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REVERSE MORTGAGE AND FINANCIAL SUSTAINABILITY

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Abstract. This paper analyzes the effects that contracting a reverse mortgage has on the finances of families of a country or group whose members who aged 65 or older are the sole owners of the 100% of the property, regardless of the receipt of a retirement pension. For this purpose, an economic-financial model based on the life cycle model is defined, which considers a double source of randomness: mortality and dependence of family members. Long-term effects are measured using probabilistic, temporal and monetary indicators. For each country, the model must be adapted according to the legal framework for retirement and long-term care benefits and for the actuarial mortality and long-term care tables. As an illustration, this model was applied on Spanish families using data from the Spanish Survey of Household Finances 2017. The results obtained indicate that a family in Spain that meets the conditions for contracting a reverse mortgage sees, on average, an increase in its initial income and a decrease in both its probability of having liquidity problems in the future and the value of this lack of liquidity. It is also concluded that family composition influences the magnitude of these positive effects.

Keywords: life cycle, Markov process, Spanish Survey of Household Finances, simulation, long-term care, reverse mortgage.

JEL Classification: D14, D15, G21, G51.

Introduction

According to Instituto Nacional de Estadística (2020), in 2019 almost 75.9% of Spanish families owned their own houses. If we focus on the collective of people aged 65 or older, this percentage rises to 89.8%. Spanish Ministry of Transport, Mobility and Urban Agenda (Ministerio de Transportes, Movilidad y Agenda Urbana [MITMA], 2020) has determined

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the mean assessed value of homes over five years old for Spain to be of €1,644.8 per m^2. These figures highlight the importance of housing as an asset in Spanish families' finances.

Today, the scarce liquidity assigned to our habitual residence has long ceased to be a dogma, especially after retirement. The market offers different products that allow us to obtain an income using our habitual residence as guarantee. These include Reverse Mortgage (RM) and Life Annuities. Several differences can be found between both products, the main one being that Life Annuities imply the immediate loss of ownership of the dwelling, while with RM this does not happen and, even after the death of the contractor (or the last beneficiary), the inheritors have the option to drop the debt and keep the ownership of the dwelling. This characteristic can contribute to make RMs more appealing to a certain collective of clients. However, in Spain, reverse mortgages have very little market penetration. Therefore, in this paper we focus on the contracting of RMs, analyzing its impact on Spanish family economies as a supplement, for example, to the retirement pension.

A Reverse Mortgage can be defined as a mortgage loan or credit from which the owner of the dwelling draws down sums of money on a regular basis until reaching the maximum amount determined by a percentage of the dwelling's assessed value at the moment of contracting it. When this percentage is reached, the borrower cannot make any more drawdowns and the debt continues to generate interest. The recovery of drawdowns plus interest by the institution usually takes place upon the death of the mortgage debtor (or the last beneficiary) through debt cancelation by the heirs or foreclosure of the mortgage by the credit entity. This definition is valid in general; however, since each country has its own regulations and due to the specific characteristics of the financial market, RMs will have differential elements that in practice can help explain the different implementation of this product.

The peculiarities of the United States, Australia and Japan, to name three non-European markets where this product has been implemented, can be found in Huan and Mahoney (2002), Chatterjee (2016), and Davidoff et al. (2017); Ong (2008) and Whait et al. (2019); and Mitchell and Piggott (2004), respectively.

In the academic literature, RMs have been studied from several points of view. Costa-Font and González (2007), through telephone surveys, concluded that the main reasons to contract an RM in Spain would be raising life standards or helping relatives, and that a deep-rooted culture in favor of bequests exists. In Italy, Fornero et al. (2016) focused on the determinants of interest in RM and found that the main predictors of higher interest in RM are risk aversion and negative expectations about living standards after retirement. Likewise, in Australia, Whait et al. (2019) highlighted the extraordinary negative vision that people have about RMs, which is reinforced by high interest rates and expenses. Instead, the bequest motive is not a definitive argument against RM.

Other reasons are related with supply. RMs are a risk product for suppliers. Loss of house value, longevity risk, and reputational risk are, in this order, the main risks for the provider (Al-Umaray et al., 2017). Longevity risk (Barrieu et al., 2012), derived from the fact that the person lives longer than expected, can be mitigated through the use of dynamic mortality tables and transferred by means of securitization (Wang et al., 2008; Yang, 2011). Reputational risk, also highlighted by Megyeri (2018), is considered as one of the motives explaining the absence of equity release products in UK. One of the main tools to reduce reputational risk is the correct design of the product and accurate advice for clients, so that any one person (as well as his/her relatives) acquiring the products comprehend and are aware of its characteristics and limitations. To facilitate this last aspect, providers usually restrict the product offer to certain personal and/or familiar profiles.

Another aspect that has been extensively studied in the literature is the No Negative Equity Guarantee (NNEG) clause (see, among others, Li et al., 2010; de la Fuente Merencio et al., 2018; Dowd et al., 2019; Sharma et al., 2020). This clause guarantees that the owner and/or his/her heirs will cancel the total debt with the delivery of the property (known in Spain as *dación en pago*, or dation in payment). Depending on the market, its implementation is different so that, in the more developed ones, NNEG is included in most RMs that are issued. According to Simón (2016), in the American market, more than 95% of RMs issued by the Federal Housing Administration (FHA) through the Home Equity Conversion Mortgage (HECM) program, include the NNEG clause and are insured by the Federal Government with premiums financed with the RM provisions (Mortgage Insurance Premium, MIP). In the English market, this public insurance does not exist, and a large part of the entities offering RMs assume the risk of a drop in the value of the property; thus, for example, in order to be part of the Equity Release Council, they must include NNEG in their products, among other requirements (Equity Release Council, 2018).

Spanish Law 41/2007, of December 7 2007, on the regulation of reverse mortgages and dependency insurance, which establishes certain tax regulations and amends Law 2/1981, of March 25 1981, on the Regulation of the Mortgage Market and other mortgage and financial system regulations, (Ministerio de la Presidencia, Relaciones con las Cortes y Memoria Democrática, 2007) adds a series of requirements that provide certain tax advantages to the product, which, in practice, have become the usual standard in the market. Three of these requirements are highlighted below:

- It must be the owner's habitual residence.
- The applicant and the beneficiaries designated by him/her must be persons aged 65 years or older, or affected by dependency, or persons with a recognized degree of disability equal or higher than 33%.
- The mortgaged property must be appraised and insured against damages in accordance with the terms and requirements set forth in articles 7 and 8 of Law 41/2007.

In Spain, credit institutions, financial credit establishments and insurance companies authorized to operate in Spain may be mortgagees of an RM. An RM can be issued by a natural person or by legal entities other than those previously mentioned but, in such a case, the RM will not be governed by Law 41/2007 and therefore will not have tax benefits or tariff reductions.

The figures of the mortgagor and beneficiaries are defined in the Law 41/2007 and by the Banco de España (2017) but generate legal controversy (García, 2015; Simón, 2016, 2018). The variety of families and the reputational and legal risks to which creditors are subject mean that the offer is limited to certain family, ownership and cohabitation structures that minimize or nullify the risks.

Spanish legislation does not include NNEG, although, when the loan is extinguished and the heirs decide not to reimburse the overdue debts with interest, the creditor may only recover as far as the assets of the inheritance reach (Ley 41/2007, Spain). Thus, there is a de facto "dation in payment of the inheritance", which together with the high cost derived from the reputational risk, leads us to believe that RMs marketed in Spain will include this clause.

The aim of this paper is to contrast the usefulness of contracting an RM to improve a family's financial situation by quantifying its effect through a series of impact indexes. All this is done by including the increase in expenses (net of public system benefits) derived from a possible dependency of the different members.

The main contributions of this work are threefold:

1. Definition of a theoretical model on the effects that contracting an RM has on the finances of families of a country or a specific group, whose members who aged 65 or older are the sole owners of the 100% of the property, regardless of the receipt of a retirement pension.
2. Model adaptation according to the Spanish legal framework for retirement and long-term care benefits and for the Spanish actuarial mortality and long-term care tables and quantification of the impact of contracting an RM on the finances of Spanish families over time.
3. Differentiated analysis of the impact of taking out RMs by family profile. This is the first study in which the effect of the RM on the finances of Spanish families has been quantified.

In what follows, the paper is structured in four sections, the bibliography and two appendices. Section 1 details the economic and financial characteristics of the model applied in this paper. Section 2 indicates the data sources used in relation to the costs of dependency and the economic and demographic data of the families within the Spanish population covered by this study. This section also develops the methodology applied, which mainly refers to the actuarial calculations and the modelling of dependency and mortality of individuals through stochastic simulation. Section 3 summarizes the results of the study which are discussed in Section 4.

1. Model

This section defines an economic-financial model to determine the impact of RMs on the finances of families that comply not only with legal conditions but also with all those determined by supply in the financial and insurance markets. These market conditions are necessary for bidders to be able to control the high reputational risk derived from these operations. Spanish Law 41/2007 defines two groups that can be applicants for, and beneficiaries of, an RM: on the one hand, people aged 65 or over and, on the other, those who are dependent or who have a recognized degree of disability equal to or greater than 33%. In this paper, we will focus our analysis on the first group, since our objective is to analyze the usefulness of RMs to compensate for the loss of income or increase in expenses derived from age.

We consider that there are two feasible family profiles for taking out an RM:

– Profile 1. Families are made up of a single member aged 65 or older, who owns 100% of the property that is his/her primary residence.

– Profile 2. Families are made up of two or more members aged 65 or older, at least two of whom own 100% of the property and are mutual heirs. If any of the members are not owners, we assumed that they will be included as beneficiaries in the mortgage.

In both cases, the property may also be lived in by persons under 30 years old, who will be emancipated and will cease to live in the property when they reach that age. The issuance of the RM is subject to informing these persons of this fact and that they agree to stop living in the property in the event of the death of the contracting and beneficiary persons.

These two-family profiles will be the focus of our study.

The model we propose in this paper, which is based on the life-cycle model (e.g. Kuhn et al., 2014, 2015), uses as main variable the net balance of a family in each period (income minus expenses) until its extinction, symbolized by $S(t)$, $t = 0, 1, \ldots$ Boj et al. (2020) also use a similar model but focused on the effects of hiring private long-term care insurance.

We assume that, if in one period income exceeds expenditures, this surplus is not incorporated into the family's wealth, but is used to finance future expenditures. The balance of a period is then defined in Eq. (1):

$$\begin{aligned} S(t+1) = {} & INC(t+1) + RMD(t+1) - OEXP(t+1) - \\ & EXEXP(t+1) + S(t)+, \; t = 0, 1, \ldots, \end{aligned} \tag{1}$$

where INC is income, RMD is net income to be received from RM, $OEXP$ is ordinary expenses (i.e., not derived from dependency), $EXEXP$ is extraordinary expenses (derived from dependency), and $S(t)+ = \max(S(t), 0)$ is the balance for period t if positive, considering that $S(0) = INC(0) + RMD(0) - OEXP(0) - EXEXP(0)$. We analyze separately the self-financing produced by incorporating the positive annual balances for the following period from that of the negative annual balances, which we accumulate in another variable (as it is explained at the end of this section).

A number of additional working hypotheses are made on the temporal evolution of family composition, the structure of family income and the temporal evolution of ordinary and extraordinary expenses. These hypotheses are explained in detail in Boj et al. (2020) and are summarized below:

– The initial members of a family remain in the family until their death and no new additions occur. On the other hand, the average age of emancipation is set at 30 years (Eurostat, 2018) so that children initially older than 15 years (minors are excluded from the study) remain in the family unit until they reach that age.
– A distinction has been made between income derived from work and retirement pensions, which is calculated by adding the constant income corresponding to each family member, and the rest of the income which is not affected by changes in the family structure. The first group of income is not altered until a member of the household retires (when he or she starts receiving the retirement pension), dies (with the possible start of the widow's pension) or becomes dependent (which implies the loss of income from work).
– Ordinary expenses include a fixed part and another part that changes linearly with the number of family members.

– The benefits of the public system have been considered in the calculation of the extraordinary expenses derived from dependency (Ministerio de la Presidencia, Relaciones con las Cortes y Memoria Democrática, 2006).

Our model includes the random phenomena of death of individuals and their becoming dependent.

For statistical reasons and lack of data, only one level of dependence has been considered, the most severe and irreversible. Thus, the year of death of each person is random as well as their entry into dependency (they may never become dependent and if they do, they may do so at different ages). Dependency is modeled as a three-state stochastic model: autonomous, dependent and deceased. The probabilities of transition between states are obtained from mortality and dependency tables and are based on age reached, sex and year of birth. Using these probabilities, we were able to simulate the future evolution of the states of each member of the family from the beginning, when all members are alive and autonomous, to the extinction of the family, which occurs when all the members that are not emancipated have died. In the intervening periods, some members will perhaps continue to be autonomous, while others will be dependent or will have died. This double source of randomness configures the balance sheet as a stochastic process (defined by Eq. (1)).

A simple indicator of the initial effect of contracting an RM, which we will refer to as Income Indicator (*II*) from now on, is defined as the percentage that the periodic incomes to be received from RM represents with respect to the family's income at the time it is contracted,

$$II = \frac{RMD(0)}{INC(0)}100. \tag{2}$$

II is a static measure, which gives a snapshot of the effects of RM at the beginning, but not of the overall effects over time. In this paper we calculated three additional indicators that, although of a different nature, have the common objective of quantifying the long-term effect that contracting an RM by a family will have on its finances and, therefore, on its financial sustainability.

The first foreseeable effect of RM is given by the decrease in the likelihood that *S* will turn negative at some point in time (and therefore there will be lack of liquidity). The random variable (r.v.) "number of years of liquidity" (before a first period of illiquidity), symbolized as *YL*, takes values from 0 to *FE*, *FE* being the number of years until the extinction of the family. If a family never has liquidity problems, *YL* will take its maximum value (*FE*).

Equation (3) shows the expression of the probabilistic indicator (*PI*):

$$PI = \frac{P(\mathrm{YL} = FE)^{(with\ RM)} - P(\mathrm{YL} = FE)^{(without\ RM)}}{1 - P(\mathrm{YL} = FE)^{(without\ RM)}}100, \tag{3}$$

PI measures the decrease in the probability of illiquidity resulting from RM (in percent).

A second effect of RM is a delay in the onset of illiquidity problems, if they occur. The index can be defined by the effect on the expectation of *YL* and on other statistics such as mode or quantiles at different levels. In this paper, we will consider a first-time index (*TIE*) which quantifies the change (in percent) in the expected value of the number of years of liquidity if the household takes out a RM. *TIE* is calculated as follows:

$$TIE = \frac{E(\mathrm{YL})^{(with\ RM)} - E(\mathrm{YL})^{(without\ RM)}}{E(\mathrm{YL})^{(without\ RM)}} 100. \tag{4}$$

We added two-time indexes, symbolized by *TIEQ95* and *TIEQ99*, which measure the same as *TIE* but with respect to the 95% and 99% percentiles, respectively. Its calculation formula is like (4), changing the expectation by the corresponding percentile.

The third effect of contracting an RM will be a reduction in the value of overall liquidity needs that we will quantify through their sum, symbolized by *VLN*. This amount corresponds to a financial valuation at a zero-interest rate consistent with the working hypothesis explained in this section. *VLN* takes a value of zero if the family always has positive balance. The Financial Indicator (*FI*) quantifies the monetary amount of the lack of liquidity problems showing the percentage of reduction in its expected value:

$$FI = \frac{E(VLN)^{(without\ RM)} - E(VLN)^{(with\ RM)}}{E(VLN)^{(without\ RM)}} 100. \tag{5}$$

We added two financial indices, symbolized by *FIQ95* and *FIQ99*, which measure the same as *FI* but with respect to the 95% and 99% percentiles, respectively. Their calculation formula is like (5), changing the expectation by the corresponding percentile.

The values of the stochastic process S in each period are calculated by stochastic simulation of the possible trajectories, which allows us to obtain the distribution of the r.v. *YL* and *VLN*.

In this work, we have applied a macroeconomic model that, nevertheless, allows us to use all the data from the families included in this work, which correspond to profiles 1 and 2 described above. We believe that RM is a widespread and massively used product and we worked with a maximum scenario, i.e., we considered that all the families that can contract an RM (profiles 1 and/or 2) do so if the income to be received from the RM is positive.

2. Materials and methods

In this study, the following sources of data have been used: the Spanish Survey of Household Finances 2017 (EFF 2017, for its initials in Spanish) (Banco de España, 2019; Barceló et al., 2020) (most recent version available in Spain); the mean appraised value of real estate (Ministerio de Transportes, Movilidad y Agenda Urbana, 2020); the monthly statistical report of the SAAD (Instituto de Mayores y Servicios Sociales, 2019) dated August 31, 2019; de Prada and Borge dependency costs (de Prada & Borge, 2013), and equations for cost distribution of public services (such as dependency) as provided in the Dependency Act.

In this subsection, we describe the first three sources of data and the details on the calculation of the extraordinary costs derived from dependency, taking into account the benefits of the public system can be found in Boj et al. (2020).

2.1. The Spanish survey of household finances

EFF, which contains financial information about Spanish families (Microeconomic Studies Division (Banco de España, 2020)), has been used as the basic source for the analysis. Files databol1.xls, databol2.xls, databol3.xls, databol4.xls, and databol5.xls include processing of missing data from the survey corresponding to unanswered questions or "I don't know" answers. There are several files because the multiple imputation technique has been used, resulting in the five datasets included in these files. In statistical analyses of this study, we consider the inclusion of imputed values, which allows to carry out analyses using complete data methods.

The variable *fancine3* includes the weights assigned to households in the sample. The purpose of this variable is to balance, on the one hand, the probability of the selected household in the sample, given oversampling and geographic stratification and, on the other hand, missing responses. The total number of households in the fourth quarter of 2017 can be estimated by summing the weights included in this variable. It is critical to consider weights when obtaining totals, means, and population participation from EFF data. Nevertheless, some controversy exists regarding when weighting statistical techniques, such as regression or cluster analysis, should be used (Deaton, 1997; Cameron & Trivedi, 2005).

In the first set of imputed data (which has been used as reference) the sum of all weights is 18,536,404 households.

The three-sigma criterion is applied for the treatment of outliers. 397 surveys are eliminated. The result is 6,016 surveys that, considering the *fancine3* variable, represent 18,148,851 households.

In our database, we incorporate only surveys from families with a member over 65 years of age and eliminated those with family members between 30 and 65 years of age, obtaining a total of 1,871 surveys, which in total represent 4,272,326 Spanish families taking into account the *facine3* weight.

We eliminated the families headed by a member under 30 years of age (five surveys) and obtained 1,866 surveys, which represent a total of 4,264,851 Spanish families considering the *facine3* weight.

From this group, we selected only the subset that owns 100% of their home, obtaining 1,635 surveys, which represent a total of 3,516,126 Spanish families considering the *facine3* weight.

From this subset, we selected only the families that could afford an RM, obtaining 1,617 surveys, which represent a total of 3,431,896 Spanish families considering the weight *facine3*. The percentage of families that were eliminated due to this variable is approximately 2%.

This database will be hereinafter referred to as DBRM.

There are 585 surveys in profile 1 and 1,032 in profile 2. Considering the *facine3* weight, of the 3,431,896 Spanish households, 1,826,038 belong to profile 1 and 1,605,858 to profile 2. Extrapolating the sample, we observe that profile 1 contains more households than profile 2, even though the number of surveys is higher in profile 2. This oversampling ensures enough households to be able to study the financial behavior at the upper end of the wealth distribution of the economy accurately. Such an aspect is critical in this type of survey given that the distribution of wealth is very asymmetric and that only a small fraction of the population invests in some types of assets, which is usually more common for households with a high level of wealth.

The characteristics of each family are obtained from the variables included in the EFF (see Appendix 1). As mentioned in the previous section, the initial income of the family unit is obtained from EFF. As to its subsequent evolution, as in Boj et al. (2020), if a family member who had earned income reaches the age of 67 (Ministerio de la Presidencia, Relaciones con las Cortes y Memoria Democrática, 2011), he/she will receive a retirement pension of 78.7% of his/her salary (European Commission, 2018) provided that it doesn't exceed the legal maximum of €37,231.7 a year (Ministerio de Trabajo, Migraciones y Seguridad Social, 2018b). The amount of the widow's/widower's pension is 60% of the deceased's salary or pension (value comprised between 52% and 70%, as set forth in Spanish Royal Decree 900/2018 (Ministerio de Trabajo, Migraciones y Seguridad Social, 2018a) under certain conditions.

2.2. Life and dependency tables

The dependency tables based on the Spanish population were estimated from the PERM/F 2020 generational tables (*Resolución de 17 de diciembre de 2020* (Ministerio de Asuntos Económicos y Transformación Digital, 2020)) and the prevalence or incidence rates of dependency as reported in the monthly statistical report from the SAAD (Instituto de Mayores y Servicios Sociales, 2019) dated August 31, 2019, are included in Table 1. We have chosen to construct these dependency tables because there are no tables for public use, so that each insurance company constructs its own from its internal information.

Table 1. Prevalence rates in the Spanish population (source: own elaboration from Instituto de Mayores y Servicios Sociales, 2019)

	55–64 years	65–79 years	+80 years
Men	0.008825147	0.0190927	0.0913382
Women	0.008495301	0.0279337	0.1830447

Using these prevalence rates for all three age groups, we estimated the prevalence rate for each age x, $\hat{\lambda}_x$, from Eq. (6), which corresponds to a Makeham model (Haberman & Pitacco, 1999):

$$\hat{\lambda}_x = \alpha + \gamma \cdot e^{\beta \cdot x}. \tag{6}$$

The estimated values of the parameters are included in Table 2.

Table 2. Parameters of the prevalence rate (source: own elaboration from Instituto de Mayores y Servicios Sociales, 2019)

	α	β	γ
Man	1.150920e-08	0.04764965	0.009673332
Woman	7.369322e-09	0.06078735	0.01059000

To estimate the transition probabilities necessary for the simulation of family member states, we have relied on the method of converting prevalence rates into transition probabilities introduced by Pitacco and Olivieri (1997), Haberman and Pitacco (1999) and Pitacco (1999). The probabilities of death of dependents have been obtained by applying a surcharge of 10% (within the usual values in the Spanish market) to those of the general population of the PERM/F 2020 generational tables.

2.3. Reverse mortgage

In this paper, we have considered that the term for making drawdowns is consistent with the expected remaining number of years of life of the mortgage contracting parties/beneficiaries (i.e., the life expectancy of the household, defined as the number of years until the last family member dies).

If the RM was contracted with a single drawdown, this would amount to:

$$p \cdot AP \cdot (1+i)^{-esp}, \tag{7}$$

where *AP* is the appraised value of the property on the date of the contract, *p* is loan-to-value, *esp* is the life expectancy of the contractors and beneficiaries, and *i* is the RM rate of interest. We considered a fixed loan-to-value, $p = 0.6$, and an interest rate of 6%. The loan-to-value parameter is such that the accumulated debt after *esp* years (expected remaining number of years of life of the mortgage contracting parties/beneficiaries) is just that percentage of the appraised value of the house (see Devesa-Carpio et al., 2012).

Contracting an RM has a series of incorporation expenses. Those charged to the contracting party (ERM_0) and that we will assume are also financed with the initial income to be received from the RM are (according to the current usual practice in Spain):

- Independent advisor's fee: 1.25% on the appraised value of the property, with a maximum of €6,000.
- Arrangement fee: 0.65% of the total amount of the loan.
- Appraisal fee of €350.

Thus,

$$ERM_0 = \min\left(6{,}000, 0.0125 \cdot AP\right) + 350 + 0.0065 \cdot 0.6 \cdot AP.$$

Additionally, we must consider that, if the property subject to RM is already mortgaged, the outstanding debt (*OD*) must also be cancelled against the initial income from RM. Therefore, we obtain an additional restriction for a family to contract an RM: if (7) is greater than $ERM_0 + OD$, the annual income to be obtained with the RM has a positive amount and therefore it makes sense to contract it. For families to maintain their income after the term for making drawdowns, RM includes annuity insurance (RMAI). This RMAI is taken out at the time of mortgage origination for a single premium that is financed with the initial drawdown of the mortgage and is deferred from the end of the drawdown period; the amount of the insurance income is consistent with the drawdown of the mortgage and is collected until the extinction of the group of contractors and beneficiaries.

2.4. Methodology

The methodology includes economic and actuarial models for the various aspects analyzed in the paper. Thus, an adaptation of the life-cycle model is used to model the evolution of the relationship between labor income and consumption.

Regarding actuarial aspects, life expectancies and survival annuities of individuals and groups are computed at the time of taking out the RM in order to calculate the annual income to be received from RM. Using the PERM/F 2020 generational tables and considering the age and sex of the members of each family extracted from the EFF, we can calculate the life expectancy of each person. From these we obtained the joint life expectancy of the family. Survival annuities on one person and on groups of people with two or more members are used to calculate the premium for the life annuity insurance included in the RM. For the actuarial mathematical details on these calculations, see Gerber (1997) and Alegre (2014), among others.

Furthermore, our model takes into account the different states a person may go through until death. For this purpose, individuals' survival/dependency is modeled through a non-homogeneous Markov process with three states: autonomous, dependent, deceased (see Pitacco & Olivieri, 1997; Haberman & Pitacco, 1999). In our model, the transition probabilities between states vary with attained age and with year of birth, and the dependency state is irreversible. These transition probabilities for the Spanish population are estimated from survival/dependency tables created for this study, as explained in Subsection 3.2. The distribution of the r.v. considered in this work is obtained by applying stochastic simulation techniques. Further details on the application of the model and the simulation process used are included in Appendix 2.

3. Results

In this section, we will first give a short description of the standard house of profiles 1 and 2 and after, in Subsection 4.1 we will describe the statistics of the magnitudes defined in the paper without including RMs: years of liquidity, probability of illiquidity and present value of a family's overall liquidity needs. Then, in Subsection 4.2, the former analysis will include RMs with an initial development of the actuarial technical aspects related with the RMAI premium. Finally, in Subsection 4.3, the values obtained for RM impact indicators are presented.

The standard house in both profiles are quite different. On the one hand, the standard house in profile 1 consists of a widowed woman between 81 and 85 years of age with a life expectancy of 15.2 years, with an annual income of 19,014.82€, a property valued at 145,291.32€ and annual expenses of 8,378.69€. And, on the other hand, the standard house in profile 2 consists of a married couple with a life expectancy of 19.51 years, with an annual income of 32,846.12€, a property valued at 182,187.72€ and annual expenses of 13,862.08€.

3.1. Without reverse mortgages

This subsection provides the results of the model if households do not purchase RM (i.e., RMD = 0). We will perform, for each family in the DBRM, a total of simulations equal to 10% of the households that the family represents in the survey, and then carry out a joint treatment using, for each family unit, the first set of imputed data. At the end of this process, we will obtain the simulated values of the r.v. in which we are interested.

The probability of lack of liquidity, i.e., the probability that the r.v. YL will take a value lower than FE, will indicate whether a household will have liquidity problems considering the dependency (Table 3).

Table 3. Lack of liquidity for a family. Probability (%) without RM (source: own elaboration)

Profile 1	Profile 2	Global
5.46%	5.79%	5.59%

There are no significant differences between the probabilities of lack of liquidity for the families of the two profiles analyzed (see Table 3).

Lastly, Table 4, describes statistics of *YL* and *VLN* resulting from the simulation process for both profiles and for all families.

Table 4. Statistics of *YL* and *VLN* without RM (source: own elaboration)

	YL (Years)			*VLN* (€)		
	Profile 1	Profile 2	Global	Profile 1	Profile 2	Global
Mean	15.79	22.49	18.44	5,097.97	8,689.39	6,521.37
SD	10.84	10.10	11.05	33,690.41	54,576.39	43,229.41
1% percentile	0	0	0	0	0	0
5% percentile	1	5	1	0	0	0
50% percentile	15	23	18	0	0	0
95% percentile	33	37	35	4,643.13	13,144.05	7,005.21
99% percentile	40	42	41	157,320.52	279,318.66	206,048.18

The families in profile 2 live without liquidity problems, on average, seven years longer than those in profile 1, even though when liquidity problems occur, they are usually of greater overall amount (see Table 4). Additionally, the first positive *VLN* value occupies the 94.53%, 94.20%, 94.40% percentiles in profile 1, profile 2 and overall, respectively.

Although the probabilities of illiquidity of households in the two profiles are similar, the composition of households does influence the evolution of liquidity needs. The main reason for this difference may be that in profile 1 households there is only one source of income and when he/she become dependent, the expenses incurred cannot be fully covered by the income, whereas in profile 2, if one member becomes a dependent, there are 2 or more sources of income to cover the expenses incurred.

3.2. With reverse mortgages

Assuming, for simplicity, that the surcharges for internal and external management fees of the annuity are zero, Eq. (8) allows us to calculate the amount, *C* Euros, of the constant periodic withdrawals:

$$ERM_0 + OD + C \cdot \ddot{a}_{\overline{esp+1}|i} + C \cdot \Pi = p \cdot AP \cdot (1+i)^{-esp}, \tag{8}$$

being

$$\ddot{a}_{\overline{esp+1}|i} = \sum_{t=0}^{esp} (1+i)^{-t}. \tag{9}$$

In (8), Π is the single premium in Euros corresponding to a unitary annuity due, deferred *esp*, which starts to be collected if any of the household members is still alive after *esp* years and for life as long as the family is not extinguished.

If RM has only one debtor and no additional beneficiaries,

$$\Pi = {}_{esp/}a_x = \sum_{t=esp+1}^{w-x} {}_t p_{x,g1} \cdot (1+I)^{-t},$$

where w is the last age at which a person can be alive following a life table and ${}_t p_{x,g1}$ is the probability that a person x years old from generation $g1$ is alive t years after.

If there are two persons between contractors and beneficiaries:

$$\Pi = {}_{esp/}a_x + {}_{esp/}a_y - {}_{esp/}a_{xy},$$

being

$${}_{esp/}a_{xy} = \sum_{t=esp+1}^{w-\max(x,y)} {}_t p_{x,g1} \cdot {}_t p_{y,g2} \cdot (1+I)^{-t}.$$

If there are three persons between contractors and beneficiaries:

$$\Pi = {}_{esp/}a_x + {}_{esp/}a_y + {}_{esp/}a_z - {}_{esp/}a_{xy} - {}_{esp/}a_{xz} - {}_{esp/}a_{yz} + {}_{esp/}a_{xyz},$$

being

$${}_{esp/}a_{xyz} = \sum_{t=esp+1}^{w-\max(x,y,z)} {}_t p_{x,g1} \cdot {}_t p_{y,g2} \cdot {}_t p_{z,g3} \cdot (1+I)^{-t}.$$

This premium calculation scheme can be easily extended to groups of more than three people (Alegre, 2014).

We emphasize that the actuarial income involved in the estimation of Π is calculated at the technical interest rate of the insurance operation (I), which is different from the interest rate of the loan (i), applied to financial income (9), being $i > I$.

As a first result, Table 5 presents the descriptive statistics of the annual income to be received from RM.

A family in profile 1 (profile 2) obtains, on average, an additional income from RM of €5,016.16 (€3,786.74) per year (see Table 5). One of the reasons for this difference between the two profiles is that the mean age of the head of household in profile 2 is lower than in profile 1 and therefore the income is expected to have more annuities.

The probability of lack of liquidity of a family taking out an RM is included in Table 6.

Table 5. Description of C (€) (source: own elaboration from Banco de España, 2019)

Description	Profile 1	Profile 2	Global
Minimum	53.73	56.67	53.73
Maximum	44,212.42	31,703.56	44,212.42
Median	2,932.38	2,565.05	2,666.86
Mean	5,016.16	3,786.74	4,231.53
SD	6,013.09	3,833.63	4,774.14
1st Quartile	1,413.96	1,383.21	1,387.45
3rd Quartile	5,811.18	4,719.98	5,089.01

Table 6. Lack of liquidity for a family. Probability (%) with RM (source: own elaboration)

Profile 1	Profile 2	Global
2.77%	3.59%	3.10%

Contracting of an RM reduces the probability of illiquidity in all cases (see Table 6). As in subsection 4.1 (Table 3), the differences between the two profiles are insignificant.

Lastly, Table 7 describes statistics of *YL* and *VLN* with RM resulting from the simulation process for both profiles and for all families.

Table 7. Statistics of *YL* and *VLN* with RM (source: own elaboration)

	YL (Years)			*VLN* (€)		
	Profile 1	Profile 2	Global	Profile 1	Profile 2	Global
Mean	15.99	22.81	18.69	2,476.85	5,651.11	3,734.91
SD	10.16	9.58	10.48	23,817.22	43,820.41	33,255.01
5% percentile	2	7	2	0	0	0
50% percentile	15	23	18	0	0	0
95% percentile	33	37	35	0	0	0
99% percentile	39	42	41	79,570.92	214,538.38	130,043.85

Families in profile 2 that contract an RM live without liquidity problems, on average, 6.91 years longer than those in profile 1 despite the fact that when liquidity problems occur, they are usually of a greater overall amount (see Table 7). Additionally, the first positive *VLN* with RM occupies the 97.22%, 96.40%, 96.90% percentiles in profile 1, profile 2 and overall, respectively.

Comparing the data in Table 4 with Table 7, it is observed that taking out an RM increases the average number of years that a family lives without liquidity problems and, if these occur, the value of overall liquidity needs is reduced.

3.3. Impact indicators of reverse mortgage

Impact indicators defined in Section 2 are shown in Table 8.

Table 8. Impact indicators (source: own elaboration)

Indicator	Profile 1	Profile 2	Global
Income	14.51%	6.41%	9.65%
Probabilistic	49.26%	37.99%	44.54%
Temporal (TIE)	1.26%	1.42%	1.35%
Temporal (TIEQ95)	0%	0%	0%
Temporal (TIEQ99)	2.56%	0%	0%
Financial (FI)	51.41%	34.96%	42.47%
Financial (FIQ95)	100%	100%	100%
Financial (FIQ99)	49.42%	23.19%	36.88%

Contracting an RM has positive effects on the financial situation of families throughout their existence (see Table 8). The greatest effects are observed in increase in initial income, decrease in probability of lack of liquidity and decrease in present value of overall liquidity needs (which reaches 51.41% in profile 1 families). However, the impact of contracting RMs in years without liquidity shortages is lower. In general, these positive effects are greater for profile 1 families.

4. Discussion

In this paper, the maximum scenario has been considered, i.e., that all the families that can contract an RM do so because they belong to profiles 1 and 2. In this way, we believe that this is a widespread and massively used product. A future line of work will consist of restricting the study to a subgroup within profiles 1 and 2 that are considered to be those who may indeed be more interested in contracting an RM because they need it; for example, those families whose initial wealth is less than twice (or another percentage) the appraised value of the property (Martinez-Lacoba et al. (2020) use the hypothesis that only a reduced percentage of families contracts RMs).

As we mentioned in the introduction, one of the main risks that the provider faces with RM is longevity risk. The use of accurate mortality tables adapted to a specific population and with good projections about future mortality can reduce this risk and then encourage potential providers to offer RMs. In this work, we have used generational mortality tables currently used in Spain that incorporate the dependency risk to create generational mortality-dependency tables. Regarding mortality tables, other options are possible. For instance, Debón et al. (2013) use the Lee-Carter model to construct dynamic tables for Spanish mortality and apply them to a specific type of RM. Considering also that Atance et al. (2020) conclude that the best model in terms of prediction ability for each sex and European country is, in general, the Lee–Carter model, we may think that this is a good option. But the question of how to incorporate the dependency risk in these dynamic tables remains, which is not an easy task and would require more statistical studies.

Another important source of risk is the loss of value of the property. It is a common practice to calibrate the loan-to-value parameter in a manner that reduces the effects of this loss. Although in developed markets the loan-to-value parameter usually depends on the initial age, we have considered a common value for it since using different ones for this parameter would complicate the analysis and would not provide significant additional results.

RMs and life annuities are products of a very different nature, although both can be used to increase the income of the elderly. A line of future research will consist in replicating precisely this work using life annuities and comparing the effects that contracting each of these products has on the finances of families in each territory.

Conclusions

Based on a theoretical model that includes, on the one hand, the randomness in mortality and dependency of the members of a family and, on the other hand, the temporal evolution of family income and expenses, this paper quantifies the effects that contracting an RM has on the finances of Spanish families based on data extracted from EFF 2017. The results depend on the selected country, because for each country, the model must be adapted according to the legal framework for retirement and long-term care benefits, to the actuarial mortality and long-term care tables and to the economic magnitudes of the family finances of each country.

Although the results of the paper do not provide new elements of actuarial technique for RM pricing, they can be useful for detecting market niches and as a promotional marketing tool.

This study shows that a family in Spain that meets the conditions for contracting an RM sees, on average, a 9.65% increase in its initial income (4,231.53€), a 44.54% decrease in its probability of having liquidity problems in the future (5.59% without RM and 3.10% with RM), and a 42.47% decrease in the value of lack of liquidity (6,521.37 without RM and 3,734.91 with RM).

Regarding the differentiated effects on the two profiles, a household of profile 1, by contracting an RM, obtains, on average, a 14.51% increase in its initial income (5.016,16€), a 49.26% decrease in its probability of having liquidity problems in the future (5.46% without RM and 2.77% with RM), and a 51.41% decrease in the value of lack of liquidity (5,097.97 without RM and 2,476.85 with RM). However, in profile 2, the study shows that contracting an RM, the family sees, on average, a 6.41% increase in its initial income (3,786.74€), a 37.99% decrease in its probability of having liquidity problems in the future (5.79% without RM and 3.59% with RM), and a 34.96% decrease in the value of lack of liquidity (8,689.39 without RM and 5,651.11 with RM). Then, we conclude that family composition (mainly the number of members with income in the family and their life expectancy) influences the magnitude of the positive effects of taking out an RM, so that families with only one person over 65 years of age are those that benefit most from this product. The main reason for this improvement in the positive effects of RM on Profile 1 families is that contracting RM provides a second additional source of income to the family (making the income situation of these families similar to that of Profile 2 families, who have 2 or more sources of income to start with) that can contribute to defraying the costs of becoming dependent, in the event that such a situation arises.

Author contributions

Conceptualization, M.M.C.; methodology, E.B., M.M.C. and X.V.; software, E.B.; validation, M.M.C. and X.V.; formal analysis, E.B., M.M.C. and X.V.; investigation, E.B., M.M.C. and X.V.; resources, X.V.; data curation, E.B. and X.V.; writing–original draft preparation, E.B., M.M.C. and X.V.; writing–review and editing, E.B., M.M.C. and X.V.

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APPENDIX 1

The characteristics of each family are obtained from the following variables included in the EFF:

np2_1: Main housing tenure regime. It takes a value of 1 for ownership and of 0 for other tenure regimes.

p2_1b: Possession of the entire main dwelling or a part of it (Totality, A part).

p2_5: Current appraised value of the property in Euros.

p2_12_1,..., p2_12_4: Outstanding amount to be amortized (maximum of four loans).

np_1: Number of household members.

p1_3_1,..., p1_3_9: Relationship with the reference person of the household (Reference person (RP), Partner, Child, Father RP, Mother RP, Mother RP, Father Partner, Mother Partner, Grandfather/Grandmother, Grandson/Granddaughter, Brother/Sister, Other Relative, Other Member not Related with RP or Partner).

p1_1_1_1,..., p1_1_9: Sex of family members (Male, Female).

p1_2d_1,..., p1_2d_9: Age of family members (years).

p1_4_1: Marital status of head of household (Single, Married, Domestic Partner, Separated, Divorced, Widowed).

neducdom: Level of education of head of household. It takes a value of 1-3 (Lower than High School, High School, University Studies).

expenses: Constructed as the sum of three variables: *alim* (annual expenditure on food), *nodur* (annual expenditure on other non-durable goods), and *gimpvehic* (annual expenses for vehicle acquisition value).

riquezanet: Net wealth calculated after a whole process of defining intermediate variables regarding real assets, financial assets and debts.

renthog16_eur17: Sum of labor and non-labor incomes of all household members in 2016.

p6_14_1_1_1, p6_14_1_2, p6_14_1_3,..., p6_14_9_1, p6_14_9_2, p6_14_9_3: Regular gross monthly income of household members from employment (maximum 3) in Euros.

p6_47_1_1_1, p6_47_1_2, p6_47_1_3, p6_47_1_4,..., p6_47_9_1, p6_47_9_2, p6_47_9_3, p6_47_9_4: Type of pension (maximum 4) (Retirement Pension or Benefits [includes Early Retirement Pension, Early Retirement], Sickness or Disability Benefits, Pension Plans, Widow's or Widower's Pension or Benefits, Orphan's Pension or Benefits).

p6_49_1_1_1, p6_49_1_2, p6_49_1_3, p6_49_1_4,..., p6_49_9_1, p6_49_9_2, p6_49_9_3, p6_49_9_4: Gross amount of pensions in Euros.

APPENDIX 2

The balance modelled in Eq. (1) is a stochastic process with two sources of randomness: on the one hand, mortality/survival and, on the other, the dependency of each family member. With respect to the dependency contingency, the model used only considers one level of dependency, which in the case of Spain corresponds to the most severe. Thus, the stochastic model describing the survival/dependence of each member includes three states: autonomous (a), dependent (d), deceased (t). The mortality and dependency tables show the transition probabilities from one state to the other as a function of sex, year of birth and age attained.

As an example, consider a family consisting of a 70-year-old man and a 68-year-old woman. A possible simulation of the states is (aa, aa, aa, da, da, da, ta, ta, ta, tt), which indicates that the man remains active for two years, then becomes a dependent and dies as a dependent three years later, while the woman never becomes a dependent and dies active at the age of 76. The trajectory corresponding to the stochastic process *S* is obtained by taking into account the ordinary expenses and extraordinary expenses derived from dependency, as well as the ordinary income and extraordinary income obtained from RM, depending on the status of each member in each of the periods up to the extinction of the family.

The annual state vectors for household 2 of Profile 2 (a 72-year-old man and a 70-year-old woman) corresponding to two simulations are included in Table 9 and Figure 1 shows the corresponding simulated paths of *S* for this household with RM.

Table 9. Annual state vectors for household 2 of Profile 2 with RM (source: own elaboration)

Simulated paths	Annual state vector
Simulated path 1	(aa, aa, aa, aa, aa, aa, aa, aa, aa, aa, aa, aa, aa, aa, aa, ta, ta, ta, ta, ta, td, td, td, td, td, td, td, td, td, td, td, tt)
Simulated path 2	(aa, aa, aa, aa, aa, aa, ta, ta, ta, ta, ta, ta, ta, ta, ta, ta, ta, ta, ta, ta, ta, tt)

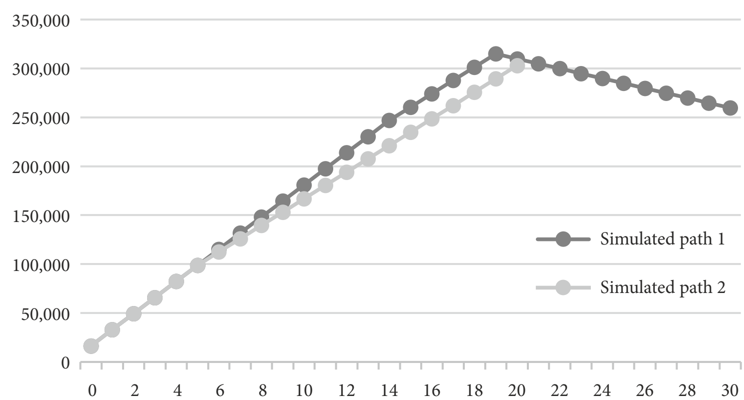

Figure 1. Simulated paths of the stochastic process S for household 8 of Profile 2 with RM (source: own elaboration)