RETIREMENT FROM THE LABOUR MARKET AND ITS SOCIAL IMPACT. EVIDENCE FROM ITALY USING DYNAMIC MICROSIMULATION.

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Abstract

The recent literature – including among others Redmond, Sutherland and Wilson (1998), Gupta and Kapur (2000) Mitton, Sutherland and Weeks (2000) – has highlighted model alignment and validation as crucial issues to be tackled when microsimulating the consequences of public policies. This is specifically important in order to properly consider individual choices and reactions. The main aims of this paper are to deal with these issues in the case of retirement from the labour market and to present new evidence on the effect of different policy options relative to fiscal and social security reforms (e.g. on inequality and poverty) in the case of Italy. The analytical framework we use is based on MIND (Micro Italy National Dynamics), a dynamic ageing microsimulation model, already being used to simulate pensioners' inequality trends in Italy by Bianchi, Romanelli, Vagliasindi (2003), that incorporates behavioural analysis of individual choices of retirement age, derived from the Stock-Wise (1990) option value model.

Using this dynamic model we can examine behavioural changes along proposed pension reform path. In this way, we investigate the suitability of dynamic micro-simulation to describe the evolution of income and wealth distribution, as well as inequality and poverty trends. The paper discusses some validation experiments involving external checks on key macro variables (e.g. dependent workers' incomes, and demographic variables) at national and regional levels (North, Centre and South). We test the appropriateness of the main assumptions and specification of the model and policies' effectiveness using Monte Carlo replications. In particular, our analysis allows us to test MIND's ability in forecasting demographic and economic trends, in capturing socio-economic dynamics for regional areas and in assessing the effects of current fiscal and social security reforms on inequality and poverty trends.

In this respect, the form of the individual reaction function, that rules the choice of retirement age, and the external options present in the market, can play a key-role. Consequently, it is

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necessary first to validate and calibrate the model as to reproduce, at least in the short term, the dynamics shown in the official data supplied by the *Casellario INPS* and ISTAT. Specifically, we try to mimic the trend of the percentage change in the quota of workers retired between 1996 and 1999, modifying the parameters' value of the retirement choice function included in the model MIND, till the simulated output fits as well as possible the official data.

Finally, our attention focuses on analysing the evolution of income concentration and poverty indices in the short and long run, also taking into account differences along regional dimensions. The simulation experiments in general show that:

i) inequality and poverty tend to increase among pensioners' families, notwithstanding greater disincentives to anticipated retirement, lower unemployment and more regular careers;

ii) the recent increase and the possible future indexation of social and lowest pensions to per capita income, by reducing poverty, reduces inequality issues in the short and long run.

1. Introduction.

The recent literature – including among others Redmond, Sutherland and Wilson (1998), Gupta and Kapur (2000) Mitton, Sutherland and Weeks (2000) – has highlighted model alignment and validation as crucial issues to be tackled when microsimulating the consequences of public policies. In particular, to analyse the effects of social security policies on the labour market, it is important to study the evolution of: (a) demographic and family structures, (b) incomes and pension treatments considering the main sectors: private and public dependent workers and self employed workers. For these purposes, the use of dynamic microsimulation models is particularly effective and allows us to examine the increase in the pensioners/workers ratio, determined by the present demographic evolution in Italy, and the pension/wage ratio, that may cause strains in the social security budget, both in the short and the long run. Microsimulation models, once validated, allow us to carefully consider the effects of social policies on the distribution of individual and family incomes and to tackle issues related to inequality and poverty.

The main aim of this paper is to deal with social security issues and to present new evidence on the effect of alternative policy options relative to fiscal and social security reforms on inequality and poverty in the case of Italy. Its analytical framework is based on MIND (Micro Italy National Dynamics), a dynamic ageing model that incorporates behavioural analysis of individual choices of retirement age, derived from the Stock-Wise (1990) option value model.

The paper discusses some validation experiments performed on the model inputs, procedures and simulation results. The MIND's input consists mainly of microdata derived from the 1995 Bank of Italy's households' survey.[1] It is widely recognised that self-selection and underreporting can seriously affect the quality and reliability of the data included in the survey. In order to tackle these issues we calibrate the sample with respect to the actual population, attaching appropriate household weights, according to several dimensions, such as the demographic structure, the education level of workers, sex and geographic areas.[2] The validation process has involved external checks such as the ex-post comparison (from 1996 since 1999) of grossed up aggregation of the key macro variables (e.g. dependent workers' incomes, and demographic variables) with official data (e.g. supplied by the Italian National Institute for Statistics ISTAT) at national and at regional level (North, Centre and South). Specifically, our analysis allows us to test MIND's ability in forecasting demographic and economic trends, in capturing socio-economic dynamics for regional areas and in assessing the effects of current fiscal and social security reforms on inequality and poverty trends.

We microsimulate the future evolution of pension treatments, that in the '90^s have been substantially modified by the introduction of two new laws.[3] In this framework we will tackle the issue of adjusting (or indexing) the lowest pension treatments to per capita income (or real wages).[4] We also test the appropriateness of the main assumptions and specification of the model and policies' effectiveness using Monte Carlo simulations.

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[1] The model (jointly developed in the Universities of Parma and Pisa) is based on annual periods, mainly because the official data, involved in the building and use of the model, are supplied on an annual basis. Starting from the SHIW (see Banca d'Italia, 1997) data, we build alternative samples and use them to microsimulate the MIND (Micro-Italy-National-Dynamics). The software developed is written in FORTRAN95 and includes about 9000 code lines. The model simulates 50 years (1996/2045) in about an hour on a PC using an initial sample of 40.000 individuals.

[2] The SHIW survey includes 8,135 families and 23,294 individuals; setting the minimum weight equal to one we get an initial expanded sample $MIND_E$ of 104,017 families and 271,208 individuals. In policy analysis $MIND_E$ sample is too large to perform Monte Carlo experiments for a period of 50 years. Accordingly, using a procedure similar to the one discussed in Cannari e Nicoletti Altimari (1998) we have reduced the size of the expanded sample. Using the original Bank of Italy weights, we get the sample $MIND_1$ or the sample $MIND_2$ using our modified weights. Finally, we also consider the sample $MIND_3$ (of 41,941 individuals and 15,068 families), which maintains the maximum observed heterogeneity as it includes, at least once, each family of the SHIW sample.

[3] The Amato law (L.503/92), raised the old age pension retirement age, lowered future pensions for workers subject to the old defined benefit regime (called "retributivo" and based on final wages, i.e. received in the last years of the working period), modified the indexation rule. The Dini law (L.335/95) introduced a new defined contribution regime (called "contributivo" and based on social contributions) for the new entrant workers and a long transition phase (the so called "mixed regime") for mature ones It also suppressed minimum pensions, shifting vertical redistribution outside the pension system and implying a larger role for welfare benefits (i.e. the social pensions) in the future. Moreover, it envisaged some sort of wage indexation of the lowest pensions from 2009.

[4] In particular we consider the two lowest types of Italian pensions; the "assegni sociali" (i.e. the social pensions) and the "pensioni integrate al minimo" (i.e. minimum pensions that received a social integration to reach a minimum threshold, which is slightly above the level of social pensions). In this way we strongly restrict the application of indexation to wages and reintroduce an automatic vertical redistribution inside the pension system. This put us out of the wider debate on the issue of price versus wage indexation of pensions, that has taken place even before Italian reforms and dates back at least to Aaron (1966). Several contribution to this subject, highlight the risk that a full wage indexation may turn out politically unsustainable. For a brief review of this topic and the related one (of a passage from a PAYG system to capitalization) we refer to Visco and Vagliasindi (1992) and Gronchi and Aprile (1998).

Indexation to prices, introduced before the 1992 reform, has a number of drawbacks.[5] First, it transforms social and minimum lowest pensions from a social minimum into a biological one and it reintroduces differences between pensions depending on the year of retirement (the so called "vintage pensions") setting the premises for future discretional interventions aimed at eliminating such problems, on an equity basis.[6] Considering behavioural reactions to changing incentives, we will appraise consequences on retirement ages per area, employment and sex, pension expenditures, average pension treatment and inequality and poverty of the new defined contribution system, and the indexation to per capita income for the lowest (welfare) pensions.

The paper is organised as follows. In section 2 we describe the structure of the model, its modules, their interrelations and the basic hypotheses that we adopted. Section 3 discusses validation experiments on the behavioural reaction function for retirement choice, considering the official trends (from 1996 to 1999). In section 4, we estimate under different indexation policy and behavioural regimes retirement ages per area, employment and sex, total pension expenditures and the average individual pension treatments. In section 5, using a Monte Carlo experiment, we study the consequences of the demographic-evolution (e.g. family structure) and social security reforms on inequality and poverty. Section 6 concludes with some final remarks on the relevance of the dynamic microsimulation experiments.

2. The MIND dynamic ageing model: a brief description.

The MIND model considers both the national socio-demographic dynamics and the different Italian regional geographical areas (North, Centre, South and Islands).[7] Similarly to other models currently developed for other countries, the MIND structure is organised in modules, which simulate the evolution of: (***a***) demographic and family structures, (***b***) socio-economic

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[5] In 2001 the indexation rule has been modified. A larger number of pensions is now fully indexed to price dynamics. In our simulations we consider this new indexation regime and apply it to the new indexed lowest pensions, without considering the discretional benefit increase taking place from 2001 onwards.

[6] Non-welfare pensions have different purchasing power depending on the year of retirement (since they depend on the past wages) and (differently from future wages) do not grow in real terms, during the retirement period. Starting from "high" individual pension treatments, trade unions accepted a partial indexation to prices. In this way, since wages and incomes grow in real terms, there is no certainty about the future value of the pensions during the retirement period. This uncertainty stems from the inflation level, normally incorporated in nominal wage and incomes growth. In the transition phase, this mechanism is expected to consistently reduce the relative purchasing power of "privileged" pension treatments when real wages grow. However, by lowering the purchasing power of ongoing pension it creates "vintage pensions" and a periodical stimulus to rise the level of pensions a few years after the retirement.In the seventies and the eighties the vintage pensions reflected also other factors.

[7] The main differences between our models and the one developed by Cannari and Nicoletti Altimari (1998) refer to the inclusion of a geographically differentiated demographic evolution and a retirement choice based on the option value model.

phenomena related to work incomes and (***c***) optimal retirement choice and pension treatments.[8]

The "demographic" module includes the subsections on mortality, marriage, divorce, singles, and birth. First of all, based on the observed data on the population in the base year 1995, the demographic modules determines the number of deaths; subsequently, on the basis of different transition rates, survivors can get married, divorce or become single. Finally, it simulates births. Marriage-rates, birth-rates and divorce-rates depend on the geographical area and individuals' age.[9]

The "work and incomes" module is organised as follows: the first sub-module simulates the entry in the labour market and the second one derives workers' incomes. The choice between the three different categories of work is stochastic, depending on the probabilities to be dependent workers (private or public) or self-employed. The education degree (years of education, EDU) is also given through a stochastic procedure which simulates the probability of completing a first degree, for individual older than 24.[10] Following Andreassen, Fredriksen and Ljones (1993), the estimation of income levels, based on cross sectional data, has the standard log-linear specification suggested by Mincer (1974).[11] For the individual *i*, the forecast value ($\hat{y}_{it}$) at time t is obtained by replacing the values assumed by the characteristics of the individual in the vector $\mathbf{x}_i$ of the equation $\hat{y}_i = e^{(\mathbf{x}_i b + \hat{u}_i)}$ where, to avoid biases, the estimated residuals $\hat{u}_i$ are also included.[12]

[8] See, for example, NEDYMAS by Nelissen (1994), DYNAMOD by Antcliff, Grusskin, Harding e Kapuscinski (1996) and DESTINIE built at INSEE (1999). Transaction probabilities (e.g. related to death) are constant overtime as usual in these type of models, even if a decrease of mortality can be assumed. MIND demographic structure is however validated along a 50 years period, based on IRP (1995) forecasts. For more specific demographic microsimulation methods see Bongaarts et al. (1987) and Hammel et al. (1990).

[9] Every year the model attributes to each individual a probability of death, depending on his sex, age and living area. We generate a random number r with uniform distribution in the interval 0-1. If r is greater than the relevant probability the individual lives and his age is increased, otherwise he is taken out of the database. In this case, if he was married, the civil state of the partner is modified; if was head of the family, the partner (or the eldest relative) is the new family head and inherits his wealth; the number of family components is decreased. The marriage is simulated in two phases. In the first one MIND selects candidates (aged between 17 and 48), based on a given probability table. In the second phase, each female candidate gets married to the best candidate (for whom the difference between the extracted random number and the theoretical probability is minimised). Inside each marriage, births depend on the mother's age, the geographical area and the number of existing children. The new individuals enter the database modifying the characteristics of their families. Each partner can divorce on the basis of a probability table. Children and 2/3 of the family wealth (half in the absence of children) go to the wife with a 92% probability, as in Cannari and Nicoletti Altimari (1998). Individuals aged between 28 and 35 become singles with a probability equal to 20% of their probabilities of marriage. Transaction probabilities are derived from ISTAT data and from the SHIW sample. All demographic probability tables are reported in Vagliasindi (2002).

[10] The relative probabilities are derived from ISTAT data on the 1999 labour force and from the SHIW sample.

[11] In particular we consider a structure diversified for AGE, AGE^2, SEX, EDU and HOURSA for three occupational sectors (dependent, self-employed, public) and geographical areas (North, Centre, South). Almost all the coefficient are of the right sign and statistically significant at the 99% confidence level. For more details, see Bianchi, Romanelli, Vagliasindi (2001).

[12] Real income at period t is derived from: $\hat{y}_{it} = \hat{y}_i \ (1+g)^{t-t_0}$, where g, the real growth rate of incomes, is assumed to be to 1% after 2000 and t_0 is the initial simulation period. The number of hours worked by entrants (HOURS) are

Finally, the "social security" module determines the retirement age and pension treatments using a reaction function based on the option value (OV) model from Stock and Wise (1990). In this way workers are allowed to choose to postpone retirement when the expected value of their utility to retire is growing over time. As in Stock and Wise, individuals, given the available information, calculate the expected values of the utility of retiring today and in future. The differential benefit $OV_t(t)$ of postponing the retirement to the next year is then considered. If OV is positive the retirement will be postponed otherwise (negative OV) the worker retires immediately. OV is estimated each year until the maximum age of retirement is reached. In the calculation of OV we consider the different computing procedures (defined benefit, 'mixed' or defined contribution)[13] depending on the characteristics and contribution of each individual and on the benefits and requisites related to workers' type and period.

In our simplified specification of the model, in each period t workers calculate the differential benefit $OV_t(t+1)$ of postponing retirement to time $t+1$ and decide to retire if $OV_t(t+1) \leq 0$.

$$OV_t(t+1) = E_t\, V_t\,(t+1) - E_t\, V_t\,(t) = aY_t - B_t(t) + \sum_{s=t+1}^{S}(1+r)^{t-s}\cdot(B_s(t+1)-B_s(t))$$

where $V_t(R)$ is the value at time t to retire at time R and depends on the actualised flows of incomes Y_s[14] and pensions $B_s(R)$[15].

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estimated on the basis of the average number of hours worked (HOURSA) and of the respective standard error (STDERR), depending on the sector and the geographical area: HOURS = HOURSA (AGE, SECT, AREAGEO) + (STDERR(AGE, SECT, AREAGEO) ´ ***rd***) where ***rd*** is a random number with normal standard distribution which introduces a stochastic element.

[13] In the Italian PAYG system future treatments are based: (i) on final wages in the old ***defined benefit*** regime ("regime retributivo"), (ii) on social contributions in the future new ***defined contribution*** regime ("regime contributivo" introduced by the Dini law L.335/95) for the new entrant workers and (iii) on a mixture of final wages and social contributions in the so called ***mixed*** regime ("regime misto") for mature workers, during a long transition phase leading towards the new contributive regime. For an overview of future trends of the the Italian PAYG system see Ministero del Tesoro (1998). For an interesting reform proposals see Visco Vagliasindi (1991), Baldacci Peracchi (2000) and De Santis (2001).

[14] In order to reconstruct the history of wages and social contributions of each worker in our database, necessary to calculate his pensions, we used the following simplifying hypothesis: 1) a future real rate of discount, equal for all to 2.5%, 2) a real rate of per capita growth of 1%, 3) absence of individuals that temporarily suspend the payment of their contributions, 4) payment of pension and incomes at each end of year, 5) indexation of pensions to the rate of inflation 1.8%: total (i.e. 100 %) if inferior to the double of the value of the social pension (equal to 6.500.000 – € 3357 - in 1999), partial at 90% if inclusive between the double and the triple of this value and at 75% otherwise, 6) workers face a social constraint to retire set at 66 for dependent workers, 67 for public and 68 for self-employed (in this way we generate a corner solution). However in the present work we realise also additional simulations using different sets of hypotheses; in particular: ***a***) a future real rate of discount equal to 4%; ***b***) a real rate of per capita growth of 2%: ***c***) a future rate of inflation equal to 2.5%. The first two are discussed in the appendix, while the increase in inflation is skipped because it produces only very minor consequences.

[15] The indirect utility specification of labour and pension incomes are respectively $U_y(Y_s) = aY_s + \omega_s$ $(0 \leq a \leq 1)$ and $U_b(B_s(t)) = B_s(t) + \xi_s$, with ω_s and ξ_s zero mean random variables whose variance can be estimated as in Stock and Wise (1990). For recent work in this area see Gruber and Wise (1999) and Peracchi (1999).For related studies on SHIW data see also Di Pino Mucciardi (2001) and Spataro (2000). In our paper the comparison involves flows of gross

$$V_t(R) = \sum_{s=t}^{R-1}(1+r)^{t-s}\, U_y(Y_s) + \sum_{s=R}^{S}(1+r)^{t-s} U_b(B_s(R)) = a\sum_{s=t}^{R-1}(1+r)^{t-s}\, Y_s + \sum_{s=R}^{S}(1+r)^{t-s} B_s(R)$$

Given our simplifying assumptions, each worker derives the age that maximises the value of retiring (V). In fact, the differential benefit monotonically decreases, reaching the maximum when it becomes null, since the variation, ?$_t$, of the option value from time t to time $t+1$ is:[16]

$$?_t = a\,(Y_{t+1} - Y_t) - \left(\frac{2+r}{1+r}\right)(B_{t+1}(t+1) - B_t(t)) + \sum_{s=t+2}^{S}(1+r)^{t-s}[(1+r)(B_s(t+2) - B_s(t+1)) - (B_s(t+1) - B_s(t))]$$

Assuming that the absolute increment of the pension benefit ($B_s(j+1)$-$B_s(j)$) decrease at a rate equal or greater then ($r/(1+r)$),[17] ?$_t$ is negative when: $a \le \frac{2+r}{1+r}\frac{B_t(t)}{Y_t}$

Hence, being r relatively small, this condition becomes $a = 2\,(B_t(t)/Y_t)$ and is satisfied by a ratio $B_t(t)/Y_t = 50\%$ (independently from the value of a).

3. Validation of "social security" procedures

As our analysis is focused on the exit from the labour market, the impact of discretionary social security policies and indexation of the lowest pensions to per capita income, it is particularly important to properly calibrate and validate the reaction function simulating retirement decisions, i.e. the social security module. For this purpose, we want to set the parameters of the module as to reproduce, at least in the short term, the dynamics of the socio-economic phenomena.

Given the difficulties in comparing our database with the entire universe of pensioners (e.g. as it is difficult to introduce new families etc. to correct remaining biases), it is important to verify that our database evolves along the same lines of reality.[18] Accordingly, we try to mimic the trend of the percent change in the quota of workers retired between 1996 and 1999. In order to gain this result, we change the parameter's value of the retirement choice function till the simulated output fits as good as possible with the official data. The reaction function included in our model is based on the comparison between the present value of the expected utility of the flow of the pension benefits obtained by an agent opting for an immediate retirement with the one obtained postponing it to the next period. However, when retirement is postponed, the problem arises whether (and to which

incomes. Obviously, being individual interested to disposable incomes, the tax system and the income tax progressivity may affect the results, but it is quite impossible to envisage how these will evolve in the next 45 years.

[16] We consider real quantities, so $B_{t+1}(t) = B_t(t)$. In what follows, we assume that equality holds. In fact, *a fortiori* the results still hold if strict inequality is supposed.

[17] In this way we have $(1+r)(B_s(t+2) - B_s(t+1)) - (B_s(t+1) - B_s(t)) = 0$.

[18] The official data used for the analysis are supplied by *Casellario INPS* and from ISTAT.

extent) we should take into account the wage income earned in the following period. It's important to consider the functional form of the indirect utility functions and in particular the chosen value of a.[19] In particular, we assume for the same amount of money, the utility of income from labour is lower than the utility gained from pension benefits. This justifies a value of a less than one.

The validation of the social security module is carried out trying different values for the parameter a until reaching the lowest distortion between simulated output and official data. In particular we consider the time period between 1996 and 1999 and compare the simulated and official percent change in the quota per age class of the individuals retired and still alive in 1999. Obviously we do not consider the right to cumulate pension benefits with labour income, which was not possible at that time. In this respect, our estimate of a can be considered as an upper bound for the real future value. In fact, there are now stronger incentives to anticipate retirement given the possibility to enjoy both the wage and the pension benefit. In performing our analysis we also try to disaggregate the results, as far as possible, by considering sex and occupational sector (dependent, self-employed, public) of the agents. In table 1 we report the R^2 coefficients calculated comparing the results achieved using different value of the parameter with the ISTAT and INPS data.

Table 2: R^2 for different values of a

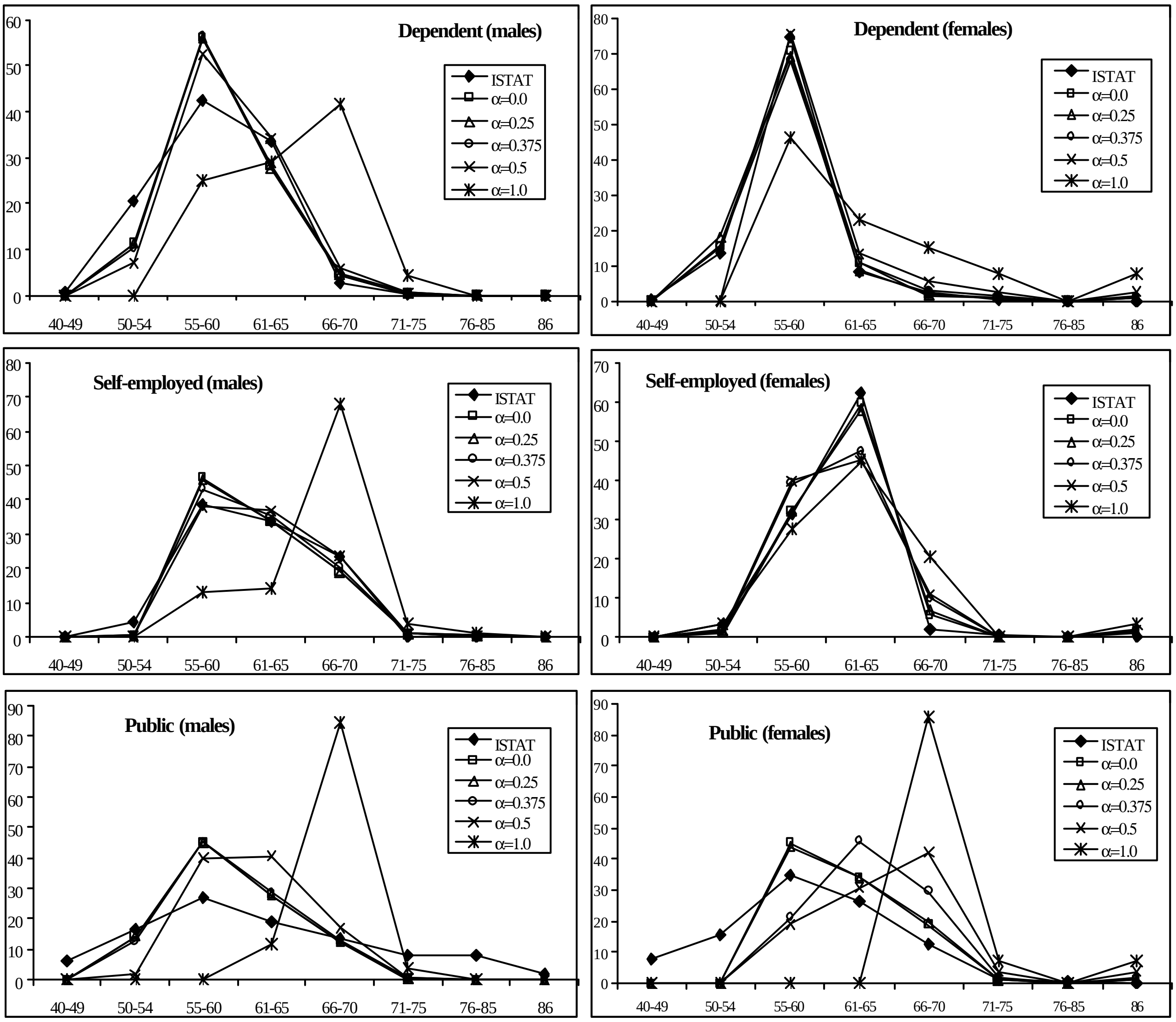
a	**MALES**			**FEMALES**		
	D	**SE**	**P**	**D**	**SE**	**P**
0.00	0.90	0.96	0.92	0.99	0.99	0.82
0.125	0.90	0.96	0.92	0.99	0.98	0.81
0.25	0.89	0.96	0.91	0.99	0.98	0.81
0.375	0.89	0.98	0.90	0.99	0.91	0.47
0.50	0.89	0.98	0.71	0.95	0.89	0.28
1.00	0.20	0.24	0.01	0.72	0.85	0.003

Our results show a high correlation between the simulated output and the official data. They also illustrate that the R^2 is decreasing with respect to a in almost all the cases considered, reaching its maximum when the parameter is equal to 0. For the category of formerly self-employed males, this is not the case: the best choice is for a = 0.5 even if the lower values of the parameter don't produce strong distortions with respect to the official data.

In figure 1 we report all the profiles obtained using the sample $MIND_3$ (the best-aligned small sample with respect to elders) and different values of the parameter. The following seems to emerge: lower the value of α the better the fit.

[19] We remember that the indirect utility specification of labour and pension incomes are respectively $U_y(Y_s) = aY_s$ $(0 \leq a \leq 1)$ and $U_b(B_s(t)) = B_s(t)$.

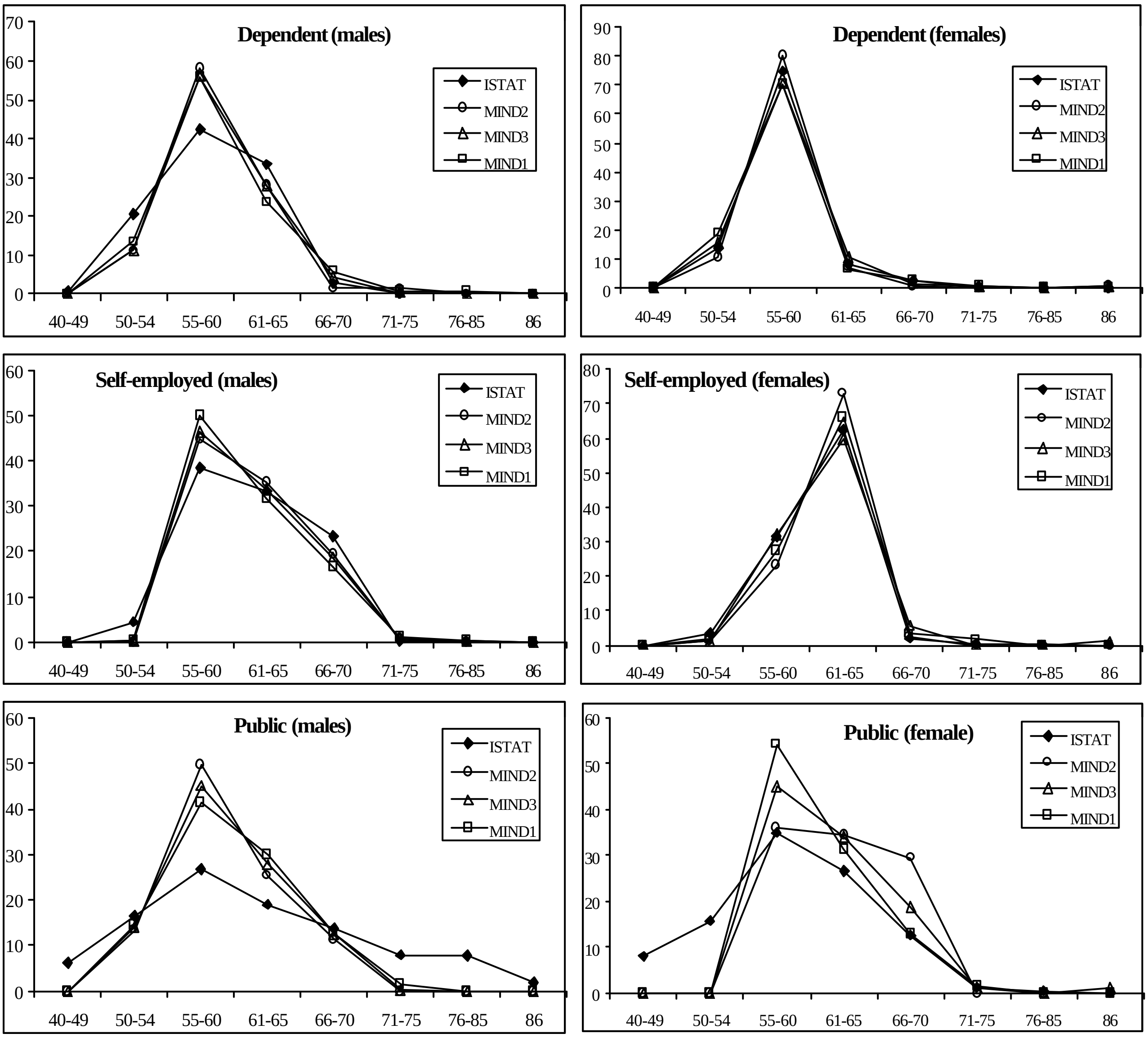
Figure 1: change in quota (%) for different sectors - $MIND_3$



From the analysis of the results, a = 0.0 (or eventually a = 0.125) seems to be the value that grants the simulated output to best fit the data. In the present work we'll show the whole results only for this value of a (figure 1).

As the small samples - $MIND_1$, $MIND_2$, $MIND_3$ - are well-aligned, we use these databases to perform the analysis. In the figure 2 we report the simulated results and official (dark diamond) data per age class and for all the categories. Usually the simulation produces profiles very similar to the ones supplied by the INPS and ISTAT statistics, except for the case of the public sectors (especially for females). This may be due in part to the tendency, in a period perceived as uncertain, to retire early in order to avoid future restrictions as well as to take advantage of economies of scope of the family and of possibilities offered by the informal sector.

Figure 2: change in quota (%) for different sectors (workers retired between '96 and '99). a=0.0



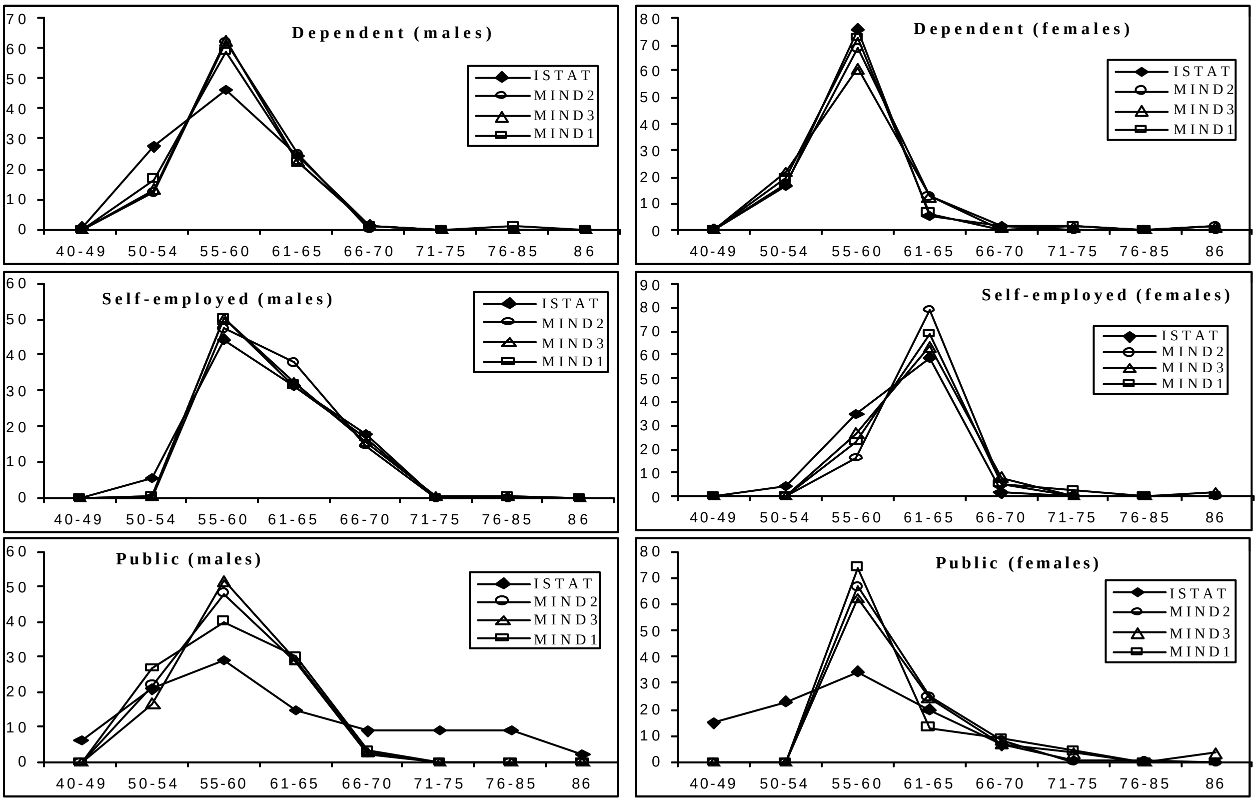
Our model seems to concentrate the values around the modal classes. In particular the model doesn't replicate completely the phenomenon of "young pensioners" (workers who decide to retire before the age of 50).

We may ascribe this discrepancy to a common sense of uncertainty coming from the approval in 1995 of the Social Security System reform, which characterises the temporal interval used in our validation process and probably represented an accelerating factor towards the choice of retirement. However, we can assume that this feature disappears after the early phase of the reform.

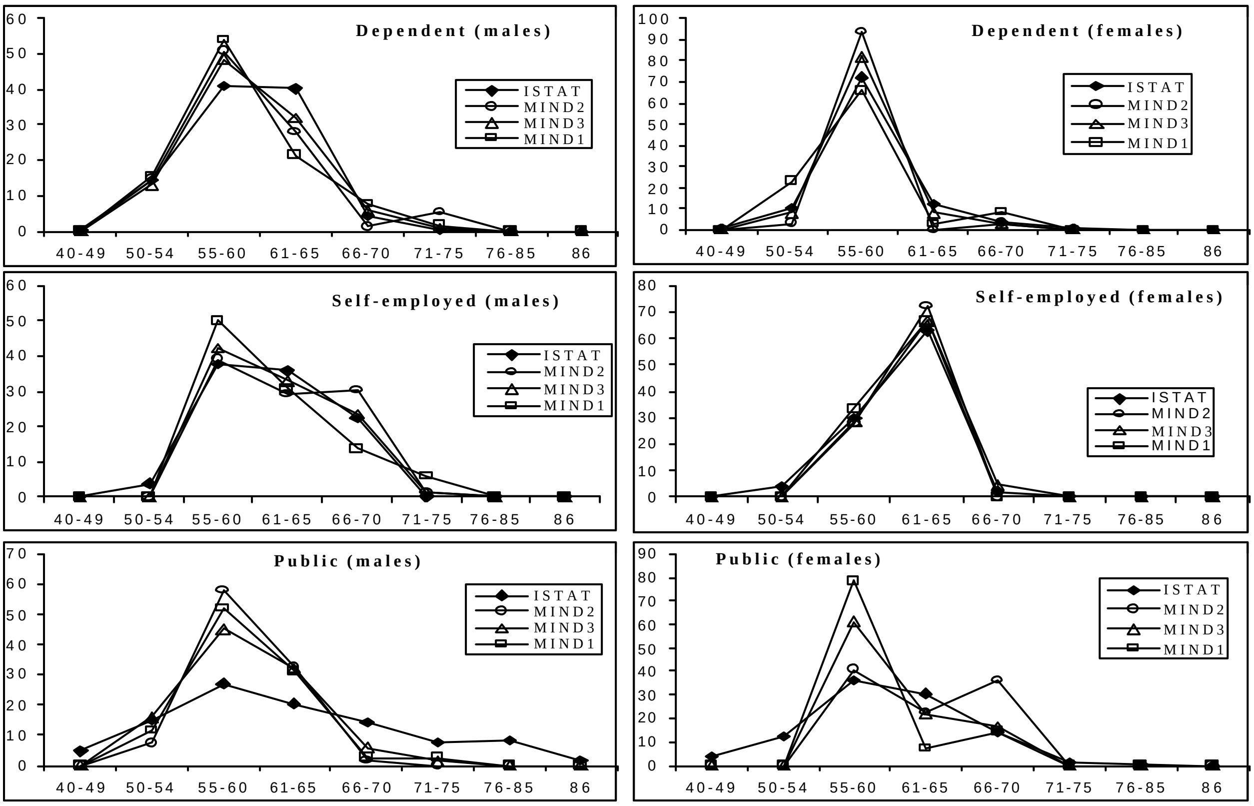
Similar conclusions can be drawn if we consider the results disaggregated at the regional level (figure 3 reports the results obtained using the three small samples). Setting the parameter equal to zero is still the choice that better assures the simulated results to mimic the official data. The regional profiles produced by the model are quite similar to the national ones except for some categories in the South[20] where they reveal some slight differences.

Figure 3: change in quota (%) for different sectors and regional areas

a) NORTH

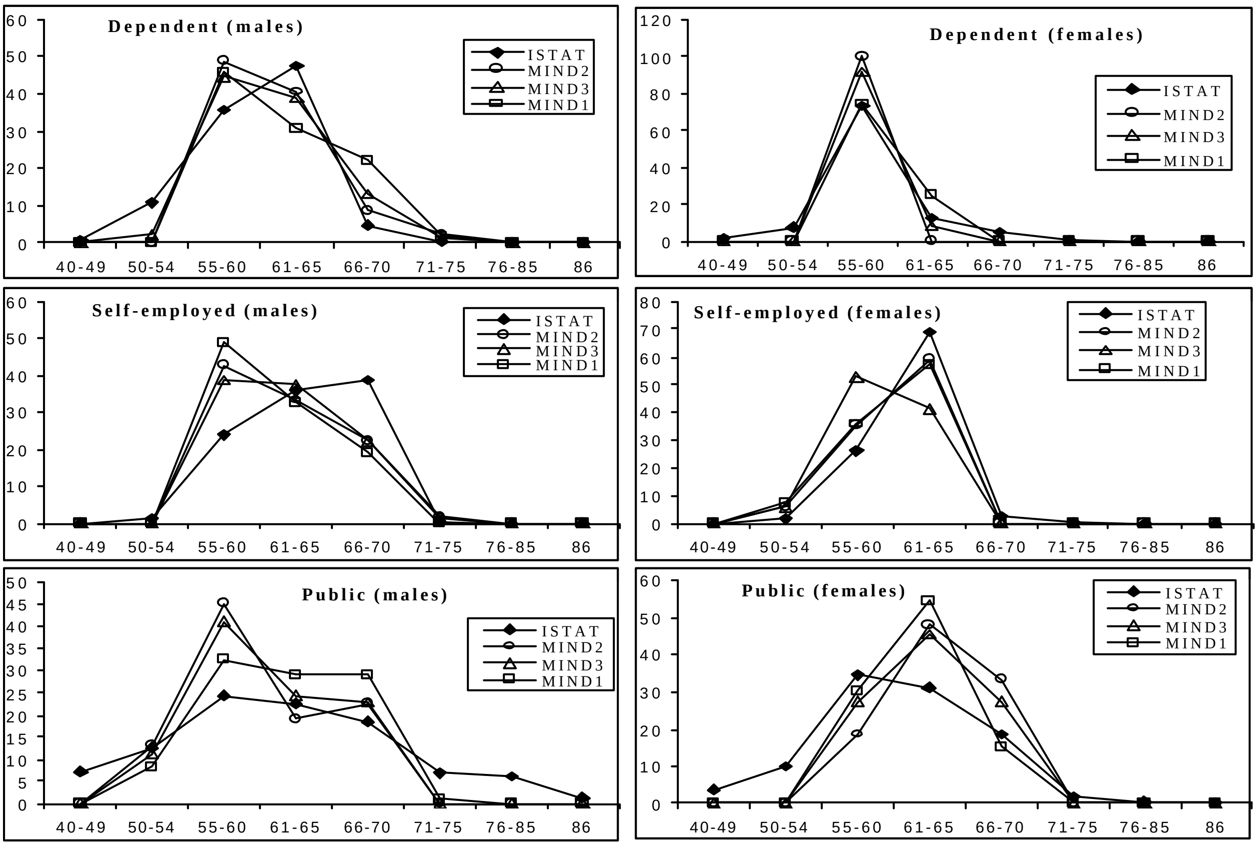


b) CENTRE



[20] In particular in three cases (dependent and self-employed males and public females) the results show different modal classes with respect to the INPS and ISTAT statistics.

c) SOUTH



If the real value of a is zero or it is very close to zero, any incentive policy, that acts on wages to induce workers to postpone retirement, such as increasing by γ = 35% gross labour incomes if one choses to delay retirement, would be ineffective. In fact, in this case $a^* = a\,(1+\gamma) \approx a \approx 0$.

On the other hand, previous estimates of the parameter and the possibility that our results underestimate a, due to the uncertainties rising from Social Security reforms, may suggest to consider also a value of a below or equal to 0.50. In this case, a policy that increase by 35% wages to induce workers to postpone retirement, will induce a smaller delay than a value a^* equal to 75%. In fact, this level $a^* = a\,(1+\gamma)$ will be reached for γ = 35% only with a value of a greater than 0.55.

Hence, we can use these two values of the parameter (a^* = 0, 0.75) in order to define two extreme scenarios (of behavioural regimes), even with high incentives to retire later.

4. Retirement choices, retirement age, pension expenditure and average treatments.

The MIND model can be used for many purposes, e.g. to estimate under different indexation policy and behavioural regimes: (***i***) retirement ages per area, employment and sex, (***ii***) total pension expenditures and the average individual pension treatments, (***iii***) poverty and the concentration of gross incomes (net of capital incomes) among families with at least one pensioner.

In particular, we consider the current indexation policy (in ***B*** the basic scenarios) and an alternative one (in ***A*** the alternative scenario), consisting in indexing lowest pensions to per capita income, to alleviate poverty and inequality issues. Around 15% of pensioners will be entitled to indexation to per capita income but also other pensioners may indirectly benefit due to the pressure of higher indexation to prices (e.g. 100% instead of 75%). We consider two alternative hypotheses on retirement behaviour, depending on whether workers: (***1***) decide their retirement age maximising the expected pension benefits; (***2***) look for the maximisation of their whole benefits flow coming from labour and pension incomes.[21]

In this way, we simulate four different scenarios (***B1***, ***A1***, ***B2***, ***A2***) usually taking ***B1*** and ***A1*** as the base scenarios. We believe that, in the context of individual retirement choices these two alternatives may be useful as boundary cases, since they are able to include a number of intermediate behaviours in their ranges. In order to reduce the variance induced by the dynamic ageing approach, the reported results are mean values of 20 Monte Carlo replications. In the dynamic simulation, each micro-unit is aged for each time-period by the empirically based survival probabilities. Assuming that N individuals in our database have a transition probability p to undertake a given action, e.g. getting higher education, we expect $N\,p$ outcomes with a standard error given by $\sqrt{Np(1-p)}$. Accordingly, for small values of N the relative error $\sqrt{Np(1-p)}/Np$ becomes very large. Hence, in different replications of our dynamic microsimulation, we can get very different results. In practice, considering mean values (of 20 replications, instead of a single one) we substantially reduce variance (uncertainty introduced by the dynamic ageing approach) by 95%. The reduction of variance can be performed using other "ad hoc" techniques - such as *selective sampling* and *side walk* methods. However, the use of such techniques may have some drawbacks, e.g. altering the probabilities of the events.[22]

In what follows we report our estimates of the average retirement age per area, employment and sex under the two different scenarios. When $\alpha^* = 0.75$ workers (males an females) tend to retire later to enjoy longer the higher wage incomes (as shown in the retirement age table 2 and 3).[23],

[21] Specifically, we obtain the two maximising behaviours (***1*** and ***2***) by assuming different indirect utility function of labour income in the Stock and Wise option value model; i.e. in case ***1*** we assume $\alpha^* = 0$ while in case ***2*** we set $\alpha^* = 0.75$. This alternative means that workers either consider only the benefits from pensions or value the net benefit of 1 € from their wage as equivalent to 0.75 € from their pension (or to 0.56 € from their pension, when wages are increased by 35% to induce workers to postpone retirement).

[22] On this topic, see Gupta Kapur (2000) chapters 17 and 18.

[23] Hence, to avoid corner solutions, we have set a social constraint to retire at 66 for dependent workers at 67 for public and 68 for self employed.

Table. 2 Retirement age(mean values) per area, employment and sex (***B1*** and ***B2***)

	B1						***B2***					
	MALES			FEMALES			MALES			FEMALES		
	D	**SE**	**P**	**D**	**SE**	**P**	**D**	**SE**	**P**	**D**	**SE**	**P**
NORTH												
2005-2007	57.5	59.8	58.8	57.5	60.1	58.6	58.8	63.4	61.0	60.6	64.2	67.0
2008-2010	57.5	59.6	58.3	58.3	59.5	58.4	59.6	62.8	61.5	60.1	66.8	67.0
2011-2013	57.8	59.4	58.6	58.0	61.6	59.6	59.8	61.9	62.5	59.9	64.2	67.0
2014-2016	57.4	58.6	58.3	58.6	59.5	59.8	59.5	63.5	61.3	61.1	66.7	67.0
2017-2019	57.4	57.9	58.4	59.2	60.1	59.9	59.2	62.1	60.8	62.8	68.0	67.0
2020-2022	57.7	58.9	60.0	59.2	61.0	62.3	65.5	63.3	66.7	65.8	67.4	67.0
2023-2025	58.1	59.9	59.7	60.7	61.9	62.5	65.1	65.0	66.2	65.8	67.6	67.0
2026-2028	58.0	59.1	59.8	61.0	61.5	63.2	65.2	66.4	66.4	65.9	67.1	66.9
2029-2031	58.0	59.8	59.1	60.8	63.1	63.2	65.2	67.6	66.5	65.8	68.0	67.0
2032-2034	57.9	59.4	59.0	61.8	63.9	64.1	65.1	67.8	66.2	65.9	68.0	67.0
2035-2037	58.3	59.7	59.2	62.7	64.6	64.7	65.4	68.0	66.9	66.0	68.0	67.0
2038-2040	58.7	59.8	59.1	63.8	64.8	64.7	65.5	68.0	66.9	66.0	68.0	67.0
2041-2043	58.6	59.8	59.1	64.1	64.9	64.8	65.7	68.0	67.0	66.0	68.0	67.0
2044-2045	58.9	59.8	59.1	64.1	64.9	64.7	65.8	68.0	67.0	66.0	68.0	67.0
CENTRE												
2005-2007	58.7	59.2	59.6	60.8	58.6	60.5	62.6	67.4	60.3	62.8	62.0	65.7
2008-2010	58.4	59.6	59.2	59.9	60.6	59.8	64.5	68.0	61.2	63.3	61.9	65.9
2011-2013	58.2	59.5	60.0	59.4	59.7	59.9	63.4	67.6	62.7	63.7	59.9	65.5
2014-2016	59.1	60.2	59.4	60.0	59.9	60.3	64.0	68.0	63.3	63.7	62.4	65.4
2017-2019	57.9	60.1	61.3	60.4	61.8	63.4	63.8	68.0	62.9	63.9	64.9	66.0
2020-2022	59.3	59.6	59.6	61.1	60.6	63.1	64.4	68.0	66.7	64.6	66.9	66.3
2023-2025	58.6	59.8	59.9	61.8	62.1	63.9	65.5	66.0	66.5	65.6	65.3	67.0
2026-2028	58.8	60.9	60.3	62.7	62.4	63.9	65.8	68.0	66.6	66.0	67.7	66.9
2029-2031	59.7	60.6	59.3	62.5	63.8	64.3	65.9	68.0	66.6	65.8	67.6	67.0
2032-2034	59.8	60.7	59.3	63.8	63.5	64.9	66.0	68.0	66.7	66.0	67.9	67.0
2035-2037	59.9	60.9	59.1	63.8	63.6	64.8	66.0	68.0	66.8	66.0	68.0	67.0
2038-2040	60.3	60.9	59.0	64.4	63.8	64.8	66.0	68.0	67.0	66.0	68.0	67.0
2041-2043	60.2	60.9	59.1	64.6	63.6	64.8	66.0	68.0	67.0	66.0	68.0	67.0
2044-2045	60.2	60.8	58.9	64.7	63.7	64.9	66.0	68.0	67.0	66.0	68.0	67.0
SOUTH												
2005-2007	60.8	62.6	59.5	61.5	60.3	61.9	65.2	64.2	64.1	63.8	62.7	67.0
2008-2010	60.2	61.6	59.8	61.1	60.5	62.3	63.9	65.1	63.1	63.6	62.4	67.0
2011-2013	60.0	61.2	60.1	61.5	62.3	61.5	63.8	65.0	64.6	63.4	64.8	66.6
2014-2016	60.7	61.2	60.0	60.5	60.7	62.1	64.2	64.2	65.1	63.4	62.9	67.1
2017-2019	60.3	61.4	60.6	63.2	62.7	63.1	64.3	64.1	65.2	63.9	66.4	67.0
2020-2022	59.6	61.2	61.4	61.7	63.2	64.1	64.7	67.5	66.1	65.1	66.5	67.0
2023-2025	60.1	60.7	62.1	63.7	64.0	64.4	65.7	67.1	66.7	65.3	67.7	66.9
2026-2028	60.0	60.4	61.2	63.2	63.8	64.6	66.0	67.8	66.7	65.9	67.8	67.0
2029-2031	60.4	59.6	60.0	64.1	64.3	64.7	66.0	68.0	66.8	66.0	68.0	67.0
2032-2034	59.8	59.0	59.4	64.2	64.5	64.8	66.0	67.5	67.0	66.0	67.9	67.0
2035-2037	60.0	59.3	59.7	64.5	64.8	64.8	66.0	68.0	67.0	66.0	68.0	67.0
2038-2040	60.3	59.3	59.8	64.6	64.8	64.8	66.0	68.0	67.0	66.0	68.0	67.0
2041-2043	60.3	59.3	59.7	64.5	64.7	64.8	66.0	68.0	67.0	66.0	68.0	67.0
2044-2045	60.4	59.3	59.8	64.4	64.6	64.8	66.0	68.0	67.0	66.0	68.0	67.0

Table. 3 Retirement age (mean values) per area, employment and sex (***A1*** and ***A2***)

	A1						***A2***					
	MALES			FEMALES			MALES			FEMALES		
	D	**SE**	**P**	**D**	**SE**	**P**	**D**	**SE**	**P**	**D**	**SE**	**P**
NORTH												
2005-2007	57.5	59.8	58.8	57.5	60.1	58.6	58.9	63.4	61.1	60.6	63.1	67.0
2008-2010	57.5	59.6	58.3	58.3	59.5	58.4	59.5	62.6	61.5	60.1	66.4	67.0
2011-2013	57.8	59.4	58.6	58.0	61.6	59.6	59.7	62.0	62.3	59.9	68.5	67.0
2014-2016	57.4	58.6	58.3	58.6	59.5	59.8	59.4	63.5	61.3	61.0	66.5	67.0
2017-2019	57.3	57.9	58.5	59.2	60.0	59.8	59.2	61.9	60.7	62.6	67.3	67.0
2020-2022	57.7	58.8	60.0	59.1	61.1	61.6	65.2	62.4	66.7	65.7	67.1	67.0
2023-2025	58.1	59.9	59.7	60.9	61.8	63.1	65.0	65.0	65.9	65.5	67.2	67.0
2026-2028	57.9	59.1	59.8	60.8	61.4	63.4	65.1	66.1	66.4	65.7	66.7	66.9
2029-2031	58.0	59.8	59.2	61.0	62.9	64.6	65.2	67.5	66.4	65.6	67.6	66.9
2032-2034	57.9	59.5	59.1	62.3	64.6	64.9	65.0	67.7	66.3	65.9	68.0	67.0
2035-2037	58.2	59.9	59.2	63.8	64.8	64.9	65.3	68.0	66.9	66.0	67.7	67.0
2038-2040	58.7	59.8	59.2	64.5	65.0	65.0	65.4	68.0	66.8	66.0	68.0	67.0
2041-2043	58.6	59.8	59.2	64.7	65.1	65.0	65.7	68.0	67.0	66.0	68.0	67.0
2044-2045	58.9	59.9	59.3	64.9	65.1	65.1	65.9	68.0	67.0	66.0	68.0	67.0
CENTRE												
2005-2007	58.7	59.2	59.6	60.8	58.6	60.5	62.6	67.4	60.0	63.8	62.0	66.0
2008-2010	58.4	59.6	59.2	59.8	60.6	59.8	64.5	65.5	61.2	62.8	61.7	65.5
2011-2013	58.2	59.5	60.0	59.4	59.7	59.9	63.4	67.6	62.7	63.6	59.6	65.5
2014-2016	59.1	60.2	59.5	60.1	59.8	60.2	64.0	67.3	63.2	63.7	62.3	65.2
2017-2019	58.0	60.2	61.3	60.2	61.8	63.9	63.6	67.8	62.9	63.8	64.8	66.0
2020-2022	59.4	59.6	59.5	61.2	60.5	63.9	64.0	67.1	66.4	64.3	66.7	66.1
2023-2025	58.7	59.8	59.9	62.3	62.2	63.6	65.7	65.7	66.5	64.8	64.8	67.0
2026-2028	58.9	60.9	60.3	63.3	62.5	64.4	65.7	68.0	66.6	66.0	67.4	66.9
2029-2031	60.0	60.8	59.4	63.3	64.0	64.9	65.9	67.8	66.5	65.6	67.5	67.0
2032-2034	59.8	60.8	59.3	63.5	64.1	64.9	66.0	68.0	66.7	66.0	67.9	67.0
2035-2037	60.1	61.0	59.2	64.6	63.7	64.9	66.0	68.0	66.8	66.0	68.0	67.0
2038-2040	60.5	61.1	59.2	64.9	64.0	65.0	66.0	68.0	67.0	66.0	68.0	67.0
2041-2043	60.4	61.0	59.0	65.0	64.0	65.0	66.0	68.0	67.0	66.0	68.0	67.0
2044-2045	60.3	60.9	59.1	65.0	64.1	65.1	66.0	68.0	67.0	66.0	68.0	67.0
SOUTH												
2005-2007	60.8	62.6	59.5	61.6	60.3	61.9	65.1	64.1	63.8	63.8	62.7	67.0
2008-2010	60.2	61.6	59.8	61.1	60.5	62.3	63.8	65.0	63.1	63.5	62.4	67.0
2011-2013	60.0	61.2	60.1	61.5	62.3	61.4	63.3	64.3	64.8	63.4	64.5	66.6
2014-2016	60.7	61.2	60.0	60.5	60.7	62.1	64.3	64.3	64.5	63.3	62.8	67.1
2017-2019	60.2	61.4	60.6	63.1	62.7	63.3	64.3	64.2	64.7	63.6	66.3	67.0
2020-2022	59.6	61.2	61.4	61.5	63.2	64.2	64.8	67.3	66.5	64.9	66.3	67.0
2023-2025	60.2	60.7	62.1	63.3	64.1	64.6	65.6	66.7	66.7	64.5	67.5	66.9
2026-2028	60.0	60.4	61.4	63.5	63.6	64.9	65.9	67.4	66.9	65.6	67.3	66.9
2029-2031	60.6	59.7	60.2	64.2	64.3	65.0	66.0	67.7	66.8	66.0	67.9	67.0
2032-2034	59.9	59.0	59.4	64.5	64.9	65.1	66.0	67.5	67.0	66.0	67.9	67.0
2035-2037	60.3	59.4	59.8	64.9	65.1	65.1	66.0	68.0	67.0	66.0	68.0	67.0
2038-2040	60.4	59.4	59.8	65.1	65.0	65.1	66.0	68.0	67.0	66.0	68.0	67.0
2041-2043	60.5	59.3	59.9	65.1	65.0	65.1	66.0	68.0	67.0	66.0	68.0	67.0
2044-2045	60.4	59.4	59.9	65.0	65.0	65.1	66.0	68.0	67.0	66.0	68.0	67.0

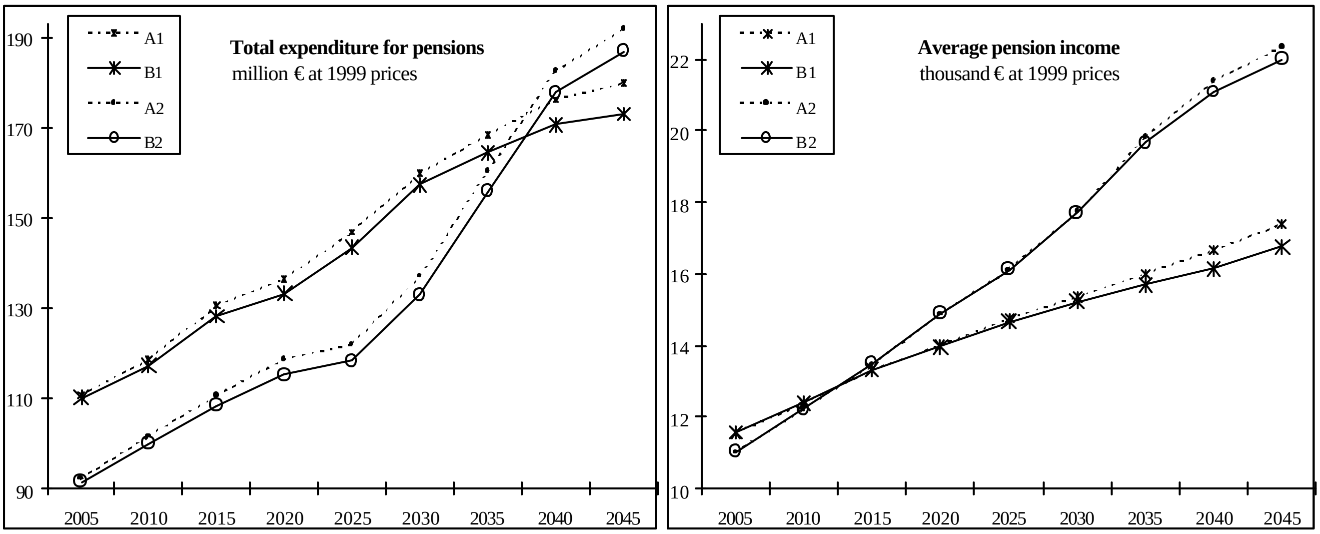
Tables 2 and 3, considering three year periods, report the estimated retirement age (mean values) with the two "maximising behaviours" (***1*** and ***2***), under *scenario* ***B*** and ***A*** respectively. Values are disaggregated per sex, area (North, Centre and South) and type of employment.

Considering the *basic scenario* ***B*** (current price indexation in Table 2), the male average retirement age increases less than females in the north (right from the start), while the opposite is true for the centre and the south. In the long run there is a strong tendency to postpone the exit from labour market, for both sexes and all geographic areas. The message is quite similar in the *alternative scenario* ***A*** (in Tables 3), both males and females tend to postpone retirement to enjoy the higher wage incomes for a longer period.

One can also examine the effect of indexation reform under the two "maximising behaviours" (***1*** and ***2***). In case ***1*** (maximisation of the expected pension benefits), while the male average retirement age keeps constant (slightly increasing only for dependent workers), females show a stronger tendency to postpone their exit from labour market. This evidence is common to all geographic areas. In case ***2*** (maximisation of the whole life benefits flow from labour and pension), both males and females tend to postpone retirement as far as possible (till the age limit) in order to enjoy the higher wage incomes for a longer period.

Let us continue our analysis it is useful to show the trend of total pension expenditure and the average individual pension treatment till 2045 under the three different scenarios, as in fig.4.

Fig. 4 Aggregate expenditure for pensions and average treatment (***A*** and ***B***)



In the basic scenario, according to our microsimulation model, aggregate pension expenditure increases for the whole period. Total expenditure is initially higher under pension benefit maximisation (***1***), but grows faster under hypothesis ***2***, because the initial savings, due to the postponement of retirement (and the shorter retirement period), are compensated by the increasing level of the average treatment.

We can easily derive the additional cost of indexing lowest pensions to per capita income. In practice, under ***A1*** the cost per year is quite negligible, ranging from 1% around 2020 to reach 4% in 2045. The cost is substantially lower (about one half) under ***A2***.

5. Inequalities and poverty among pensioners' families: a counterfactual experiment.

Let us now consider poverty and gross labour incomes concentration among families with at least one pensioner.

5.1. Distribution of gross incomes and poverty among families of pensioners

Dealing with concentration and poverty indexes[24] - varying between 0 (equality) and 1 (maximum inequality) - we assume the family as the unit of comparison, and an absolute poverty threshold anchored to per capita income, initially z_n = 7.64 thousand € with n= 2 components and the ISTAT equivalence scale.[25]

Table. 4 ISTAT equivalence scale

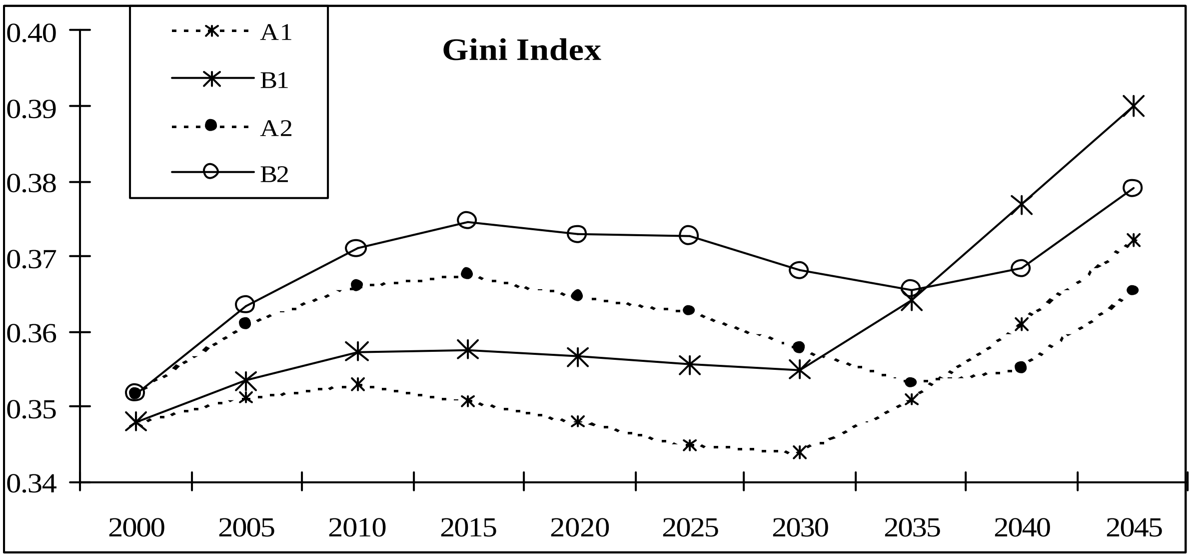
n	**1**	**2**	**3**	**4**	**5**	**6**	**7**
ISTAT eq.scale	0.67	1.00	1.42	1.80	2.27	2.61	2.95

The analysis considers all the families with at least a retired individual (generally the head of the family or the spouse) from 2000 till 2045 each five years.[26] The whole distribution of family incomes and its evolution can be analysed, as usual, using the Gini index.[27]

As shown in fig. 5, inequality increases over the whole period (from a level of 0.35 to 0.39, i.e. by 12%, under ***B1***, i.e. pension benefits' maximisation, but only. to 0.37, about 7%, under ***A1***, indexation to per capita income, represented by the dotted lines). It remains stable between 2010 and 2030 under ***B1,*** whereas in the same period indexation (under ***A1***) reverses the increasing trend of concentration. With the new regime (***B1***) inequality is increasing, especially after 2030, as integration to the minimum disappears. The gap between the two hypotheses (G_{B1}-G_{A1}) is increasing (with a difference that ranges from 0.6% to 5%). Between 15 and 18% of pensioners are entitled to per capita income indexation, but also other pensioners indirectly benefit from it, due to the pressure of higher indexation no prices (e.g. 100% instead of 75%).

[24] Cf. Atkinson (1970), (1971) and (1983), Champernowne Cowell (1998) and Mervyn (1983).
[25] These series of coefficients, increasing with the number of individuals, is aimed at eliminating the heterogeneity of incomes due to the different numerousness of family units.
[26] Between 2000 and 2020 the "defined benefit" system of calculus prevails and the mixed one begins. Subsequently the defined benefit comes to an end and the defined contribution takes over (even if pension treatments already liquidated with the previous system survive for a while). After 2035 only the "defined contribution" calculus survives (even if pensioners retired under the mixed and defined benefit treatment are still present).

Fig. 5 Gini Index for families of pensioners.



The deviations from the basic trends are given by an initially greater inequality with total benefit maximisation (for α = 0.75, i.e. ***A2*** and ***B2***) till 2025 and smaller inequality under the new regime after 2035 due to the slower increasing trend of concentration. In particular, the concentration level in 2015 is approximately the same as in 2045: i. e. inequality rises quickly till 2015 and is flat afterwards with a delay of about 5 years.

By indexing the lowest pensions to per capita income, the main policy aim was to reduce poverty. Considering the diffusion of poverty,[28] we notice initially a decreasing trend (from 0.17 to 0.16 in 2020 under ***A1***). However, this trend is reversed from 2020 onwards, as the diffusion of poverty increases till 0.19, a phenomenon amplified by the absence of indexation. In fact, under ***B1*** the final level of the index from its initial value 0.17 reaches a value of about 0.21 while indexation strongly slows down this increasing trend (+7%). The increasing trend of poverty diffusion is a little bit different under ***B2*** similar. In fact, it remains almost stable during all the period. However, under ***A2***, poverty diffusion shows a really strong decrease until 2025 and then stabilizes. .

The reduction in poverty diffusion is around 12-13% under the different scenarios with indexation ***A***. Case ***2*** represents an optimistic scenario, because pension decisions are postponed and higher pension levels are reached.

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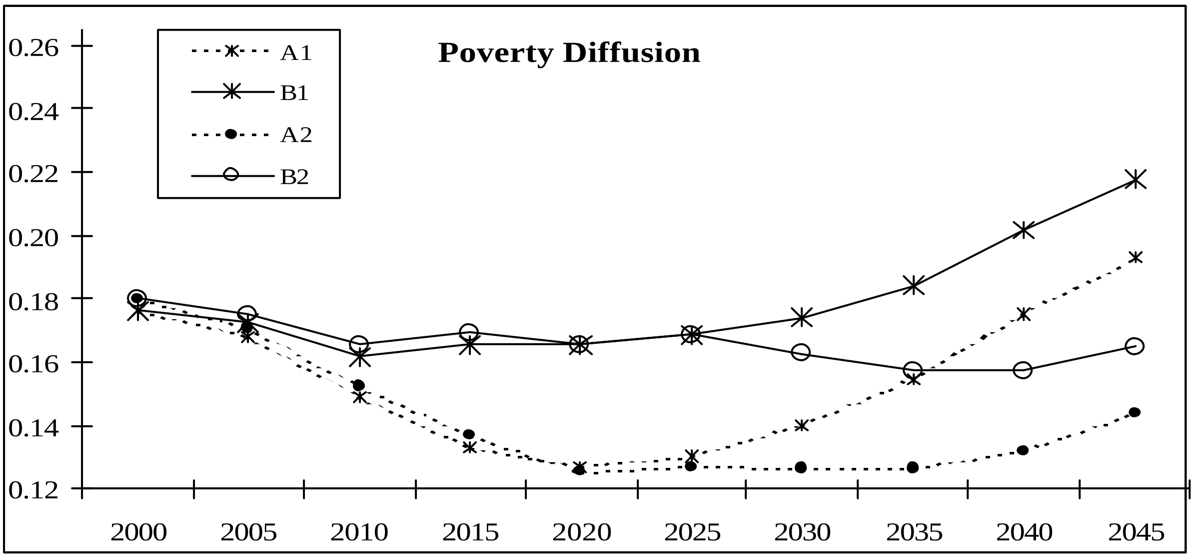
[27] The ***Gini index***: $G(\mathbf{y}) = \sum_{i=1}^{N-1}(p_i - q_i) / \sum_{i=1}^{N-1} p_i = \frac{1}{2n(n-1)m} \cdot \sum_{i=1}^{N}\sum_{j=1}^{N}\left|y_i - y_j\right|$ (with $1 \le i \le n$) can be expressed as a function of the cumulated fractions of population p_i and of the equivalent family incomes q_i and represents the average difference of all equivalent family incomes y_i.

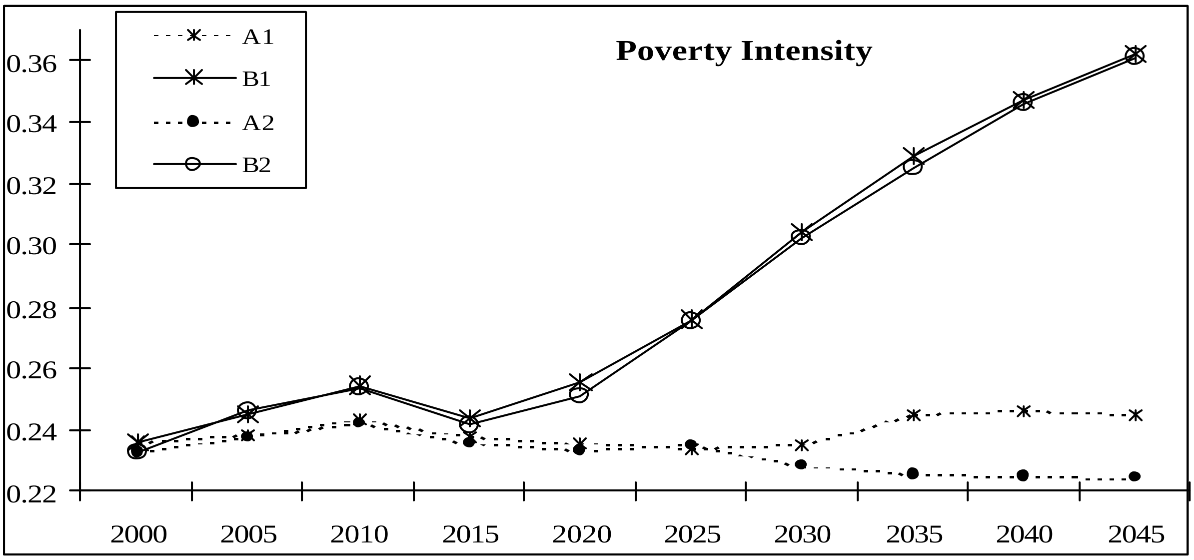
[28] Our ***poverty diffusion*** index is the usual ***head count ratio***, $H = q/n$ indicating the quota of population under the poverty threshold, i.e. with an equivalent family income y_i below z_n.

Fig. 6 Poverty diffusion among pensioners' families.



Moreover, indexing the lowest pensions to per capita income keeps poverty intensity constant[29], whereas poverty increases sharply from 0.24 to 0.36 (i.e. around 52%) under ***B1***. Levels are slightly lower, but the trend is the same under ***B2.***

Fig. 7 Poverty intensity among pensioners' families.



With indexation the trend starts diverging in 2020, but differently from case ***A1***, where it raises again after 2030, poverty intensity decreases under ***A2***. The Gini index among the poor displays very similar trends,[30] even if inequalities increase more slowly under ***B*** and decrease more promptly under ***A.*** Starting from 14%, the Gini index among the poor remains substantially stable till 2025,

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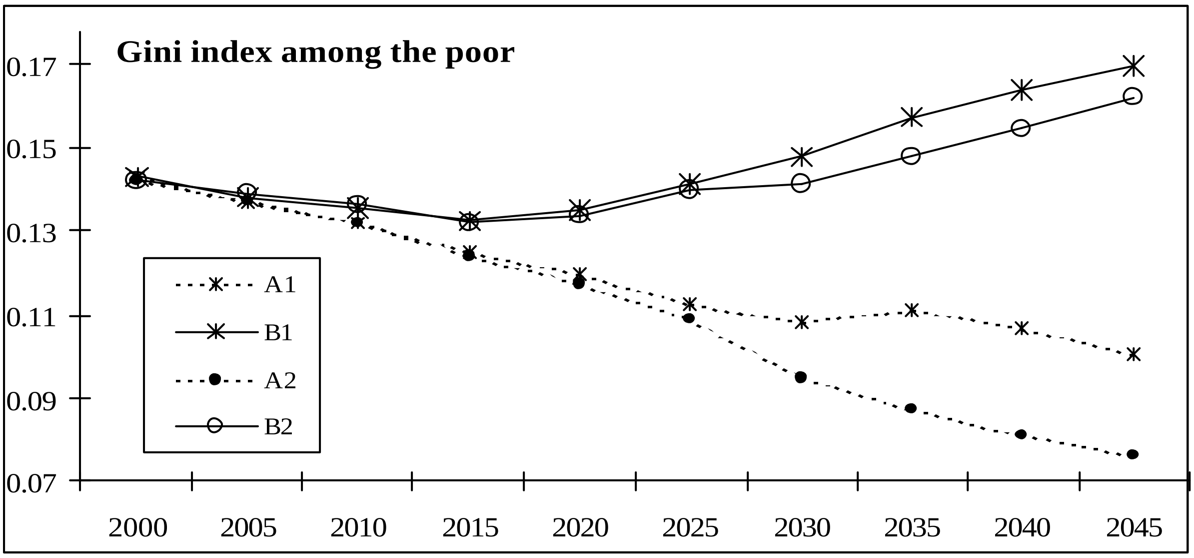
[29] To measure ***poverty intensity*** we use the ***income gap ratio***: $I = \left(\sum_{i=1}^{q} g_i / q \right) / z = \sum_{i=1}^{q} g_i / qz$ equal to the ratio between the average *poverty gap* and the poverty threshold (where the *poverty gap*, $g_i = z - y_i$, is the difference between the poverty threshold and the family income).

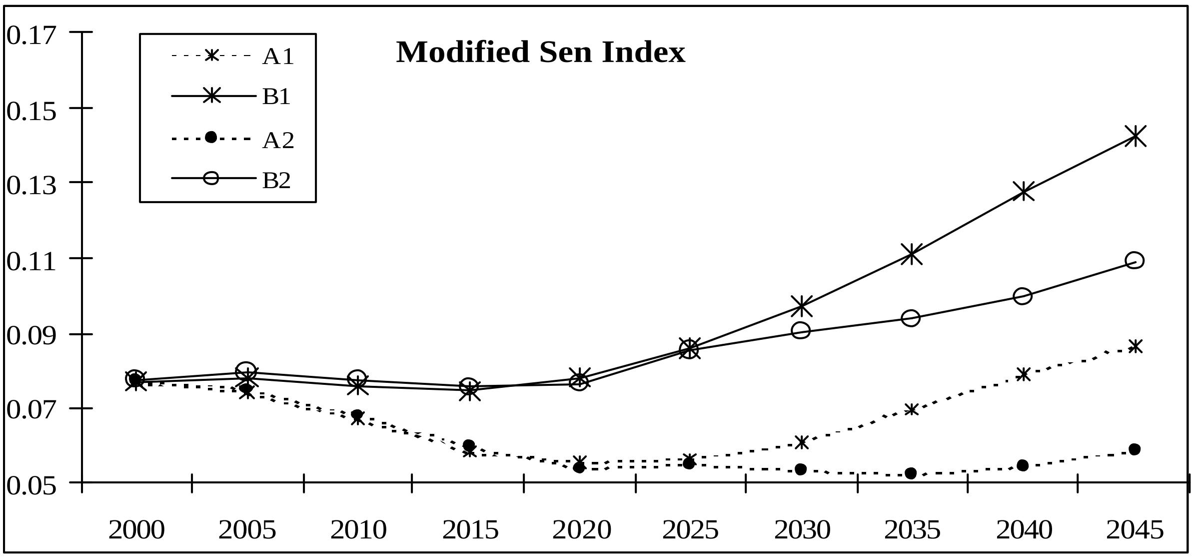
increasing afterwards till 17% without indexation (i.e. +18% in the whole period with ***B1***). Levels are slightly lower till 2025, but diverge afterwards under ***B2.*** Instead, the Gini index among the poor decreases sharply (around 30%) with indexation ***A1***, from 14% to around 10%. The decrease is is sharper under ***A2*** reaching a value of 0.07 (i.e. with a reduction of 46%)

Fig. 8 The Gini index among the poor for families of pensioners.



Finally, the modified Sen index (which summarises the poverty trend)[31] shows the evolution of poverty (replicating the intensity index with an enlarged oscillation band).

Fig. 9 The modified Sen index for families of pensioners.



The poverty trend under the two hypotheses diverges: (***a***) it decreases till 2020 and then increases, indexing the lowest pensions to per capita income (from 0.08 to 0.09, i.e. +7% with ***A1***), (***b***) it is almost constant in the first period and it then strongly increases in the absence of indexation

[30] We derive the ***Gini index for the poor*** G_p, considering only the poor (i.e. the fraction q of the whole population n whose equivalent family y_i income is below the poverty threshold z).
[31] The *Sen index* is calculated following Shorroks (1995): $S = (2\text{-}H)HI+H^2(1\text{-}I)G_p$. It is based on the ***head count ratio*** *H*, the ***income gap ratio*** *I* and the ***Gini index for the poor*** G_p.

(from 0.08 to 0.14, i.e. by 85% with ***B1***). Poverty issues are reduced if workers postpone retirement under ***B2*** (from 0.08 to 0.11, i.e. +42%) - as well as under ***A2*** (from 0.08 to 0.06, i.e. -24%).

Beyond the divergences due to differences in individual behaviours, we reach clear-cut conclusions that we may briefly summarise as follows: (***i***) inequality increases among the families of pensioners, due to the reforms;[32] (***ii***) the absence of indexation (of the lowest and social pensions) to per capita income speeds up the rising trend of inequality, hardening poverty problems by increasing its diffusion and intensity; (***iii***) by indexing welfare pensions to per capita income, we can limit inequality increases and mitigate poverty problems, decreasing concentration and reducing the diffusion and intensity of poverty.[33] Clearly, the desirability of this policy is enhanced once we consider the minor budgetary costs of per capita income indexation limited to welfare pensions and its negligible implications for the defined contribution system.

5.2 Monte Carlo outcomes and their significance.

In the previous section, the Monte Carlo approach has been proposed as a procedure for achieving variance reduction and for this purpose a small number of replications has been considered as appropriate.[34] Moreover, it has another important advantage, as through Monte Carlo replications it is possible to quantify the uncertainty of outcomes conditional to given assumptions (e.g. a rise in workforce education level or in inflation level) or policies (e.g. the adoption of an alternative indexation to per capita income for lowest pensions). This in turn allows us to measure the reliability of the simulation results and to improve the precision of the sensitivity analysis with respect to alternative policies or scenarios. The previously discussed results depend on the economic hypotheses and the working of the model (see sections 2 and 3). In particular, we may want to establish whether the effects of the two indexation options (***A*** and ***B***) are 'robust' and can be distinguished on the basis of the adopted indexes. In fact, the variability of the outcomes may be so high that our conclusions may lose significance, not allowing a clear discrimination between the effects of the two options. Such issues - dealt with by means of the Monte Carlo method - refer to the sensitivity of the results, compared to the relative weight of the stochastic component.[35] In what follows we analyse the statistic properties of our indexes (considering only scenario ***1***, since the

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[32] This result is consistent with what was expected with the introduction of the defined contribution system and the suppression of the minimum pensions, i.e. the reduced role for welfare aims side the defined contribution pension system.
[33] Hence, indexing welfare pensions to wages reduces the need for vertical redistribution taking place outside the defined contribution pension system.
[34] The issues of properly achieving variance reduction and evaluating the uncertainty of simulation outputs are of crucial importance, even if in the past they have been in part disregarded, also because of the prohibitive costs involved in replicating experiments, especially for long time periods and extended databases. Currently, according to Wolf (2001) "in survey-data item-imputation applications of the multiple-imputation technique, a small number (say 3-6 replications) has been viewed as sufficient" (cf. p.24).
[35] A further experiment can examine the consequences of the two options in alternative scenarios, modelling and simulating, for instance, also the values of the real rate of interest and of per capita growth as stochastic processes.

other is very similar), drawing information on their variability and building confidence intervals for their estimated values. From the indices' standard errors computed for the 20 Monte Carlo replications and reported in table 5, we infer: (***i***) the relative stability of the results and (***ii***) the absence of an increasing trend in stochastic components. Our Monte Carlo experiment follows the distributive consequences along reform paths and allows us to confirm the reliability of the results discussed in section 4.1. The standard errors reported in table 6 are very low and never higher than 3% of the mean value of the calculated indexes.

Table 5 Standard errors (values $\times 10^3$)

year	**Gini**		**Diffusion**		**Intensity**		**Gini of poor**		**Sen modified**	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
2000	2.43	2.43	3.09	3.09	3.63	3.63	2.62	2.62	1.57	1.57
2005	2.37	2.40	3.57	3.65	3.21	3.40	2.36	2.23	1.91	2.01
2010	2.84	2.86	3.50	3.70	4.46	4.07	2.94	2.64	1.76	1.82
2015	3.74	3.60	3.05	4.17	5.37	5.07	3.21	2.67	1.81	1.95
2020	4.42	4.54	2.62	3.70	5.25	3.56	3.71	2.90	1.74	2.07
2025	5.18	5.23	2.91	3.19	4.71	4.02	3.58	2.35	1.78	1.98
2030	5.13	4.36	3.30	3.54	3.77	4.59	2.93	3.26	1.82	2.01
2035	3.36	3.50	3.11	3.01	4.53	3.30	4.91	3.03	2.01	1.87
2040	3.05	3.91	2.39	3.24	5.16	4.56	4.76	3.12	2.10	2.41
2045	3.63	3.12	3.13	3.47	3.58	4.24	3.92	1.99	1.97	2.63
mean	***3.61***	***3.60***	***3.07***	***3.48***	***4.37***	***4.04***	***3.49***	***2.68***	***1.84***	***2.03***

These values, oscillating on average between 1% and 3%, confirm the results' reliability. The standard errors of the Gini index, oscillating around 1%, deserve special consideration because they refer to the whole family sample (with at least a retired person) and not only to the poor ones.

Table 6 Standard errors in percentage

year	**Gini**		**Diffusion**		**Intensity**		**Gini of poor**		**Sen modified**	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
2000	0.70	0.70	1.80	1.80	1.54	1.54	1.81	1.81	2.03	2.03
2005	0.67	0.68	2.18	2.18	1.35	1.39	1.70	1.59	2.57	2.57
2010	0.80	0.80	2.42	2.36	1.83	1.60	2.19	1.92	2.61	2.39
2015	1.07	1.01	2.38	2.60	2.26	2.08	2.53	1.99	3.09	2.61
2020	1.27	1.27	2.15	2.31	2.23	1.39	3.06	2.12	3.15	2.65
2025	1.50	1.47	2.33	1.95	2.01	1.46	3.12	1.64	3.15	2.31
2030	1.49	1.23	2.44	2.09	1.60	1.51	2.65	2.18	2.99	2.07
2035	0.96	0.96	2.08	1.68	1.85	1.00	4.34	1.90	2.89	1.69
2040	0.84	1.04	1.40	1.64	2.10	1.31	4.38	1.89	2.66	1.89
2045	0.98	0.80	1.67	1.63	1.46	1.17	3.82	1.16	2.28	1.84
mean	***1.03***	***1.00***	***2.09***	***2.02***	***1.82***	***1.45***	***2.96***	***1.82***	***2.74***	***2.21***

In order to be able to distinguish the two policies on the basis of the adopted indexes we must estimate the probability that the value of a single index for a given year with option ***A*** could be attributed to ***B*** (and vice versa). With normal distribution of the Monte Carlo replications it would be easy to determine the confidence intervals at the 99% or at 90% levels- simply by adding and subtracting the standard error ***n*** (= 2.32 or 1.28) times the mean values - and verify if they overlap. When that is not true, the probability of the event would be inferior to 1‰ or 1% (or to 5% and to 10% with ***n*** respectively equal to 0.8 and 0.2).

Since we don't know the form of the probability density functions of the indices, we cannot test the significance of the difference between the two means. However, we can use the following simple ***n***-sigma criterion. In particular we assume the two options as distinct when the intervals, calculated by adding and subtracting ***n*** times the standard error to the mean values, are separated.

In table 7 we found, for each single index, the maximal n values for which such intervals are still separated.[36] Assuming two thresholds (***n°*** = 1 and ***n****= 2), the indexes are ***sufficiently distinct*** (***n*** > ***n°*** from 2005 or 2010, or from 2015 with the Gini index) and ***clearly distinct*** with the more stringent criterion only from the second decade (***n*** > ***n****).

Table 7 Results of n for the alternative indices

year	Gini		Diffusion		Intensity		Gini of poor		Sen modified	
	1	**20**	**1**	**20**	**1**	**20**	**1**	**20**	**1**	**20**
2005	0.44	1.95	0.57	2.56	1.02	4.56	0.25	1.11	0.98	4.39
2010	0.79	3.53	1.72	7.71	1.32	5.89	0.58	2.58	2.46	10.99
2015	0.94	4.21	4.49	20.09	0.58	2.57	1.25	5.59	4.26	19.04
2020	0.98	4.37	6.12	27.37	2.30	10.28	2.36	10.55	6.00	26.85
2025	1.03	4.62	6.29	28.14	4.80	21.47	4.83	21.60	7.81	34.95
2030	1.14	5.11	4.96	22.18	8.23	36.82	6.39	28.56	9.46	42.33
2035	1.90	8.50	4.88	21.85	10.78	48.22	5.80	25.96	10.65	47.63
2040	2.28	10.18	4.80	21.45	10.44	46.71	7.23	32.31	10.82	48.38
2045	2.64	11.79	3.76	16.83	14.99	67.06	11.72	52.39	12.31	55.04
mean	***1.35***	***6.03***	***4.18***	***18.69***	***6.05***	***27.07***	***4.49***	***20.07***	***7.19***	***32.18***

As already discussed, in order to reduce the variance induced by the dynamic ageing, we use replicated Monte Carlo simulations. The benefits from using this approach are evident from the results reported in table 6, where for each index of interest there are two values of ***n*** , one associated to a single replication and the other to the mean value of 20 replications. From the results of the

[36] Given the mean value of an index I and its standard error σ, the n-sigma confidence interval is given by $I \pm \boldsymbol{n}\sigma$. Considering two alternative policies, we have an upper I_B and a lower I_A values and the related standard errors σ_B and σ_A, so that we can build the associated confidence intervals. We are interested to the maximum value of ***n*** for which the two confidence intervals are still separated, that is: $I_A + \boldsymbol{n}\,\sigma_A = I_B - \boldsymbol{n}\,\sigma_B$ The value of ***n*** can be easily calculated as $\boldsymbol{n} = (I_B - I_A)/(\sigma_A + \sigma_B)$.

table we can conclude that a clear distinction of the effects of the two policies (***A*** and ***B)*** systematically emerges only when using the variance reduction procedure.

Summing up, on the basis of our Monte Carlo experiment we can conclude that for policy purpose, a comparison between ***A*** and ***B*** results is: (***i***) only partially satisfactory with respect to a single outcome, for poverty indexes (not very satisfactory for Gini index), even if it is already unlikely to confuse the effects of the two options, (***ii***) quite good considering the mean values of just 20 replications, with a clean distinction of the effects of the two options.

5. Conclusive remarks

At the beginning of the ‘90s, the panel of the National Academy of Science (US) on microsimulation models highlighted the crucial importance of the validation of such models, formulating (see Cohen et al. 1991) explicit research recommendations on validation methods and on the criteria to evaluate the uncertainty of simulation outputs. Nevertheless, as observed by Wolfson (2000), in the last ten years such recommendations have been neglected, maybe also because of the high costs involved in validation experiments. Accordingly in this paper, having validated the demographic and the socio-economic dynamics for geographical area, in the short and long run, we calibrate the model as to reproduce the dynamics shown in the official data supplied by the *Casellario INPS* and ISTAT. By validating microdata and sharpening the model specification, we obtained a reliable tool for simulating, at a disaggregated level, the evolution of the distribution of incomes and pensions and for highlighting the redistributive consequences of pension reforms using the traditional concentration and poverty indexes.[37] In particular, the adopted reforms increase income concentration and poverty intensity among pensioners. Furthermore, the Monte Carlo analysis confirmed the reliability of our results and in particular that the increase of inequality and poverty is largely due to the current indexation system.

We plan to undertake future research, incorporating and corroborating behavioural functions – such as the ones which endogenise retirement choice (the base of the option value) - to sharpen the model’s forecasting abilities with respect to policy changes. A more accurate specification of the Italian reality would also require the introduction of a “migration” module, but, as far as we know, the data that would allow us to model the phenomenon accurately are not yet available.

[37] Our dynamic microsimulation results encourage us to face the future challenges to incorporate and to verify the heuristic value of individual “reaction functions” (e.g. in the family, in the processes of creation and distribution of the wealth and in the labour market). This modelling strategy seems to be supported by recent research in the field. As observed by Harding (2000) transition probabilities are being replaced by hazard models.

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