

LABORsim: An Agent-Based Microsimulation of Labour Supply – An application to Italy

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Abstract. Most Oecd Countries are experiencing a rapid population ageing. Italy adds to this picture a very low labour market participation of the elders, so that most projections of the impact of ageing on the labour market are rather pessimistic. However, there are other long run modifications currently underway that will presumably have a sizeable impact on the labour market, above all changes in the retirement legislation, in educational choices and participation behaviour. In this paper we present *LABORsim*, an agent based microsimulation model of labour supply, which offers new insights on the likely evolution of the labour force in the next decades in Italy. *LABORsim* integrates the current demographic projections with simulation modules modelling retirement rules, retirement behaviours, migrations, education and participation choices, plus a console to implement various policy scenario analyses. When all these factors are taken into account, projections for next decades are not that pessimistic. In most scenarios, the overall participation rate is expected to increase steadily for the next two decades, while shortages in the labour force supply and an unfavourable dynamics for the economic dependency rate are expected to show up only after 2020, when the baby boom generations will arrive at their retirement ages. This is not enough, however, to allow Italy to meet the EU Stockholm and Lisbon targets for male and female employment rates for many decades to come. The sharp increase in the participation rates for the elderly (aged 55–64), mainly driven by the recent changes in the retirement eligibility criteria, will make it possible to meet the Stockholm target of 50% employment rate in this age group by 2015, i.e. with only 5 years of delay.

Key words: microsimulation, participation, employment, retirement, education, policy evaluation

JEL Classifications: E24, H3, H55, I2, J1, J2, J6, N4, O52, C63

1. Introduction

In the next decades most Oecd Countries will experience a rapid population ageing, because of the increase in life expectancy occurred in the second half of last century, and to a concurrent sharp decrease in fertility rates. This will have strong consequences both on the sustainability of social security systems – financed in most cases through a pay-as-you-go mechanism – and on the labour market, with possible labour supply shortages. Within this general picture Italy is no exception, having one of the oldest populations among Oecd countries. What is worse, Italy also has one of the lowest participation rates to the labour market, particularly for

women and the elderly. Ageing and low participation, taken together, justify the very pessimistic projections that are currently made about the evolution of economic dependency ratios in the next decades.

Most projections, however, are based on a very simplistic extrapolation of cross-sectional participation rates as measured today. Oecd [2004], for instance, applies the participation rates measured in 2000 to the demographic projections, and estimates a dramatic reduction in the consistency of the labour force – dropping from 24 to 17 millions by 2050 – and an increase in the economic dependency ratio that is the second worst in all Oecd countries forecasts.

This kind of projections are unsatisfactory under many respects. First, participation choices should be viewed in a life cycle perspective. To extrapolate cross-sectional data observed today can produce paradoxical results for the pseudo-individuals belonging to the new cohorts simulated: they would participate little when they are young – since young people today generally go to school – and they will participate little when they get old – since today's elders have generally started working very early, and are willing to retire.

Second, existing low employment rates for people aged 50 and over, in Italy, are probably below their long run equilibrium. As regards women, many of those who are not participating to the labour market, actually never worked during their lives – again, in a life cycle perspective, they once and for all decided to “offer” their labour services within the family. In the data, however, a trend towards a higher participation is clearly detectable for new cohorts. Moreover, both men and women during the last two decades took advantage of the very generous early-retirement schemes available up to the Eighties. Such a “filtering out” of the labour force has a negative impact on the participation rates observable today for the elders, but will vanish in the future due to the major reforms of the pension system delivered in the last twelve years.

In this paper we present an agent based microsimulation model of labour supply, which offers new insights on the likely evolution of the labour force in the next decades in Italy. The main focuses of the model are on demography, migration, retirement rules, retirement behaviours, education and participation choices. All behavioural rules implemented are cohort specific, and have been estimated on Italian Central Statistical Office (Istat) and Eurostat data over the years 1993–2003. The eligibility criteria implemented for the pension system carefully mimic the actual three-layer retirement rules in force in Italy. When all these factors are taken into account, projections for next decades are not that pessimistic. Even in the less favourable scenario – assuming that the positive trend in higher participation in education and in higher labour force participation for women will dry out – the overall participation rate is expected to increase steadily for the next two decades.

The paper is structured as follows. Section 2 deals with some background issues on participation. Section 3 presents the model. Section 4 discusses the simulation results in the standard scenario. Section 5 concludes.

2. Some Background Issues on Participation in Italy

The process of population ageing currently underway in Italy is more pronounced than in most other Oecd countries. In the last decades the total fertility rate has declined steeply, going below the replacement rate of 2.1 as soon as at the beginning of the 80s, reaching 1.24 in 2000¹. At the same time, life expectancy is among the highest among Oecd countries. Even though a slight recovery in fertility rates is expected for next years, the transition process to the new demographic regime will have a deep impact on the age structure. In the next two decades, the baby boom generations of the 60s and early 70s will enter in their retirement ages, and will be replaced by new labour force cohorts roughly half in size². By 2050, more than one in three Italians will be over the age of 65.

An additional source of concern about Italy is the fact that the participation rates of the elders are peculiarly low. Figure 1 compares participation rates for people aged 55–64 in a selection of EU countries. Italy is 14th out of 16, and contrary to most countries has experienced a decrease in the participation rates during the Nineties.

Putting together ageing and low participation of the elders it is straightforward to build future scenarios in which the economic dependency rate – the ratio of people out of the labour force on those who participate – will become hardly sustainable. Oecd launched in 2001 a thematic review on this issue, and built projections about the future evolution of old age dependency rates in Oecd member countries (see for instance Oecd [2004]). They applied the participation rates measured in 2000 by gender and five-years age groups to the best available demographic projections, and compared the evolution of a demographic and an economic old age dependency rate (see Figure 1).

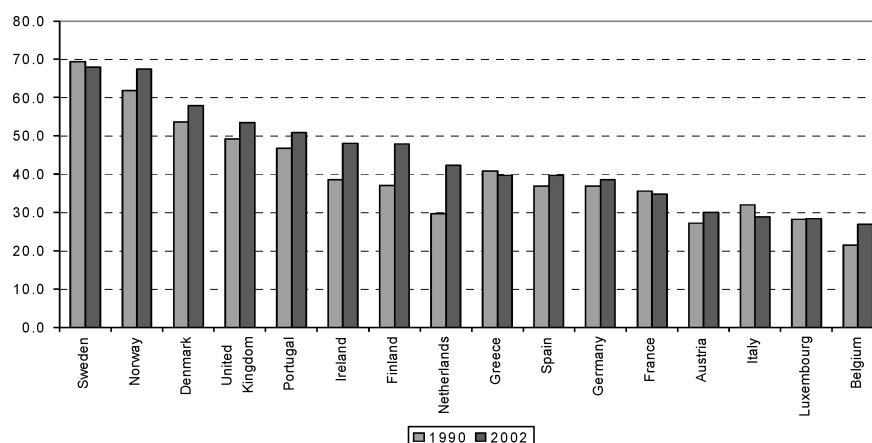
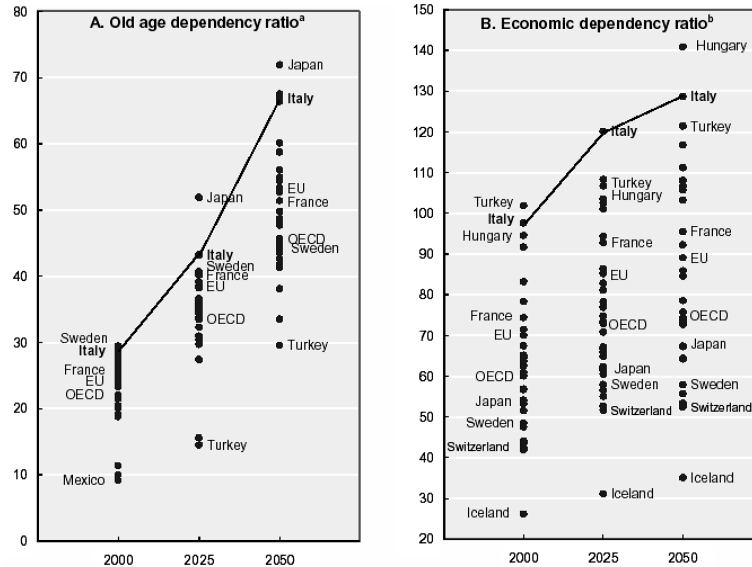


Figure 1. Participation rates in 1990 and 2002, people aged 55–64, various EU countries. Source: Eurostat LFS 2002.



Panel A, left: People aged 65 and over to people in the age bracket 20-64.

Panel B, right: People out of the labour force to those in the labour force, excluding under 20.

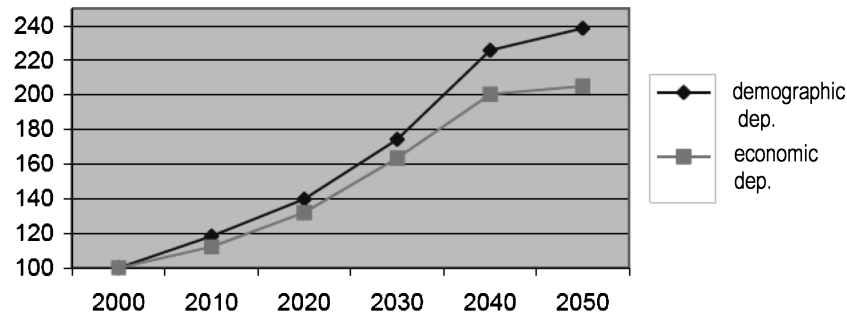
Source: Oecd [2004].

Figure 1. Old age demographic and economic dependency rates, Oecd countries.

The most revealing comparison is about Italy and Japan. Both countries are facing the most rapid ageing in the population (left panel). In Japan, however, workers stay longer in the labour market, so that the share of those who are not active remains below the Oecd average (right panel). On top of ageing, Italy adds one of the lowest participation rates for people aged 50 and over, so that the economic dependency rate is expected to reach a record level of almost 130% by 2050.

These “gloom” estimates do not stand alone. Figure 2 shows projections by the Italian Welfare Ministry for the European Commission: the economic dependency rate is expected to follow closely the trend of the demographic dependency rate.

How reliable are these projections? While the future evolution of the population age structure reflects a secular change that can hardly be questioned, the use of cross-sectional participation rates by age and gender is unsatisfactory under many respects. The general argument is that participation choices should be viewed in a life cycle perspective, since the choices made by young people as regards education and the entry in the labour market have an impact on all their subsequent working career. The use of cross-sectional evidence mixes behaviours of young individuals with the behaviour of their contemporary elders, that as a rule are not coherent each other. For what concern the Italian case, this general argument goes together with the following points.



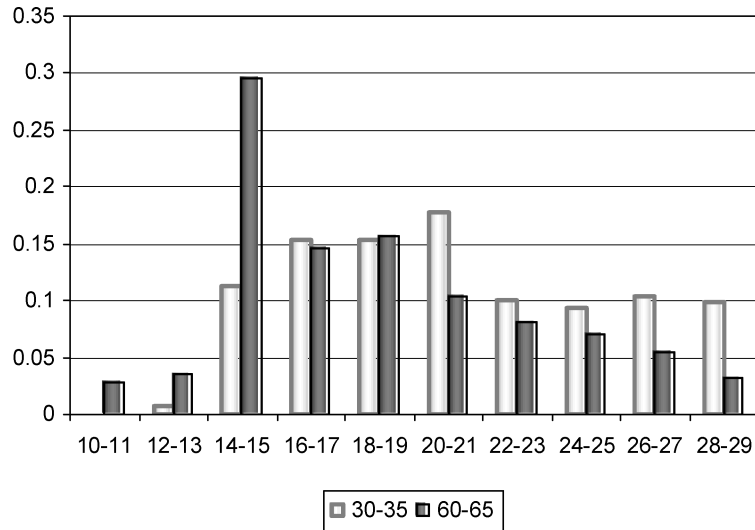
Source: EC [2003]. Year 2000 = 100

Figure 2. Old age demographic and economic dependency rates, Italy.

First, the legislation has changed. Actual low participation of the elders in Italy (both males and females) has to be linked with a retirement legislation that is no more in force. The old system was particularly biased towards early withdrawing from the labour market, both because it allowed seniority pensions, and because of the defined benefit rule used for the computation of pension entitlements, that most of the time provided a financial incentive to retire as soon as one became eligible. The retirement legislation in force today has higher age requirements, and – because of the introduction of a defined contribution rule – does not embed incentives towards an as-soon-as-possible retirement behaviour.

Second, the working careers of individuals has shifted forward in the life cycle. Actual low participation of the elders in Italy reflects working careers that on average started well before what can be observed for new cohorts today. In Figure 3 we considered two cohorts: those that in 2001 were aged 60–65, and those that will be in the same age bracket in thirty years. Plotting the declared age at which they began their working life, as comes out from the European Community Household Panel (Echp), the shift toward later entries in the labour market is clear. This means that individuals of actual cohorts will arrive to the retirement ages with shorter seniority in comparison with those who retired during the last decades³, and this will contribute to postpone their retirement because seniority requirements (aside age requirements) in the eligibility criteria will be met later.

Strictly connected with the last point is the fact that newer generations have on average, in Italy, a higher level of education (see section on education below). Actually, later entries in the labour market can be explained by and large by higher participation to education. This will presumably have an additional, direct impact on the participation to the labour market of future elders, both because higher education has a positive effect on the employability of workers – that is, on their *capability* of finding and retaining a job – and on their willingness to do it, since high skill jobs usually bear a lower disutility of work.



Source: Our elaborations on Eurostat data, ECHP, wave 6.

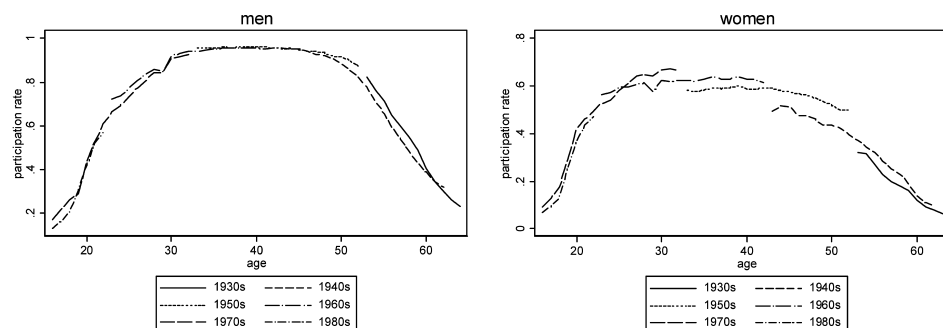
Note: Ages are grouped in 2-years classes in order to avoid heaping at even ages.

Figure 3. Reported age at first job/business, two cohorts, 2001.

Starting later to work may also affect retirement choices via wages, and consequently pensions. On the one side, shorter contribution spells mean lower pensions, given the same wage profile. Individuals will then have the incentive or the need to withdraw later from the labor market, in order to achieve the same standard of living when retired. On the other side, better educated people should have higher wage profiles. They could then be willing to retire earlier. However, (i) as the supply of skilled labor force increase, the returns to education may go down, and (ii) better educated people may revise upwards their standard of living. Moreover, the Italian pension system pays little attention to the amount of contributions, in determining eligibility.⁴ Age and seniority are much more important. It is thus quite implausible that this consideration could reverse the causal link between higher education and later exit from the labour market.

Finally, actual low participation of elder women has to be linked with life cycle choices made many decades ago, when a large share of Italian women decided once and for all to “offer” their labour services within the family instead of within the labour market. A simple analysis of unconditional participation profiles of women by cohort reveal a trend towards a lower share of those who work within the family (see Figure 4). This is coherent with a decreasing average household sizes that goes together with decreasing fertility rates, and with a long run reduction in the gender differences as regards the attitudes towards the labour market.

To sum up, whilst the demographic trends will point in the future to scenarios where the elders will be a very large share of the population, this will not necessarily



Source: Our elaborations on Istat data, RTFL, 1993-2003.

Figure 4. Participation profiles by cohorts, males (left panel) and females (right panel)

turn into a high economic dependency upon people in the labour force. There have been in the last decades many changes – in the retirement legislation, in educational choices, in the working careers, in the participation behaviours of women – that will have a long run impact on future participation to the labour force, and will probably countervail the demographic ageing of the population.

These issues point to the importance of a micro-foundation of the projections of participation rates, in order to take dynamically into account all the socio-demographic and economic trends at work, and correctly simulate the effects of the changes in the legislation. Applying cross-sectional evidence to demographic projections, or even assuming convergence of gender and age-group cross-sectional participation rates to some Oecd average, as also done by Oecd (2004), looks no more than providing scenario analysis, and says very little about the likelihood of each scenario.

3. A Micro-Foundation of Participation Rates

A natural way to overcome the problems outlined above is to use a dynamic microsimulation. Microsimulation modelling has been an active field of research since the seminal work of Orcutt in the 1950s (Orcutt, 1957). Although for many years it has been confined to a small niche of practitioners, it is now being revitalized by a new wave of interest, partly due to the rise in computer power that has made it widely accessible.⁵ Microsimulation modelling involves the generation of data on individual units, rather than the analysis of pre-determined, “representative” groups of cells, or of the aggregate system as a whole (i.e. general equilibrium models), and are particularly suited for policy evaluation and scenario analysis. When microsimulations do not consider behavioural changes to a change in the environment (e.g. policy), they are defined as ‘static’ (e.g. tax-benefit models). Dynamic microsimulations on the other hand incorporate behavioural responses.⁶

In general, microsimulations consider many dimensions of socio-economic systems. However, we are interested here mainly in (i) education, (ii) participation, (iii) retirement, aside the effects of demographic change. Among the dynamic microsimulation models surveyed in Zaidi and Rake, (2002) DYNASIM2 (USA, (Wertheimer, 1986)), CORSIM (USA, (Favreault and Caldwell, 1999)), MOSART (Norway, (Fredriksen, 1998)), DESTINIE (France, (Bonnet and Mahieu, 2000)) and SAGE (UK, (SAGE, 2001–2004)) explicitly consider all the three issues above; DYNAMOD-2 (Australia, (King et al., 1999)) considers (i) and (ii) alone; PENSIM (UK, (Curry, 1996)) only (ii) and (iii).

A few microsimulation models are also available for Italy. Among those who have a similar approach to ours, the Bank of Italy's DYNAMITE model (Ando et al., 2004) focuses on household formation and income dynamics, while MIND (Vagliasindi et al., 2004) and DYNASIM⁷ (Mazzaferro and Marciano, 2005) focus on the distributional impact of social security provisions.

LABORsim is a dynamic aging, discrete-event, probabilistic agent-based microsimulation model of labour supply. Setting the focus of *LABORsim* we gave precedence to the phenomena pointed out in previous section, namely to the retirement legislation reforms, the process of seniority accumulation, the changes in the educational choices of young people and the participation behaviours of women. All these factors have been integrated with the best demographic projections available, with an additional focus on migrations dynamics. In the balance between the desire to include all relevant dimensions and endogenous feedbacks of the phenomenon under investigation, and the need to keep the model manageable and easy-to-use for policy and scenario evaluations, we pushed towards the latter. Thus there are things that remain out of the model, at this stage.

In particular, monetary variables (wages and pensions) are not considered, although future extensions of the model could easily include them. Also, family structure is not considered. However, in estimating an upward trend in the participation rates of women, we implicitly take the evolution of family structure into account. Moreover, it should be remembered that, as most microsimulations, *LABORsim* is not a general equilibrium model. In *LABORsim* the demand for labour is not considered but for the analysis of unemployment differentials, while the overall unemployment rate is a scenario parameter.

In what follows, we briefly discuss the technical implementation, the data used, and then proceed describing the overall structure of the model, and the modules it is composed of.

3.1. THE TECHNICAL IMPLEMENTATION

From a technical point of view, the main novelty of *LABORsim* is the choice of an agent-based object-oriented framework. Object-oriented programming allows to define almost stand-alone software objects to represent individuals, institutions,

etc., each with own variables and methods. This increases the modularity of the microsimulation, and the transparency of the code. Agent-based models share a common architecture, and often an implementation based on specifically-built software platforms.⁸ The use of such platforms brings four main advantages: (i) standardization (many technical issues are solved using the software routines); (ii) efficiency (these routines have been designed by professional programmers, rather than by economists that had to learn programming later on in their careers); (iii) brevity (there is less code to write and the code is easier to interpret; hence easier to debug and exchange); (iv) availability of external tools and resources (like graphical interfaces, statistical libraries, etc.).

LABORsim is written in Java, an object-oriented programming language, using JAS (Java Agent-based Simulation Library)⁹, an open source platform for discrete-event agent-based modelling. JAS provides a number of libraries for the management of time, the collection of on-line statistics, on-line graphical widgets and database storage capabilities. Adopting Swarm original philosophy (Luna and Stefansson, 2000), in addition to providing objects and utilities that make code writing easier and faster, JAS provides templates for the construction of models. The description formalism and the specific semantic used follow indeed the same Swarm protocol, characterized by a clear-cut distinction between the model (a class that provides the environment and executes the simulation) and the observer (a set of routines to look into the model and collect statistics, which are then displayed through a graphical user interface).

Two databases are used to support the simulation, accessed through the standard JDBC-ODBC driver. One contains all technical data, i.e. the initial population, the demographic projections and the estimated parameters, which are not supposed to be modified by the user unless when an update is required. The other one (the scenario database) contains the console to manage all scenario parameters. The console is organized in different forms:

- a *demography* form, to choose which demographic projections are to be used, both for natives and for immigrants;
- a *participation-to-education* form, to set the cohort after which the estimated trend towards higher participation to the schooling system is supposed to halt;
- a *probability-of-graduation* form, where the estimated probabilities for increasing one's own educational attainment can be varied, for instance in order to mimic the effects of a reform of the schooling system;
- a *participation-to-labor market* form, to manage the expected trend towards higher participation rates;
- an *unemployment differentials* form, for changing the estimated coefficients for the unemployment differentials among different groups of the population; this again can be used to mimic the effects of specific policies (e.g. aimed at reducing the negative effect on employability of previous unemployment spells);

- three forms for modifying the parameters governing *pension eligibility* requirements, one for each scheme (defined benefit, defined contribution and mixed scheme); the default values being those currently considered by the legislation;
- three forms for setting the values of the parameters affecting the *probability of retirement*, given eligibility (one for each scheme).

The output of the simulation consists of online graphics of the most relevant statistics disaggregated by gender and area. Moreover, whenever specified by the user all personal variables of all artificial individuals are recorded in each simulated year, and stored in a panel data structure in the same scenario database. *LABORsim* also supports a multi-run feature, to allow automatic multiple simulation runs with the same values of the parameters. The results of all simulation runs are stored with a specific run id in the same scenario database.

On a standard Mobile Intel Pentium 4 laptop with 1.8 GHz CPU and 360 MB RAM, simulating an initial population of 50,000 individuals up to 2050 takes 3.5 minutes with the online statistics only, and about 1 hour if the panel data creation option is specified (the resulting panel data has more than 2 million records).

3.2. THE DATA

All behavioral parameters have been estimated on waves 1993–2003 of the *Rilevazione Trimestrale delle Forze Lavoro* (RTFL), the Quarterly Labour Force Survey delivered by the Italian Central Statistical Office (Istat).

In particular, the initial population has been derived from the April 2003 RTFL wave, resampling it in order to have a database of about 50,000 individuals all with constant inflating factor. From this, at each run of the simulation a sample of variable size is extracted¹⁰.

Unfortunately, RTFL data do not include information on seniority, which is relevant for pension eligibility. We recovered this variable with a two step process. First, we imputed the age when individuals started their work career by means of a standard regression imputation, using the European Community Household Panel as a donor (Echp, various waves). The variables common to the two datasets on which age at first job was estimated are age, education, area of residence, sector of activity, marital status and family dimension¹¹. The difference between age and age at first job gives a sort of potential seniority.

In a second step, seniority was finally imputed assuming (i) an uninterrupted participation spell for those still at work, and (ii) a continuing spell of participation between start of first job and end of last job. These spells have then been discounted by average yearly unemployment rates, conditional on individual characteristics. It should be noted that (i) implies some degree of underestimation, while (ii) leads to some degree of overestimation, since conditioning on being (not) employed now the likelihood of past unemployment is probably (higher) lower than the average, unconditioned unemployment rate. The two errors thus (partly) elicit each other. Moreover, this procedure allows to recover a sufficient amount of variability

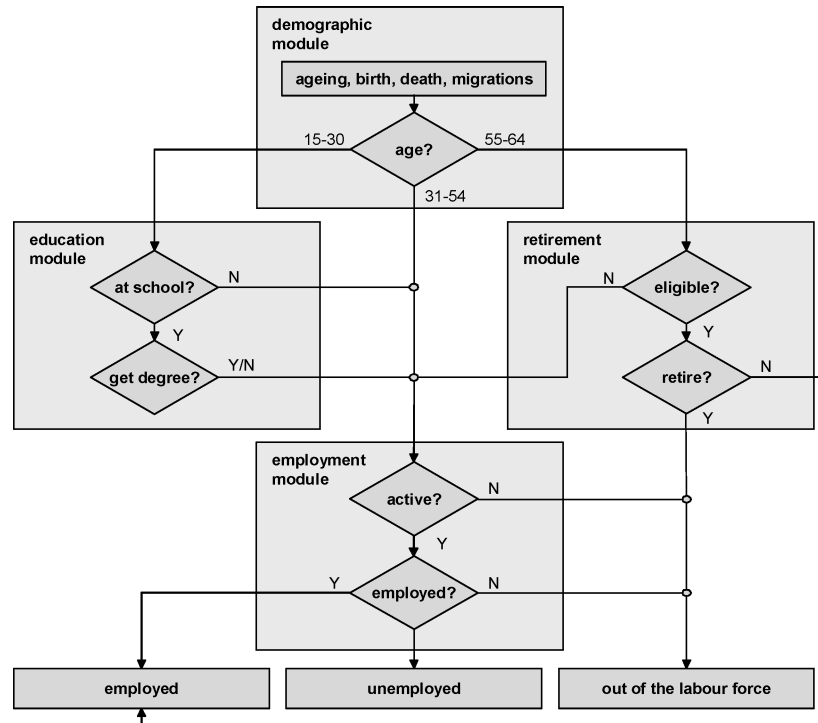


Figure 5. The four modules of the simulation.

in individual seniority, including a fair amount of uninterrupted (full seniority) careers.

3.3. THE MODEL STRUCTURE

The simulation is made up of four modules: Demography, Education, Retirement and Employment (see Figure 5).¹² The *Demography module* takes care of population ageing, determining the number and characteristics of newborn individuals and of individuals that leave the population, either because they migrate out of Italy or because they die. As regards individuals aged 14 and below and those aged 65 and over no other steps are needed, since they are out of the labour force.

For those who are in the labour force age, we distinguish between three moments in their lifetime: youth (15–30 years), prime age (31–54 years) and old age (55–64). Young individuals decide whether to attend formal education, and – given enrolment – the event whether they get a degree is determined. This is accomplished by the *Education module*. The next module is concerned only with the elderly, and regards retirement choices (*Retirement module*). First, eligibility is checked. Eligible individuals then decide whether they want to retire or not.

Young people after 15, prime age individuals and elderly people who are not eligible enter the *Employment module* (thus, we explicitly model the case of working

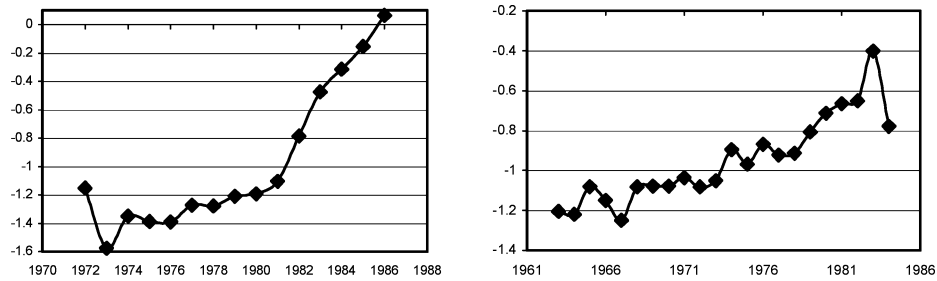
students). The first decision is whether to participate to the labour market. Conditional on participation, then, their employment status is determined. As regards eligible people who do not retire, we assume that they are active and employed.

3.4. THE DEMOGRAPHIC MODULE

The demographic evolution of the simulated population is aligned with Istat projections by sex, age and geographic location. However, official forecasts only consider three scenarios – namely a low, central and high scenario, where all relevant variables (fertility and mortality rates, plus migrations) are changed. In order to allow for a richer scenario analysis, we extrapolated from the official projections the separate evolution of natives and immigrants under the three hypotheses. We can thus run our experiments under nine different demographic scenarios. Our spatial analysis focuses on three macro-regions: North, Centre and South of Italy. New cohorts aged 0 identify newborn individuals. The consistency of the simulated population of natives in any sex, age and geographic class is aligned with the projections of the selected scenario by randomly removing or cloning individuals. This is equivalent to the assumption that people who move are *ex-ante* similar to those who do not move but *ex-post* similar to the people in the destination area¹³, and allows neglecting the problem of internal migration. Since official statistics only provide projections on the flow of migrants from abroad, the same approach cannot be used for immigration from abroad. The flow of migrants is then evolved according to the mortality rates used by Istat. Immigrants are supposed to have the same average level of education as in the corresponding sex, age and geographical cell, and – given the level of education – to have the same probability to still attend school. We suppose that all immigrants older than 15 who are not students enter in the simulation as employed, and with a seniority of zero. Of course these assumptions reduce the heterogeneity of their career paths. However, immigration in Italy is not as massive a phenomenon as in other Oecd countries: Istat central demographic projections assume a constant flow of 156,000 new immigrants each year, joining a population of about 57 millions in the base year. Hence, the reduction in overall heterogeneity turns out to be negligible.

3.5. THE EDUCATION MODULE

This module is formed by two sub-modules, one for determining the status of student and the other for determining whether the individual gets his/her degree. We consider three level of education: basic, diploma and university degree. The first level is compulsory, and we model it as driven only by age. As Figure 6 shows, we detect an increasing trend towards higher participation rates, both for high school and for university. We model this trend linearly, and estimate the probability of being a student conditional on sex, age, geographical location, lagged status as student and cohort (Table I and II). The reference group is composed by non-student males living in the South.



Source: Our elaboration on Istat data, RTFL, 1993-2003

Figure 6. Cohort-effect in schooling participation rates, high school (left panel) and university (right panel). Coefficients of year-of-birth dummies in a logit regression reported.

Table I. Logit estimates for high school participation. Data: Istat, Rtfli, 1993–2003.

Parameter	Estimate	Error	Chi-Square	Pr > ChiSq
Number of obs.	106,022			
woman	0.2950	0.0297	98.9079	<.0001
north	-0.1575	0.0323	23.7897	<.0001
center	0.2466	0.0428	33.1466	<.0001
lagged student	5.7608	0.0330	30411.2442	<.0001
age	3.1394	0.2329	181.6358	<.0001
age squared	-0.0919	0.00637	207.9202	<.0001
cohort	0.1137	0.00480	562.3682	<.0001
._const	-254.6	9.8287	671.1519	<.0001

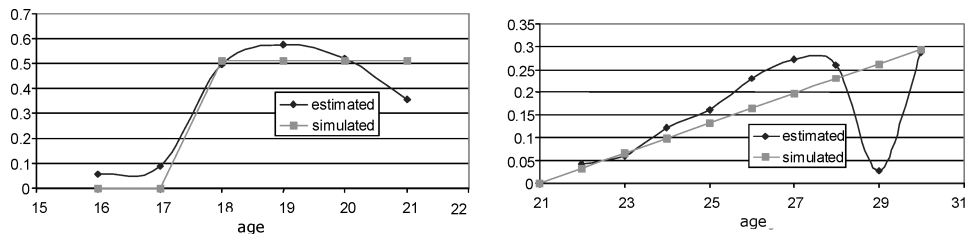
In the scenarios console we allow the user to choose a cohort after which the linear trend towards increasing participation comes to a stop.

The probability of graduating is also estimated on Rtfli data, in the period 1998–2003, conditioning only on age. Figure 7 shows the estimated probability and the approximation implemented in Labor Sim, which maintains the overall probability of getting the degree, over the age bracket considered, equal to the empirical one. We assume that everybody leave high school before 22, and that no one attends university after 30, an assumption not too far from what we observe in the data (only 1.2% of people aged 22 are still enrolled at high school, while only 2.9% of people aged 31 are still attending university; both figures decrease for later ages).

Thus, educational paths are completely modeled. Of any individual below 30 we know whether s/he is still in education, and what degree s/he has. We may have students who work, students that drop out before completing the degree, students that had dropped out and return to education.

Table II. Logit estimates for university participation. Data: Istat, RtfI, 1993–2003.

Parameter	Estimate	Error	Chi-Square	Pr > ChiSq
Number of obs.	167,564			
woman	0.2152	0.0198	118.4854	<.0001
north	-0.4721	0.0223	448.2335	<.0001
center	-0.1580	0.0272	33.7918	<.0001
lagged student	5.6032	0.0252	49629.8288	<.0001
age	1.8367	0.0475	1495.9943	<.0001
age squared	-0.0373	0.000995	1409.3989	<.0001
cohort	0.0336	0.00317	112.5205	<.0001
._const	-92.0507	6.3470	210.3386	<.0001



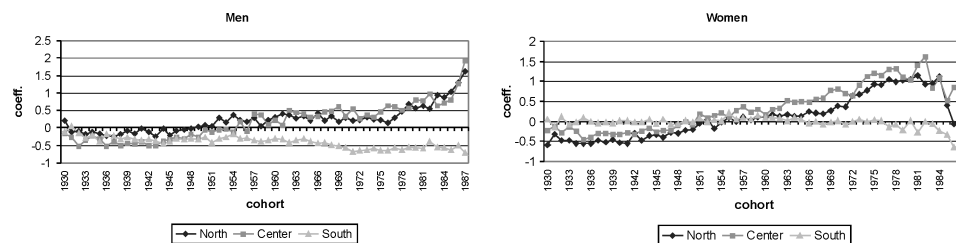
Source: Our elaboration on Istat data, RTFL, 1993-2003

Figure 7. Probability of graduating, high school (left panel) and university (right panel).

3.6. THE RETIREMENT MODULE

This module is based on the distinction between eligibility and retirement choice. Given the Italian legislation, time, age and simulated seniority, eligibility is deterministically determined. In short, the legislation identifies three different schemes, according to seniority in 1995: the old defined benefit scheme for workers who had more than 18 years of seniority in 1995, the new defined contributions for workers who started working after 1995, and a mixed scheme for workers who had less than 18 years of seniority in 1995. The detailed eligibility criteria up to the Maroni reform of August 2004 for these three schemes have been implemented.¹⁴

On the contrary, the choice of postponing retirement can be affected by a number of issues. In the past, with an extremely generous welfare scheme for pension holders, many workers decided to retire as early as possible. This has in particular been true during the reform period, as workers were afraid to postpone retirement fearing that the rules could change against them. With the purpose of improving the balance of the system some proposals have been recently discussed, aiming at creating incentives to workers for postpone retirements. In order to allow the



Source: Our elaboration on Istat, RTFL, 1993-2003

Figure 8. Cohort-effect in labour market participation rates, males (left panel) and females (right panel). Coefficients of year-of-birth dummies in a logit regression reported.

creation of flexible scenarios, and given that there are only poor data on which to estimate the retirement propensity, we have modelled the retirement choice in an entirely parametric way: the user must specify the probability of retiring as early as possible (i.e. as soon as the individual becomes eligible) and the probability of postponing retirement until the age of 65. For These two parameters are sex, education and scheme-specific. For each parameter, two values must be imputed: one for the base year, and one for the final year of the simulation. In each simulated year a linear interpolation of these two extremes is then used. The residual probability of retiring is distributed in the interval between age of eligibility and 65 according to a simple algorithm specifying that, given a cohort of individuals becoming eligible at the same age, the flow of retirement must remain constant.^{15,16}

3.7. EMPLOYMENT MODULE

The employment status of individuals is simulated in two steps: First, their participation to the labour market is decided; conditional on participating, then, the employment/unemployment status is simulated.

As already mentioned, labour market participation choices seem to entail a relevant cohort-effect, especially for women. We modelled participation as a function of lagged participation, a polynomial of age, year of birth, the status of student and the educational level, by conditioning on not being retired. The choice of a linear specification of the cohort-effect has been made after a preliminary analysis of the coefficients of specific year-of-birth dummies¹⁷.

Not factoring in life-cycle factors such as family formation processes could weaken the ability of the model to capture sufficient heterogeneity in employment paths. However conditioning participation rates on lagged activity status, in addition to other individual characteristics, brings enough heterogeneity for the purpose of the model (forecasting *aggregate* participation rates, rather than obtaining realistic *individual* career paths).

We estimated this model separately by sex and geographical area, and found significant cohort-effects in most subgroups (see Figure 8). The only exception is

Table III. Logit estimates for male labour market participation. Data: Istat, Rfl, 1993–2003.

Logit estimates		Number of obs = 637423 Wald chi2 (8) = 108843.36 Prob > chi2 = 0.0000 Pseudo R2 = 0.5846				
Log pseudo-likelihood = -123089.77						
part.	Coef.	Robust Std. Err.	z	P > z	[95% Conf. Interval]	
lagged part.	2.968351	.0138102	214.94	0.000	2.941284	2.995419
age	.1215354	.0132734	9.16	0.000	.09552	.1475507
age squared	.0006595	.0003399	1.94	0.052	-6.58e-06	.0013257
age cubed	-.0000314	2.76e-06	-11.39	0.000	-.0000368	-.000026
student	-3.165786	.0284844	-111.14	0.000	-3.221615	-3.109958
diploma	.5887948	.0147846	39.82	0.000	.5598176	.617772
univ. degree	.9996766	.0280698	35.61	0.000	.9446608	1.054692
cohort	.0040348	.0018856	2.14	0.032	.0003392	.0077305
_const	-11.34523	3.765515	-3.01	0.003	-18.7255	-3.96495

Table IV. Logit estimates for female labour market participation. Data: Istat, Rfl, 1993–2003.

Logit estimates		Number of obs = 684238 Wald chi2 (8) = 230110.25 Prob > chi2 = 0.0000 Pseudo R2 = 0.6111				
Log pseudo-likelihood = -184363.12						
part.	Coef.	Robust Std. Err.	Z	P > z	[95% Conf. Interval]	
lagged part.	4.354981	.0098822	440.69	0.000	4.335612	4.37435
age	-.2488898	.0134446	-18.51	0.000	-.2752407	-.2225389
age squared	.0071877	.0003326	21.61	0.000	.0065358	.0078395
age cubed	-.0000665	2.64e-06	-25.14	0.000	-.0000717	-.0000613
student	-2.109739	.0324601	-64.99	0.000	-2.173359	-2.046118
diploma	.8268708	.0111389	74.23	0.000	.8050389	.8487026
univ. degree	1.586245	.0240933	65.84	0.000	1.539023	1.633467
cohort	.0139369	.0015227	9.15	0.000	.0109525	.0169213
_const	-26.74826	3.044314	-8.79	0.000	-32.71501	-20.78152

for the South of Italy, where the cohort-effect is less significant, and reversed. For the sake of brevity we omit to report all six sets of regression results. However, in order to give an intuition of the estimated dynamics we report the results of two additional logit regressions for the participation probability, for males and females, pooling together the three macro-areas (Table III and Table IV below).

The reference group is composed by non-students, low educated previously inactive individuals.

In the scenarios console we let the user specify the cohort after which the trend comes to a stop. However, since it is hard to believe that the weak but negative cohort-effect in the South will continue in the future, we removed the year-of-birth variable in the related regressions (both for males and females). We also added two additional convergence effects, one by gender and the other by area, that by default are set to zero. Setting them to a positive value one can choose to let participation rates in the South of Italy become closer to participation rates in the North, participation rates for women become closer to participation rates for men, or both. The user has to specify the fraction of the gap that has to be filled in each year of the simulation. This option becomes valuable for scenario analysis and policy evaluation, since it can be used to mimic the effects of specific policies aimed at increasing participation rates for subgroups of the population where they are particularly low.

Finally, we come to the employment status. As already mentioned, the microsimulation model does not model the demand side of the economy. Consequently, the employment module simply aims at reproducing the observed heterogeneity in unemployment rates across subgroups. The average unemployment rate in each simulated year is an exogenous parameter to be set by the user. To estimate the unemployment differentials we modelled the probability of becoming unemployed as a function of lagged unemployment, sex, age class (below 20, 20–50, over 50), educational level, geographical area and the average overall unemployment rate with a logit regression. We thus replaced the usual value of 1 for the constant with the average overall unemployment rate. The reference group is composed by prime age employed men living in the North with high school diploma.

Table V. Logit estimates for unemployment. Data: Istat, Rfl, 1993–2003.

Parameter	Estimate	Error	Chi-Square	Pr > ChiSq
Number of obs.	860, 172			
unempl. rate	−36.4554	0.1095	110834.681	<.0001
female	0.7660	0.00872	7718.4177	<.0001
low education	0.1398	0.00912	235.2739	<.0001
univ. degree	−0.5715	0.0176	1053.8429	<.0001
center	0.2625	0.0125	444.2999	<.0001
south	1.0572	0.00962	12083.8515	<.0001
lagged unempl.	3.0731	0.00924	110652.437	<.0001
young	0.9247	0.00904	10466.5191	<.0001
old	−0.5818	0.0159	1331.7270	<.0001

4. Results

4.1. THE STANDARD SCENARIO

Our standard scenario¹⁸ exactly replicates Istat central demographic projections up to 2050, i.e. we choose the central forecast both for natives and immigrants. We assume conservatively that the linear trend towards increasing participation to education ends for individuals entering high school and university in the base year, i.e. respectively born after 1990 and 1985. Analogously, we assume that the trend towards increasing labour market participation stops for individuals born after 1980. The additional convergence effects by gender and area are set to zero. The average unemployment rate is set to a constant value of 8% of the work force for all simulated years. We assume that the probability of postponing retirement, given eligibility:

- (i) depends on the pension scheme, the defined benefit scheme being not actuarially fair and thus providing stronger incentives for early retirement¹⁹;
- (ii) depends on education, higher education being generally associated with higher utility from work;
- (iii) does not depend on gender, given that eligibility criteria for men are already stricter than those for women.

The Maroni reform also allows women in the defined benefit and mixed scheme to retire earlier by switching to the defined contribution scheme, that is by accepting a lower pension. We suppose that only a few women will actually choose this opportunity, and that the majority of female workers (60%) will wait for the other eligibility criteria to be met.

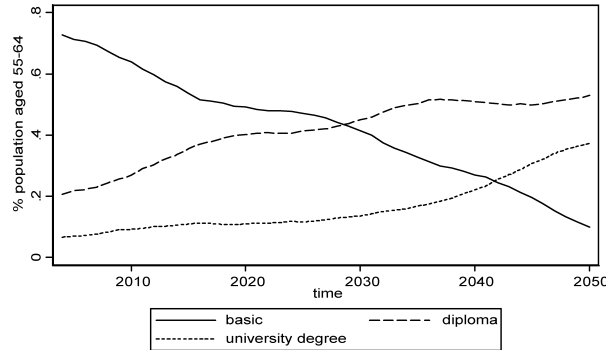
Table VI summarizes. All these values are assumed to remain constant for all simulation periods.

4.2. EDUCATION

The graph below shows the evolution of the distribution of educational levels in the standard scenario.

Table VI. Standard scenario parameters.

	Education		
	Basic	High-school	University
Defined Benefits & Mixed			
% early retirement	0.7	0.6	0.5
% late retirement	0	0.1	0.2
Defined Contributions			
% early retirement	.4	.3	.2
% late retirement	.2	.3	.4



Source: *LABORsim* standard scenario.

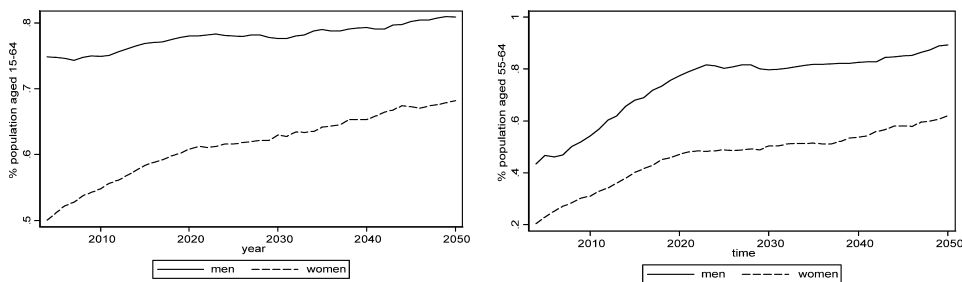
Figure 9. Evolution of the educational attainment distribution, people aged 55–64.

Even if the trend towards higher participation to the educational system has been stopped for the future, the simple demographic effects of younger cohorts replacing older ones with lower education are important. The share of people having attained a university degree is expected to rise to over 20% of the population by 2040.

4.3. PARTICIPATION

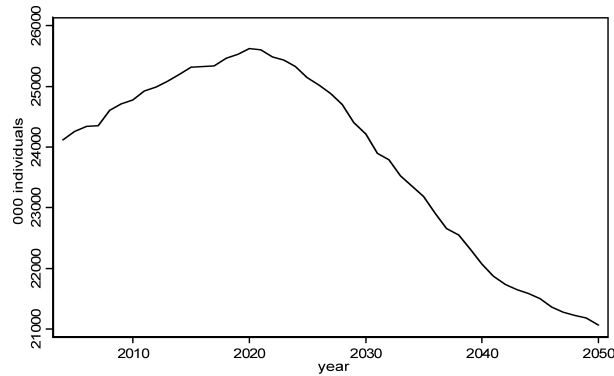
Higher education people tend to participate more to the labour market. Thus, the effects of the changes in the composition of the working age population described above, together with the effects of tightening requirements for retirement and the replacement of older cohorts with younger, more active, cohorts, imply higher participation rates. This holds even without extending the estimated trend towards higher participation rates beyond the level reached by younger cohorts in the initial population.

Note that these projections, although based on conservative assumptions, are more optimistic than those generally available in the literature. Figure 11 shows



Source: *LABORsim* standard scenario.

Figure 10. Projected participation rates as share of population in working age (left panel) and of population aged 55–64 (right panel).



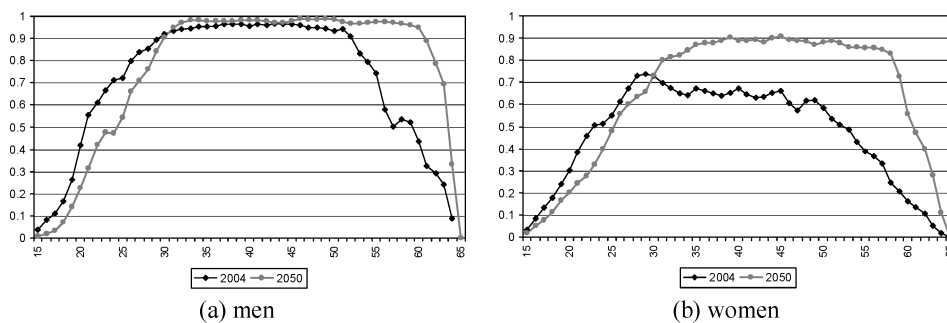
Source: *LABORsim* standard scenario.

Figure 11. Evolution of the labour force, thousands of individuals.

our forecast for the evolution of the labour force: it is expected to increase steadily for the next two decades, and to start decreasing only after 2020, when the baby boom generations will arrive at retirement ages. As a comparison, the “constant” scenario in Oecd (2004) (which assumes constant participation rates by gender and five-years age groups) forecasts the labour force to decrease steadily down to below 17 millions in 2050, while the “average” scenario (which assumes participation rates to reach the Oecd average by 2030) forecasts the labour force to drop below 19 millions. Our forecasts for 2050 remain above 21 millions.

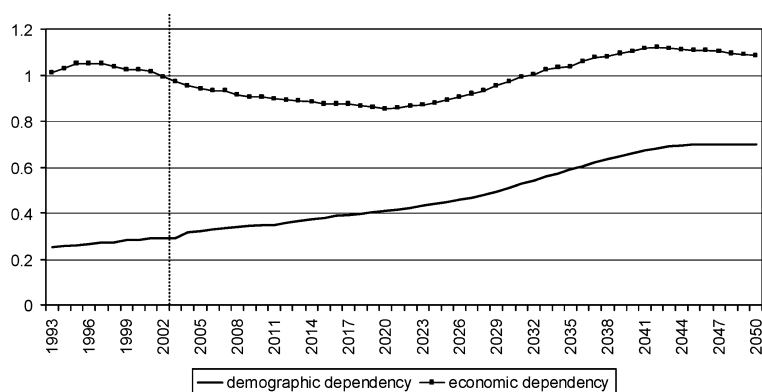
Figure 11 shows the evolution of the age profile of participation rates. The profile for men shifts towards older ages from the base year to the final year of the simulation. The profile for women, in addition to the shift towards older ages, shows also a significant shift upwards.

The implications on the economic dependency rate are shown in Figure 13. Instead of the rise predicted by most projections (see section 2 above), we actually forecast a decrease in the dependency rate. An increase is expected to take place



Source: *LABORsim* standard scenario.

Figure 12. Participation rates, age profile for the base and final year.



Demographic dependency rate: 65 and over / 20 and over
 Economic dependency rate: inactive, 20 and over / active, 20-64
 Source: Istat, RTFL 1993-2003 and *LABORsim* standard scenario.

Figure 13. Evolution of the demographic and economic dependency rates, population over 20.

only after 2020, as the baby boomers will gradually retire from the labour market. However, we forecast the economic dependency rate to stabilise in the final years of the simulation around a value only 10% higher than in the base year.

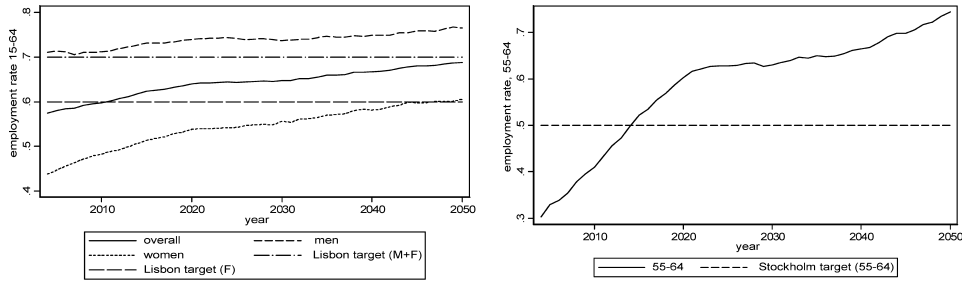
4.4. EMPLOYMENT AND THE EU TARGETS

The European Council has set (Lisbon, march 2000) the long run goal of full employment for the European economy, agreeing upon a 2010 target of 70% overall employment rate for the population aged 15–64 (60% for the female employment rate). The European Council has later set (Stockholm, march 2001) short terms target for 2005, and a new 2010 target of 50% employment rate for the elderly (aged 55–64).

Although we forecast higher participation rates, we predict that Italy will not be able the overall and female targets for many decades to come (Figure 14, left panel). The sharp increase in the participation rates for the elderly (aged 55–64) however, mainly driven by the recent changes in the retirement eligibility criteria, will make it possible to meet the Stockholm target of 50% employment rate in this age group by 2015, i.e. with only 5 years of delay (Figure 14, right panel).

4.5. RETIREMENT

Finally, the effects of the reforms of the pension system undertaken in the period 1992–2004 are clearly visible in the left panel of Figure 15, which depicts the share of eligible and retired workers in the age bracket 55–64. The different trend for women can be explained (a) with the differences introduced by the Maroni reform in the eligibility requirements for men and for women (more generous for



Source: *LABORsim* standard scenario.

Figure 14. Projected employment rates as share of population in working age (left panel) and of population aged 55–64 (right panel).

the latter), and (b) with the increasing female participation rate documented above, which raises the number of women who can claim a pension. Note that as the share of workers belonging to the defined contribution scheme increases, the gap between women who *can* retire and women who actually *choose* to retire increases. This is due to the different values of the parameters governing retirement choice for the two schemes (see table 6 above), which account for the waning of the bias towards early retirements implicit in the legislation. The same parameters are valid for both genders. However, the Maroni reform has decreased the freedom men have in choosing when to retire, hence the figure for retired male workers follows more closely that of eligible male workers.



Graphs by genere

Source: *LABORsim* standard scenario.

Figure 15. Share of eligible and retired workers, people aged 55–64, by gender.

4.6. CONCLUSIONS AND FURTHER DEVELOPMENTS

In this paper we have presented *LABORsim*, a dynamic ageing, discrete-event, probabilistic agent-based microsimulation model of labour supply, and an application to Italy. The Italian case is interesting because of the combination of rapid population ageing and low participation rates of the elderly. Due to these two causes, it is generally argued that Italy will experience a sharp decline in the labour force in the forthcoming decades, with a consequent increase in the economic dependency rate (the ratio of inactive to active people). In contrast, we showed that changes in the retirement legislation, in educational choices, in the working careers, in the participation behaviours of women will countervail the demographic ageing of the population, allowing Italy to broadly meet the Lisbon targets.

However, the welfare implications of these projections have not been addressed. Old people will work more in the future, and as a consequence they will impose a lower burden on younger generations. However, these people could possibly be worse-off with respect to old people now, stay at work at later ages possibly reflecting both a choice and a necessity. That is, many people will choose to study more, thus delaying their entrance in the labour market. On the other side, due to a less favourable pension scheme people will need to work more in order to sustain their income. Moreover, if the trends toward a reduction in family size and an increase in job precariousness that can be detected in the data will continue, intergenerational solidarity could be affected (in either way: from young to old people and vice-versa), with significant welfare implications.

In order to investigate these issues it is necessary to explicitly model income and family networks. We thus plan to include new modules in Labor Sim, to deal with wages, pensions and family evolution.

The modular structure of *LABORsim*, as the separation between the code and the input data, allow for an easy application of the model to different national contexts. Hence, we also plan to use *LABORsim* for cross-country comparisons, and for the evaluation of policy proposals both at a national and at a EU level.

Notes

¹Here and in what follows we refer to the “central” scenario of the population projections produced by the Italian Statistical Office (Istat), see <http://demo.istat.it/index.html>.

²New births averaged 950 thousands during 1960–69, and 890 thousands during 1970–1974. In recent years (1998–2002) they averaged 530 thousands per year (see Marano and Sestito (2005)).

³In the same direction goes the fact that youngsters today experience on average more and longer unemployment spells with respects to what happened to older cohorts.

⁴A minimum level is required, in order to guarantee a minimum pension (equal to 1.2 times the amount of the benefits for poor people).

⁵Mitton et al. (2000) witnesses this renewed interest.

⁶For a review of the microsimulation literature, see Zaidi and Rake (2002), O’Donoghue (2001) and Anderson (1997, ch.2)

⁷which has nothing to do with the original DYNASIM model cited above

⁸For a review of the literature on agent-based modelling in economics, see Tesfatsion (2001).

⁹JAS is available from <http://jaslibrary.sourceforge.net>. See Sonnessa (2004, 2006) for details.

¹⁰Actual simulation runs are generally based on 5,000 to 50,000 artificial individuals.

¹¹Pure regression imputation tends to underestimate the variance. Hence, as is standard, we added a noise term to the predicted values in order to avoid this problem.

¹²For more details on the data, model specification and estimation, and scenario parameters, see Leombruni and Richiardi (2005).

¹³The alternative assumption that migrants keep their pre-migration behaviour is equally arbitrary. Note that there are extremely little data concerning the behaviour of individuals *before* and *after* migration.

¹⁴For a detailed account of the Maroni reform, together with its evaluation within the *LABORsim* framework, see Leombruni and Richiardi (2006).

¹⁵A more detailed description of the algorithm can be found in Leombruni and Richiardi (2005).

¹⁶Mazzaferro and Marciano (2005) adopt a similar approach and model retirement decisions parametrically. They suppose that individuals retire immediately if they become eligible due to the age requirement, while they have a retirement propensity of .5 in each year if they become eligible due to the seniority requirement. In Vagliasindi et al. (2004) individuals choose the timing of retirement by looking at the differential benefit of postponing retirement to the following year. The empirical evidence on retirement choices has been investigated by Spataro (2005), Brugiavini and Peracchi (2004, 2003), Marano and Sestito (2004), Colombino et al. (2002), Colombino (2000) and Miniaci (1998).

¹⁷Note that the interpretation of the dummy coefficients in Figure 8 as full cohort-effect is not straightforward, since we included the lagged participation status (which is correlated with the cohort-effect) as an explanatory variable.

¹⁸For a detailed account of the results of the standard scenario, see Leombruni and Richiardi (2005)

¹⁹the Maroni reform (august 2004) tried to counterbalance this bias by introducing monetary incentives in order to induce workers to postpone retirement.

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