The social and economic effects of introducing reverse mortgages in Chile

José Luis Ruiz, Pablo Tapia and José Donoso

Abstract

This study simulates the social and economic effects of introducing reverse mortgages in Chile. It uses the 2009 Social Protection Survey and recent simulation methodologies to analyse the monetary gain associated with taking out such a loan, which is paid in periodic instalments over the homeowner's lifetime. Eligible individuals are retired homeowners, who account for 70% of the older population. Monies received increase exponentially depending on the age at which the reverse mortgage is taken out. Lastly, the increase in liquidity has significant social potential, as it could reduce the poverty rate in the target group by 15%.

Key words

Housing, housing finance, mortgages, pensions, retirement, prices, economic aspects, mathematical models, social aspects, Chile

JEL classification

G21, G22, G28

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I. Introduction

In recent decades, global population trends have shown increases in longevity and in the share of older persons as a percentage of the total population. Data from the National Institute of Statistics (INE) of Chile show that in 1950, persons aged 65 and over accounted for 4% of Chile's population, a number that has continued to grow and is projected to reach 22% in 2025. Consequently, persons in this age group are gaining increasing importance in the design of public policy and place pressure on the funding of pension systems. This situation becomes urgent when one considers that the pensions received by Chileans are lower than other countries in the Organization for Economic Cooperation and Development (OECD) and that 70% of the population considers them insufficient to maintain an adequate standard of living (Presidential Advisory Commission on the Pension System, 2015).

One alternative that can help to improve pensioners' living standards is the reverse mortgage. Broadly speaking, a reverse mortgage is a financial product aimed at retired homeowners, whereby a financial institution agrees to pay homeowners a monthly amount for as long as they live; upon their death, ownership of the property passes to the lender unless the heirs return the full amount paid. The main purpose of this instrument is to free up some of the illiquid wealth tied to homes without the owners having to vacate their property. This brings with it a series of economic benefits, such as increased household liquidity and the acquisition of resources that complement pensions and help to reduce poverty among older persons. However, as reverse mortgages are not available in Chile, the aim of this study is to simulate their possible economic and social benefits.

We follow the methodology proposed by Ma and Deng (2013) and Wang and Kim (2014) to model monthly reverse mortgage payments for a given a house price.[1] Using the revenue generated by reverse mortgages, we analyse their contribution to the household income and, at per capita level, how the payments vary depending on the age at which pensioners take out a reverse mortgage and to what extent this instrument affects the poverty rate of the target group.

Reverse mortgages have been analysed in Chile by Muñoz (2011) and by Alonso, Tuesta and Lamuedra (2013). This study focuses on the social potential of the reverse mortgage through simulations based on updated models, using variants such as the loan-to-value (LTV) ratio, changes in real estate prices and mortality rates, among others. This innovative approach adds to the interest of this study: the fact that this subject is widely documented in the literature it offers a reliable basis against which to compare our findings.

Our analysis shows that monthly payments from a reverse mortgage would amount to 62,508 Chilean pesos on average for contracting parties, which is an increase of 107% over the average monthly pension of 58,245 pesos received by the individuals in the sample. The monetary gain from the instrument leads to an increase in liquidity corresponding to 57% of per capita income. In addition, the evidence suggests that the older individuals are when they take out a reverse mortgage, the higher the payments they receive, as interest rates also increase with age. This means that if all eligible persons were to take out a reverse mortgage upon retirement, the poverty rates in this population group would fall by approximately 15%. Raising the retirement age for women to 65 —the same age as for men— would reduce poverty even further, leading to a 19% decline.

This article is divided into six sections. Following this introduction, section II provides details on the pension situation in Chile. Section III reviews the theoretical and empirical literature on reverse mortgages and their social potential. Section IV presents the analytical framework and the simulation data and section V discusses the findings of the simulations. Lastly, section VI concludes.

[1] Prices correspond to the 2009 Social Protection Survey; see [online] https://www.previsionsocial.gob.cl/sps/biblioteca/encuesta-de-proteccion-social/bases-de-datos-eps/.

II. Pensions in Chile

Until 1980, Chile had a pay-as-you-go pension system, in which pensions were funded through different institutions called "cajas de pensión", with differentiated rules and benefits. With population ageing and declining rates of active workers paying into the pension system rendering it insolvent, a new pension system was created in 1981. This new system comprised fully funded individual accounts for workers entering the labour market, with workers already in the old system able to opt in. Those who remained in the old system continued to contribute to it, but their were pensions financed out of general tax revenue. Workers enrolled in the new pension system pay into individual accounts managed by Pension Fund Administrators (AFPs), responsible for collecting, registering and investing pension contributions. AFPs also pay benefits through programmed withdrawals,[2] while lifetime income payments are made by life insurance companies.[3]

The main objective of any pension system is to guarantee a stable income for workers at the end of their working life, and this income should correspond to their earnings during their active life. The former pay-as-you-go system offered replacement rates of around 70% to those meeting the requisite conditions.[4] The current system has a number of advantages over the pay-as-you-go system; however, this model alone cannot resolve the issue of financing old age in countries where income distribution is unequal, as is the case in Chile (Office of the Superintendent of Pensions, 2010).

After three decades of the fully funded system, it was observed that a significant portion of the population had insufficient savings to afford a decent living in their old age. This can be explained by the low density of contributions to individual accounts (Office of the Superintendent of Pensions, 2006) and by payment differentials related to gender and other factors. The current pensions system underwent a key reform in 2008 with the introduction of a solidarity pillar that aims to fight poverty and is funded through general taxation (Office of the Superintendent of Pensions, 2010). This improvement, however, proved insufficient. The Presidential Advisory Commission on the Pension System was established in 2015 and tasked with reviewing and the pension system and proposing improvements thereto. It reported that 50% of retirees received pensions below 82,650 pesos, with a significant gender gap: the median pension for women stood at 42,561 pesos, while for men that figure was 112,333 pesos. Half of Chilean retirees receive at most 34% of their average income for the last 10 working years. This includes retirees under the pre-1980 pension system. Thus, it is estimated that taking into account only workers in the fully funded system retiring between 2025 and 2035, half of pensioners would earn no more than 37% of their average income for the last 10 working years. Moreover, this is extremely low compared to the average replacement rate for OECD countries which stands at 66%.

Lastly, the above is closely related to the fact that 70% of Chileans believe that pension incomes are insufficient to cover adequate living standards (OECD, 2013). This led to protests in 2016, in a demand for changes to the pension model that would offer better benefits (*The Economist*, 2016).

III. Literature on reverse mortgages

One of the main dilemmas facing retired homeowners is whether to remain in their homes and accept a low retirement income, or to sell their home and use some of the proceeds for rented accommodation, using the rest as a stream of income (Bartel and Daly, 1980). Economically speaking, the latter is option is rational; however, there are significant psychological costs associated with renting and moving homes

[2] See [online] https://www.spensiones.cl/portal/institucional/594/w3-propertyvalue-9924.html#faqs.

[3] See [online] https://www.spensiones.cl/portal/institucional/594/w3-propertyvalue-9924.html#faqs.

[4] Persons who contributed for less than 15 years are not entitled to pension payments.

(Davidoff, 2010). Reverse mortgages offer a possible solution to this conundrum. This financial product, which emerged in the United States in the 1980s and has since spread to a number of countries (including Canada, Australia, Spain and Japan), allows retired homeowners to borrow money, using their homes as collateral, without having to give up residence.

Phillips and Gwin (1993) identify three categories of reverse mortgages: term reverse mortgages, which entail payments of a fixed sum for a determined period, after which the loan is repaid through the sale of the property; split-term reverse mortgages, which are similar to the first but with the difference that homeowners continue to live in the property after the prescribed term of payments, which are to be repaid when the homeowner changes residency, sells the property or dies; and lastly, tenure reverse mortgages, which are considerably more common than the previous two and consist in payments of a fixed sum until the individual, moves, sells the house or dies, for a loan amount that has a positive correlation with the age of the borrower and value of the property and a negative correlation with interest rates (Fornero, Rossi and Urzi, 2016).

It is suggested that individuals who take out reverse mortgages are older persons who are asset-rich but cash-poor, i.e. who have substantial wealth (represented by home equity) but have liquidity constraints (Moulton and others, 2015). In this sense, Nakajima and Telyukova (2017) find that take-up rates of the instrument are higher among those with low income, who own expensive homes, have outstanding mortgages, live on their own and are in poor health.

Simulations of reverse mortgages were carried out in different countries to determine their potential before they were put into effect. The results have been mixed. One of the most relevant studies with regard to reverse mortgage simulations is Mayer and Simons (1994), conducted in the early stages of the use of this instrument in the United States, in which the authors claim that reverse mortgages could reduce poverty in the target group by about three quarters. The authors convert the value of the house to a lifetime annuity with monthly payments (tenure). However, owing to a lack of data and advanced methodologies, the authors assumed random property values and loan-to-value ratios. The latter variable, which corresponds to the percentage of the home that can be used as collateral, is the most questionable: the authors set the value at 75%, while subsequent studies calculate it mathematically, resulting in lower values.

Kutty (1998) conducts a study of reverse mortgages already contracted in the United States. Using tenure reverse mortgages as a basis, he argues that if all households in the target group were to contract such a loan, less than one-third would be lifted out of poverty. In the United Kingdom, Hancook (1998) uses the same methodology as Kutty (1998) to model the effect of the implementation of reverse mortgage schemes and concludes that poverty would be reduced by less than 5%. The differences in findings can be partially attributed to the fact that reverse mortgage income is tax-free in the United States but is subject to taxation in the United Kingdom (Ong, 2008).

Moscarola and others (2015) analyse the potential social gain to be obtained from the development of reverse mortgages in European countries where the instrument has yet to be introduced. The authors use three scenarios with arbitrarily-selected interest rates and two scenarios each with a different percentage of the property used as collateral to simulate the reduction in vulnerability in the target group. Spain and Belgium have the greatest potential, with poverty reduction peaking at close to 25%. Poverty could be reduced by more than 10% in France and Italy, but that rate would be lower in the other countries studied (Switzerland, Austria, the Netherlands, Germany and Denmark).

In Chile, Muñoz (2011) argues that if the entire target group took out a reverse mortgage, poverty would fall by 88%. However, this study is not based on a tenure reverse mortgage, but a split-term reverse mortgage. Furthermore, it does not take into account the increased liquidity created by the instrument in per capita terms, as most international studies do, nor does it include a disagreggation of the findings in distinct target groups. Fuentes and Moris (2014) examine the legal feasibility of introducing

reverse mortgages in Chile, concluding that the current legal environment, which lent itself to effective drafting of contracts, and the existence of suitable legal mechanisms to protect contracting parties created favourable conditions.

The present study is based on the methodology applied by Ma and Deng (2013) and Wang and Kim (2014), who introduce the principle of insurance pricing. This principle involves a simulation that avoids losses to the lender in the event that the borrower's loan balance exceeds the value of the home at a given time, as occurs when the property value appreciates less than expected or the contracting party lives longer than estimated: this takes into account the relationship between mortgage insurance premiums and expected losses to the lender. As previous studies have not addressed this relationship, its importance has been overlooked. If financial institutions are allowed to define monthly payments at the equilibrium point where the expected values of the insurance premiums received are equal to the value of expected losses, monthly payments would be more realistic, which plays a key role in motivating financial institutions to participate in this type of market. However, as the simulation method used by these authors was not intended to analyse the social impact of reverse mortgages, the present study is ground-breaking in this regard.

Lastly, despite the theoretical potential of reverse mortgages, demand for and use of the instrument are lower than expected (Davidoff, Gerhard and Post, 2017). In the United States, only 2.1% of eligible homeowners had reverse mortgage loans in 2011, the highest level of demand to date (Nakajima and Telyukova, 2017). Davidoff, Gerhard and Post (2017) argue that this is because target groups may find the instrument difficult to understand. This is upheld by Moulton and others (2015), who maintain that the take-up of reverse mortgages is low because seniors shy away from complicated financial instruments or do not fully understand what they entail.

IV. Methodology and data

1. Analytical framework

We use a tenure reverse mortgage, which is widely documented and provides a reliable platform for comparing our findings, to calculate monthly payments. We then follow Ma and Deng (2013) and Wang and Kim (2014), in which monthly payments are calculated using the house price at the time the loan is contracted. A random house price is selected in order to model the change in monthly payments depending on the age group to which the homeowner belongs when a reverse mortgage is taken out, for a property of the same value. We apply the same method, instead using the real value of the home that is being used as collateral.

House prices were based on the 2009 Social Protection Survey (EPS), which is representative of the population and has detailed and reliable information on the pensioners making up the target group. Notwithstanding the above, the value of the property at the time of each individual's retirement is required for the model. To this end, we apply the simulation used in Ma and Deng (2013) and Wang and Kim (2014), adding one prior step to obtain the home price at retirement by using the 2009 values for each individual. This study presents the methodology used by those authors for calculating monthly payments, with extensive use of life tables (Office of the Superintendent of Pensions, 2009a).

The algorithm used to simulate the monthly payments includes the following:

(i) the house price according to the 2009 Social Protection Survey.

(ii) the estimated house price at the time of retirement.

(iii) the estimated house price at the term of the mortgage.

(iv) the loan-to-value ratio.

(v) the estimated monthly payments (using life tables).

The simulation begins with the house price based on 2009 values as the base variable, which is obtained as described in section IV.3. We then proceed as follows:

(a) Based on the 2009 house for individual i, ($P_{2009,i}$), the price of the home at the time of each individual's retirement ($P_{j,i}$)is estimated based on the methodology developed by Szymanoski (1994). For a description of this methodology, see annex A1.

$$P_{J,i} = \frac{P_{2009,i}}{exp\left(\mu \cdot t_i + 0{,}5 \cdot \sigma^2 \cdot t_i\right)} \tag{1}$$

Where μ corresponds to the average annual growth of property prices (Central Bank of Chile) in the economy and σ^2 represents the variation in that growth rate, while t_i indicates the number of years elapsed between the retirement of individual i and 2009, according to information obtained from 2009 Survey.

(b) Once the house price at the time of retirement has been obtained, we calculate the price at the term of the contract ($P_{T,i}$), approximate to the price of the property when the individual i meets his or her life expectancy (in accordance with Szymanoski, 1994).

$$P_{T,i} = P_{J,i} \cdot exp\left(\mu \cdot T_i + 0{,}5 \cdot \sigma^2 \cdot T_i\right) = \frac{P_{2009,i} \cdot exp\left(\mu \cdot T_i + 0{,}5 \cdot \sigma^2 \cdot T_i\right)}{exp\left(\mu \cdot t_i + 0{,}5 \cdot \sigma^2 \cdot t_i\right)} \tag{2}$$

In this case, T_i represents the expected duration of the contract in years —that is, the life expectancy of i— less the retirement age, which is obtained by combining data from the National Institute of Statistics (2010a) and the mortality tables from the Office of the Superintendent of Pensions. Similarly, values for life expectancy and age at retirement will depend on the sex of the individual.

(c) We obtain the loan-to-value (LTV) ratio, which is the maximum percentage of the home's value at the age of retirement that can be used as collateral, as seen in equation (3).

$$LTV_i = \frac{P_{T,i} / \left(1 + r\right)^{T_i}}{P_{J,i}} \tag{3}$$

Where r is the discount rate of the loan, which comprises the linear sum of the country's risk-free interest rate[5] (i_{lr}), the insurance premium[6] (IP_m) and the lender's margin[7] (LM). These are the elements that typify the national economy.

(d) We calculate the current loan value (CLV), understood as the loan amount disbursed by the financial institution when only a lump sum is paid on signature of the contract. This is described in equation (4), which includes the up-front insurance premium[8] for the loan (IP_0).

$$CLV_i = P_{J,i} \cdot \left(LTV_i - IP_0\right) \tag{4}$$

[5] Monthly average of secondary market 10-year interest rates of peso-denominated bonds (BCP) tendered by the Central Bank of Chile (see [online] https://si3.bcentral.cl/Boletin/secure/boletin.aspx?idCanasta=1MRMW2951).

[6] The 0.5% rate in effect in the United States market is used (Rodda and others, 2003). The same rate is used in the papers establishing the methodology applied (Wang and Kim, 2014; Ma and Deng, 2013).

[7] Variable that usually ranges between 1% and 2% (Rodda, Herbert and Lam, 2000). We use 1%, following Wang and Kim (2014).

[8] The 2% rate in effect in the United States market is used (Rodda and others, 2003). The same rate is used in the paper establishing the methodology applied (Wang and Kim, 2014).

(e) According to Wang and Kim (2014), monthly payments are determined as in equation (5), where represents the expected duration of the loan in months.

$$LM_i = \frac{CLV_i}{\sum_{n=0}^{n=(\tau_i-1)} (1+r)^{-n}} \quad (5)$$

Equation (5) gives the value of monthly payments assuming that all individuals live out their life expectancy. However, this figure is merely theoretical, as borrowers may die before or after that date. As this could give an inaccurate estimate of monthly payments, to improve the scope of the simulation, we expand equation (5) by including a discount factor that considers the probability of i being alive to receive the payment in month N, ($p_{N,i}$), assuming the individual was alive at the time the reverse mortgage was taken out, as expressed in equation (6).

$$LM_i = \frac{CLV_i}{\sum_{N=0}^{N=T} \left[(1+r)^{-N} \cdot (p_{N,i}) \right]} \quad (6)$$

Where the term T represents the period in which the probability of survival falls to 0.

Regarding equation (6), it is important to bear in mind that in this study we obtain $p_{N,i}$ from the life tables of the Chilean pension system for 2009 (see annex A2), where the probability of dying is given in annual intervals and not monthly intervals as required by the model. We will therefore assume that the probability that an individual is alive in a given year is equal to the probability that the same individual is alive in every month of that year. The Chilean pension system life tables to 2009 are the basis for determining the threshold value T (110 years for both sexes). This corresponds to a loan duration of T = 540 months for an individual retiring at 65 and T = 600 months for an individual retiring at 60.

2. Economic parameters

Knowledge of specific parameters of the Chilean economy is required for our model:

Discount rate on reverse mortgages

In the specialized literature, the discount rate used to calculate reverse mortgage payments is obtained by adding a risk-free interest rate, usually for a 10-year period, together with a differential representing the lender's margin and another to cover a monthly insurance premium paid over the life of the loan. The Central Bank of Chile 10-year interest rate in pesos (BCP-10), with an annual average of 5.67% in 2009, was used as the risk-free rate. Annual rates of 1% and 0.5% (Rodda, Hebbert and Lam, 2000) will be used for the lender's margin and monthly insurance premium, respectively, as practised for reverse mortgages in the United States.

Initial cost of the loan

This corresponds to the value of the property at the time of borrowing, multiplied by an up-front insurance premium of 2% (used in Ma and Deng (2013) and in Wang and Kim (2014)).

Mean and standard deviation of percentage change in house prices

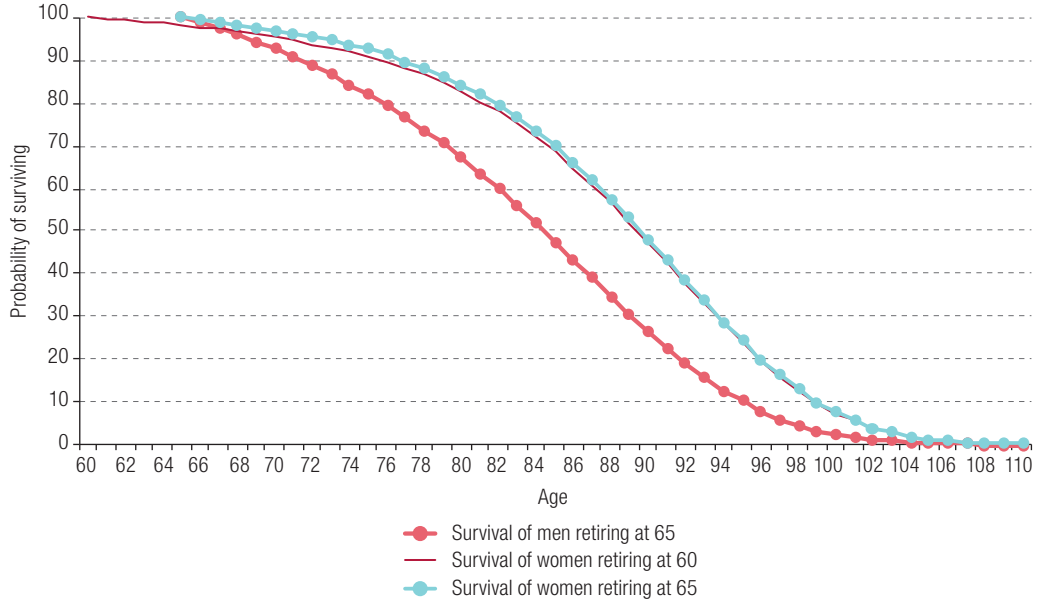
The variables related to movement in house prices are obtained using the real estate price index provided by the Central Bank of Chile, available from 2003 to 2014. To that end, we use the simple average of the variation in the annual index and the standard deviation over the period, which previously stood at 4.4% and 2.9%, respectively.

Life expectancy and life tables

The life tables for Chile as of 2009 were used to determine the life expectancy of the individuals in our sample. The life expectancy for men is 76 years, while for women it is 81 years (INE, 2010b). The survival probabilities of individuals over the term of the loan are estimated using the life tables for lifetime income pensions in Chile in 2009, disaggregated by sex. These tables are included in annex A2.

There are gender differences in the probability of survival. Data on the probability of survival for men retiring at 65 and for women retiring at 60 and 65, taking 110 as the upper age limit for both genders, show that at each age men are less likely to be alive than women. This difference is greatest in the median ages of the life span analysed (see figure 1).

Figure 1
Survival probability, by sex and age at retirement
(Percentages)



Source: Prepared by the authors, on the basis of Office of the Superintendent of Pensions, "Compendio de Normas del Sistema de Pensiones, Libro III, Título X, Tablas de Mortalidad, Anexo Nº 5", Santiago, 2009 [online] http://www.spensiones.cl/portal/compendio/596/w3-propertyvalue-4350.html.

3. Data

The Social Protection Survey (EPS) is a longitudinal survey that is representative of the population; its 2009 edition compiles various observations on some 16,000 households throughout Chile. It has played a key role in the analysis and design of public policies in Chile,[9] specifically those on pensions, and is therefore a vital source of information for our study. The sample population, comprising only the target group for reverse mortgages —namely homeowners of retirement age (women aged 60 and over and men aged 65 and over)— was extracted from this Survey.

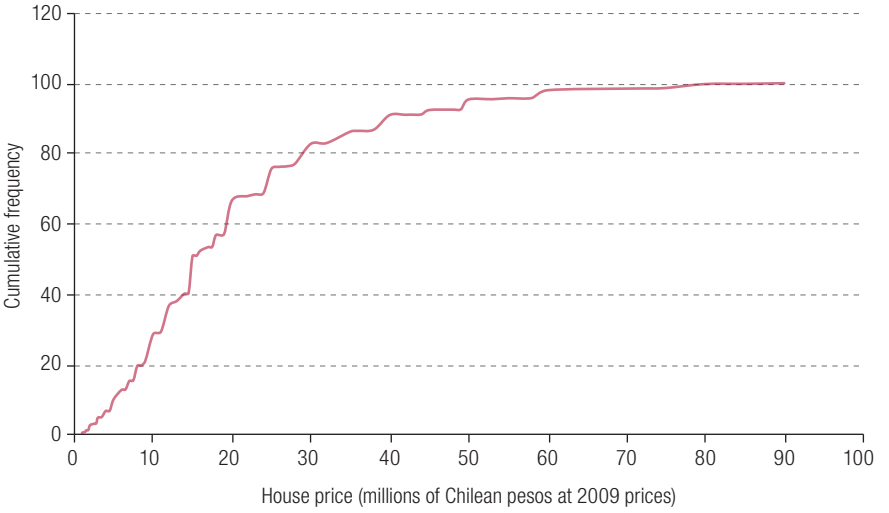
The following question was asked in the Survey to determine the price of homes: "If you were to sell your house today, how much would it be worth?"[10]The answer to that question is hereinafter

[9] The Presidential Advisory Council for Pension Reform (2015) was able to identify shortcomings in pension policy thanks to the Survey.

[10] Question D17 of the 2009 Social Protection Survey.

referred to as the "house price". However, because it is based on a personal appreciation, it may be biased. To correct this bias, we assume that individuals' mobility between regions is low and we thus classify individuals by their region of birth and by deciles according to the expansion factor, forming homogeneous groups based on property value. Thus, for each individual, the average value for the corresponding segment is imputed as the house price. This solves possible bias and also covers the observations of individuals who did not know or did not answer the question on the value of their home. In addition, the values given to the homes in the sample are not normally distributed. This is corrected by removing data for house prices above percentile 97.5, which corresponds to house prices above 100 million pesos. The resulting distribution is shown in figure 2. This is also represented in table 1 showing a comparison between the variables house price and imputed house price, which is the value of the house based on the aforementioned adjustments.

Figure 2
Distribution of house prices in Chile
(Percentages)



Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

Table 1
Comparison of house prices and imputed house prices

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
House price *(millions of pesos at 2009 prices)*	1 752	20.60	15.00	1.00	90.00
Imputed house price *(millions of pesos at 2009 prices)*	2 627	20.40	4.11	2.50	50.00

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

Lastly, 2,627 observations were selected from this process, representing a population of 1,623,326 households; women make up 59.1% of the population and the average age is 71 years. Of the respondents, 65% are heads of household with an average household income of 103,749 pesos. The average per capita income is 34,724 pesos (see table in annex A3). In light of the above, 86.25% of the sample are below the poverty line.[11]

[11] Urban poverty line in terms of people living in income (absolute) poverty in Chile (see [online] http://observatorio.ministeriodesarrollosocial.gob.cl/casen/casen_def_pobreza.php), which stands at 64,134 pesos per capita.

V. Empirical section

To simulate the monthly payments, we must first establish house prices at the time of retirement and at the term of the loan, and the initial price of homes imputed to 2009 in the Social Protection Survey, in line with the modelling in Szymanoski (1994). We note that the average property price at the time of retirement is 14 million pesos, while the average for the expected property value at the term of the contract is slightly more than 30 million pesos (see table 2). From the above, we obtain the loan-to-value (LTV) ratio, the average of which is 59.42%. This value can be broken down by sex, where the average LTV for women is 53.92% and for men 72.36%. The above figures are consistent with the fact that the expected duration of mortgages is lower for men, because of their later retirement age and shorter life expectancy than women.

Once we have obtained the LTV ratio, we can calculate the current loan value (CLV), understood as the amount the financial institution disburses in a lump sum to the homeowner at the time the reverse mortgage is taken out, as opposed to making monthly payments. The average CLV is 8 million pesos, which is used to calculate monthly payments, assuming that all eligible individuals take out a reverse mortgage. The average for monthly payments is 62,508 pesos, with a standard deviation of 29,760 pesos. However, when taking into account self-funded pensioners[12] in the sample, the average pension income is 145,808 pesos. That income could rise by 43% if we included reverse mortgage payments. When we consider in the sample retirees receiving the solidarity pension (non-self-funded), the average pension amounts to 58,245 pesos; the addition of monthly payments from the reverse mortgages would see this income rise by 107%. These large increases can be explained by the low pensions in Chile but they also show that older persons possess high volumes of illiquid wealth.

It is also appropriate to analyse reverse mortgage payments by gender, as this determines retirement age and life expectancy, bases on which the duration of the mortgage and the loan amount available to pensioners are calculated. Gender also determines the amount of the basic pension, which in turn defines the initial wealth base, since the average pension for women is 51,174 pesos, while that for men is 89,185 pesos (see table 2). This is attributable to differences in labour participation and the existing wage gap between women and men in Chile (Sáez, 2010).

Table 2
Estimate of reverse mortgage parameters

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
House price at retirement *(millions of pesos at 2009 prices)*	2627	14.00	5.40	1.12	47.80
House price at term of loan *(millions of pesos at 2009 prices)*	2627	31.6	13.60	1.83	122.00
Loan-to-value ratio *(percentages)*	2627	59.42	8.44	53.92	72.36
Current loan value *(millions of pesos at 2009 prices)*	2627	8.07	3.43	0.79	33.10
Monthly payments *(pesos)*	2627	62 508	29 760	6 807	285 512
Monthly payments for women *(pesos)*	1552	51 174	20 539	7 883	178 732
Monthly payments for men *(pesos)*	1075	89 158	31 053	6 807	285 512

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

As we have mentioned, there is a five-year difference in retirement age between women and men, which affects the execution of the reverse mortgage contract because its duration is determined by age at retirement. Chilean women currently retire at 60 —we use this as the standard scenario in this study but have also analysed an alternative scenario in which women retire at the same age as men (65 years). As expected, raising women's retirement age resulted in a 55% increase (28,221 pesos) in

[12] This means the State does not contribute to their pensions. This applies to 1093 individuals (41% of the sample).

monthly reverse mortgage payments and a narrowing of the gender gap by 74.3%, as shown in table 3. Therefore, financial conditions being equal, the amount received from a reverse mortgage will also be equal; this must be taken into account if this instrument is to be incorporated in public policy design.

Table 3
Analysis of monthly payments by sex and retirement age
(Chilean pesos)

Status	Retirement age for women	Retirement age for men	Total monthly payments	Monthly payments for women	Monthly payments for men
Standard scenario	60	65	62 508	51 174	89 158
Alternative scenario	65	65	82 308	79 395	89 158
Variation			19 800	28 221	0

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

On the basis of the above results in the standard scenario, monthly payments from reverse mortgages would be a valuable addition to household income. They have the potential to increase the household income of the target group by about 60% on average, from 103,749 pesos to 166,258 pesos. Consequently, per capita income also increases by approximately 57%, from 34,724 pesos to 54,537 pesos, as seen in table 4. This affects not only the distribution of wealth but also plays a role in improving the quality of life in those households thanks to increased income.

Table 4
Impact of reverse mortgages on income (standard scenario)
(Chilean pesos)

Variable	Mean	Standard deviation	Minimum	Maximum
Household income without reverse mortgage	103 749	136 576	0	2 000 000
Household income with reverse mortgage	166 258	141 879	7 883	2 121 002
Mean variation of household income	60.25%			
Per capita income without reverse mortgage	34 724	49 533	0	450 000
Per capita income with reverse mortgage	54 537	57 525	2 037	519 441
Mean variation of per capita income	57.06%			

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

After simulating the monthly payments and assuming that all eligible individuals take out a reverse mortgage, its effects on poverty in the sample can be analysed. We observe that reverse mortgages could generate a 15% reduction in poverty rates for the sample as a whole (see table 5).

Table 5
Potential effect of reverse mortgages on poverty (standard scenario)
(Percentages, except for figures in left column)

Variable	Observations	Poverty rate		Percentage reduction in poverty
		Without reverse mortgage	With reverse mortgage	
Total	2 627	86.25	73.17	15.17
Contributors to pension fund administrators (AFPs)	434	90.71	83.77	7.65
Respondent is head of household	1 935	81.30	65.24	19.75
Respondent is not head of household	692	95.48	87.95	7.89
Women	1 552	88.40	79.64	9.91
Men	1 075	81.18	57.94	28.63

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Table data based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

In this sense, the potential effect is low compared to studies conducted in the United States (Mayer and Simons, 1994; Kutty, 1998), Spain and Belgium (Moscarola and others, 2015), but greater than that detected in the United Kingdom (Hancock, 1998), Denmark, Germany, Holland, Austria and Sweden (Moscarola and others, 2015). The reduction in poverty seen in our simulation falls between the levels reported for Italy and France (Moscarola and others, 2015), as shown in table 6. This indicates that our simulation model is reliable, since the projected poverty reduction is within the ranges defined in the specialized literature and this also confirms the accuracy of the economic parameters selected.

Table 6
Potential effect of reverse mortgages on poverty, by country
(Percentages)

Country	Percentage reduction in poverty	Data year	Author
Sweden	3	2012	Moscarola and others, 2015[a]
United Kingdom	4	1995	Hancock, 1998
Austria	4	2012	Moscarola and others, 2015[a]
Netherlands	5	2012	Moscarola and others, 2015[a]
Germany	6	2012	Moscarola and others, 2015[a]
Denmark	8	2012	Moscarola and others, 2015[a]
France	14	2012	Moscarola and others, 2015[a]
Italy	16	2012	Moscarola and others, 2015[a]
Belgium	25	2012	Moscarola and others, 2015[a]
Spain	27	2012	Moscarola and others, 2015[a]
United States	29	1991	Kutty, 1998
United States	74	1990	Mayer and Simons, 1994

Source: Prepared by the authors.
[a] Values correspond to the upper limit for each country listed in the document.

If we consider only persons paying into to the AFP system, poverty is reduced by 7.65%, which is a significantly smaller decrease than in the sample as a whole. This is because, although the monthly payments to AFP contributors would be 20% higher than the sample average, their initial income is close to two-thirds of the average income of the entire sample (see table 5). Poverty reduction as a result of reverse mortgages is greater among heads of household than the sample average and slightly more than twice that among other household members. The instrument's effect would therefore be smaller than initially estimated, comparable to that seen in Denmark and Germany (Moscarola and others, 2015). The impact is small but positive for just over 100,000 households.

Lastly, it is possible to isolate the gender indicator. Initial poverty is almost 10% higher among women because men's per capita income is 50% higher than women's. As table 7 shows, in the standard scenario women receive much lower reverse mortgage payments than their male counterparts, resulting in poverty reduction of 9.91% among women compared with 28.63% among men. Therefore, if taking out a reverse mortgage is included in the decision to retire, it becomes imperative to ensure equal financial conditions for both men and women, because although the instrument will improve the well-being of retirees and their households, it could also accentuate gender-based wealth gaps.

When women's retirement age is raised, the instrument's social potential leads to a 5.31% fall in poverty among women, which is greater than the standard scenario but still lower than that among men. This widens the percentage reduction in poverty across the sample by 3.81%.

Table 7
Potential effect of reverse mortgages on poverty by sex and age at retirement
(Percentages in the three rightmost columns)

Status	Retirement age for women	Retirement age for men	Percentage reduction in total poverty	Percentage reduction in poverty among women	Percentage reduction in poverty among men
Standard scenario	60	65	15.17	9.91	28.63
Alternative scenario	65	65	18.98	15.22	28.63
Variation			3.81	5.31	0.00

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

Our findings may seem encouraging, but it must be borne in mind that they were obtained assuming that all qualifying persons took out reverse mortgages, which is unrealistic. Indeed, the likely outcome of reverse mortgages on poverty reduction is not as expected. Davidoff, Gerhard and Post (2017) and Nakajima and Telyukova (2017) argue that only 1.7% of eligible individuals in the United States do, in fact, take out reverse mortgages; furthermore, they are far more popular among homeowners who are alone, low-income, in poor health, and whose properties are more expensive than the average. Therefore, if we focus on this group only —that is, those most likely to take out reverse mortgages— the present study shows that poverty is reduced by close to 2%. This is because the individuals in this segment are so poor to begin with that monthly payments are insufficient to lift many of them out of poverty, but they do increase liquidity and, thus, the well-being of those who take out reverse mortgages. However, consideration must be given to the fact that our calculations are based solely on conditions observed in the present and not what could occur in the future, such as future income, family support networks or possible subventions.

1. Analysis by age group

Our above analysis is based on the assumption that individuals take out a reverse mortgage upon retirement, but they are free to do so at any time after their retirement date. However, the older the individual entering into the contract, the more effects there are on the monthly payments. First, taking out a reverse mortgage at an older age reduces the number of payment periods that can be expected, therefore increasing the amount of each payment. This, in turn, reduces the discount on the loan-to-value (LTV) ratio, which rises as individuals present a lower risk to the lender. Both lead to an increase in the monthly payment. This is nevertheless offset by a lower appreciation of the property, thus decreasing the LTV ratio.

In the specialized literature, there is a positive relation between the age at which the transaction is originated and the monthly payments (Ma and Deng, 2013). The aim of this section is therefore to simulate how monthly payments would vary depending on the age group to which a representative individual taking out a reverse mortgage in Chile belongs. For this purpose, a non-gender-specific life table is used, as shown in table A2.1 of annex A2.

Two cases are presented: in the first (see table 8), the price of the home at origination of the reverse mortgage is the average house price at the time of retirement of the individuals in the sample, i.e. 14 million pesos at 2009 prices. We then analyse how the monthly payments would vary if a representative individual owning a property of this value took out a reverse mortgage at 65, 70, 75 or 80 years of age (see table 8).

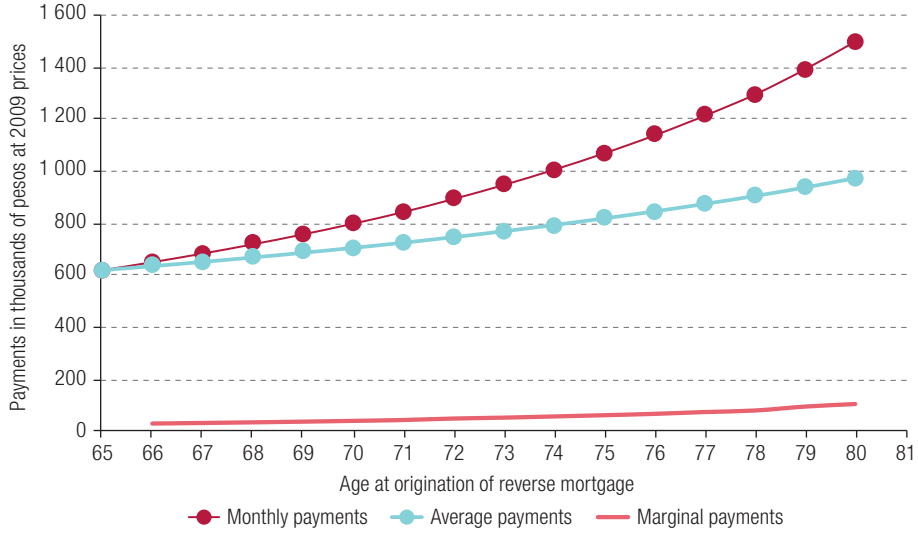
Table 8
Case 1: analysis of reverse mortgages by age group

Imputed house price of 14 million pesos at 2009 prices				
Age when taking out reverse mortgage	65	70	75	80
Imputed house price *(millions of pesos at 2009 prices)*	14.00	14.00	14.00	14.00
Expected house price at term of loan *(millions of pesos at 2009 prices)*	32.70	26.10	21.00	16.80
Loan-to-value ratio (*percentages)*	57.9	66.25	77.19	89.36
Current loan value *(millions of pesos at 2009 prices)*	7.73	8.99	10.50	12.20
Monthly payments (*pesos)*	62 387	80 179	107 080	149 793

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

As the age at origination increases, the expected value of the home at the term of the loan decreases, while the LTV expands. This means that the increase in the latter variable is the dominant effect. In view of the above, the current loan value rises, which is enhanced by the shorter duration of the contract, thus leading to higher monthly payments at increasing rates. This is clearly shown in figure 3: there is a positive relationship between monthly, average and marginal payments and age at origination. A representative individual taking out a reverse mortgage at age 65 would receive periodic monthly payments of 62,387 pesos, which would gradually increase to 149,796 pesos if the mortgage is taken out at age 80. Further details on payments can be found in annex A4.

Figure 3
Case 1: monthly payments



Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

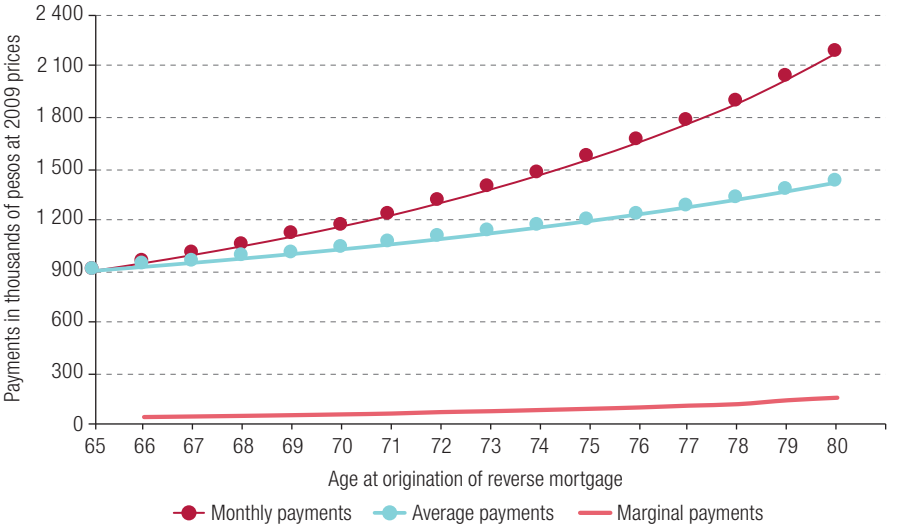
In the second case (see table 9 and annex A1), the same methodology is used but we consider the initial value of the home as the average house price imputed to 2009, i.e. 20.04 million pesos, maintaining the loan-to-value ratio at each age and the rate of increase of monthly payments. Specifically, an individual retiring at 65 would receive an additional 90,907 pesos per month from a reverse mortgage and that figure that would increase to 218,270 pesos if the mortgage is taken out at 80 years (see figure 4 and annex A4). Thus, if this instrument is introduced, there will be dispersion in payments owing to the distribution of the age at which reverse mortgages are taken out. The distribution of house prices, which will depend on future appreciation, will also lead to dispersion.

Table 9
Case 2: analysis of reverse mortgages by age group

Imputed house price of 20.04 million pesos at 2009 prices				
Age when taking out reverse mortgage	65	70	75	80
Imputed house price *(millions of pesos at 2009 prices)*	20.04	20.04	20.04	20.04
Expected house price at term of loan *(millions of pesos at 2009 prices)*	47.60	38.01	30.60	24.50
Loan-to-value ratio *(percentages)*	57.19	66.25	77.19	89.36
Current loan value *(millions of pesos at 2009 prices)*	11.30	13.10	15.3	17.80
Monthly payments *(pesos)*	90 907	116 832	156 031	218 270

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

Figure 4
Case 2: monthly payments



Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.

VI. Conclusions

Our study simulated the social and economic potential of introducing reverse mortgages for pensioners in Chile. We used the methodology proposed by Ma and Deng (2013) and Wang and Kim (2014), with some innovations such as the use of life tables from Chile, as well as data on house prices taken from the 2009 Social Protection Survey, which is highly representative of the population and linked to pension systems. A sample of 1,623,326 pensioners was used, representing approximately 9% of the adult population in Chile (Office of the Superintendent of Pensions, 2009a). The implementation of reverse mortgages will not resolve income poverty among older persons in Chile, but it can help homeowners, who could use it as collateral to enhance their economic independence by recovering some illiquid wealth.

We conclude that the increase in liquidity that comes with taking out a reverse mortgage reduces the percentage of the older population living in poverty. If all qualifying individuals took out a reverse mortgage, the poverty rate would decline by 15%; when we restrict the sample to pensioners contributing to the current fully funded system, the poverty rate is reduced by 7.65%. However, the poverty rate declines by 2% if we consider only the characteristics of the population among which reverse mortgages have been most popular where implemented (Davidoff and others, 2017; Nakajima and Telyukova, 2017), such as being alone, low-income, in poor health and having a property worth more

than the average. These results are in line with the ranges found in the specialized literature, confirming the reliability of our findings —albeit only at a trend level— because random events are incompatible with the predictive capacity we seek.

We find that with the introduction of reverse mortgages at retirement, individuals could use on average 59% of their property as collateral, receiving constant monthly payments of 62,508 pesos, which is equivalent to 60% of the average income of households with retirees. This represents a 57% increase in retirees' per capita income. However, analysis of monthly payments reveals a gender gap, as women receive 42.6% (37,984 pesos) less than men. This difference stems from women's higher life expectancy and lower retirement age, which increases the duration of their mortgages. However, raising their retirement age to 65 narrows the gender gap narrows to 10.9% (9,763 pesos). This indicates that if reverse mortgages were introduced as public policy, it would be necessary to ensure equal financial conditions for both men and women; failing this, although reverse mortgages will improve the well-being of retirees and their households, they could accentuate gender-based wealth gaps.

From another standpoint, our simulations made it possible to analyse how monthly payments would vary according to the age at origination of the reverse mortgage. An individual taking out such a mortgage at age 65 can use 57% of the home's value as collateral; that figure climbs to 89% if the individual takes out a mortgage at 80, which illustrates a positive correlation between the amount received through a reverse mortgage and the age at which it is taken out. Therefore, if this instrument is to be introduced in a public policy context, account must be taken of the dispersion that will result in mortgage payments owing to the distribution in the age of the contract. The distribution of house prices, which will depend on future appreciation, will also lead to dispersion. The diversity that these elements bring to the financial instrument means that more than one type of financial institution may be interested in offering reverse mortgages.

In summary, the findings presented in this study show that reverse mortgages can be useful in increasing liquidity for pensioners. This is important in a context where 70% of Chileans hold that pensions are insufficient to maintain an adequate standard of living in old age. Moreover, we illustrate the significant social potential in terms of poverty reduction, which could lead to undeniable gains in well-being for the target group. What matters most in the use of reverse mortgages is that older persons have access to credit and thus increase their income, without detriment to their current economic situation. However, consideration should be given to the debtor's heirs, as this instrument is a mortgage and does not involve a transfer of ownership. As this could lead to a conflict of interest between the two parties, there is a need for legislation that offers the necessary protection to both heirs and creditors (Fuentes and Moris, 2014).

Bibliography

Alonso, J., D. Tuesta and M. Lamuedra (2013), "Potencialidad del desarrollo de hipotecas inversas como complemento pensionario: el caso de Chile", *Working Paper*, No. 9, Madrid, Banco Bilbao Vizcaya Argentaria (BBVA).

Bartel, H. and M. Daly (1980), "Reverse annuity mortgages as a source of retirement income", *Canadian Public Policy/Analyse de Politiques*, vol. 6, No. 4, Toronto, University of Toronto Press.

Central Bank of Chile (2017), "Base de datos estadísticos. Indicadores sectoriales" [online] https://si3.bcentral.cl/Siete/secure/cuadros/arboles.aspx.

Comisión Asesora Presidencial sobre el Sistema de Pensiones (2015), *Informe final*, Santiago [online] http://www.comision-pensiones.cl/Informe_final_CP_2015.pdf.

Davidoff, T. (2010), "Interest accumulation in retirement home equity products", *Working Paper*, Vancouver, University of British Columbia.

Davidoff, T., P. Gerhard and T. Post (2017), "Reverse mortgages: what homeowners (don't) know and how it matters", *Journal of Economic Behavior & Organization*, vol. 133, Amsterdam, Elsevier.

Fornero, E., M. Rossi and M. Urzì (2016), "Explaining why, right or wrong, (Italian) households do not like reverse mortgages", *Journal of Pension Economics & Finance*, vol. 15, No. 2, Cambridge, Cambridge University Press.
Fuentes, M. and D. Moris (2014), "El futuro de la hipoteca inversa en Chile", undergraduate dissertation, Santiago, University of Chile.
Hancook, R. (1998), "Can housing wealth alleviate poverty among Britain's older population?", *Fiscal Studies*, vol. 19, No. 3, Hoboken, Wiley.
INE (National Institute of Statistics) (2010a), *Boletín informativo. Enfoque estadístico hombres y mujeres en Chile*, Santiago.
___(2010b), *Compendio estadístico año 2010*, Santiago.
INE/ECLAC (National Institute of Statistics/Economic Commission for Latin America and the Caribbean) (n/d), *Estimaciones y proyecciones de población por sexo y edad. Total país 1950-2050*, Santiago.
Kutty, N. (1998), "The scope for poverty alleviation among elderly home-owners in the United States through reverse mortgages", *Urban Studies*, vol. 35, No. 1, Thousand Oaks, Sage.
Ma, S. and Y. Deng (2013), "Evaluation of reverse mortgage programs in Korea", *Seoul Journal of Business*, vol. 19, No. 1, Seoul, Seoul National University.
Mayer, C. and K. Simons (1994), "Reverse mortgages and the liquidity of housing wealth", *Real Estate Economics*, vol. 22, No. 2, Hoboken, Wiley.
Moscarola, F. and others (2015), "Reverse mortgage: a tool to reduce old age poverty without sacrificing social inclusion", *Ageing in Europe – Supporting Policies for an Inclusive Society*, A. Börsch-Supan and others (eds.), Berlin, Walter De Gruyter.
Moulton, S. and others (2015), "Who gets a reverse mortgage? Identifying household level determinants of U.S. reverse mortgage choices", paper presented at the twenty-second session of the Conference of the European Real Estate Society, Istanbul, 24-27 June.
Muñoz, M. (2011), "Hipoteca revertida en Chile: una alternativa para la reducción de la pobreza", master's thesis, Santiago, University of Chile.
Nakajima, M. and I. Telyukova (2017), "Reverse mortgage loans: a quantitative analysis", *The Journal of Finance*, vol. 72, No. 2, Hoboken, Wiley.
OECD (Organization for Economic Cooperation and Development) (2013), *Pensions at a Glance 2013. OECD and G20 Indicators*, Paris.
Office of the Superintendent of Pensions (2010), *El sistema de pensiones en Chile*, Santiago.
___(2009a), "Compendio de normas del sistema de pensiones, Libro III, Título X, Tablas de mortalidad" [online] http://www.spensiones.cl/portal/compendio/596/w3-propertyvalue-4350.html.
___(2009b), "Compendio de Normas del Sistema de Pensiones, Libro III, Título X, Tablas de Mortalidad, Anexo Nº 5", Santiago [online] http://www.spensiones.cl/portal/compendio/596/w3-propertyvalue-4350.html.
___(2006), *El sistema de pensiones en Chile*, Santiago.
Ong, R. (2008), "Unlocking housing equity through reverse mortgages: the case of elderly homeowners in Australia", *European Journal of Housing Policy*, vol. 8, No. 1, Abingdon, Taylor & Francis.
Phillips, W. and S. Gwin (1993), "Reverse mortgages", *Transactions of the Society of Actuaries*, No. 44, Schaumburg, Society of Actuaries.
Rodda, D., C. Herbert and H. Lam (2000), *Evaluation Report of FHA's Home Equity Conversion Mortgage Insurance Demonstration*, Abt Associates Inc., March.
Rodda, D. and others (2003), *Refinancing Premium, National Loan Limit, and Long-Term Care Premium Waiver for FHA's HECM Program*, Cambridge, U.S. Department of Housing and Urban Development.
Sáez, R. (2010), "La OCDE y el ingreso de Chile", *Estudios Internacionales*, vol. 43, No. 166, Santiago, University of Chile.
Szymanoski, E. (1994), "Risk and the home equity conversion mortgage", *Real Estate Economics*, vol. 22, No. 2, Hoboken, Wiley.
The Economist (2016), "The perils of not saving", London, 27 August.
Wang, P. and J. Kim (2014), "The value of reverse mortgage loans: case study of the Chinese market", *Journal of Asian Finance, Economics and Business*, vol. 1, No. 4, Korea Distribution Science Association.

Annex A1

Modelling of house prices at different periods

To perform the modelling for this study, we must know the price of houses in periods outside the sampling period. Specifically, we must estimate house prices at the term of the mortgage (period subsequent to the sample) and, the price at the time of retirement (period prior to the sample). To do this, we follow Szymanoski's model (1994), which is detailed below.

We define the following variables:

$$H_t: \textit{House price in year } t$$

$$H_0: \textit{House price in year } t=0 \textit{ initial}$$

Let us assume the percentage H_t with respect to H_0 is X_t:

$$X_t = \frac{H_t}{H_0}$$

Then:

$$x: \textit{Random variable of the set of observations } X_t$$

Applying the natural logarithm to X_t we obtain the percentage change in the house price between the initial period and random period "t":

$$Y_t = ln(X_t) \rightarrow X_t = exp(Y_t)$$

Where:

$$y: \textit{Random variable of the set of observations } Y_t$$

Using the exponential function $g(a)=exp(a)$ we have:

$$g(y)=exp(y) \rightarrow E(x)=E(exp(y))=E(g(Y))$$

Here, Szymanoski (1994) argues that long-term house price trends can be modelled by a geometric Brownian motion (GBM) process. Consequently, we assume that Y_t is a GBM, which implies that in the period "t", Y_t has a mean of $\mu \cdot t$ and a standard deviation of $\sigma\sqrt{t}$, which depicts normal distribution. At the same time, the above means that X_t is defined as a GBM with a log-normal distribution.

Consequently, we know that since $F(y)$ is the probability function of "y" and $f(y)$ is the density function of "y", then:

$$E\big(g(y)\big) = \int_{-\infty}^{+\infty} g(y)dF(y) = \int_{-\infty}^{+\infty} g(y)f(y)dy \qquad \text{(I)}$$

As stated, variable "y" follows a normal distribution, which means that $f(y)$ is a normally distributed density distribution with a mean of μ and standard deviation of σ.

$$f(y) = \frac{1}{\sigma\sqrt{2\pi}} exp\left[-\frac{1}{2}\left(\frac{y-\mu}{\sigma}\right)^2\right] \qquad \text{(II)}$$

Replacing (II) in (I):

$$E\left(g(y)\right) = E\left(exp(y)\right) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{+\infty} exp(y) \cdot exp\left[-\frac{1}{2}\left(\frac{y-\mu}{\sigma}\right)^2\right] dy \quad \text{(III)}$$

We standardize the above and replace *"y"* with $(y-\mu)/\sigma$, obtaining the following:

$$E\left(exp(y)\right) = exp\left(\mu + 0,5\sigma^2\right) \cdot \left(\frac{1}{\sqrt{2\pi}}\right) \int_{-\infty}^{+\infty} exp\left[-\frac{1}{2}\left(y-\sigma\right)^2\right] dy = exp\left(\mu + 0,5\sigma^2\right) \cdot \beta \quad \text{(IV)}$$

Where the value of β is 1:

$$\beta = \left(\frac{1}{\sqrt{2\pi}}\right) \int_{-\infty}^{+\infty} exp\left[-\frac{1}{2}\left(y-\sigma\right)^2\right] dy \; = 1 \quad \text{(V)}$$

Through equations (IV) and (V) we have:

$$E(X) = E\left(exp(y)\right) = exp\left(\mu + 0,5\sigma^2\right) \quad \text{(VI)}$$

Thus, assuming that x is a stochastic variable, with μ and σ as constants and time as a function, equation (VI) is calculated as:

$$E\left(x(t)\right) = exp\left(\mu \cdot t + 0,5\sigma^2 \cdot t\right) \quad \text{(VII)}$$

We then have:

$$E\left(H(t)\right) = H_0 \cdot exp\left(\mu \cdot t + 0,5\sigma^2 \cdot t\right) \quad \forall t \geq 0 \quad \text{(VIII)}$$

$$E\left(H(t)\right) = \frac{H_0}{exp\left(\mu \cdot t + 0,5\sigma^2 \cdot t\right)} \quad \forall t \leq 0 \quad \text{(IX)}$$

Annex A2

Life tables

Table A2.1
Life tables for 2009[a]
(Ages and percentages)

Age (t)	Men		Women		
				retiring at 60	retiring at 65
	Q_t	p_t	Q_t	p_t	p_t
60			0.31	1	
61			0.33	99.69	
62			0.37	99.36	
63			0.40	98.99	
64			0.44	98.60	
65	1.24	1	0.48	98.16	1
66	1.36	98.76	0.53	97.69	99.52
67	1.49	97.42	0.57	97.17	98.99
68	1.64	95.97	0.63	96.62	98.43
69	1.81	94.39	0.69	96.01	97.81
70	1.99	92.68	0.76	95.35	97.13
71	2.20	90.84	0.85	94.62	96.40
72	2.42	88.84	0.95	93.82	95.58
73	2.66	86.69	1.08	92.93	94.67
74	2.92	84.38	1.23	91.93	93.65
75	3.23	81.92	1.40	90.79	92.49
76	3.36	79.27	1.59	89.52	91.20
77	3.91	76.61	1.82	88.10	89.75
78	4.31	73.62	2.08	86.50	88.12
79	4.75	70.45	2.38	84.70	86.28
80	5.26	67.10	2.73	82.68	84.23
81	5.87	63.57	3.14	80.42	81.93
82	6.56	59.84	3.60	77.90	79.36
83	7.31	55.91	4.13	75.10	76.50
84	8.16	51.83	4.73	71.99	73.34
85	9.08	47.60	5.41	68.59	69.87
86	10.07	43.28	6.17	64.88	66.09
87	11.13	38.92	7.03	60.87	62.01
88	12.27	34.59	7.97	56.60	57.65
89	13.46	30.34	9.01	52.08	53.06
90	14.17	26.26	10.14	47.39	48.28
91	16.02	22.54	11.37	42.59	43.38
92	17.37	18.93	12.70	37.74	38.45
93	18.75	15.64	14.12	32.95	33.57
94	20.22	12.71	15.64	28.30	28.83
95	21.74	10.14	17.24	23.87	24.32
96	23.32	7.93	18.93	19.76	20.13

Table A2.1 (concluded)

Age (t)	Men		Women		
				retiring at 60	retiring at 65
	Q_t	p_t	Q_t	p_t	p_t
97	24.93	6.08	20.72	16.02	16.32
98	26.59	4.57	22.60	12.70	12.94
99	28.36	3.35	24.62	9.83	10.01
100	30.26	2.40	26.30	7.41	7.55
101	32.26	1.68	27.71	5.46	5.56
102	34.42	1.13	29.61	3.95	4.02
103	36.71	0.74	31.65	2.78	2.83
104	39.15	0.47	33.82	1.90	1.93
105	41.76	0.29	36.15	1.26	1.28
106	44.53	0.17	38.36	0.80	0.82
107	47.50	0.09	41.29	0.49	0.50
108	50.66	0.05	44.12	0.29	0.30
109	54.02	0.02	47.16	0.16	0.17
110	100.00	0.01	100.00	0.09	0.09

Source: Prepared by the authors, on the basis of Office of the Superintendent of Pensions, "Compendio de Normas del Sistema de Pensiones, Libro III, Título X, Tablas de Mortalidad, Anexo Nº 5", Santiago, 2009 [online] http://www.spensiones.cl/portal/compendio/596/w 3-propertyvalue-4350.html.

[a] For the purposes of this table, as in the rest of the document, it is assumed that individuals take out a reverse mortgage at the time of their retirement.

Where:

Q_t = Probability that individual is not alive in year t+1,but alive in t.

p_t = Survival probability or probability that the individual is alive in year t, and was alive when the reverse mortgage was taken out.

For women, two values are presented for P_t. The first value is given for the current situation, with women retiring at 60. The second corresponds to the hypothetical scenario of women retiring at the same age as men, i.e. at 65 years.

Lastly, table A2.2 shows the probability of a representative individual being alive at a random age, represented in each row of the table, and the age at origination of a reverse mortgage, between 65 and 80 years, in the columns. The values in this table correspond to the geometric average of the survival probabilities by sex, weighted by the percentage of each gender in the sample.

Table A2.2

Survival probabilities, by age at which a representative individual takes out a reverse mortgage

(Ages and percentages)

	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
65	100															
66	99.2	100														
67	98.3	99.1	100													
68	97.4	98.2	99.1	100												
69	96.4	97.2	98.0	99.0	100											
70	95.3	96.1	96.9	97.8	98.9	100										
71	94.1	94.8	95.7	96.6	97.6	98.7	100									
72	92.8	93.5	94.3	95.2	96.2	97.4	98.6	100								
73	91.3	92.1	92.9	93.8	94.7	95.8	97.1	98.4	100							
74	89.8	90.5	91.3	92.1	93.1	94.2	95.4	96.7	98.3	100						
75	88.0	88.7	89.5	90.4	91.3	92.4	93.6	94.9	96.4	98.1	100					
76	86.1	86.8	87.6	88.4	89.4	90.4	91.5	92.9	94.3	96.0	97.9	100				
77	84.1	84.8	85.6	86.4	87.3	88.3	89.4	90.7	92.1	93.8	95.6	97.7	100			
78	81.9	82.5	83.3	84.1	85.0	85.9	87.0	88.3	89.7	91.2	93.0	95.1	97.3	100		
79	79.4	80.1	80.8	81.6	82.4	83.4	84.4	85.6	87.0	88.5	90.2	92.2	94.4	97.0	100	
80	76.8	77.4	78.1	78.8	79.7	80.6	81.6	82.8	84.1	85.6	87.2	89.1	91.3	93.8	96.7	100
81	73.9	74.5	75.1	75.9	76.7	77.5	78.5	79.7	80.9	82.3	83.9	85.8	87.8	90.2	93.0	96.2
82	70.7	71.3	71.9	72.6	73.4	74.2	75.2	76.3	77.5	78.8	80.4	82.1	84.1	86.4	89.1	92.1
83	67.3	67.9	68.5	69.1	69.9	70.7	71.6	72.6	73.7	75.0	76.5	78.2	80.0	82.2	84.8	87.7
84	63.7	64.2	64.8	65.4	66.1	66.8	67.7	68.7	69.7	71.0	72.3	73.9	75.7	77.8	80.2	82.9
85	59.8	60.3	60.8	61.4	62.0	62.7	63.5	64.4	65.5	66.6	67.9	69.4	71.0	73.0	75.2	77.9
86	55.7	56.1	56.6	57.1	57.7	58.4	59.1	60.0	60.9	62.0	63.2	64.6	66.1	68.0	70.0	72.5
87	51.3	51.7	52.2	52.7	53.2	53.9	54.6	55.3	56.2	57.2	58.3	59.6	61.0	62.7	64.6	66.8
88	46.9	47.2	47.6	48.1	48.6	49.2	49.8	50.5	51.3	52.2	53.2	54.4	55.7	57.2	59.0	61.0
89	42.3	42.6	43.0	43.4	43.9	44.4	45.0	45.6	46.3	47.1	48.1	49.1	50.3	51.7	53.2	55.1
90	37.7	38.0	38.4	38.7	39.1	39.6	40.1	40.7	41.3	42.0	42.8	43.8	44.8	46.1	47.5	49.1
91	33.3	33.5	33.8	34.2	34.5	34.9	35.4	35.9	36.4	37.1	37.8	38.6	39.5	40.6	41.9	43.3
92	28.9	29.1	29.3	29.6	29.9	30.3	30.7	31.1	31.6	32.2	32.8	33.5	34.3	35.2	36.3	37.6
93	24.6	24.8	25.1	25.3	25.6	25.9	26.2	26.6	27.0	27.5	28.0	28.6	29.3	30.1	31.0	32.1
94	20.7	20.9	21.0	21.2	21.5	21.7	22.0	22.3	22.7	23.1	23.5	24.0	24.6	25.3	26.0	27.0
95	17.1	17.2	17.4	17.5	17.7	17.9	18.1	18.4	18.7	19.0	19.4	19.8	20.3	20.8	21.5	22.2
96	13.8	13.9	14.0	14.2	14.3	14.5	14.7	14.9	15.1	15.4	15.7	16.0	16.4	16.9	17.4	18.0
97	11.0	11.0	11.1	11.2	11.4	11.5	11.6	11.8	12.0	12.2	12.4	12.7	13.0	13.4	13.8	14.3
98	8.5	8.6	8.6	8.7	8.8	8.9	9.0	9.2	9.3	9.5	9.6	9.9	10.1	10.4	10.7	11.1
99	6.4	6.5	6.5	6.6	6.7	6.8	6.8	6.9	7.0	7.2	7.3	7.5	7.6	7.9	8.1	8.4
100	4.8	4.8	4.8	4.9	4.9	5.0	5.1	5.1	5.2	5.3	5.4	5.5	5.6	5.8	6.0	6.2
101	3.4	3.5	3.5	3.5	3.6	3.6	3.6	3.7	3.8	3.8	3.9	4.0	4.1	4.2	4.3	4.5
102	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.7	2.7	2.8	2.9	2.9	3.0	3.1
103	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.1	2.1
104	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.4	1.4
105	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9
106	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6
107	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
108	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
109	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
110	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Prepared by the authors, on the basis of Office of the Superintendent of Pensions, "Compendio de Normas del Sistema de Pensiones, Libro III, Título X, Tablas de Mortalidad, Anexo Nº 5", Santiago, 2009 [online] http://www.spensiones.cl/portal/compendio/596/w 3-propertyvalue-4350.html.

Annex A3

Descriptive statistics of the sample

Table A3.1
Descriptive statistics of the sample

Variable	Mean	Standard deviation	Minimum	Maximum
Sex (Men=1) *(percentages)*	40.92	45.76	0	1
Age	71.22	7.96	60	96
Head of household (head of household=1) *(percentages)*	65.09	47.68	0	1
Household income *(pesos at 2009 prices)*	103.75	136.58	0	2 000.00
Per capita income *(pesos at 2009 prices)*	34.72	49.53	0	450.00
Poverty rate *(percentages)*	86.25	34.44	0	1
Imputed house price *(millions of pesos at 2009 prices)*	20.40	4.11	2.50	50.00

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.
Note: Based on a sample of 2,627 observations representing a population of 1,623,326 individuals.

Annex A4

Reverse mortgage payments by age at origination

Table A4.1
Reverse mortgage payments by age at origination
(Chilean pesos)

House price at retirement	14.00 millions of pesos at 2009 prices	20.04 millions of pesos at 2009 prices
Age at origination	Monthly payments - case 1	Monthly payments - case 2
65	62 387	90 907
66	65 453	95 375
67	68 741	100 166
68	72 273	105 312
69	76 074	110 850
70	80 179	116 832
71	84 616	123 297
72	89 619	130 588
73	94 972	138 387
74	100 786	146 860
75	107 080	156 031
76	113 898	165 965
77	121 423	176 930
78	129 535	188 751
79	139 169	202 790
80	149 793	218 270

Source: Prepared by the authors, on the basis of Social Protection Survey, 2009.