E)\mathbf{E}_{\Omega(a+1)/\Omega(a)}max\Big\{V^U\Big(\Omega(a+1)\Big), V^I\Big(\Omega(a+1)\Big)\Big\}\Big]$$

$$(9)$$

The utility function takes a general form, Constant Relative Risk Aversion (CRRA) as in Equation 10:

$$U\left(R^k(a)\right) = \frac{1}{1-\gamma}R^k(a)^{\frac{1}{1-\gamma}} \tag{10}$$

The second stage of analysis is between A_1 and A_2, A_1 is the lower age that the workers can choose to retire and at A_2 everyone is retired. In this period the individuals can choose to continue to work in both sectors or be unemployed, but those individuals who achieve the minimum years in formality (F_1) may get a full pension, so they could be retired and also enjoy B_3 as pensioner's home production-leisure as in Equations 11 and 13. Otherwise, the pension could be achievable in this period when a_F (total of years worked in formality) achieve at least the threshold F_1. Note, as Equation 12 shows the pension is always a choice in this stage of the workers life. Additionally, there are three full pensions which depend on a_F, if the workers decide to continue working, they can achieve a higher rate of replacement in the future, but their life is limited to A when everyone is dead.

$$V^P\left(\Omega(a)\right) = U\left(r_F R^k(a) + B_3(S)\right) + \beta \mathbf{E}_{\Omega(a+1)/\Omega(a)} V\left(\Omega(a+1)\right) \tag{11}$$

$$V\left(\Omega(a)\right) = max\left\{V^U\left(\Omega(a)\right), V^I\left(\Omega(a)\right), V^F\left(\Omega(a)\right) V^P\left(\Omega(a)\right)\right\} \tag{12}$$

The home production leisure function (Equation 13) for the pensioners depend only on the educational achievement and it is constant during the retirement period.

$$B_3(S) = b_{31}(S) \tag{13}$$

The individuals who achieve the full pension are those who work in formality for 30 years or more:

$$\mathbf{I}_{a_F \geq 30} = \begin{cases} 1 & \text{if the individual has worked in formality for 30 years or more} \\ 0 & \text{otherwise} \end{cases} \tag{14}$$

The third stage of analysis starts at A_2 years old, and all the individuals are retired. The value function of these pensioners is shown in Equation 15 and is determined by the income that the individual would receive and the number of years in formality (F_1 and F_2). It is determined by the replacement rate and the last wage received in the active life. There would be three types of pensions: the full, the Advanced age and the survival pension. At the age of A everyone is dead.

$$V\Big(\Omega(a)\Big) = U\Big(r_F R^k(a) + B_3(S)\Big)\mathbf{I}_{a_F \geq 30} + U\Big(r_A R^k(a) + B_3(S)\Big)\mathbf{I}_{30 > a_F \geq 10}$$

$$+ U\Big(b_3 + B_3(S)\Big)\mathbf{I}_{a_F < 10} + \beta\mathbf{E}_{\Omega(a+1)/\Omega(a)}V\Big(\Omega(a+1)\Big)$$

$$(15)$$

The individuals who achieve the Advanced age pension are those who work between 10 years and 30 years in formality during the whole working life:

$$\mathbf{I}_{30 > a_F \geq 10} = \begin{cases} 1 & \text{if they have worked in formality for 10 years or more and less than 30} \\ 0 & \text{otherwise} \end{cases}$$

$$(16)$$

The rate of replacement (r_F) in the full pension type is not unique, it increases in the number of years that the workers is in formality. In the estimation I will consider three rates, at 30 ($a_{F>30}$), 35 ($a_{F>35}$) and 40 ($a_{F>40}$) years in formality.

6. Estimation

I estimate the model using the Method of Simulated Moments (MSM), through the maximization of the value function conditional on the state variables minimizing the distance between the estimated moments in the model and the moments in the data, weighing with the inverse of the estimated variance of the moments. I select moments to match the choices along the working career and the educational endowment and the transition between states, to estimate the discount factor β, the shape of the utility function γ, the parameters that determine the home production-leisure function, the parameters to enter into formality from informality and unemployment and the idiosyncratic shocks.

In Table 7 I show the estimation of the Mincer equation for the formal and informal workers, each worker based on their educational endowment and the experience that they achieve in the labor market, receives a wage offer which form part of their utility function and decides either to work or to remain unemployed. The education and the experience are better rewarded for the formal workers than for the informal ones. However, the informal workers receive better offers in their youth (the constant term is higher). The standard deviation of the idiosyncratic shocks in the wages is estimated by MSM and is shown in Table 8, informal shocks have a higher deviation than formal ones.

Coefficients estimated from the Mincer equations

Name	Symbol	Value	Standard deviation
Constant formal	α_0^f	0.2606	(0.0227)
Constant informal	α_0^i	0.3962	(0.0805)
Schooling formal	α_1^f	0.2982	(0.0027)
Schooling informal	α_1^i	0.2707	(0.0056)
Experience formal	α_2^f	0.1622	(0.0035)
Experience informal	α_2^i	0.0979	(0.0057)
Experience^2 formal	α_3^f	-0.0117	(0.0004)
Experience^2 informal	α_3^i	-0.0077	(0.0007)

Table 7: Parameters of the Mincer equation

The transition function (λj and φj) parameters (education endowment and experience achieved) are estimated through the marginal effect of the multinomial function shown in Table 3.

Parameters estimated by Simulated Method of Moments

Name	Symbol	Value	Standard Deviation
Discount factor	β	0.9475	(0.0014)
Risk aversion	γ	1.2757	(0.0018)
Benefits $B_1(S)$			
Medium Education	$B_1(2)$	0.4691	(0.0004)
High Education	$B_1(3)$	0.9382	(0.0002)
Home production in active life $B_2(XX, S)$			
Constant	b_{22}	100.9925	(5.589)
Low Education	$b_{21}(1)$	38.1481	(0.781)
Medium Education	$b_{21}(2)$	36.9016	(1.631)
High Education	$b_{21}(3)$	49.5058	(2.396)
Low Education	$b_{23}(1)$	43.465	(1.090)
Medium Education	$b_{23}(2)$	51.5392	(0.925)
High Education	$b_{23}(3)$	57.3335	(2.557)
Home production in retirement life $B_3(S)$			
Survival pension	b_3	1838.1	(2.0)
Low Education	$b_{31}(1)$	1060.395	(1.87)
Medium Education	$b_{31}(2)$	3182.1625	(48.91)
High Education	$b_{31}(3)$	2113.5710	(112.4)
Cost of entering in formality			
Age multiplier	Π	97.6199	(4.09)
Informal-Formal (Low Education)	$\phi_{11}(1)$	1.18	(0.0141)
Informal-Formal (Medium Education)	$\phi_{11}(2)$	0.591	(0.0)
Informal-Formal (High Education)	$\phi_{11}(3)$	0.0004	(0.0)
Unemployed-Formal (Low Education)	$\phi_{12}(1)$	45.044	(1.22)
Unemployed-Formal (Medium Education)	$\phi_{12}(2)$	4.504	(0.12)
Unemployed-Formal (High Education)	$\phi_{12}(3)$	0.015	(0.0)
Shocks			
Std Variation informal	σ^i	0.3602	(0.00)
Std Variation formal	σ^f	0.2109	(0.00)

Table 8: Parameters estimated by Simulated Method of Moments

The parameters estimated by MSM are shown in Table 8. In the first block there are the general parameters of the model, the discount factor which is in line with the literature, is close to 0.95 and the risk aversion is 1.28 which is a bit lower than in the literature[17]. The second block shows the parameters of the benefits that the formal workers enjoy extra-wage, which is fixed at zero for those in the lower educative level. In the third block, there are the home production-leisure parameters in active and in the fourth one, the parameters in retirement. The parameters of the home production-leisure are higher for the more educated, reflecting the outside option of the wage. In the fifth block, there are the parameters of the cost to enter into formality, the low educated have a higher cost than the higher educated ones.

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[17] For instance, Joubert (2012) finds 1.55 for Chile.

Parameters calibrated

Name	Symbol	Value
Thresholds		
Minimum full retirement age	A_1	65
Advanced age retirement age	A_2	70
Death	$\overline{A}$	80
Years in formality to achieve full pension	F_1	30
Years in formality to achieve advanced age retirement	F_2	10
Rates of replacement		
Full pension (40 years of formality)	r_{F-40}	1.13
Full pension (35 years of formality)	r_{F-35}	0.96
Full pension (30 years of formality)	r_{F-30}	0.81
Advanced age pension	r_A	$0.7*r_{F-30}$
Unemployment benefits for former formal workers	b_2	0.6

Table 9: Parameters calibrated. Source: Forteza and Ourens (2009), Rofman et al. (2010)

Some parameters are calibrated in Table 9. The minimum retirement age is 65 years old as the minimum age to achieve the full pension and 70 years old is the age to achieve the Advanced age pension. Additionally, to achieve the full pension the workers have to work at least 30 years in formality and 10 years to get the Advanced age pension. The full pension has three levels with three different rates of replacement at 30, 35 and 40 years in formality with 1.13, 0.96 and 0.81 rates of replacement respectively. The Advanced age pension is at 70% of the full pension with 30 years of formality. Everyone is dead at 81 years old.

In Table 10 there are the estimation for all education levels, the model fits well if the interval is considered. The model has more problems at the beginning and at the end in the career, and specially between formal and informal workers, with an overestimation of informality in youth and an underestimation close to retirement.

	Formal		Informal		Unemployed	
	Data	Model	Data	Model	Data	Model
23-28	0.5311	0.3993	0.3615	0.5112	0.1074	0.0895
	[0.5073, 0.5482]		[0.3400, 0.3841]		[0.0962, 0.1163]	
29-34	0.6286	0.6194	0.3091	0.3505	0.0623	0.0301
	[0.5979, 0.6534]		[0.2768, 0.3415]		[0.0510, 0.0722]	
35-44	0.7418	0.7564	0.2107	0.2256	0.0475	0.0180
	[0.7148, 0.7621]		[0.1958, 0.2295]		[0.0398, 0.0574]	
45-54	0.7104	0.7466	0.2218	0.1947	0.0678	0.0588
	[0.6870, 0.7277]		[0.2143, 0.2299]		[0.0507, 0.0943]	
55+	0.7127	0.8314	0.2067	0.0836	0.0807	0.0849
	[0.6882, 0.7374]		[0.1890, 0.2359]		[0.0603, 0.1100]	

Table 10: Moment matching: Formal, informal and unemployed workers at all educational levels. The interval is estimated based on the multinomial model, performing bootstraps and considering the middle 90%.

In Table 11 the moment matching of the formal activity is shown. The model matches quite well taking into consideration the interval, especially the high educated and the general estimation. However, in the case of the low educated and the medium educated there is an underestimation (more than 10 points) at the beginning and an overestimation (also 10 points) in the last years of the career.

	Low Education		Medium Education		High Education	
	Data	Model	Data	Model	Data	Model
23-28	0.4048	0.2654	0.6001	0.4811	0.6754	0.6150
	[0.3628, 0.4356]		[0.5863, 0.6154]		[0.6310, 0.7167]	
29-34	0.4788	0.5115	0.7061	0.6917	0.8839	0.7783
	[0.4429, 0.5081]		[0.6682, 0.7324]		[0.8492, 0.9187]	
35-44	0.5959	0.6514	0.8474	0.8515	0.9186	0.8538
	[0.5739, 0.6185]		[0.8018, 0.8833]		[0.9041, 0.9315]	
45-54	0.5761	0.5440	0.8594	0.9432	0.9290	0.9037
	[0.5088, 0.6290]		[0.8119, 0.8955]		[0.9049, 0.9468]	
55+	0.6620	0.7644	0.7081	0.8753	0.9584	0.9327
	[0.6209, 0.6964]		[0.6491, 0.7931]		[0.9364, 0.9779]	

Table 11: Moment matching: Formal workers. The interval is estimated based on the multinomial model, performing bootstraps and considering the middle 90%.

In Table 12 the moment matching is consider comparing the informal activity. In this case the model behavior is the other side of the coin, the estimation is again quite good in the general case and in the medium educated workers, and in this case the high educated group is mostly in the interval, but there is an overestimation of the low educated group. The model matching for the unemployed workers is the residual and it is presented in Table A.3.

	Low Education		Medium Education		High Education	
	Data	Model	Data	Model	Data	Model
23-28	0.4490	0.6485	0.3169	0.4149	0.2438	0.3189
	[0.4045, 0.4932]		[0.3004, 0.3324]		[0.1973, 0.2876]	
29-34	0.4367	0.4523	0.2412	0.2757	0.0988	0.2161
	[0.4066, 0.4743]		[0.2054, 0.2817]		[0.0720, 0.1136]	
35-44	0.3313	0.3145	0.1216	0.1453	0.0688	0.1428
	[0.3142, 0.3486]		[0.0882, 0.1544]		[0.0554, 0.0797]	
45-54	0.3187	0.3469	0.1186	0.0537	0.0549	0.0608
	[0.3003, 0.3379]		[0.0852, 0.1564]		[0.0376, 0.0767]	
55+	0.2518	0.1386	0.1875	0.0322	0.0320	0.0365
	[0.2236, 0.2852]		[0.1468, 0.2383]		[0.0147, 0.0495]	

Table 12: Moment matching: Informal workers. The interval is estimated based on the multinomial model, performing bootstraps and considering the middle 90%.

In Table 13, there is the model matching of the transitions. Here the model behavior is also quite good, because the formal workers tend to stay in this sector more than the informal and the unemployed ones. Informality is an easier sector to enter from unemployment than the formality. However, the transition from the unemployment to the informality is underestimated.

| | Unemployment | | Formal | | Informal | |
	Data	Model	Data	Model	Data	Model
Unemployed (-1)	0.4414	0.3228	0.1928	0.2593	0.3658	0.4181
	[0.3668, 0.5152]		[0.1501, 0.2268]		[0.3141, 0.4193]	
Formal (-1)	0.0295	0.0267	0.8824	0.8347	0.0881	0.1388
	[0.0238, 0.0425]		[0.8751, 0.8907]		[0.0761, 0.0974]	
Informal (-1)	0.0743	0.1234	0.2393	0.4755	0.6864	0.4013
	[0.0593, 0.1034]		[0.2142, 0.2673]		[0.6719, 0.7068]	

Table 13: Moment matching: Transitions. The interval is estimated based on the multinomial model, performing bootstraps and considering the middle 90%.

In this benchmark case the initial heterogeneity of the model, only the education endowment and the experience achieved, does not allow for the differentiation of individuals.

| At 65 and 70 years old | $Full_{40}$ | $Full_{35}$ | $Full_{30}$ | | Advanced age | |
			Age 65	Age 70	Age 65	Age70
Low Education	0.0%	1.4%	22.9%	44.4%	75.4%	54.2%
Medium Education	0.3%	40.9%	55.3%	58.5%	3.6%	0.3%
High Education	6.2%	56.4%	35.4%	37.3%	2.0 %	0.0%

Table 14: Pension achievement

| | Low Education | | Medium Education | | High Education | |
	Age 65	Age 70	Age 65	Age 70	Age 65	Age 70
Mean	24.83	27.32	33.98	34.05	35.46	35.51
Start age	4.16		3.13		2.56	
$p_{0.025}$	14	18	29	30	30	30
$p_{0.125}$	18	22	31	31	32	32
$p_{0.25}$	21	25	32	32	33	33
$p_{0.5}$	25	29	34	34	36	36
$p_{0.75}$	29	30	36	36	38	38
$p_{0.875}$	31	31	37	37	39	39
$p_{0.975}$	34	34	39	39	40	40

Table 15: Years in formality

Pension achievement is shown in Table 14, all the workers achieve at least an Advanced age pension, given that the requirements are very loose, only 10 years of contribution or formality. For the low educated workers almost 54% achieve the Advanced age pension and 44% the first step of full pension. Note that, most of this individuals reach the pension after the age of 65, then they continue to working in order to have this right[18]. There is a significant share of medium educated workers who continue to work after 65 in order to achieve a full pension, and only 0.3% get only the Advanced age pension. At the age of 70, 58% of these workers have the first step of full pension, and 41% and 0.3% the second and third step. Most of the high educated

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[18] At age 65 the only pension that they can achieve is the full pension.

workers get the second and third steps of the full pension. In this estimation, the main problem about the pension achievement is in the low part of the distribution. Most of the high educated achieve a pension, meanwhile the low educated have to work until the age of 70 to achieve an Advanced age pension. This point will be discussed in the policy experiments.

The distribution of the formality path is shown in Table 15. The age to start in formality is lower for higher educated workers, 2 years before, and the average years in formality is almost double when comparing these groups. Most of the workers prefer to retire when they have the possibility, it is clear that for high educated workers the distribution is the same at 65 and 70 years old. This is not the case for the medium and low educated workers, where the workers about 75% and 25% respectively continue working after 65. Informality affects the low educated workers more, as they do not enjoy the current and the future benefits.

7. Policy experiments

In this section I want to perform some policy experiments in order to analyze different situations, which could be probable in different scenarios. First I will analyze which will be the situation if the rate of replacement is also lower[19] (as in a PAYG scheme) and the age of retirement is lower. Then I make the requirements stricter, and then I perform changes that could affect the distribution, affecting differentially the low and the high educated workers.

	General		Low Education		Medium Education		High Education	
	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy
23-28	0.399	0.404	0.265	0.274	0.481	0.484	0.615	0.618
29-34	0.619	0.616	0.512	0.503	0.692	0.694	0.778	0.777
35-44	0.756	0.745	0.651	0.649	0.852	0.851	0.854	0.853
45-54	0.747	0.755	0.544	0.556	0.943	0.944	0.904	0.918
55+	0.831	0.677	0.764	0.564	0.875	0.785	0.933	0.770

Table 16: Formality path with the first policy experiment: replacement rates and retirement age at 60.

	$Full_{35}$		$Full_{30}$		Advanced age	
	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy
Low Education	1.4%	0.0%	44.4%	32.2%	54.2%	67.8%
Medium Education	41.2%	1.3%	58.5%	97.4%	0.3%	1.4%
High Education	62.6%	3.3%	37.3%	96.4%	0.0%	0.3%

Table 17: Pension achievement with the first policy experiment: replacement rates and retirement age at 60.

The first policy experiment is to reduce the rate of replacement that the workers would get with the full pension[20] and the minimum age to get a pension is 60 years old. In Table 16 the formality path is shown, there is a decrement of formality at the end of the career. For the medium educated workers the fall is almost 20 points, and for the low and high educated workers is 15 points. Those workers decide to be in unemployment more than to work.
The pension achievement changes are shown in Table 17. The main change is the rise from about 60% to 97% in the medium educated who which achieve the first step of the full pension. Those workers with low education who achieve a full pension is 12 points lower than in the benchmark, this tendency is confirm in Table 18 which shows that the years of formality is lower in the low part of the distribution.

The distribution in Table 18 shows that the low educated workers work less formally, especially between the age of 65 and 70. On average at the age of 70, the low educated workers have about 2 years less in formality and it is explained principally by the low part of the distribution. The medium educated workers work less in formality (almost 3.5 years in average at the age of 70), and it is explain principally because they prefer to go in retirement as soon as possible and for this reason the distribution is more homogeneous in this variable with the policy experiment.

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[19] In the benchmark calibration I consider the rate of replacement in the case of individual a capitalization scheme, here I consider the rate of replacement of PAYG.
[20] The rate of replacement are now 0.8 and 0.7 in the full pension, the Advanced age pension is 70% of the latter one.

	Low Education			
	Benchmark	Policy	Benchmark	Policy
Years of formality (at 65)	24.8	23.9		
Years of formality (at 70)	27.3	25.6		
Age of start in formality	4.15	4.08		
	Distribution at age 65		Distribution at age 70	
$p_{0.025}$	14	14	18	15
$p_{0.125}$	18	17	22	20
$p_{0.25}$	21	20	25	22
$p_{0.5}$	25	24	29	27
$p_{0.75}$	29	29	30	30
$p_{0.875}$	31	30	31	30
	Medium education			
	Benchmark	Policy	Benchmark	Policy
Years of formality (at 65)	33.9	30.56		
Years of formality (at 70)	34.1	30.74		
Age that start in formality	3.15	3.13		
	Distribution at age 65		Distribution at age 70	
$p_{0.025}$	29	28	30	30
$p_{0.125}$	31	30	31	30
$p_{0.25}$	32	30	32	30
$p_{0.5}$	34	30	34	30
$p_{0.75}$	36	31	36	32
$p_{0.875}$	37	32	37	32
$p_{0.975}$	39	34	39	34

Table 18: Formality with the first policy experiment: replacement rates and retirement age at 60.

The second policy puts stricter requirements to achieve both the full and Advanced age pension. The minimum years in formality to achieve them are 35 and 20 respectively. Table 19 shows the pension achievement for the three levels of education. In this scenario, there are changes principally again for those with low and medium education, in the former, almost 6% do not reach the Advanced age pension and only 17% achieve a full pension. For the medium educated, there are changes with more workers (7% instead of 0.3%) that achieve only the Advanced age pension and the first step of the full pension, the second and third step were reached for about 41% and now this percentage is only 1%.

	Full3		Full2		Full1	
	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy
Low Education	0.0%	0.0%	1.4%	0.0%	44.4%	17.8%
Medium Education	0.3%	0.0%	40.9%	1.2%	58.5%	91.7%
High Education	6.2%	0.0%	56.4%	6.5%	37.3%	91.0%
	Advanced Age		Survival			
	Benchmark	Policy	Benchmark	Policy		
Low Education	54.2%	75.9%	0.0%	6.3%		
Medium Education	0.3%	7.1%	0.0%	0.0%		
High Education	0.0%	2.6%	0.0%	0.0%		

Table 19: Pension achievement with the second policy experiment: formality years of requirement 20 and 35. Full3 pension is 43 and 40 years, Full2 pension is 40 and 35 years and Full1 pension is 35 and 30 years in the policy and in the benchmark respectively.

In Table A.4 there is an increment in the formality among individuals over 55 years old in all educative levels. For those lower and medium educated it is about 7% higher and for the high educated the difference is 1.5%. The years in formality is shown in Table 20. There are changes in the distribution around the new thresholds, among the low educated there is a decrease in the low part of the distribution (18 to 17 in the 2.5 centile) and an increase in the high part of the distribution (30 to 33 in the 75 centile and 32 to 35 in the highest part). Additionally, there changes for the medium educated, there is an increase in the formality for all the workers of the distribution, but the change is higher in the low part of the distribution where most of the workers work formally in order to achieve the new threshold and enjoy a full pension.

	Low Education	
	Benchmark	Policy
Years of formality (at 65)	24.8	25.5
Years of formality (at 70)	27.3	28.5
	Distribution at age 70	
$p_{0.025}$	18	17
$p_{0.125}$	22	22
$p_{0.25}$	25	25
$p_{0.5}$	29	29
$p_{0.75}$	30	33
$p_{0.875}$	32	35
$p_{0.975}$	35	35
	Medium education	
	Benchmark	Policy
Years of formality (at 65)	34.0	34.9
Years of formality (at 70)	34.1	35.7
	Distribution at age 70	
$p_{0.025}$	29	33
$p_{0.125}$	31	35
$p_{0.25}$	32	35
$p_{0.5}$	34	35
$p_{0.75}$	36	36
$p_{0.875}$	37	37
$p_{0.975}$	38	39

Table 20: Formality with the second policy experiment: formality years of requirement 20 and 35.

The third policy puts looser requirements to achieve a full pension, only 25 years in formality. This policy decreases the years of formality for all the educative levels especially in the last part of the career (over the age of 45) as in shown in Table A.5. Those workers who achieve an Advanced age pension is half that of the benchmark even if they work less in formality, because this decrement is after 65 then they reach the new minimum threshold and go in retirement.

	$Full_3$		$Full_2$		$Full_1$	
	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy
Low Education	0.0%	0.0%	1.4%	0.4%	44.4%	76.2%
Medium Education	0.3%	0.2%	40.9%	28.9%	58.5%	71.0%
High Education	6.2%	3.3%	56.4%	51.5%	37.3%	45.5%
	Advanced Age		Survival			
	Benchmark	Policy	Benchmark	Policy		
Low Education	54.2%	23.44%	0.0%	0.0%		
Medium Education	0.3%	0.0%	0.0%	0.0%		
High Education	0.0%	0.0%	0.0%	0.0%		

Table 21: Pension achievement with the third policy experiment: formality years of requirement 25. $Full_3$ pension is 35 and 40 years, $Full_2$ pension is 30 and 35 years and $Full_1$ pension is 25 and 30 years in the policy and in the benchmark respectively.

For the medium educated workers, there is also a decrement in the years in formality, on average half a year lower. This happens only in the low parts of the distribution but the medium and high part of the distribution stay in the same shape as the benchmark.

	Low Education	
	Benchmark	Policy
Years of formality (at 65)	24.8	24.6
Years of formality (at 70)	27.3	25.9
	Distribution at age 70	
$p_{0.025}$	18	17
$p_{0.125}$	22	22
$p_{0.25}$	25	25
$p_{0.5}$	29	25
$p_{0.75}$	30	28
$p_{0.875}$	31	31
$p_{0.975}$	34	33
	Medium education	
	Benchmark	Policy
Years of formality (at 65)	34.0	33.3
Years of formality (at 70)	34.1	33.3
	Distribution at age 70	
$p_{0.025}$	29	27
$p_{0.125}$	31	30
$p_{0.25}$	32	32
$p_{0.5}$	34	33
$p_{0.75}$	36	35
$p_{0.875}$	37	36
$p_{0.975}$	39	38

Table 22: Formality with the third policy experiment: formality years of requirement 25.

Finally, the fourth policy is designed to put stricter requirements on the minimum age to go in retirement, 67 and 72 instead to 65 and 70 for the full and Advance age pension respectively. This policy experiment is considered to obtain more resources to cover deficits[21]. Workers in all educative levels work more formally than in the benchmark after the age of 45 as is shown in Table A.6. Note for example, that those low educated work at the age of 67, 2.5 years more in formality than in the benchmark at the age of 65 (Table 24). Pension achievement is shown in Table 23, workers in all educative levels achieve higher pension due to the fact that they work more formally. However, 42% of the low educated only achieve an Advance age pension. The distribution of total years in formality (Table 24) is more variable for the low educated than in the benchmark.

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[21] Note if most of the low educated workers continue working after the age of 65, then this requirement will not affect them. The budget could be affected if more workers have access a full pension with higher replacement rates, but those parameters do not deeply affect the worker's behavior.

	Full$_3$		Full$_2$		Full$_1$	
	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy
Low Education	0.0%	0.0%	1.4%	7.1%	44.4%	50.8%
Medium Education	0.3%	7.3%	40.9%	60.7%	58.5%	32.2%
High Education	6.2%	29.2%	56.4%	57.7%	37.3%	13.2%
	Advanced Age		Survival			
	Benchmark	Policy	Benchmark	Policy		
Low Education	54.2%	42.1%	0.0%	0.0%		
Medium Education	0.3%	0.0%	0.0%	0.0%		
High Education	0.0%	0.0%	0.0%	0.0%		

Table 23: Pension achievement with the fourth policy experiment: age of 67 as full pension requirement.

	Low Education	
	Benchmark	Policy
Years of formality (at 65/67)	24.8	27.2
Years of formality (at 70/72)	27.3	28.9
	Distribution at age 70	
$p_{0.025}$	18	19
$p_{0.125}$	22	24
$p_{0.25}$	25	27
$p_{0.5}$	29	30
$p_{0.75}$	30	31
$p_{0.875}$	31	33
$p_{0.975}$	34	37
	Medium education	
	Benchmark	Policy
Years of formality (at 65/67)	34.0	35.0
Years of formality (at 70/72)	34.1	35.0
	Distribution at age 70	
$p_{0.025}$	29	31
$p_{0.125}$	31	32
$p_{0.25}$	32	34
$p_{0.5}$	34	36
$p_{0.75}$	36	38
$p_{0.875}$	37	39
$p_{0.975}$	39	41

Table 24: Formality with the fourth policy experiment: age of 67 as full pension requirement.

8. Final considerations

In this paper, I simulate a discrete choice model where the workers choose between working in the formal or in the informal sector. These choices depend on the wages that are paid in each sector (by education and experience), and the benefits that the workers can enjoy in retirement age. The model replicates the existence of a large share of informal salaried workers, especially in the lower side of the distribution where the low educated workers account for the majority.

The Argentinean pension system is considered strict in term of requirements in order to be covered in retirement age, which is a most significant problem for the low educated workers. However, the requirements to have the right for an Advanced age pension are not so strict for a salaried worker (only 10 years) and both in my estimations and in the literature all workers at least achieve this pension[22].

The model estimation captures the informality in all the educative levels and also the transitions among the formality, informality and unemployment. Pension achievements are in line with other estimations of the literature, showing that among the salaried workers the main problems is with the low educated ones.

The policy experiments show that, workers decide to work less in formality when the compulsory career is shorter and replacement rates are lower (PAYG scheme), even if they achieve a lower pension income. When the requirements became stricter, they work more in formality especially those workers who are closer to the new thresholds. It is remarkable that when the first step of full pension requirement is less strict, they work less formally even those who are in the top of the distribution. The main changes in the behavior occur in the last part of the career, that is after the age of 45.

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[22] Note, that this special pension was designed mainly for women and self employed workers.

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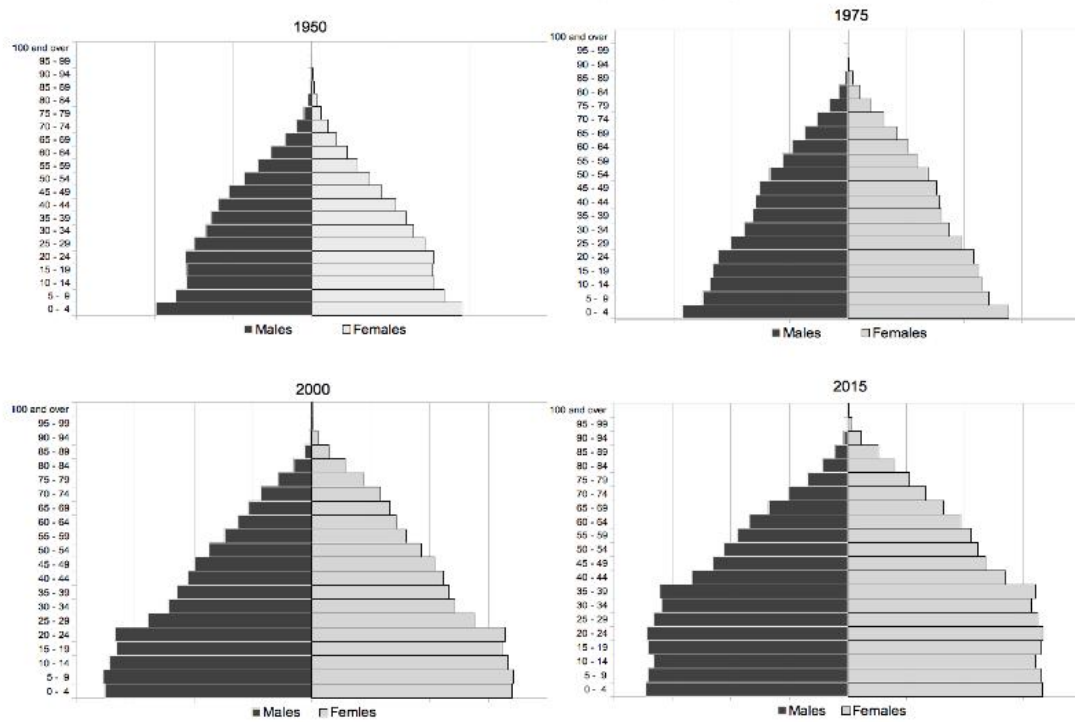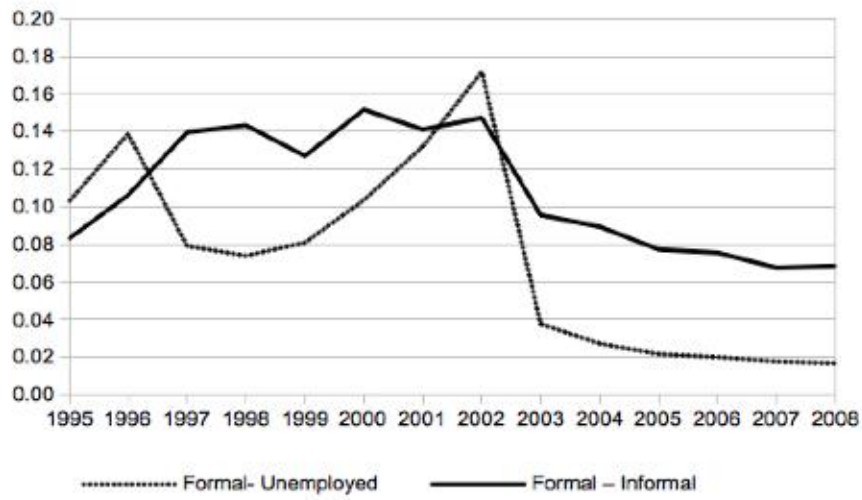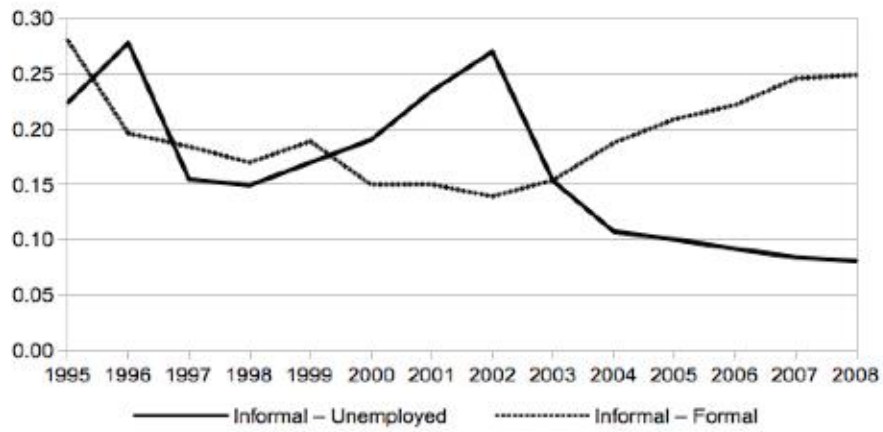
Appendix

Figure A.1: Argentinean population pyramid 1995, 1975, 2000 and 2015.
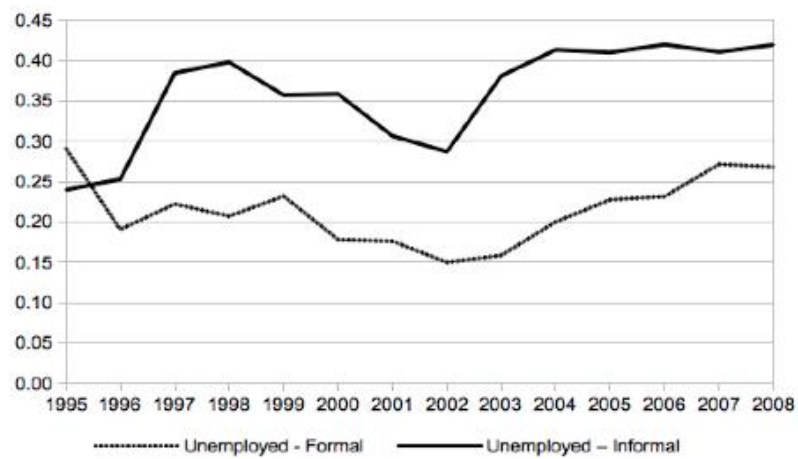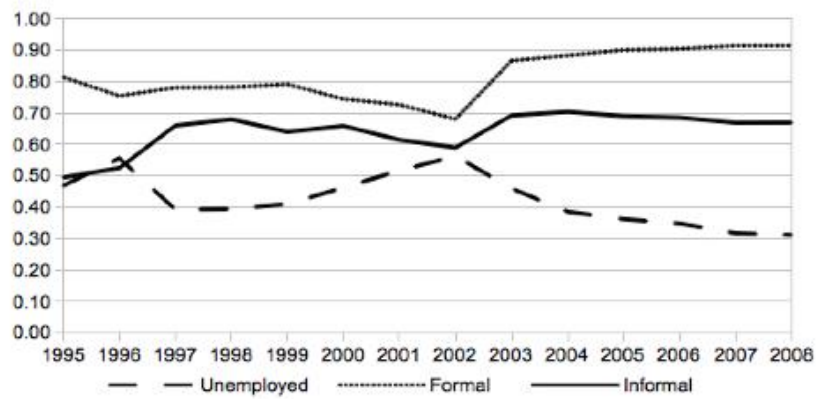Source: CELADE.

(a) From formal

(b) From informal

Figure A.2: Transition from formality (informality) to the other states

(a) From unemployment

(b) Stayer

Figure A.3: Transition from unemployment to the other states and those who remain in the same state

Age group: 23-28 years old			
Unemployed	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.3805	0.0597	0.1079
Medium Education	0.3741	0.0371	0.1094
High Education	0.3889	0.0329	0.1416
Formal	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.1531	0.7707	0.1402
Medium Education	0.2291	0.8636	0.2276
High Education	0.3220	0.9086	0.3241
Informal	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.4664	0.1695	0.7519
Medium Education	0.3969	0.0993	0.6630
High Education	0.2891	0.0584	0.534
Age group: 29-34 years old			
Unemployed	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.3726	0.0413	0.0941
Medium Education	0.3533	0.0247	0.1021
High Education	0.3255	0.0151	0.1010
Formal	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.1781	0.8215	0.1733
Medium Education	0.2723	0.8992	0.2671
High Education	0.3902	0.9435	0.4046
Informal	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.4493	0.1372	0.7326
Medium Education	0.3744	0.0762	0.6308
High Education	0.2843	0.0415	0.4944
Age group: 35-44 years old			
Unemployed	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.3736	0.0356	0.1039
Medium Education	0.3480	0.0199	0.1043
High Education	0.2972	0.0104	0.0977
Formal	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.2003	0.8471	0.1888
Medium Education	0.3055	0.9171	0.3058
High Education	0.4405	0.9560	0.4438
Informal	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.4262	0.1173	0.7073
Medium Education	0.3466	0.0630	0.5899
High Education	0.2623	0.0336	0.4585

Table A.1: Probabilities of being in each sector (only men) based on the multinomial model.

Age group: 45-54 years old			
Unemployed	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.3829	0.0330	0.1143
Medium Education	0.3352	0.0179	0.1152
High Education	0.2999	0.0094	0.0936
Formal	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.2220	0.8654	0.2072
Medium Education	0.3450	0.9275	0.3289
High Education	0.4725	0.9616	0.4876
Informal	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.3951	0.1016	0.6786
Medium Education	0.3198	0.0546	0.5559
High Education	0.2277	0.0291	0.4188
Age group: 55-65 years old			
Unemployed	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.4235	0.0379	0.1351
Medium Education	0.3568	0.0209	0.1395
High Education	0.2624	0.0092	0.0864
Formal	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.2245	0.8688	0.2226
Medium Education	0.3605	0.9290	0.3437
High Education	0.5372	0.9654	0.5351
Informal	Unemployed (-1)	Formal (-1)	Informal (-1)
Low Education	0.3520	0.0933	0.6423
Medium Education	0.2828	0.0501	0.5168
High Education	0.2003	0.0253	0.3785

Table A.2: Probabilities of being in each sector (only men) based on the multinomial model.

	Low Education		Medium Education		High Education	
	Data	Model	Data	Model	Data	Model
23-28	0.1462	0.0862	0.0830	0.1039	0.0808	0.0661
	[0.1298, 0.1703]		[0.0694, 0.0966]		[0.0464, 0.1147]	
29-34	0.0845	0.0362	0.0527	0.0326	0.0172	0.0056
	[0.0710, 0.0968]		[0.0384, 0.0675]		[0.0090, 0.0429]	
35-44	0.0729	0.0342	0.0311	0.0032	0.0126	0.0034
	[0.0618, 0.0861]		[0.0232, 0.0458]		[0.0076, 0.0222]	
45-54	0.1053	0.1091	0.0220	0.0031	0.0161	0.0355
	[0.0696, 0.1551]		[0.0152, 0.0354]		[0.0108, 0.0227]	
55+	0.0862	0.0970	0.1044	0.0925	0.0096	0.0307
	[0.0624, 0.1122]		[0.0514, 0.1687]		[0.0047, 0.0174]	

Table A.3: Moment matching: Unemployed workers. The interval is estimated based on the multinomial model, performing bootstraps and considering the middle 90%.

	General		Low Education		Medium Education		High Education	
	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy
23-28	0.399	0.398	0.265	0.264	0.481	0.480	0.615	0.612
29-34	0.619	0.622	0.512	0.513	0.692	0.697	0.778	0.780
35-44	0.756	0.746	0.651	0.628	0.852	0.851	0.854	0.857
45-54	0.747	0.757	0.544	0.550	0.943	0.955	0.904	0.924
55+	0.831	0.891	0.764	0.838	0.875	0.937	0.933	0.949

Table A.4: Formality path with the second policy experiment: 35 years of formality as full pension requirement and 20 years in formality as *Advance age* pension requirement.

	General		Low Education		Medium Education		High Education	
	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy
23-28	0.399	0.398	0.265	0.264	0.481	0.484	0.615	0.619
29-34	0.619	0.620	0.512	0.513	0.692	0.694	0.778	0.780
35-44	0.756	0.758	0.651	0.628	0.852	0.853	0.854	0.854
45-54	0.747	0.720	0.544	0.544	0.943	0.894	0.904	0.848
55+	0.831	0.807	0.764	0.743	0.875	0.839	0.933	0.922

Table A.5: Formality path with the third policy experiment: 25 years of formality as full pension requirement.

	General		Low Education		Medium Education		High Education	
	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy	Benchmark	Policy
23-28	0.399	0.402	0.265	0.279	0.481	0.484	0.615	0.606
29-34	0.619	0.624	0.512	0.513	0.692	0.699	0.778	0.785
35-44	0.756	0.753	0.651	0.647	0.852	0.849	0.854	0.854
45-54	0.747	0.749	0.544	0.533	0.943	0.948	0.904	0.939
55+	0.831	0.889	0.764	0.854	0.875	0.906	0.933	0.955

Table A.6: Formality path with the fourth policy experiment: age of 67 as full pension requirement.

Transitions	Benchmark	1st Policy	2nd Policy	3rd Policy	4th Policy
Informal-Formal	0.476	0.485	0.484	0.465	0.474
Informal-Unemployed	0.123	0.113	0.100	0.138	0.122
Informal-Informal	0.401	0.402	0.416	0.397	0.404
Formal-Formal	0.835	0.795	0.85	0.825	0.853
Formal-Unemployed	0.027	0.036	0.014	0.033	0.019
Formal-Informal	0.139	0.166	0.136	0.142	0.129
Unemployed-Formal	0.259	0.347	0.224	0.349	0.234
Unemployed-Unemployed	0.323	0.218	0.223	0.292	0.292
Unemployed-Informal	0.418	0.435	0.553	0.359	0.475

Table A.7: Transitions with the policy experiments.

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