

**UNIVERSITÀ
DEGLI STUDI
DI PADOVA**

Sede Amministrativa: Università Degli Studi Di Padova

Dipartimento di Scienze Economiche “Marco Fanno”

SCUOLA DI DOTTORATO DI RICERCA IN:
ECONOMIA E MANAGEMENT

CICLO XXI

Assessing Social Security Reforms under Uncertainty

Direttore della Scuola: Ch.mo Prof. Guglielmo Weber

Supervisore: Ch.mo Prof. Luciano G. Greco

Dottorando: Devis Geron

Contents

Acknowledgements	iii
1 Riassunto della Tesi	1
2 Summary of the Thesis	7
3 Paper 1	11
3.1 Introduction	12
3.2 Model and Calibration	14
3.2.1 Model	14
3.2.2 The Italian Pension System	17
3.2.3 Calibration and Optimization Problem	19
3.3 Simulations and Findings	23
3.3.1 Comparison between Different Regimes	25
3.3.2 Introduction of Social Security	30
3.4 Conclusions	33
3.5 Appendix	34
3.5.1 Data and Methodology	34
3.5.2 Optimization Problem and Simulation Procedure	35
3.6 References	38
4 Paper 2	41
4.1 Introduction	42
4.2 Analytic Framework	46
4.2.1 Model	46
4.2.2 The Italian Pension System	50
4.3 Calibration and Optimization Problem	52
4.4 Findings	57
4.4.1 Individual Behavior	59
4.4.2 Elimination of Social Security	60
4.4.3 Comparison between Different Schemes	63

4.4.4	Optimal Social Security	70
4.5	Conclusions	71
4.6	Appendix	74
4.6.1	Data and Methodology	74
4.6.2	Technical Appendix	76
4.7	References	82
5	Paper 3	85
5.1	Introduction	86
5.2	Model and Institutional Framework	88
5.2.1	Model	88
5.2.2	Institutional Framework	91
5.2.3	Calibration and Optimization Problem	94
5.3	Findings	96
5.3.1	Comparison between Severance Pay and Pension Funds	98
5.3.2	Risk-return Combination and Payout Form	99
5.3.3	Optimal Payout Mix in Pension Funds	100
5.4	Conclusions	104
5.5	Appendix	106
5.5.1	Data and Methodology	106
5.5.2	Optimization Problem and Simulation Procedure	108
5.6	References	111

Acknowledgements

I am very grateful first of all to my supervisor Luciano Greco, a wonderful person and teacher, who has always supported me in all circumstances from the very beginning of my Thesis through its finalization. I am also very grateful to Alessandro Buccioli, who provided me with very helpful and kind support in all aspects of the Thesis throughout the last years. I then wish to gratefully thank Guglielmo Weber, Laurence J. Kotlikoff, Nunzio Capuccio and Efreem Castelnovo for their valuable advice and very insightful comments on my work, as well as Antonio Nicolò for precious assistance in several moments of my PhD.

I wish to warmly thank the whole staff of the Department of Economics “Marco Fanno” for providing me with the opportunity to study and work in an intellectually stimulating environment, where I have always collected all needed personal and technical assistance. A special thought is dedicated to Mrs. Lina Fiocco.

I finally (last, but certainly not least) wish to send the warmest thanks to my family and to my fiancée for their special love and invaluable support, which have crucially helped me to carry out my Dissertation during all good and (especially) difficult moments.

Chapter 1

Riassunto della Tesi

La Tesi si propone di analizzare la capacità dei sistemi pensionistici di assicurare gli individui contro rischi di natura macroeconomica e demografica. A tal fine, il lavoro effettua delle simulazioni di comportamenti individuali lungo il ciclo di vita, in un modello di equilibrio parziale in stato stazionario, caratterizzato da incertezza su salari, rendimenti finanziari e aspettativa di vita. Il modello è calibrato in modo da riprodurre fatti stilizzati dell'economia italiana. In particolare le variabili stocastiche (macroeconomiche e demografiche), quali salari, rendimenti finanziari, mobilità sociale e probabilità di sopravvivenza seguono processi stimati sulla base dei dati disponibili per il contesto socio-economico italiano, per lo più nell'arco del periodo 1990-2004.

La Tesi si compone di tre saggi.

I primi due lavori si prefiggono di confrontare la capacità di assicurare rischi collegati ai salari, ad opera da un lato di un tipico sistema pensionistico di tipo retributivo (di seguito nell'abbreviazione inglese DB, Defined Benefit) che eroga pensioni basate sui salari percepiti negli ultimi anni di lavoro prima del pensionamento; dall'altro lato, ad opera di un tipico sistema pensionistico contributivo a capitalizzazione figurativa dei contributi (di seguito nell'abbreviazione inglese NDC, Notional Defined Contribution) che eroga pensioni basate sui contributi versati nel corso dell'intera vita lavorativa e capitalizzati ad un tasso *figurativo* ("notional"), ad esempio il tasso medio di crescita dell'economia. Questo confronto è effettuato alla luce delle riforme pensionistiche introdotte in Italia negli anni '90, che determinarono il passaggio del sistema pensionistico pubblico da uno schema retributivo (DB), con pensioni calcolate sulle retribuzioni degli ultimi cinque anni lavorativi prima del pensionamento (per i dipendenti del settore privato), ad uno schema contributivo a capitalizzazione figurativa (NDC), con pensioni calcolate sui contributi versati (e quindi sui salari percepiti) nel corso dell'intera vita lavorativa e capitalizzati ad un rendimento pari al tasso medio di crescita

del PIL nominale. La maggior parte dei lavori nella letteratura correlata, che si concentrano sul confronto tra diverse tipologie di sistema previdenziale in base ai differenti meccanismi di finanziamento (a ripartizione, a capitalizzazione o misti) o in base a differenti gradi di progressività (programmi più o meno redistributivi). I primi due lavori della presente Tesi intendono invece comparare schemi alternativi (DB e NDC) nell'ambito di un sistema pensionistico (pubblico) a ripartizione (ossia un sistema in cui i contributi versati dai lavoratori in un dato periodo finanziano i trasferimenti ai pensionati), con particolare considerazione della variabilità dei salari nel corso della vita lavorativa e della correlazione tra pensioni e salari (questi ultimi come *proxy* del "capitale umano").

Il primo lavoro considera un modello con un agente rappresentativo, soggetto a incertezza su salari aggregati e rendimenti finanziari nonché al rischio di mortalità. Il nuovo sistema pensionistico italiano di tipo NDC (contributivo a capitalizzazione figurativa) risulta migliorare il benessere individuale "ex-ante" (ossia, il benessere individuale misurato all'inizio della vita economica) rispetto al precedente sistema di tipo DB (retributivo), in termini puramente assicurativi. Questo guadagno deriva dal fatto che il nuovo regime pensionistico, nel calcolo delle pensioni, aggrega (in "pooling") una serie più estesa di salari rischiosi, determinando in tal modo una migliore diversificazione del rischio sui salari, che causa una riduzione in termini attesi nella varianza delle pensioni stesse.

Il secondo lavoro estende la portata della precedente analisi considerando un modello con agenti eterogenei appartenenti a diverse classi sociali (ossia, a diverse classi di reddito lavorativo), soggetti a incertezza sia sui salari specifici di ciascuna classe sia sulla mobilità sociale (stocastica) intra-generazionale durante la vita lavorativa, oltre a sopportare la rischiosità dei rendimenti finanziari e dell'aspettativa di vita. In questo scenario il precedente risultato si ribalta, in quanto il vecchio sistema DB risulta migliorare il benessere "ex-ante" (misurato all'inizio della vita lavorativa, quando gli individui conoscono soltanto la loro classe sociale *iniziale* di appartenenza) rispetto al nuovo sistema NDC in termini puramente assicurativi, per individui appartenenti a ogni classe iniziale. Il nuovo sistema NDC migliora il benessere, in termini puramente assicurativi, soltanto da una prospettiva "ex-interim", intesa come il momento in cui la mobilità stocastica intra-generazionale (la maggior fonte di incertezza relativa al "capitale umano") si è realizzata e quindi gli individui conoscono anche la loro classe *finale* di appartenenza (che può essere stocasticamente uguale o diversa rispetto alla classe iniziale). Tramite l'erogazione di pensioni basate sui salari rischiosi percepiti nel corso dell'intera vita lavorativa, il nuovo regime pensionistico induce un duplice effetto rispetto al precedente regime. In primo luogo, il nuovo schema NDC provoca una

migliore diversificazione su una più estesa serie di salari rischiosi individuali, riducendo in tal modo la varianza delle pensioni. Questo effetto prevale da una prospettiva “ex-interim” (migliorando il benessere individuale), ossia dopo che la mobilità stocastica è avvenuta, e gli individui sono quindi soggetti soltanto alla rischiosità insita nei salari percepiti nella classe finale. In secondo luogo, il nuovo schema comporta una più alta correlazione tra pensioni (“asset” previdenziale) e salari percepiti nel corso dell’intera vita lavorativa (nell’ambito sia della classe iniziale che della classe finale, considerati come *proxy* per il “capitale umano” individuale), in tal modo aumentando la quantità complessiva di incertezza cui gli individui sono soggetti nel corso della loro intera vita. Questo effetto prevale da una prospettiva “ex-ante” (riducendo pertanto il benessere individuale), ossia quando l’intera incertezza salariale, specialmente la gran parte di essa che è legata alla mobilità sociale stocastica intra-generazionale, è ancora irrisolta.

Complessivamente, emerge che gli effetti puramente assicurativi dei sistemi previdenziali svolgono un ruolo secondario nel determinare (sia “ex-ante” che “ex-interim”) variazioni di benessere individuale, rispetto agli effetti di trasferimento (ovverosia effetti legati a cambiamenti nell’aliquota contributiva e nei trasferimenti pensionistici tra i diversi sistemi). In particolare, l’introduzione di un sistema previdenziale che riproduca sia il precedente che l’attuale regime pensionistico risulta generalmente diminuire il benessere individuale “ex-ante”, soprattutto a causa di un rendimento implicito sui contributi previdenziali considerevolmente inferiore rispetto al rendimento medio sui mercati finanziari. Considerando individui eterogenei, da una prospettiva “ex-interim” (quando, in particolare, una porzione significativa dei contributi pensionistici è già stata versata), un sistema previdenziale di qualsiasi tipo (DB o NDC) risulta leggermente desiderabile esclusivamente per gli individui le cui condizioni reddituali peggiorano durante la vita lavorativa. Un sistema previdenziale potrebbe pertanto costituire uno strumento assicurativo a beneficio degli individui che sopportano un peggioramento della propria classe sociale (durante la vita lavorativa), sebbene l’ordine di grandezza di questo implicito effetto redistributivo sia relativamente ridotto.

Il terzo lavoro della Tesi si focalizza prevalentemente su un’altra fonte di rischio cui sono soggetti gli individui, il cosiddetto “rischio di longevità” (“longevity risk”, ossia il rischio che un lavoratore viva più a lungo di quanto atteso, e quindi si ritrovi con insufficienti risorse risparmiate per gli ultimi anni di vita), ponendo l’attenzione sul cosiddetto “secondo pilastro” pensionistico, il pilastro degli schemi di previdenza privata complementare. Ero-gando pensioni sotto forma di rendita dal pensionamento fino alla morte dell’individuo, i sistemi pensionsistici tipicamente garantiscono un’assicurazione contro il rischio di longevità, nonché contro il rischio opposto che l’individuo

muoia lasciando risparmi che non sono stati dal medesimo goduti con il consumo (a seguito dell'auto-assicurazione attraverso il risparmio di risorse in quantità superiore al necessario) nel caso sia assente una motivazione di lascito ereditario. In molti paesi gli schemi pensionistici privati complementari a capitalizzazione (cioè finanziati attraverso la contribuzione degli individui, capitalizzata al tasso di rendimento di mercato) stanno acquisendo una rilevanza sempre maggiore, in conseguenza del peggioramento delle prospettive di sostenibilità finanziaria dei sistemi pubblici (a ripartizione). Pertanto, emergono delle questioni cruciali relativamente all'opportunità (e al grado) di un intervento pubblico a supporto della previdenza complementare (ad esempio rendendo obbligatoria l'adesione, o fornendo incentivi fiscali), nonché relativamente alle forme (obbligatorie o volontarie) in cui il capitale pensionistico dovrebbe essere accumulato ed erogato dopo il pensionamento.

L'analisi del terzo lavoro è complessivamente volta ad investigare le determinanti della scelta individuale di contribuire a forme di previdenza privata complementare, attraverso la valutazione degli effetti dell'ultima riforma previdenziale in Italia (2004) sul comportamento di un agente rappresentativo soggetto a incertezza su salari aggregati, rendimenti finanziari e aspettativa di vita. La suddetta riforma permette agli individui di scegliere tra due schemi alternativi a cui versare contributi (obbligatorie), in aggiunta ai contributi per il sistema pensionistico pubblico. Da un lato, lo schema aziendale del Trattamento di Fine Rapporto (il cosiddetto *TFR*), a rendimento relativamente ridotto ma (quasi) sicuro, eroga il capitale accumulato in un'unica soluzione ("lump-sum") al pensionamento (o comunque al momento di cessazione del rapporto di lavoro). Dall'altro lato, uno schema a capitalizzazione di fondi pensione, a rendimento più rischioso ma in media più elevato, eroga il capitale accumulato sotto forma di rendita dal pensionamento in poi. Investire nei fondi pensione risulta aumentare leggermente il benessere degli individui rispetto alla scelta di contribuire allo schema del *TFR*. Questo esito è dovuto unicamente al fatto che i fondi pensione offrono una migliore combinazione rischio-rendimento, poiché gli individui nel modello preferiscono ricevere il capitale accumulato in somma fissa al pensionamento piuttosto che sotto forma di rendita dal pensionamento in avanti (in linea con l'effettiva preferenza per l'erogazione in un'unica soluzione esibita dalla maggior parte dei lavoratori, come riportato in letteratura da lavori empirici sull'argomento). Di conseguenza, il mix ottimale dei due schemi complementari manterrebbe comunque una piccola frazione di *TFR*. Gli individui risultano dunque preferire il versamento in un'unica soluzione, ossia forme più liquide di risparmio previdenziale, nonostante l'assicurazione contro il rischio di longevità (e contro il rischio opposto di mortalità "prematura" con risparmi non utilizzati) fornita da pensioni erogate sotto forma di ren-

dita. Questo risultato è dovuto a due motivi principali: *a)* la pre-esistenza di (cospicue) rendite pensionistiche pubbliche, che riduce il valore relativo dell'assicurazione aggiuntiva fornita da rendite private; *b)* la convenienza relativa di investire, al momento del pensionamento, nei mercati finanziari ad alto rendimento atteso una quota consistente delle risorse ricevute in somma fissa.

Chapter 2

Summary of the Thesis

The Thesis analyzes the insurance provided by pension systems against macroeconomic and demographic risks. This purpose is accomplished by simulating individual life-cycle behaviors in a steady-state partial equilibrium model with uncertainty on wages, financial market returns and life expectancy, calibrated so as to reproduce stylized facts of the Italian economy. In particular, stochastic (macroeconomic and demographic) variables, such as wages, financial market returns, social mobility and survival probabilities follow processes that have been estimated based on available data for Italy, mostly over the period 1990-2004.

The Thesis is composed of three essays.

The first two papers focus on comparing the insurance provided against wage-related risk by a typical Defined Benefit pension system (providing benefits based on the risky wages earned in the last years before retirement) on the one hand, and a typical Notional Defined Contribution system (providing benefits based on all working-life contributions, capitalized at a “notional” rate of return e.g. the growth rate of the economy) on the other hand. This comparison is performed in the light of the Italian pension reforms in the 1990s, which turned the system from a Defined Benefit (DB) scheme providing pensions based on wages earned in the last five years before retirement (for private-sector employees) into a Notional Defined Contribution (NDC) scheme providing pensions based on all working-life contributions (notionally capitalized at the average GDP growth rate) and thus wages. Unlike most works in the related literature, comparing different types of pension systems based on different financing mechanisms (unfunded, fully funded or mixed) or different degrees of progressivity (more or less redistributive programs), the first two papers in this Thesis aim to compare alternative schemes (DB and NDC) within a (public) unfunded social security system (namely a system wherein pension benefits to retirees are paid for by concurrent workers’

contributions) particularly in the light of the variability of working-life wages and the correlation between pension benefits and wages (the latter as proxies for “human capital”).

The first paper considers a model with a representative individual facing uncertainty on aggregate wages and financial market returns as well as mortality risk. The new NDC Italian pension system turns out to improve “ex-ante” individual welfare (namely, individual welfare measured at the beginning of lifetime) with respect to the old DB scheme, from a purely risk-insurance perspective. This relative gain stems from the new regime pooling a longer series of risky wages in computing benefits, thereby yielding a better wage-risk diversification which causes a reduction (in expected terms) in the variance of pensions.

The second paper extends the scope of the analysis by considering a model with heterogeneous agents belonging to different social (i.e. labor-income) classes, facing uncertainty on class-specific wages and stochastic intra-generational social mobility during working life, besides riskiness related to financial market returns and life expectancy. In this setting the previous result reverses, in that the old DB system turns out to improve welfare in “ex-ante” terms (namely at the beginning of lifetime, as individuals only know their *initial* social class) with respect to the new NDC system from a purely risk-insurance perspective, for individuals belonging to all initial social classes. The new NDC system proves welfare-improving in pure risk-insurance terms only from an “ex-interim” perspective, defined as the time after stochastic social mobility (the bulk of uncertainty related to “human capital”) has occurred and individuals also know their *final* social class (which may stochastically be equal or different from the initial class). By means of providing pension benefits that are based on all working-life risky wages, the new regime causes a twofold risk-related impact as compared to the old regime. Firstly, the new scheme causes a better diversification over a longer series of individual risky wages, thereby reducing the variance of pension benefits. This effect prevails from an “ex-interim” perspective (thus yielding a welfare gain), after stochastic social mobility has occurred, and individuals face only final class-specific wage risk. Secondly, the new scheme causes a higher correlation between pensions (the social security “asset”) and working-life wages (both within the initial and the final class, deemed as a proxy for “human capital”), thereby increasing the overall uncertainty individuals are confronted with during their whole lifetime. This effect dominates from an “ex-ante” perspective (therefore yielding a welfare loss), as all wage uncertainty, notably the bulk of uncertainty on “human capital” that is stochastic social class mobility, is still unresolved.

Overall, pure risk-insurance effects of social security turn out to play a

minor role in determining (either ex-ante or ex-interim) welfare variations with respect to transfer effects (i.e. effects related to changes in contribution rates and pension transfers across regimes). In particular, the introduction of a social security system reproducing both the old and the new statutory Italian scheme turns out to generally decrease “ex-ante” welfare of individuals, mainly due to the implicit return on social security contributions being substantially lower than the average return on financial assets. Considering heterogeneous individuals, from an “ex-interim” perspective (namely, after social mobility has occurred and a significant portion of working-life contributions has been paid), a pension system of either type turns out to be slightly desirable only for individuals whose labor income conditions worsen during working life. Social security may thus act as an “insurance” tool for individuals experiencing a worsening of their social class (during working life), although the magnitude of these implicit redistributive effect is relatively small.

The third paper is mainly concerned with another source of risk facing individuals, that is the “longevity risk” (namely the risk of workers outliving their savings after retirement), by focusing on the so-called “second pillar” of private complementary pension schemes. Generally, by paying out benefits in the form of annuities from retirement until individual death, pension systems typically provide insurance against longevity risk, as well as insurance against the opposite risk of dying with savings that have not been consumed while alive (due to self-insuring by setting aside more than enough wealth) in the absence of a bequest motive. As in many countries fully funded complementary private pension schemes (i.e. schemes funded by own individuals’ contributions, capitalized at financial market returns) are becoming ever more important, as a consequence of worsening financial sustainability prospects for public unfunded pension systems, key issues emerge as to whether (and to what extent) these supplementary programs should be supported by governments (e.g. through mandating participation, or providing fiscal incentives), and as regards the mandatory or voluntary forms in which pension capital should be accumulated and paid out after retirement.

The analysis overall investigates the determinants of the individual choice of contributing to supplementary private pension funds, by evaluating the effects of the latest (2004) pension reform in Italy on the behavior of a representative agent facing uncertainty on aggregate wages, financial market returns and life expectancy. This reform let individuals choose between contributing to two alternative complementary schemes (each in addition to the mandatory contribution to the public social security system). On the one hand, the established firm-based severance pay scheme (the so-called *TFR*), yielding a low but (almost) safe return and paying out the accumulated amount in

lump-sum form at retirement (or upon leaving the firm). On the other hand, a fully funded scheme of pension funds, yielding a riskier but more rewarding return and paying out the accumulated capital in the form of annuities from retirement onwards. Investing in pension funds turns out to be slightly welfare improving with respect to contributing to the severance pay scheme. This result is uniquely due to the fact that pension funds offer a preferred risk-return combination, since individuals in the model turn out to prefer receiving the capitalized amount at retirement in lump-sum fashion than in the annuitized form (consistently with the actual preference of most workers for lump-sum payout over annuities, as reported in the related empirical literature). Consequently, the optimal mix of the two schemes would maintain a small fraction of severance pay. The preference towards lump-sum i.e. more liquid retirement assets, despite the longevity-risk insurance (and the insurance against the opposite risk of dying “too early” and leaving unintended accumulated savings) provided by supplementary private annuities, is due to two main reasons: *a*) the pre-existence of (sizeable) public annuities, reducing the relative value of additional longevity-risk insurance from private pensions; and *b*) the convenience of investing considerable resources (out of a lump-sum payout) in rewarding financial markets upon retirement.

Chapter 3

Social Security Incidence under Uncertainty Assessing Italian Reforms

Devis Geron
Department of Economics, University of Padova

Abstract

This paper analyzes the welfare effects of the Italian social security system in a simulated model with uncertainty on wages, financial market returns and life expectancy. It aims to evaluate variations in risk-insurance properties after the introduction of the new pension system in the mid 1990s, and compare the importance of risk-insurance and transfer effects in driving welfare changes. The new regime (providing pension benefits based on all working-life contributions), as compared to the previous regime (providing pension benefits based on the last wages before retirement), is shown to yield a slight ex-ante welfare improvement from a purely risk-insurance perspective. This relative gain stems from risk diversification across all working-life wages in computing benefits. Overall, risk-insurance effects of social security seem to play a minor role in determining welfare variations with respect to transfer effects.

3.1 Introduction

Economic and demographic trends over the last decades have induced the need to reform Pay-As-You-Go (PAYG) pension programs and restore their financial sustainability. These issues raise some fundamental questions that have been widely investigated by the economic literature: are there economic reasons that could still justify the existence of PAYG pension systems? What are the effects we should expect to obtain from systemic or marginal reforms? What is the “desirable” size of social security? This paper aims to tackle these issues from the perspective of the risk-insurance properties of social security, by means of analyzing the welfare consequences from the Italian pension reforms in the 1990s that turned the system from a typical Defined Benefit (DB) scheme to a Notional Defined Contribution (NDC) scheme.

In general, the introduction of social security does not seem to improve individual welfare, e.g. in settings with capital crowding-out (Imrohoroglu, Imrohoroglu and Joines, 1999; Krueger and Kubler, 2006), income risk and time-inconsistent preferences (Imrohoroglu, Imrohoroglu and Joines, 2003), income risk and altruistic preferences in a dynastic framework (Fuster, Imrohoroglu and Imrohoroglu, 2007).

However, recent studies (Campbell and Nosbusch, 2007; Gottardi and Kubler, 2009; Krueger and Kubler, 2006) have emphasized the role that social security may play in increasing individuals’ welfare in stochastic OLG settings, even in case its internal rate of return is below market return. Social security systems, especially of PAYG type, have indeed been shown in the literature to be capable of enhancing risk insurance in the presence of uncertainty (on factor returns, demographic trends, future fiscal policy decisions, and so on), dating back to contributions by Enders and Lapan (1982) and Merton (1983).

A first form of insurance possibly provided by social security systems is insurance against the well-known “longevity risk”, namely the risk of individuals outliving their savings after retirement (Barr and Diamond, 2006). In the absence of annuity markets a social security system can be welfare-increasing by paying pension benefits to retirees in the form of annuities (Imrohoroglu, Imrohoroglu and Joines, 1995). PAYG social security systems may also compensate for the inefficient allocation of risks among different generations. Since individuals cannot trade in risk sharing with individuals of other generations who are not yet born (Ball and Mankiw, 2007), there is room for government to introduce a (contingent) social security system making different generations share demographic and macroeconomic risks, typically by providing pensioners with claims to labor income (Krueger and Kubler, 2006), or also workers with claims to physical capital. Social secu-

rity is in fact an additional asset yielding a return whose degree of correlation with returns on other assets - notably on individual savings - crucially determines insurance of individuals through diversification of risks. Finally, as Nishiyama and Smetters (2008) claim with reference to the US system, social security can also generally provide insurance against negative shocks to individual income, due to a benefit formula pooling a series of individual (risky) wages.

In the spirit of the last intuition, suggesting that *ceteris paribus* a pension system can generally provide risk insurance through a benefit formula averaging out across a series of stochastic wages, this paper investigates the variations in risk-insurance properties of the Italian social security system after the major pension reforms introduced in the 1990s. These reforms turned indeed the Italian pension system from a DB regime providing benefits based on the last wages before retirement into a NDC scheme providing benefits based on all working-life contributions (thus wages). Therefore, while most of the analysis on the effects of the Italian pension reforms so far has been concerned with changes in both individual transfers and social security financial viability,¹ this paper focuses on evaluating and comparing risk-insurance properties under a typical DB scheme (like the pre-reforms Italian regime) on the one hand and a typical NDC scheme (like the post-reforms Italian regime) on the other hand. The paper performs this analysis by using simulations from a life-cycle model of a representative agent belonging to a representative generation in steady state. The model considers a partial equilibrium setting with mortality risk and uncertainty on factor returns, i.e. aggregate wages and financial market yields, under market incompleteness notably in the absence of contingent-claims markets (*à la* Arrow-Debreu), particularly of annuity markets.

By applying the salient features of the Italian pension system to a calibrated model representing the (stylized) Italian economy, the paper firstly delves into the main issue by performing a comparison between the old DB scheme and the new NDC scheme. From a purely risk-insurance perspective the new regime proves to slightly improve “ex-ante” welfare (namely, individual welfare measured at the beginning of lifetime), due to its capability of performing better wage-risk diversification. This effect results from a reduction in the ex-ante variability of pensions as a longer series of wages (or contributions) enters the benefit formula. The paper then analyzes whether

¹In particular, some studies have estimated the impacts of reforms from a generational accounting perspective (Cardarelli and Sartor, 2000) and the effects on social security financial sustainability (Sartor, 2001). Another strand of the literature on Italian pension reforms has been concerned with impacts related to intra-generational redistribution (Fonseca and Sopraseuth, 2005).

social security can actually improve individual welfare in the presence of macroeconomic and demographic risks under market incompleteness. The introduction of a social security system reproducing the statutory Italian pension schemes (both the old and the new regime) turns out to decrease ex-ante welfare of individuals, mainly due to the implicit return of the pension system being substantially lower than the average return on financial assets. Overall, risk-insurance effects of social security do not seem to significantly drive welfare gains, and appear instead to be largely outweighed in magnitude by other components of the overall welfare variation, mainly by transfer effects.

The paper is organized as follows. Section 2 presents the model. Section 3 illustrates the considered policy experiments, and presents the main findings. Section 4 concludes. Finally an Appendix provides technical details on calibration and simulation procedures.

3.2 Model and Calibration

3.2.1 Model

The partial equilibrium model considers a discrete time setting (every period in the model corresponds to one year in real life) representing an economy where both wages and financial returns are completely determined by foreign markets.² The pre-tax income of every individual in every period t is determined by an exogenous stochastic real average market return r_t on their savings (government bonds, corporate bonds, stocks) and by an exogenous stochastic real wage w_t earned during working life. After retirement, every individual receives a pension benefit that is linked to their wages during their working lives, according to a given benefit rule.

The economy is considered in steady state. The model takes into account yearly average wage growth, both at the aggregate level (growth rate of labor productivity g) and at the cohort-specific level (seniority wage growth sw). Both growth rates are assumed to be constant and to enter the model as exogenous deterministic trends that are applied to the underlying stochastic

²Italy can be approximately regarded as a small open economy worldwide and, by further approximation, in the European Union. The paper assumes that real financial returns and wages in Italy are determined by European capital and labor markets. This assumption is quite realistic as regards interest rates. As for wages, it is less realistic because the European labor market is not integrated. However, the paper further assumes that markets are competitive, so that the high-level integration in the European markets of goods can be thought of as influencing the determination of Italian real wages through the prices of tradable goods, in the wake of the Stolper-Samuelson theorem.

dynamics of wages w_t . Total population mass is also assumed to grow at a deterministic constant rate m .

Individuals in the economy live from age 1 to at most T years, surviving at every age t (with $t = 1, \dots, T$) to age $t + 1$ with a given (age-dependent) conditional survival probability. The economy is populated by overlapping generations, each consisting of an infinite number of agents. In each period, a constant fraction of individuals passes from each age to the next (respectively, dies) according to constant survival probabilities (respectively, to constant mortality probabilities). Since the model is considered in steady state under the assumption of partial equilibrium, the whole analysis throughout the paper will focus on a single representative individual belonging to a representative generation, instead of considering all overlapping generations through time. With reference to this single representative individual, both time periods and the individual's age are denoted by t (with $t = 1, \dots, T$).

Individuals in the model ex-ante maximize expected discounted lifetime utility with respect to within-period consumption and within-period leisure:³

$$E_0 \left[\sum_{t=1}^T \beta^{t-1} \left[\prod_{k=1}^t \psi_k \right] U_t(c_t, l_t) \right]$$

where β in the above formula is the subjective time discount factor; ψ_t is the conditional survival probability from age $t - 1$ to age t , with $\psi_1 = 1$ and $\psi_{T+1} = 0$; c_t and l_t are respectively consumption and leisure entering the utility function of agents at age t . The within-period utility function takes the CES form:

$$U_t(c_t, l_t) = \frac{1}{1-\rho} (c_t^{1-\sigma} + \gamma_t l_t^{1-\sigma})^{\frac{1-\rho}{1-\sigma}}$$

where $\frac{1}{\rho}$ is the intertemporal elasticity of substitution between consumption of different years, $\frac{1}{\sigma}$ is the intratemporal elasticity of substitution between consumption and leisure, and γ_t represents the time-varying leisure preference parameter following the formula:

$$\begin{aligned} \gamma_t &= 1 && \text{for } t = 1, \dots, \tilde{t} \\ \gamma_t &= \left(\frac{1}{\psi_t} - \left(\frac{1}{\psi_{\tilde{t}}} - 1 \right) \right)^\theta && \text{for } t = \tilde{t} + 1, \dots, T \end{aligned}$$

The leisure preference parameter is structured so that it is constant (normalized to 1) until a given period \tilde{t} in lifetime, and increases thereafter (more steeply as age increases). This assumption aims to represent the utility from leisure (disutility from labor) as roughly constant during the initial part of working life when individuals are younger, and then increasing (at sharper rates for later ages) when individuals are older and less healthy.⁴

³The expected value refers to time $t = 0$, namely prior to individuals entering the economy.

⁴Survival probabilities in the model can be considered as a proxy for the average health conditions of individuals. As individuals become older, survival probabilities decline, re-

In every period t individuals are provided with a given time endowment \bar{T} , and choose consumption c_t and labor supply $\bar{T} - l_t$. Individuals work and receive a wage w_t for each unit of time spent working, i.e. a total wage $w_t(\bar{T} - l_t)$, at every age t (if alive) until they endogenously choose to retire at age t_{ret} . After retiring individuals are assumed to no longer go back to work in subsequent periods (i.e. in every period from t_{ret} onwards, l_t is constantly equal to \bar{T}). That is, the retirement decision is irreversible. While working, individuals pay in social security contributions at a rate h out of their labor income.⁵ After retiring they receive a pension benefit p_t at every age t (if alive) until death at T .

Denoting gross labor income in every period t , namely $w_t(1 + g)^{t-1}(1 + sw)^{t-1}(\bar{T} - l_t)$, as W_t , the within-period budget constraint of a given individual at every age t would therefore read as follows:

$$\begin{aligned} A_{t+1} &= A_t(1 + r_t) + (1 - h)W_t - c_t & \text{for } t = 1, \dots, t_{ret} - 1 \\ A_{t+1} &= A_t(1 + r_t) + p_t - c_t & \text{for } t = t_{ret}, \dots, T \end{aligned}$$

where A_t represents the beginning-of-period asset holdings of the individual aged t .

Agents are assumed to be borrowing constrained:

$$A_t \geq 0 \quad \text{for } t = 1, \dots, T$$

Furthermore the model assumes there is no bequest motive, thus individuals do not leave any bequest in case they live until age T : $A_{T+1} = 0$. In case an individual dies before reaching age T , accumulated assets, i.e. accidental bequests, are assumed to be destroyed and provide no utility to other individuals who are still alive.⁶

Markets in the model are incomplete. In addition to individuals being borrowing constrained, agents in the economy cannot insure against uncertainty by trading contingent claims *à la* Arrow-Debreu. Notably, annuity markets are missing in the model, reflecting the very small size of the current Italian annuity market (Guazzarotti and Tommasino, 2008).⁷

flecting poorer health conditions. The leisure preference parameter is thus assumed to be inversely proportional to survival probabilities (from a given age onwards).

⁵Government is assumed to enter the model only through running an unfunded social security system. The contribution rate h therefore represents the only form of income taxation in the model.

⁶This assumption is made for the sake of simplification when performing numerical computations. Alternative assumptions regarding accidental bequests may involve redistributing unintended bequests to all or some of the surviving generations according to some criteria, e.g. in a lump-sum fashion or proportionally to wealth conditions of the survivors.

⁷In general annuity markets are actually narrow in real economies, seemingly contradicting the predictions of the traditional life cycle model. The literature has traditionally

3.2.2 The Italian Pension System

The major Italian pension reforms considered in the model are the so-called Amato reform (1992) and Dini reform (1995).

Before the introduction of the Amato reform (i.e. under the “pre-Amato” system, herein the “old” regime) the Italian pension system was an unfunded Defined Benefit system, in which pension benefits were based on wages earned in the last five years of working life (only on last year’s wage for public sector employees). Individuals were allowed to retire after 35 years of work and contribution to social security (20 years for public sector employees), or alternatively when they reached 60 years (55 for females) with at least 15 years of contribution. Pension benefits were computed by applying to the average wage over the last five working years a “replacement rate” (denoted by RR) amounting to 2% (so-called “accrual rate”) for every year of work and contribution.⁸ The maximum possible replacement rate was equal to 80% (corresponding to 40 years of work) for individuals working 40 years or more. The contribution rate under the old system was equal to 24%. Denoting gross labor income in every period t , i.e. $w_t(1+g)^{t-1}(1+sw)^{t-1}(\bar{T}-l_t)$, as W_t , the old pension benefit formula (for a private-sector employee) can be represented as follows:

$$p_{Old} = RR \cdot \frac{\sum_{t=t_{ret}-5}^{t_{ret}-1} W_t}{5}$$

$$RR = \begin{cases} (t_{ret} - 1) \cdot (0.02) & \text{for } t_{ret} - 1 \leq 40 \\ 0.8 & \text{for } t_{ret} - 1 > 40 \end{cases}$$

The 1992 Amato reform basically tightened the rules of the pension system (“post-Amato” and “pre-Dini” regime) through parametric variations, while keeping unchanged its systemic (structural) aspects. The Amato reform provided that pension benefits would be computed by applying the replacement rate (2% for every year of work and contribution) to the average of all wages earned throughout the entire working life. The contribution rate was set at 27%.

identified possible explanations for this “annuity puzzle”, such as low yields on annuities (also due to costs related to adverse selection) and the presence of a bequest motive (Friedman and Warshawsky, 1990). Even where relatively sizeable annuity markets are actually present, usually privately-provided annuities are not linked to wages, as opposed to most publicly-provided pension annuities.

⁸The accrual rate was constantly equal to 2% for most (low and middle) income levels, and gradually decreased only beyond a given income threshold. Since one representative individual is considered in this paper, a unique accrual rate value of 2% (associated to the middle-income level) is adopted.

The 1995 Dini reform introduced a systemic change, turning the Italian pension system from Defined Benefit into Notional Defined Contribution (“post-Dini” system, herein the “new” regime). In order to compute pension benefits, Social Security contributions are notionally capitalized at the growth rate of the economy during working life (depending on the aggregate growth rate of productivity and population, respectively denoted by g and m in the model). The amount accumulated in this way at retirement is turned into annuities through multiplying it by statutory annuity rates (so called “transformation coefficients”, denoted by tc). The Dini reform allowed individuals to choose their retirement age from any age between 57 and 65 years (with a minimum required number of years of contribution). Annuity rates vary according to the age at which an individual chooses to retire (the higher the retirement age, the greater the annuity rate, and the greater the pension benefit), and are periodically revised in order to account for changes in the (average) life expectancy of population.⁹ Individuals under the new system may also choose to retire later, i.e. after 65: in this case the annuity rate (transformation coefficient) used in the benefit rule remains constant thereafter, and equal to the annuity rate applied in case of retirement at 65. The contribution rate, currently in force, was set at 33%. The new pension benefit formula (for a private-sector employee) can be represented as follows:

$$p_{New} = tc \cdot \left[\sum_{t=1}^{t_{ret}-1} (0.33) \cdot W_t \cdot [(1+g) \cdot (1+m)]^{t_{ret}-t} \right]$$

where tc is increasing with retirement age, from 0.047 when $t_{ret} = 37$ to 0.061 when $t_{ret} \geq 45$. A transition period was set by law: whoever at the end of 1995 had contributed for more than 18 years, is not affected by Dini reform; whoever entered the labor market after 1995, is fully subjected to the Dini reform; for those having contributed to social security for less than 18 years at the end of 1995, a mixed regime applies, with pension determined pro-rata (proportionally to time spent contributing before and after 1995).

Social security in the model reproduces the main features of the actual pension systems in Italy, notably the contribution rate (denoted by h) equals the statutory average contribution rate on wages of employees under different regimes. The analysis will finally consider a hypothetical “flat-rate” pension system providing fixed benefits, as it is e.g. the case of the basic state pension constituting the first tier of the UK public scheme.

⁹The 1995 reform provided that transformation coefficients should be revised every ten years. However the first actual revision occurred in 2010 instead of 2005.

3.2.3 Calibration and Optimization Problem

The exogenous parameters of the model are calibrated to replicate stylized facts of the Italian economy, notably lifetime labor and consumption paths of individuals. The benchmark economy utilized in the calibration is the Italian economy under the old pension system, before the introduction of the Amato reform in 1992. Because the old pension regime has been uniquely or mostly applied in Italy so far - even after reforms in the 1990s, due to a long transition period set by law - it represents the most suitable regime to be considered when calibrating the model. While mostly applying the main *statutory* features of the old regime, the calibration makes use of a replacement rate (81.6%) approximately matching the *actual* replacement rate enjoyed at retirement by individuals in Italy under the old system (OECD, 2007).¹⁰

The baseline calibration is characterized as follows (see Table 5.1). The representative individual is assumed to enter the economy when 21 years old, corresponding to the first lifetime period ($t = 1$) in the model. This reflects the real average entry age in the labor market in Italy. Assets held by the individual at the beginning of their (economic) life are assumed to be equal to zero: $A_1 = 0$. The representative individual lives at most T periods, equalized to 80 in the model (i.e. when 100 years old in real life), surviving from every period to the next with a certain (conditional) survival probability. The sequence of conditional survival probabilities $\{\psi_t\}_{t=1}^T$ is computed as the weighted average of survival probabilities per cohort of Italian males and females in 2004, reported by the yearly demographic balance of Istat (Italian National Institute of Statistics).¹¹ Population mass of the whole economy in every period is normalized to one, i.e. yearly population growth rate (denoted by m) is equal to zero. This is in line with recent demographic trends and with demographic projections for Italy. According to the Istat demographic balance, the Italian population in the 1990-2004 period has experienced an average yearly population growth rate equal to 0.15%. Istat demographic projections for the 2007-2051 period, under the so-called “central” scenario, forecast an average yearly population growth rate close to zero, namely 0.1%.

Econometric analysis on Italian real wages (normalized around their mean) and financial market returns (computed as weighted average of returns on

¹⁰The Italian pension system in the past decades was particularly advantageous to pensioners, so that the actual replacement rate under the old scenario was higher than the one statutorily set. This situation was due to several favorable conditions, such as opportunities of early retirement (e.g. the so-called “baby pensions” to public sector employees).

¹¹2004 is one of the last years for which data are available, and is in line with the 1990-2004 time span of macroeconomic data utilized in the calibration.

government bonds, corporate bonds issued by Italian banks, and listed shares issued by Italian companies) between 1990 and 2004 (for further details see the Appendix) suggests that the processes underlying wages, denoted by w_t , and market returns, denoted by r_t , can be represented as follows (standard errors in parentheses):

$$w_t = \underset{(10.273)}{35.253} + \underset{(0.103)}{0.645} \cdot w_{t-1} + ew_t$$

where ew_t is the error term, normally, identically and independently distributed with mean zero and variance (denoted by σ_w^2) estimated to equal 2.436;

$$r_t = \underset{(0.008)}{0.054} + er_t$$

where er_t is the error term, normally, identically and independently distributed with mean zero and variance (denoted by σ_r^2) estimated to equal 0.004. The covariance between the error terms (denoted by σ_{wr}) representing the degree of correlation between the stochastic component of wages and market returns is estimated to equal 0.03. This suggests a positive but nearly zero correlation between wages and market returns. The stationary normal distributions of wages and returns processes are as follows:

$$w \sim N(99.332, 4.172)$$

$$r \sim N(0.054, 0.004)$$

The deterministic yearly growth rate (denoted by g) of aggregate real wages is assumed to be zero. This is in line with the average yearly growth rate of aggregate real compensations per employee in period 1990-2004, that was roughly zero: according to OECD (2008) data for Italy, average growth rate of real compensations in 1990-2004 was approximately equal to -0.04% . Notice that since population and aggregate wages in the model do not grow through time, the overall yearly growth of the economy in the model scenario is equal to zero, consequently no macroeconomic or demographic effects influence welfare levels of different generations under different pension schemes across time.

The only source of deterministic wage variation through time is a cohort-specific component tracking changes in wages due to career dynamics, namely to seniority-driven (contractual) increases in wages. This per-period “seniority” growth rate in real wages, denoted by sw , is set at 2% (OECD, 2008; Rosolia and Torrini, 2007) and is assumed to be constant across the whole working life. Since seniority growth of real wages (sw) regards every single cohort, as long as such contractual wage dynamics is assumed to remain constant throughout all subsequent cohorts (as it is implicitly assumed in the model), it is also consistent with an *aggregate* growth of real wages (g)

equal to zero. As a consequence of the above assumptions, the representative individual belonging to the representative generation (cohort) considered in the model enjoys a deterministic growth of wages by 2% per period.

Calibration of preference parameters is as follows. Although the literature does not provide estimates for the elasticity of intertemporal substitution in Italy, the value assigned to ρ (1.0001) lies in ranges that are suggested by various studies, such as between 0.5 and 1.5 (Battistin et al. 2009). The subjective time discount factor β (0.96) is in line with values commonly used in the literature, in that it lies well within ranges between lower values of β , e.g. equal to 0.92 in Krueger and Kubler (2006), and higher values of β , e.g. equal to 1.011 in Imrohoroglu, Imrohoroglu and Joines (1995).¹² The value assigned to the reciprocal of the intratemporal elasticity of substitution, i.e. σ (0.999), is very close to 1, implying that consumption and leisure in the calibrated model are substitutable to a very little extent. This matches the well-known fact that some consumption goods are substitutes and other consumption goods are complements with leisure. The time-profile of the leisure preference parameter γ_t resulting from values assigned to θ (90) and \tilde{t} (35) is such that the representative individual in the calibrated model is willing to retire at an age that is comparable with the actual retirement age in the presence of social security.

The reported parameter values allow the calibrated model resulting from simulations to reproduce the following stylized facts of the Italian economy. The simulated consumption drop at retirement under the old pension system in the model lies between 4% and 5%, and is comparable to the drop empirically measured for Italy (Battistin et al., 2009; Miniaci, Monfardini and Weber, 2010) under the old regime (prior to the 1992 Amato reform and as modified by the Amato reform).¹³ The calibrated lifetime consumption path increases in line with wage growth (at rate $sw = 2\%$) during working life, and drops around retirement. The consumption path, normalized by the average wage in the first model period ¹⁴, is reported in Figure 3.1. More-

¹²Notably, the value assigned to the subjective time discount factor is in line with values referred to Italy in the literature, ranging from e.g. 0.9 in Ventura (2003) to e.g. 0.985 in Fonseca and Sopraseduth (2005).

¹³Analogously to Battistin et al. (2009), consumption drop is measured as the percentage variation between the average consumption level in the 10 years before retirement and the average consumption level in the 10 years after retirement. Battistin et al. (2009) estimate a drop in nondurable consumption at retirement of 9.8 percent, but this fall turns out to be more than halved in case expenditure is deflated by a standard family size measure. Miniaci, Monfardini, and Weber (2010) estimate a drop in nondurable consumption at retirement of around 5.4 percent.

¹⁴The simulated average wage in the first model period is used in the paper to express the relative size of variables resulting from simulations. The first-period wage is used

Parameters	Symbol	Value
Demographic and macroeconomic parameters		
<i>Maximum possible life length</i>	T	80
<i>Growth rate of population</i>	m	0
<i>Variance of wages error term</i>	σ_w^2	2.436
<i>Variance of market returns error term</i>	σ_r^2	0.004
<i>Covariance of wages and market returns error terms</i>	σ_{wr}	0.03
<i>Aggregate growth rate of wages</i>	g	0
<i>Seniority growth rate of wages</i>	sw	0.02
Preference parameters		
<i>Subjective time discount factor</i>	β	0.96
<i>Reciprocal of the intertemporal elasticity of substitution</i>	ρ	1.0001
<i>Reciprocal of the intratemporal elasticity of substitution</i>	σ	0.999
<i>Parameters in leisure preference formula</i>	θ	90
$\gamma_t = \left(\frac{1}{\psi_t} - \left(\frac{1}{\psi_{\bar{t}}} - 1\right)\right)^\theta$	\tilde{t}	35

Table 3.1: Calibration

over, the calibration yields a working-life labor supply profile that is equal to the normalized value of 1 in each working-life period until retirement (t_{ret}), and constantly equal to zero after retirement.¹⁵ In the calibrated model, retirement choice (i.e. choice of the period t_{ret} when labor supply is zero, so that labor supply remains null in all subsequent periods until T) occurs at $t_{ret} = 36$, corresponding to 56 years in real life.¹⁶ This implies that individuals in the calibrated model under the old pension system choose to retire as soon as they are statutorily allowed to (i.e. after 35 years of work and contribution). This retirement choice in the model approximately matches the actual average retirement age of Italian workers under the old pension regime, around their mid-50s, mainly due to high effective replacement rate, and favorable eligibility conditions (particularly for public-sector employees).

Based on the calibrated model, the solution to the corresponding optimization problem for the representative individual entering the economy at age $t = 1$ is a sequence of optimally chosen values for consumption ($\{c_t^*\}_{t=1}^T$) and leisure ($\{l_t^*\}_{t=1}^T$) maximizing the individual's lifetime utility, provided that labor is no longer supplied in periods from t_{ret} onwards. Solutions are

because it is drawn from the stationary (i.e. “steady-state”) distribution of wages in the model.

¹⁵A constant unitary labor supply in the model allows the representative individual to obtain labor earnings (while working) that coincide with wage rates in the model economy.

¹⁶Hereafter in the paper, retirement age t_{ret} is expressed in terms of model periods. Corresponding real-life age equals the model age plus 20.

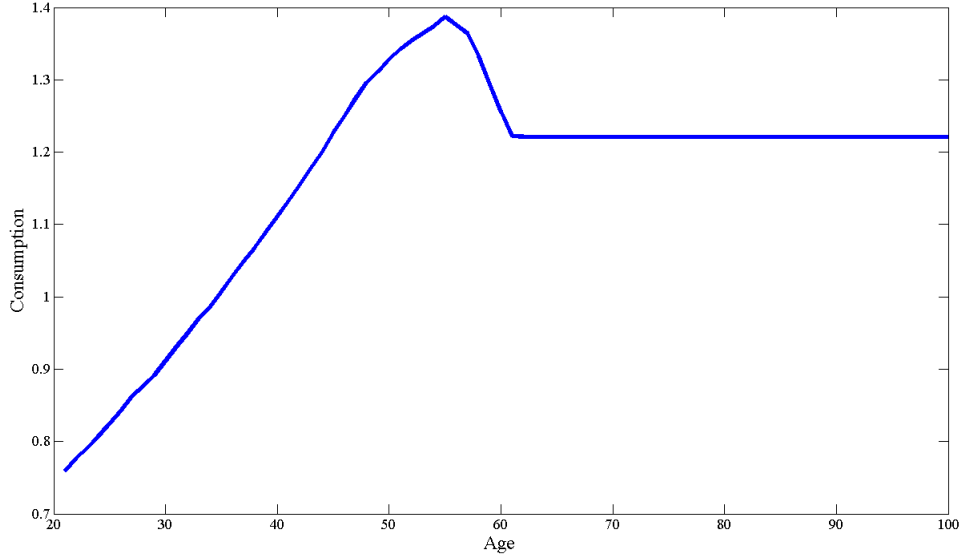


Figure 3.1: Calibrated lifetime consumption

found by numerically simulating the calibrated model: each analysis in the paper is carried out through running 1000 simulations. Therefore optimal individual behavior is state-contingent, namely depending on the specific simulated realizations of stochastic variables in each period t . Consequently, lifetime profiles for consumption and leisure ($\{c_t^*\}_{t=1}^T$ and $\{l_t^*\}_{t=1}^T$) result from averaging across 1000 different paths. For the sake of computational simplification, the optimal retirement age t_{ret} is instead computed from an ex-ante perspective, as the age maximizing the expected discounted lifetime utility (namely the value function at the beginning of life).

3.3 Simulations and Findings

In order to assess welfare consequences under different Italian pension systems, optimization is performed under the statutory old and new regimes.¹⁷ Under the old scheme, the statutory instead of the *actual* replacement rate

¹⁷Based on the main features of alternative Italian pension regimes, the paper follows the definitional and comparative approach adopted by Cardarelli and Sartor (2000) who compare the pension system before the 1992 Amato reform (old regime) and after the 1995 Dini reform (new regime) from a generational accounting perspective under no uncertainty.

is therefore considered (with the former being lower than the latter).¹⁸ In a hypothetical scenario with no social security scheme whatsoever, both the contribution rate and pension benefits would equal zero. The main features of the different settings considered in the paper are represented in Table 5.2. The system introduced by the 1992 Amato reform (“post-Amato” and “pre-Dini”) is not considered in the paper. Since this system provides pension benefits based on all working-life wages (within a DB scheme), from a risk-insurance perspective its properties are basically the same as those of the new (“post-Dini”) system which provides pension benefits based on all working-life contributions and thus wages (within a NDC scheme).

	Contribution rate h	Pension benefit p_t
<i>Actual old regime</i>	0.24	$(0.816) \cdot \frac{\sum_{t=t_{ret}-5}^{t_{ret}-1} W_t}{5}$
<i>Old regime</i>	0.24	$RR \cdot \frac{\sum_{t=t_{ret}-5}^{t_{ret}-1} W_t}{5}$
<i>New regime</i>	0.33	$tc \cdot [\sum_{t=1}^{t_{ret}-1} (0.33) \cdot W_t \cdot [(1+g) \cdot (1+m)]^{t_{ret}-t}]$
<i>No social security</i>	0	0

Table 3.2: Schemes considered in the analysis

The analysis of a steady-state setting with one representative generation requires an “appropriate” (i.e. budget-neutral) comparison to be carried out between alternative scenarios. In order to accomplish this purpose, social security budget is forced to balance in every period, i.e. it cannot run deficits nor surpluses. To this end, statutory policy parameters (namely the accrual rate, determining the replacement rate computation, under the old system and the annuity rate under the new system) are artificially changed in the model so as to have social security budget balance in every period under both pension systems, for every given level of the relative contribution rate h .¹⁹

Comparisons between alternative scenarios in the model are carried out from an “ex-ante” welfare perspective, that is by measuring welfare as individuals enter economic lifetime.²⁰ Each confrontation is thus performed in ex-ante terms (before entering the economy) based on the individual expected

¹⁸The statutory replacement rate (RR) amounts to 2% for every year of work and contribution (reaching a maximum possible value of 80%), instead of the “actual” value used for calibration equalling 81.6%.

¹⁹That is, both the replacement rate (under the old regime) and the annuity rate (under the new regime) are treated as functions of the contribution rate. The contribution rate h is instead kept at the statutory level (24% under the old scheme, 33% under the new scheme).

²⁰In comparing different settings, the macroeconomic (basically, w_t and r_t in every model period t) and demographic backdrop remains the same, with the only difference being the institutional features under each alternative scenario.

discounted lifetime utility (i.e. the value function evaluated at the beginning of life, at time $t = 1$) under alternative scenarios. The result of each comparison is expressed in terms of “*Compensating Variation*” (CV), defined as the amount of assets that should be given to individuals in a setting (e.g. with social security) before the beginning of their life, in order to let them benefit from the same level of ex-ante expected discounted lifetime utility as they would enjoy in the other setting (e.g. without social security). Hereafter in the paper, all comparisons between alternative settings are expressed in terms of Compensating Variation normalized by the average wage in the first model period.²¹

3.3.1 Comparison between Different Regimes

Comparisons are carried out between the two regimes considered in the paper, i.e. the old and the new system, so as to shed light on differences in risk-insurance properties between a typical DB system (with benefits based on the last working-life wages) and a NDC system (with benefits based on all working-life contributions, thus wages). The CV resulting from alternative comparisons between the old and the new pension regime are summarized in Table 3.3.

	CV
<i>Old vs New</i>	1.846
<i>Old vs New, ex-ante equalized transfers</i>	-0.00002
<i>New vs Flat-rate, ex-ante equalized transfer</i>	-0.000002

Table 3.3: Comparisons Old - New regime

In order to run an appropriate comparison (namely, compatible with a steady-state setting) across systems, budget imbalances are eliminated.²² When comparing the old and the new balanced pension scheme, the resulting Compensating Variation (denoted by $CV_{OldNewBB}$) to be given to the representative individual experiencing a shift from the old to the new scheme amounts to 1.846, implying that the old system is generally preferred to the

²¹The Compensating Variation measures, computed in terms of assets, are expressed as compared to the average individual wage. Notably, the first-period wage is considered because it is drawn from the stationary distribution of wages in the model.

²²This is done by artificially reducing statutory policy parameters, from 2% to 1.49% (the accrual rate per year of contribution, under the old system) and from 5.51% to 4.69% (the annuity rate under the new system).

new system.²³ This result may plausibly hinge on more favorable conditions under the old regime, notably on its lower contribution rate (24% as opposed to 33%) at which workers are forced to invest in the social security “asset”. Mandatory social security contributions yield indeed a comparatively low implicit return with respect to the average return on financial assets. The expected return on financial assets in the model basically equals the mean value of financial returns (r_t), i.e. 5.4%, whereas the implicit return on social security contributions in the budget-balance scenario (under either scheme) is around 2%.²⁴ A lower contribution rate h (namely a smaller size of the mandatory investment in social security) would therefore increase individual welfare.

After exogenously imposing budget balance, thus equality in the (zero) budget deficit, under both systems there are still two “transfer” components (net lifetime transfers) statutorily differing between the old and the new regime, namely the contribution rate i.e. the size of the compulsory social security “asset” on the one hand, and the level of pension benefits on the other hand. The above comparison based on $CV_{OldNewBB}$ therefore does not allow to draw neat conclusions about pure variations in risk-insurance properties across pension schemes. Moreover, the comparison is also misled by the fact that individuals under alternative balanced regimes make different economic choices, notably different retirement choices (retirement age t_{ret} is 50 under the old scheme, 42 under the new scheme). Fehr, Kotlikoff and Leibfritz (1999) in a general equilibrium setting without uncertainty argue that any policy-induced lifetime welfare variation can be decomposed into three components relative to changes in individual behavior, changes in net lifetime transfers and changes in factor prices. In this paper, which follows a partial equilibrium setting under uncertainty, any policy-induced ex-ante welfare variation can also be ideally decomposed into three components relative to changes in individual behavior, changes in net lifetime transfers, and changes in risk-insurance effects (rather than in factor prices). A more accurate welfare comparison aiming at investigating the merely risk-insurance impacts of social security would thus require the absence of differences in

²³It is noteworthy that individuals in the model turn out to optimally choose to retire earlier under the balanced new system (at $t_{ret} = 42$) than under the balanced old system (at $t_{ret} = 50$), plausibly due to wages of the last years before retirement becoming relatively less important in the new-regime benefit formula. In case there were no social security system at all, as expected individuals in the model would optimally choose to retire later (at $t_{ret} = 53$) than under either pension scheme.

²⁴The implicit return on social security is computed as the internal rate of return (IRR), denoted by i , on contributions (Co_t) paid in during working life with respect to expected pension benefits (p_t) received after retirement: $-\sum_{t=1}^{t_{ret}-1} \frac{Co_t}{(1+i)^{t-1}} + \sum_{t=t_{ret}}^T \frac{p_t}{(1+i)^{t-1}} = 0$

lifetime transfers and differences in individual behavior across systems.

To this end, differences in net lifetime transfers can be eliminated through exogenously equalizing the contribution rate and the ex-ante expected levels of pension benefits across the two regimes. The contribution rate under both systems is exogenously set at the old level ($h = 0.24$). Moreover the annuity rate under the new scheme is set at such a level that ensures its pension benefits are equal in expected value to those provided under the old scheme.²⁵ Since under these hypotheses differences in expected net lifetime transfers (contributions and pensions) between the two schemes are exogenously eliminated, changes in individual behavior are consequently endogenously neutralized. The representative individual under the two systems faces indeed the same macroeconomic (wages and financial returns in every period) and demographic (mortality risk) setting, and receives or pays the same net lifetime transfers (in expected value). As a result, the corresponding simulated values for consumption and leisure choices (included retirement choice at $t_{ret} = 50$) turn out to be equal or different only to a negligible extent across the two systems. When performing a comparison under such assumptions, it turns out that the Compensating Variation (denoted by $CV_{OldNewBBEqualized}$) to be given to the representative individual experiencing a shift from the balanced old to the balanced new scheme amounts to -0.00002 .

Although very small in absolute value, the fact that $CV_{OldNewBBEqualized}$ has negative sign suggests firstly that the ex-ante expected lifetime utility under the new regime is slightly greater than under the old regime; secondly, that this small ex-ante welfare difference is uniquely due to the risk-insurance component of the overall ex-ante welfare variation, because the other two components (variations in net lifetime transfers and individual behavior) are virtually absent. The welfare-variation component related to risk insurance results from differences in the ex-ante *probabilities* of alternative pension levels occurring under the two pension systems, due to their different benefit formulas. While the old DB system provides benefits based on wages earned only in the last five years of working life, the new NDC system provides pension benefits based on all working life contributions (and thus wages). The longer the working history (so, the longer the series of risky wages or contributions) entering the pension benefit formula, the greater the wage-risk diversification, thus the lower the variance of pension benefits.²⁶ Therefore the new regime ex-ante reduces the variance of pension benefits, by caus-

²⁵Put it alternatively, after equalizing the contribution rate and under the balanced-budget condition in steady state, the average pension benefit level is consequently the same across the two schemes.

²⁶This effect crucially depends on wages being only *partially* auto-correlated through time, as it has been estimated to be the case in reality.

ing higher probability of mean benefit values occurring and lower probability of tail values (low and high benefits) occurring.²⁷ It implies that, under equalized expected (mean) value of pension benefits across the two systems, risk-averse individuals enjoy a small *ex-ante* welfare gain resulting from reduced pension variability, *ceteris paribus* (that is, with exogenously equalized contribution rate and virtually equal endogenous individual behavior).

Under the assumption of exogenously equalized expected net lifetime transfers across the two schemes, causing changes in individual behavior to be endogenously neutralized, the implied risk structure under the old and the new system in the model can be expressed by the simulated age-specific variance of consumption, total income and pension benefits, normalized by their respective mean. During working life the uncertainty structure of both consumption and income turns out to be the same across the old and the new regime (as a consequence of equal expected net transfers and individual behavior), whereas from retirement onwards the variability of pension benefits (thus of related consumption and income as well) differs across the two regimes. Notably, pension variance (normalized by the respective mean values) is lower under the new system (0.005) than under the old system (0.043). This outcome confirms the pure risk-insurance effect of the new system, consisting of a reduction in the degree of uncertainty on pensions, *ceteris paribus* (namely as other welfare-variation components are absent).

This result contributes to the analysis carried out in the paper, in that it suggests that the new NDC pension system introduced in the 1990s is potentially slightly *ex-ante* welfare improving from a purely risk-insurance perspective, i.e. net of all statutory differences, with respect to the previous DB regime, due to better wage-risk diversification. The reasoning can be further extended to considering the case of a hypothetical pension system providing a flat-rate (fixed) pension, regardless of the level of wages earned (and contributions paid) during working life. For instance, let us consider a comparison between the new NDC system and an ideal flat-rate scheme, such that the flat pension benefit is equal to the *ex-ante* expected (mean) value of benefits under the new system, and the contribution rate is

²⁷This general theoretical argument becomes clearer when performing simulations in the model. Simulated pension benefits are grouped into three equally-spaced discrete levels (“low”, “middle”, “high”) that are kept the same across the two regimes (by appropriately varying policy parameters). Under the simulated old system the *ex-ante* probability of ending up in the low pension benefit level is 0.187, in the mean benefit level 0.626, in the high benefit level 0.187, for every age at which the individual chooses to retire. Under the simulated new system with the individual retiring at 50 (respectively, e.g., at 42) instead the *ex-ante* probability of ending up in the low benefit level is 0.015 (respectively 0.022), in the mean benefit level 0.97 (respectively 0.956), in the high benefit level 0.015 (respectively 0.022).

still set at the level $h = 0.24\%$. When comparing the two settings in this way, once again there are no more differences in both net lifetime transfers and economic behavior (including optimal retirement choice at $t_{ret} = 50$), and the only remaining gap is related to risk-insurance effects depending on ex-ante probabilities of alternative benefit values occurring.²⁸ In this case the CV (denoted by $CV_{NewFlatBBEqualized}$) to be given to the representative individual shifting from the balanced-budget new pension scheme to a hypothetical balanced-budget flat-rate scheme is equal to -0.000002 . From a purely risk-insurance perspective, an ideal system providing a fixed pension benefit proves, *ceteris paribus*, slightly welfare improving with respect to the new NDC system, because the degree of risk insurance further augments until becoming complete (stochasticity of working-life wages is “neutralized” by the certainty of the constant pension value).

In the light of all of the above results, welfare gains from a purely risk-insurance perspective turn out to be relatively minor: notably, $CV_{OldNewBB}$ in the baseline budget-balance scenario (1.846) is far larger than the corresponding absolute value of $CV_{OldNewBBEqualized}$ in the “risk-insurance” analysis (-0.00002). This implies that:

- the new pension scheme is potentially slightly welfare improving (solely) from a pure risk-insurance perspective due to better wage-risk diversification;
- the mere risk-insurance difference across the two considered regimes is largely outweighed in magnitude by differences in net lifetime transfers, notably in the size (contribution rate) of the pension schemes.

Robustness checks have then been performed, based on which the previous risk-insurance results turn out to be *qualitatively* robust with respect to the main preference parameters considered in the model. In particular, the results for $CV_{OldNewBBEqualized}$ (expressing the risk-insurance comparison between the old and the new scheme) and $CV_{NewFlatBBEqualized}$ (expressing the risk-insurance comparison between the new scheme and a hypothetical flat-rate system) preserve the negative sign for “reasonable” values of the subjective time discount factor β (i.e. ranging from 0.89 to 1.1), as well

²⁸When performing simulations, pension benefits are grouped into three equally-spaced discrete levels (“low”, “middle”, “high”), that are kept the same across the two scenarios. Under the new system with the individual retiring at 50 the ex-ante probability of ending up in the low benefit level is 0.015, in the mean benefit level 0.97, in the high benefit level 0.015. Under the hypothetical flat-rate scheme, the ex-ante probability of ending up with the mean value (i.e. the unique fixed benefit value) is 1 by definition, whereas the ex-ante probability of ending up in both the low pension level and the high pension level is 0. In this sense, “complete” risk insurance results from such a flat-rate system.

as particularly for a wide range of values taken on by the reciprocal of the intratemporal elasticity of substitution σ (any value until 2.2, namely both above and below the threshold of 1 between intratemporal substitutability and complementarity). The above risk-related results are also robust to different specifications of the underlying structure of both the leisure preference parameter γ and the productivity profile. Notably, in case the leisure preference parameter is assumed to be constant (equal to 1 in every life-time period), and a hypothetical hump-shaped productivity profile is assumed (accounting for decreasing utility from labor to older workers), both $CV_{OldNewBBEqualized}$ and $CV_{NewFlatBBEqualized}$ are *qualitatively unchanged*.²⁹ Under those hypotheses, they would indeed maintain negative sign, with the former becoming -0.00007 (from the baseline value -0.00002), and the latter becoming -0.000006 (from the baseline value -0.000002).

3.3.2 Introduction of Social Security

Further analysis is performed in order to assess the welfare consequences from introducing a social security system in the Italian setting. The main results regarding the introduction of social security (old and new regime) in the Italian economy, with respect to the absence of social security (*NoSS*), are summarized in Table 3.4.

	Value
$CV_{NoSS / Old}$	4.85
$CV_{NoSS / New}$	6.553
h_{Old}^*	0
h_{New}^*	0

Table 3.4: Introduction of social security

It is noteworthy to point out firstly that under the statutory (financially) unconstrained social security setting, both the old and the new system would

²⁹In the baseline scenario, γ_t is constantly equal to 1 until a certain period \tilde{t} , and thereafter it increases through time as inversely proportional to survival probabilities (ψ_t). The baseline (cohort-specific) dynamics of real wages hinges on a steadily increasing profile through time at a constant yearly rate equal to $sw = 2\%$. A hypothetical hump-shaped (cohort-specific) productivity profile can be obtained by combining the baseline time-increasing profile with time-decreasing (quadratic) survival probabilities (deemed as proxies for health conditions). The resulting hump-shaped productivity profile, denoted by $Prod(t)$, reaches a peak at around 60, and its formula in every period t is as follows: $Prod(t) = [(1 + sw)^{(t-1)}] \cdot [\psi_t^2]$

cause within-period social security budget deficits.³⁰ Under the statutory old system the simulated within-period social security deficit amounts to 14.635 times the wage earned in the first period. The within-period budget deficit under the statutory new system turns out to equal 3.691 times the wage earned in the first period.³¹ The occurrence of budget deficits under all pension regimes, as well as the improvement of social security financial sustainability (through the projected reduction in deficits) under the new system, are in line with the literature on Italian pension reforms (e.g. Cardarelli and Sartor, 2000).³²

Comparisons from an ex-ante welfare perspective are then carried out between the model economy respectively in the absence and in the presence of statutory social security schemes, by assuming balanced-budget constraints under both the old and the new regime (consistently with the steady-state nature of the model). The resulting Compensating Variation, denoted by $CV_{NoSSOldBB}$ (respectively $CV_{NoSSNewBB}$), to be given to the representative individual passing from a setting with no social security to a setting with the balanced old (respectively the balanced new) scheme amounts to 4.85 (respectively 6.553). This implies that overall the introduction of a balanced social security scheme (both of the old DB and the new NDC type) in the Italian simulated setting turns out to decrease individual welfare. The main reason why the introduction of social security turns out to decrease individual welfare is the above argued fact that the social security “asset” yields a lower implicit return than the average return on financial assets.³³ Consequently,

³⁰Each deficit measure is computed as the average value across all 1000 simulations. Although the analysis focuses on one representative individual belonging to one representative generation, the budget deficit can be simulated by considering, in every period, the coeval existence of other generations (overlapping and equal to each other) of different ages paying in contributions (if workers) or receiving pension benefits (if retirees).

³¹Equivalently, budget deficit under the old and new system is respectively equal to 13.871 and 3.714 times the average level of the (per-period) pension benefit in the economy.

³²In case comparisons are carried out between the old and the new Italian pension system by assuming budget imbalance is allowed, the resulting compensating variation to be given to the representative individual undergoing a shift from the old to the new scheme would amount to 2.064. This value is greater than the corresponding CV under the balanced-budget hypothesis ($CV_{OldNewBB} = 1.846$, as reported in Table 3.3), implying a greater loss to individuals under the new scheme. This is due to the considerably bigger budget deficit that is run under the old scheme, leading to a greater generosity towards retirees who (assumedly) are not required to pay for the deficit.

³³An additional reason for social security being welfare-decreasing in the model is related to the fact that the contribution rate (h) is constant over the whole working life. Following Hurst and Willen (2007), welfare losses could be mitigated in case workers were exempted from social security contributions when young and were required to pay higher contributions later in working life so as to leave the net present value of contributions

it also holds that the higher the size of the mandatory contribution rate h (i.e. under the new scheme with respect to the old scheme), the greater the welfare loss to individuals.

The welfare loss from introducing a social security system with statutory contribution rates (24% or 33%) is qualitatively confirmed by the analysis of the optimal *size* of the system, represented by the value of the contribution rate (denoted as h^*) which maximizes individuals' welfare (in ex-ante terms) while satisfying social security budget-balance condition. In the model the optimal size of the contribution rate (thus, of social security) turns out to be zero under both the old (h_{Old}^*) and the new (h_{New}^*) regime.³⁴ The absence of social security is thus preferred to a government-run system of either type.

These results further suggest the prevalence of transfer variations over risk-insurance effects in determining individual welfare changes. The welfare loss from introducing a social security system as well as the zero optimal size of the balanced pension schemes suggest indeed that differences in net lifetime transfers, particularly in the contribution rate (representing the size of the pension asset in which individuals are forced to invest, thus negatively affecting individual welfare), are the leading factors that outweigh risk-insurance effects in driving welfare variations.

Nonetheless risk insurance, however relatively small in magnitude, is certainly provided by social security in the model. This general effect can be ideally grouped into three types. The first one is the previously investigated wage-risk diversification, provided to a different extent depending on the length of the wage history entering the benefit formula. In addition to that, two other possible sources of risk insurance may result from social security in the model, in principle under both the old DB and the new NDC scheme. On the one hand, the provision of pension benefits in the form of annuities prevents the retired representative individual from undergoing the so-called "longevity risk", and from possibly leaving unintended bequests due to mortality risk. On the other hand, a pension system of either DB or NDC type potentially provides retirees with a hedge against financial market risk in the old age, by means of benefits being based on (past) wages. Generally government-operated pension schemes can indeed provide ex-ante risk "diversification" between wage risks (affecting wage-based pensions) and financial market risks (influencing returns on savings accumulated until retirement), since wages and market returns are estimated to be imperfectly correlated (almost uncorrelated in the model).

unchanged.

³⁴The grid used to try different values of h has a step of 0.1%.

3.4 Conclusions

The paper has investigated the welfare effects of social security in a setting marked by demographic and macroeconomic uncertainty under market incompleteness, with reference to the (stylized) Italian economy, mainly aiming at assessing and comparing risk-insurance properties under a typical DB scheme (like the old Italian pension regime) and a typical NDC scheme (like the new Italian pension regime). The analysis has been carried out by performing simulations on the life-cycle behavior of a representative individual belonging to a representative generation in steady state.

By applying the main features of the Italian pension system to the calibrated model representing the (stylized) Italian economy, it turns out that the new NDC regime slightly improves ex-ante welfare with respect to the old DB regime from a purely risk-insurance perspective. This effect is due to its capability of performing better wage-risk diversification as a longer wage history enters the benefit formula, thereby causing a reduction in the ex-ante variability of pensions. The introduction of a social security system (both of DB and NDC type) in the model economy is however shown to generally decrease ex-ante welfare of individuals, mainly due to the mandatory size of the contribution rate negatively affecting welfare, since the implicit return of the pension system is substantially lower than the average return on financial assets. Overall, risk-insurance effects of social security do not drive significant welfare gains, and are largely outweighed in magnitude by other welfare-variation components, notably by transfer effects.

Future steps may involve performing detailed robustness checks with respect to risk-related parameters (for instance, the variance of wages), in order to better evaluate risk-insurance properties of alternative social security schemes. Future research will investigate more in depth the main findings of the paper, particularly by analyzing the *intra-generational* risk-insurance and redistribution properties of the Italian pension system. Such analysis will introduce additional sources of uncertainty, through extending the model so as to consider heterogeneous agents belonging to different income groups and stochastic intra-generational social mobility.

3.5 Appendix

3.5.1 Data and Methodology

Stochastic processes for real market returns and wages have been estimated by considering available historical series for Italy over the period 1990-2004. The reason why a relatively short time span is considered is that for period 1990-2004 almost all needed data are available. In order to obtain better estimates from an econometric point of view, data have been taken at a quarterly frequency, so as to work on 60 observations instead of 15.

As for data sources, data on wages have been found in the OECD (2008) data set, with “Compensation per employee in total economy” being the OECD entry that has been utilized, since it is a measure of gross wages in the overall economy (comprising both public and private sector). Average market returns are computed as the weighted average of historical returns on three major financial assets held by Italian households: government bonds, corporate bonds issued by Italian banks, and listed shares issued by Italian companies.

Returns on government bonds have been computed as the non-weighted average yield on two main types of Italian government bonds, namely short-term bonds (BOT - Italian T-bills) and medium-to-long-term bonds (BTP - Italian T-bonds). As for returns on BOTs the source is the “Ministero dell’Economia” web site, providing BOT returns at issue. As regards BTPs return, the Bank of Italy “Rendistato” yield is utilized, since it reflects the average market performance of BTPs traded on the Electronic Bond and Government Securities Market (MOT) of the Italian Stock Exchange.

Returns on corporate bonds issued by banks constitute the great majority of all Italian corporate bonds. Their return is reported by the Bank of Italy “Rendiob” yield, reflecting the average market performance of corporate bonds issued by banks and traded on the Electronic Bond and Government Securities Market (MOT) of the Italian Stock Exchange. The “Rendiob” index is available only from the end of the 1980s to 2004.

As for stocks, average returns on listed shares have been computed using the COMIT Performance - Total Return index, which includes total returns (both prices and dividends) of all shares listed on the Stock Electronic Market (MTA) of the Italian Stock Exchange.

All of the three above mentioned types of returns have then been weighted considering the yearly portfolio composition of Italian households reported by the Bank of Italy (2007), referring to the period 1995 through 2006. Weights are computed as percentages of “Italian government bonds”, “Italian corporate bonds issued by banks” and “listed shares issued by residents” in a

simplified portfolio held by Italian households, namely a portfolio made up of only those three categories of securities. In the absence of data on portfolio composition relative to the 1990-1994 period, weights for returns in those years have been assumed to be the same as those in year 1995. Moreover, when considering observations at a quarterly frequency, the yearly weights are assumed to be the same throughout all quarters of every year.

All collected wages and financial market returns have been finally expressed in real terms by correcting them for historical inflation growth rates, reported in OECD (2008), so as to obtain the values based on which estimates for w_t and r_t in the model have been carried out.

Data used to compute the aggregate growth rate (g) of real wages in Italy in different historical periods have been found in OECD (2008) data source. The average yearly "seniority" wage growth rate sw has been computed as the difference between two terms: the approximate yearly average growth rate of real wages earned by a specific cohort from 1976 to 2004 (Italian workers entering the labor market in 1976 when 21/22 years old); minus the average yearly aggregate growth rate of wages in Italy throughout the period 1976-2004. Computing this difference is aimed at obtaining a cohort-specific measure of "seniority" wage growth. This measure is then assumed to stay constant through time, and through generations, in the model. Data on aggregate wages have been collected from OECD (2008) data base; data on the wage dynamics of the cohort that entered the labor market in 1976 have been deduced by a rough analysis of data reported by Rosolia and Torrini (2007).

Data on social security contribution rates (h) have been found at INPS (National Institute of social security) web site. Estimates on the actual replacement rate under the old Italian pension system are reported in OECD (2007).

All demographic data and projections are provided by the yearly demographic balance of Istat (National Institute of Statistics) web site.

3.5.2 Optimization Problem and Simulation Procedure

The model solution is based on optimization following finite-horizon stochastic dynamic programming. Since an analytical solution to the optimization problem can not be obtained, simulations have been run in order to solve the problem numerically. These simulations have been performed by utilizing the numerical simulation software program Matlab.

In order to take into account the fact that wages (w) and market returns (r) are stochastic variables, a randomization has been performed by letting the software program randomly draw 1000 values for w_t and r_t in every period

t . Consequently, 1000 optimal assets (thus consumption) and leisure paths have been obtained, as well as 1000 pension benefit levels. The values of these variables reported in the paper have been obtained by averaging out across the 1000 trials in every period.

Wages and market returns in the model have been discretized into three states (“low”, “mean” and “high”) each, in order to numerically solve the optimization problem.³⁵ Stochastic processes for wages and financial market returns (autoregressive and serially uncorrelated, respectively) have been approximated by Markov chains through the Tauchen procedure (Tauchen, 1986) so as to be discretized.³⁶ This procedure yields stationary transition matrices for both wages and market returns, representing the conditional probabilities of passing from one state in a given period t to another state in the subsequent period $t + 1$.

The (slight) correlation between the stochastic component of wages and market returns is considered in the procedure, by computing transition probabilities for financial returns that are conditional on the three discrete stochastic realizations of wages. The resulting transition matrices, reported below, are the PW matrix for wages and the nine PR_{ij} transition matrices for market returns conditional on realizations of the $i - th$ grid value for w at time $t - 1$ and the $j - th$ grid value for w at time t .

$$PW = \begin{bmatrix} 0.6479 & 0.3507 & 0.0014 \\ 0.0953 & 0.8094 & 0.0953 \\ 0.0014 & 0.3507 & 0.6480 \end{bmatrix}$$

$$PR11 = \begin{bmatrix} 0.2438 & 0.6604 & 0.0958 \\ 0.2438 & 0.6604 & 0.0958 \\ 0.2438 & 0.6604 & 0.0958 \end{bmatrix}$$

$$PR12 = \begin{bmatrix} 0.0598 & 0.6116 & 0.3286 \\ 0.0598 & 0.6116 & 0.3286 \\ 0.0598 & 0.6116 & 0.3286 \end{bmatrix}$$

$$PR13 = \begin{bmatrix} 0.0078 & 0.3300 & 0.6622 \\ 0.0078 & 0.3300 & 0.6622 \\ 0.0078 & 0.3300 & 0.6622 \end{bmatrix}$$

³⁵Like wages, pension benefits have been accordingly discretized into three possible states (“low”, “mean” and “high”) in order to run simulations.

³⁶Markov-chain approximation has been applied also to financial returns, although they do not follow a Markov chain since they turn out to be serially uncorrelated from estimations.

$$\begin{aligned}
PR21 &= \begin{bmatrix} 0.4452 & 0.5235 & 0.0313 \\ 0.4452 & 0.5235 & 0.0313 \\ 0.4452 & 0.5235 & 0.0313 \end{bmatrix} \\
PR22 &= \begin{bmatrix} 0.1587 & 0.6827 & 0.1587 \\ 0.1587 & 0.6827 & 0.1587 \\ 0.1587 & 0.6827 & 0.1587 \end{bmatrix} \\
PR23 &= \begin{bmatrix} 0.0313 & 0.5235 & 0.4452 \\ 0.0313 & 0.5235 & 0.4452 \\ 0.0313 & 0.5235 & 0.4452 \end{bmatrix} \\
PR31 &= \begin{bmatrix} 0.6622 & 0.3300 & 0.0078 \\ 0.6622 & 0.3300 & 0.0078 \\ 0.6622 & 0.3300 & 0.0078 \end{bmatrix} \\
PR32 &= \begin{bmatrix} 0.3286 & 0.6116 & 0.0598 \\ 0.3286 & 0.6116 & 0.0598 \\ 0.3286 & 0.6116 & 0.0598 \end{bmatrix} \\
PR33 &= \begin{bmatrix} 0.0958 & 0.6604 & 0.2438 \\ 0.0958 & 0.6604 & 0.2438 \\ 0.0958 & 0.6604 & 0.2438 \end{bmatrix}
\end{aligned}$$

In numerically solving the optimization problem the choice variables for the individual in every period t are represented by leisure (l_t) and asset holdings at the beginning of the next period (A_{t+1}). The assets variable has been discretized into a triple exponential grid of points representing different values for asset holdings of individuals. The number of grid points is 40, with the minimum grid value for assets being 0 (individuals cannot borrow in the model economy), and the maximum grid value being 500.

In most simulations within-period time endowment (\bar{T}) has been normalized to 2. This normalization of the per-period time endowment to two units turns out to be useful in calibrating the model for computational reasons. Within-period leisure in the model, l_t , has been discretized so as to take on 10 possible grid values, exponentially spaced from zero to (mostly) 2. In the baseline calibrated model individuals choose to work approximately 1 unit of time (enjoying 1 time unit of leisure) during working life, whereas they enjoy the whole time endowment after retirement.

Since all variables are discretized in order to solve the optimization problem, the corresponding simulated paths for consumption, assets and leisure are obtained by interpolating (through the *spline* method) across the discrete values resulting from the optimization.

3.6 References

Ball, L. and N.G. Mankiw (2007), “Intergenerational Risk Sharing in the Spirit of Arrow, Debreu, and Rawls, with Applications to Social Security Design”, *Journal of Political Economy* **115**, 523-547.

Bank of Italy (2007), Household Wealth in Italy 1995-2005 - Supplements to the Statistical Bulletin, <http://www.bancaditalia.it/statistiche/>

Barr, N. and P.A. Diamond (2006), “The Economics of Pensions”, *Oxford Review of Economic Policy* **22(1)**, 15-39.

Battistin, E., A. Brugiavini, E. Rettore and G. Weber (2009), “The Retirement Consumption Puzzle: Evidence from a Regression Discontinuity Approach”, *American Economic Review* **99(5)**, 2209-2226.

Campbell, J.Y. and Y. Nosbusch (2007), “Intergenerational Risksharing and Equilibrium Asset Prices”, *Journal of Monetary Economics* **54**, 2251-2268.

Cardarelli, R. and N. Sartor (2000), “Generational Accounting for Italy”, in Bank of Italy, eds., *Fiscal Sustainability*, Rome, 501-557.

Enders, W. and H.E. Lapan (1982), “Social Security Taxation and Intergenerational Risk Sharing”, *International Economic Review* **23**, 647-658.

Fehr, H., L.J. Kotlikoff and W. Leibfritz (1999), “Generational Accounting in General Equilibrium”, in A.J. Auerbach, L.J. Kotlikoff and W. Leibfritz, eds., *Generational Accounting around the World*, NBER Books, Cambridge MA, 43-72.

Fonseca, R. and T. Sopraseuth (2005), “Welfare Effects of Social Security Reforms Across Europe: the Case of France and Italy”, Working paper, Centre for Studies in Economics and Finance, Salerno, Italy.

Friedman, B.M. and M.J. Warshawsky (1990), “The Cost of Annuities: Implications for Saving Behavior and Bequests”, *The Quarterly Journal of Economics* **105(1)**, 135-154.

Fuster, L., A. Imrohoroglu and S. Imrohoroglu (2007), “Elimination of Social Security in a Dynastic Framework”, *Review of Economic Studies* **74(1)**, 113-145.

Gottardi, P. and F.E. Kubler (2009), “Social Security and Risk Sharing”, Working paper, European University Institute, Florence, Italy.

Guazzarotti, G. and P. Tommasino (2008), “The Annuity Market in an Evolving Pension System: Lessons from Italy”, Working paper, Center for Research on Pensions and Welfare Policies, Turin, Italy.

Hurst, E. and P. Willen (2007), “Social security and unsecured debt”, *Journal of Public Economics* **91(7-8)**, 1273-1297.

Imrohoroglu, A., S. Imrohoroglu and D.H. Joines (1995), “A Life Cycle Analysis of Social Security”, *Economic Theory* **6(1)**, 83-114.

Imrohoroglu, A., S. Imrohoroglu and D.H. Joines (1999), "Social Security in an Overlapping Generations Economy with Land", *Review of Economic Dynamics* **2(3)**, 638-665.

Imrohoroglu, A., S. Imrohoroglu and D.H. Joines (2003), "Time-Inconsistent Preferences And Social Security", *The Quarterly Journal of Economics* **118(2)**, 745-784.

Krueger, D. and F.E. Kubler (2006), "Pareto Improving Social Security Reform when Financial Markets are Incomplete!?", *American Economic Review* **96(3)**, 737-755.

Merton, R.C. (1983), "On the role of Social Security as a means for efficient risk sharing in an economy where human capital is not tradeable", in Z. Bodie and J.B. Shoven, eds., *Financial Aspects of the United States Pension System*, The University of Chicago Press, Chicago, 325-358.

Miniaci, R., C. Monfardini and G. Weber (2010), "How does consumption change upon retirement?", *Empirical Economics* **38(2)**, 257-280.

Nishiyama, S. and K. Smetters (2008), "The Optimal Design of Social Security Benefits", Working Paper, Michigan Retirement Research Center, University of Michigan, Ann Arbor, MI.

OECD (2007), Pensions at a Glance: Public Policies across OECD Countries - 2007 Edition, <http://lysander.sourceoecd.org>

OECD (2008), OECD Economic Outlook: Annual and quarterly data Vol 2008 Issue 1, <http://puck.sourceoecd.org>

Rosolia A. and R. Torrini (2007), "The Generation Gap: Relative Earnings of Young and Old Workers in Italy", Working paper, Bank of Italy, Rome.

Sartor, N. (2001), "The Long-Run Effects of the Italian Pension Reforms", *International Tax and Public Finance* **8(1)**, 83-111.

Tauchen, G. (1986), "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions", *Economic Letters* **20**, 177-181.

Ventura, L. (2003), "Direct Measures of Time Preference", *Economic and Social Review* **34(3)**, 293-310.

Chapter 4

Social Security Reforms with Intra-generational Social Mobility

Devis Geron
Department of Economics, University of Padova

Luciano Greco
Department of Economics, University of Padova

Abstract

The paper aims at assessing the risk-insurance and redistribution properties of typical Defined Benefit (DB) and Notional Defined Contribution (NDC) schemes in the light of the major Italian pension reforms, by simulating life-cycle behaviors of heterogeneous agents belonging to different income classes. The model considers a partial equilibrium setting with mortality risk, uncertainty on factor returns and stochastic intra-generational social mobility. Quite surprisingly, the old DB system (providing pension benefits based on the last wages before retirement) Pareto-dominates the new NDC system (providing pension benefits based on all working-life contributions) from a risk-insurance perspective. This result is due to the new scheme substantially increasing lifetime uncertainty individuals are confronted with. Overall, social security turns out to be desirable only for individuals whose income conditions worsen during working life.

4.1 Introduction

Unfunded (or Pay-As-You-Go - PAYG) social security schemes, due to their financing mechanism, necessarily involve intergenerational risk insurance (*ex-post* redistribution), in that the working “young” cohorts finance pension benefits of the retired “old” ones. Such pension schemes have traditionally been designed to carry out also *intra*-generational risk insurance (*ex-post* redistribution) across individuals belonging to the same cohort. More generally, social security may provide individuals with a tool for (partial) insurance of income risk, thus offering an efficiency argument in favor of social security. This paper aims at evaluating the risk-insurance properties of typical Defined Benefit (DB) and Notional Defined Contribution (NDC) schemes, by assessing the welfare effects of the major Italian pension reforms introduced in the 1990s, in a setting where heterogeneous individuals belong to different social classes, and face both stochastic within-class labor income fluctuations and stochastic shifts from one class to another during working life.

Even when explicitly designed to provide intra-generational risk insurance, many real-world PAYG systems are less progressive than expected, and in some cases they may even be considered not progressive at all (Lindbeck and Persson, 2003).¹ In particular, the Italian social security system has been historically affected by a tendency towards partial redistribution from individuals belonging to lower social classes in favor of same-age individuals belonging to upper social classes. This is due to the positive relation between labor income and life expectancy, and more generally health conditions (Costa, Leombruni and Richiardi, 2008). The Italian (“old”) social security system was a PAYG DB system until the early 1990s, wherein pension benefits were based on the average wage over the last 5 working years before retirement. Two major reforms (in 1992 and in 1995) turned the system into a (“new”) PAYG Notional Defined Contribution (NDC) one, where pension benefits are actuarially determined based on all working-life contributions. In general the shift from the previous DB to the current NDC system in Italy may well favor high-income individuals, since the dismissed old DB system had some progressivity elements, notably a statutory replacement rate slightly decreasing in labor income (OECD, 2007).² The new NDC

¹For instance, Feldstein and Liebman (2001) stress the fact that progressivity - if any - of the US social security system seems to be considerably less than expected. A low degree of progressivity can be generally determined by a demographic fact that is common to many countries: high-income individuals tend to live longer than low-income ones, and thus relatively gain from social security. Moreover, many PAYG DB systems have traditionally paid benefits based on the last working-life wages, thus favoring steeper wage profiles typical of highly educated and richer individuals (Lindbeck and Persson, 2003).

²Fonseca and Sopraseuth (2005) claim that the new NDC system is more likely to

system may however in some respects potentially reduce intra-generational inequality, since the old system had also some “unequal” features, notably a benefit formula (pension based on the last wages) favoring steeper earning profiles and thus typically high-income social classes (Borella, 2001).

A strand of the literature on the impact of social security reforms deals with idiosyncratic rather than aggregate uncertainty. Analysis of individual fluctuations in income and wealth dates back at least to the 1980s (e.g. Bewley, 1986), and generally focuses on consequences of such fluctuations for individual decisions (e.g. precautionary saving decisions) and welfare. While aggregate risk is intrinsically undiversifiable, idiosyncratic shocks in principle could be diversified if complete insurance markets existed (Aiyagari, 1994). In reality, however, wage shocks are hardly insurable in the market. There is therefore scope for government-administered social security systems to introduce some kind of intra-generational risk sharing in economies where heterogeneous agents are confronted with idiosyncratic (earnings) shocks. The literature in this field has essentially focused on assessing the relative importance of intra-generational risk insurance provided by progressive social security systems, against their drawbacks mainly derived from distortions on individual behavior. Such analysis aims at evaluating the relative convenience of unfunded social security with respect to a fully funded system (Conesa and Krueger, 1999; Fuster, Imrohoroglu and Imrohoroglu, 2007; Nishiyama and Smetters, 2007); of unfunded social security with respect to a mixed system partly actuarially fair and partly redistributive (Huggett and Ventura, 1999) or to a mixed system partially unfunded and partially fully funded (Storesletten, Telmer and Yaron, 1999); of an unfunded purely Bismarck-type pension scheme with respect to more progressive schemes (Fehr and Habermann, 2008). The last issue, regarding the desirability of Bismarck-type as opposed to redistributive Beveridge-type pension schemes (namely, the desirability of schemes providing benefits that are more or less correlated to individual wages), has been also tackled by a political-economy strand of literature. Within this strand, the degree of progressivity (namely, the tightness of the link between pensions and past wages) is determined as the outcome of voting by different income classes (Conde-Ruiz and Profeta, 2004; Conde-Ruiz and Profeta, 2007; Koethenbueger, Poutvaara and Profeta, 2008).

Other works in the literature have analyzed the risk-insurance properties of social security specifically in the light of the correlation between human capital (basically, wages received by the individual during working-life) and

harm low skilled self-employed, as they are characterized by lower earning profiles and pay contributions at a lower rate (20% instead of 33% for employees). The analysis performed in our paper only considers employees, since social groups are defined by labor income levels.

social security (pension benefits received by the individual after retirement), and in the light of the variability of wages. Notably, Baxter (2001) points out that the higher the correlation between an individual's human capital and social security (and thus the riskiness the individual faces), the greater the convenience to shift contributions from social security to financial assets. McCarthy (2003) claims that workers would be better off by investing in a wage-based DB social security scheme when approaching retirement, as most wage variability has been resolved (so that the riskiness of pension benefits decreases) and the risk diversification with respect to financial assets becomes more valuable. Finally, Nishiyama and Smetters (2008) point out that DB social security schemes can generally provide some insurance against negative individual income shocks, even in case the system is not explicitly progressive, as the benefit formula pools a series of individual risky wages.³

Building on the above contributions, the main goal of this paper is to evaluate and compare the risk-insurance properties of a typical DB scheme providing pension benefits based on the last working-life wages on the one hand, and a typical NDC scheme providing pension benefits based on all working-life contributions (thus wages) on the other hand, in the light of the correlation between wages ("human capital") and pensions. The comparison therefore is not between an unfunded pension system and a fully funded (or mixed) one, rather between two different schemes within a PAYG social security system. The analysis simulates life-cycle behaviors of heterogeneous agents belonging to different social (i.e. labor income) classes within a representative generation in steady state, facing uncertainty on class-specific wages and aggregate financial market returns, and undergoing stochastic intra-generational social mobility during working life.

By applying the main features of the Italian pension system to a partial equilibrium model calibrated to represent the stylized Italian economy, the paper compares the old DB pension system and the new NDC system introduced in the mid 1990s,⁴ based on welfare measures from an "ex-ante" perspective (hereafter defined as the perspective at the beginning of life-

³In considering a single representative (average) individual within a model reproducing the Italian setting, Geron (2010) finds out that the new NDC regime is ex-ante welfare-improving from a purely risk-insurance perspective, due to its "wage-risk diversification" properties, namely due to its benefit formula pooling a longer series of wages and therefore reducing the variance of (wage-based) pension benefits.

⁴By comparing the old DB and the new NDC system, the paper adopts the definitional and comparative approach followed by Cardarelli and Sartor (2000). In analyzing the long-term financial sustainability of the Italian pension system from a Generational Accounting perspective which does not consider any uncertainty issues, the authors distinguish indeed between the old regime and the new regime, denoting respectively the system before the 1992 Amato reform and the system after the 1995 Dini reform.

time, before social-class mobility occurs) and from an “ex-interim” perspective (hereafter defined as the perspective at approximately halfway in working life, after social-class mobility has occurred).⁵ When assuming away differences in net lifetime transfers across regimes, namely from a purely risk-insurance perspective, the new regime on the one hand turns out to slightly increase *ex-interim* welfare for all social classes because it reduces the variance of prospective pension benefits; on the other hand, it substantially decreases *ex-ante* welfare for all classes because it augments the degree of riskiness faced by individuals over their whole lifetime. Since the new regime provides pension benefits that are based on the whole working-life history, while it causes a better diversification over a longer series of individual risky wages, it also results in a higher correlation between pensions and working-life wages (“human capital”), as compared to the old regime. The former effect prevails from an ex-interim perspective (after stochastic social mobility has occurred) thus yielding a welfare gain; whereas the latter effect dominates from an ex-ante perspective (as all uncertainty on human capital is still unresolved), thereby causing a welfare loss.⁶

The paper also analyzes whether social security can actually improve individual welfare (notably, by providing risk insurance) in the presence of macroeconomic and demographic risks under market incompleteness. The introduction of a budget-balanced social security system reproducing both the old DB and the new NDC Italian pension scheme is shown to decrease *ex-ante* welfare of individuals belonging to all social classes. From an *ex-interim* perspective, only individuals shifting to a lower labor-income class enjoy a (relatively small) welfare improvement from the introduction of social security under both schemes. Social security may thus act as an “insurance” tool for individuals experiencing a worsening of their social conditions during

⁵Italy is therefore considered since pension reforms in the 1990s make it an appropriate case study, as far as the focus is on comparing DB and NDC schemes.

⁶When considering a single representative (average) individual in a comparable macroeconomic and institutional setting, the new NDC regime proves welfare-improving also from an *ex-ante* perspective due to better “wage-risk diversification” (Geron, 2010). However when considering different individuals heterogeneous in their labor income, uncertainty during working life considerably augments basically due to stochastic social-class shifts, as shown in this paper. Consequently, the new pension system ex-ante substantially increases the *overall* lifetime uncertainty faced by individuals, through providing pension benefits that are correlated to all working-life riskiness. The (negative) welfare effects from this higher wage-benefit correlation ex-ante outweigh the (positive) welfare effects from wage-risk diversification. Conversely, from an ex-interim perspective, namely as the variability due to the stochastic social class shift is resolved (and thus the bulk of working-life riskiness is revealed), the wage-risk diversification effect prevails over the correlation between wages and pensions, resulting in a welfare gain.

working life, although the magnitude of these implicit redistributive effect is relatively small.

The paper is organized as follows. Section 2 describes the model and the institutional framework. Section 3 shows the calibration and outlines the simulation method. Section 4 presents the main findings from the policy experiments, and Section 5 concludes. Finally, an Appendix provides more technical details on the calibration and the simulation method.

4.2 Analytic Framework

4.2.1 Model

The partial equilibrium model considers a discrete time setting (every period t corresponds to one year in real life) representing an economy where both wages and market returns are completely determined by foreign markets.⁷ The economy is thus affected by two main sources of macroeconomic uncertainty, partially correlated, wages (w_t) and market returns (r_t). The model takes into account yearly wage growth at the aggregate level (growth rate g) and at the cohort-specific level (average seniority growth rate sw), both assumed to be constant and to enter the model as exogenous deterministic trends.

The economy is populated by 3 social groups (classes) differing in their labor income level. Total population mass grows at a deterministic constant rate m from every period to the next. Each generation consists of heterogeneous individuals earning “low”, “middle” or “high” labor income in each period during working life. Every individual of a given generation enters the economy belonging to a (low, middle or high) labor income class, and will stochastically either belong to the same class or pass to another class at a certain time during working life, according to given transition probabilities. Individuals belonging to each class earn stochastic wages, denoted respectively as $w_{t,L}$, $w_{t,M}$ and $w_{t,H}$ for “low”, “middle” and “high” income class. These class-specific stochastic wages grow at different deterministic seniority

⁷Italy can be approximately regarded as a small open economy worldwide and, by further approximation, within the European Union. The paper assumes that real returns and wages are determined by European capital and labor markets. This assumption is quite realistic as regards interest rates. As for wages, although the European labor market is not integrated, the high-level integration in the European markets of goods can be thought of as influencing the determination of Italian real wages through the prices of tradable goods, in the wake of the Stolper-Samuelson theorem, provided that markets are competitive.

rates (respectively sw_L , sw_M and sw_H), and are only partially correlated with each other.

The economy is considered in steady state, therefore representative agents belonging to one given representative generation are considered in the paper.

Let us denote by j the (low, middle or high) labor income class with $j = L, M, H$, and by $w_{t,j}$ the stochastic wage earned per time unit worked in every working-life period t . Each wage $w_{t,L}$, $w_{t,M}$ and $w_{t,H}$ is a stochastic variable, taking on different possible realized values. Individuals live in the economy from age 1 to at most T years. They start their working life at $t = 1$ belonging to a given initial class, denoted by j_I (low, middle or high), and earn a wage w_{t,j_I} (respectively $w_{t,L}$, $w_{t,M}$ or $w_{t,H}$) in each working period t until period t' . After t' individuals may shift to another class or remain in the same class, based on stochastic transition probabilities described by a Social Mobility matrix (SM). Individuals will remain in the new social class (the “final” class), denoted by j_F , earning a wage w_{t,j_F} , from time $t' + 1$ until they choose to retire at time t_{ret} .⁸ After retirement individuals receive pension benefits p_{t,j_I,j_F} , possibly depending on both initial-class and final-class labor income, based on the specific benefit formula. The described individual lifetime is reported in Figure 4.1. Moreover, in every period individuals earn capital income on their accumulated assets (government bonds, corporate bonds, stocks), based on a stochastic return r_t on savings corresponding to the average market return in the economy. All macroeconomic variables in the model are considered in real terms, and price-indexed pensions are constant in real terms.

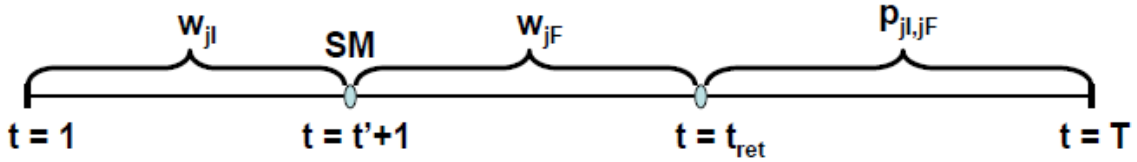


Figure 4.1: Stylized individual lifetime

Individuals aged t survive to age $t + 1$ with a given conditional survival probability. Conditional survival probabilities of every individual, denoted by $\psi_{t,j}$, vary according to both individuals' age (t) and the social class (j) they

⁸When entering their economic life at time 1 (i.e. from an “*ex-ante*” perspective), individuals only know the initial class they belong to. At time $t' + 1$ (i.e. from an “*ex-interim*” perspective) individuals also know the class to which they belong in the second part of their working life.

belong to, notably older and poorer individuals face on average lower survival probabilities. From time 1 to time t' individuals belonging to the initial class j_I face the corresponding class-specific conditional survival probabilities denoted by $\phi_{t,j}$. As individuals move to their final class at time $t' + 1$, thereafter individual survival probabilities depend both on probabilities of their initial class ϕ_{t,j_I} (to a lesser extent as age increases) and on probabilities of their final class ϕ_{t,j_F} (to a larger extent as age increases):

$$\begin{aligned}\psi_{t,j_I} &= \phi_{t,j_I} & \text{for } t = 1, \dots, t' \\ \psi_{t,j_F} &= \alpha_t \phi_{t,j_I} + (1 - \alpha_t) \phi_{t,j_F} & \text{for } t = t' + 1, \dots, T\end{aligned}$$

with α_t

- linearly decreasing from $\alpha_{t'} = 1$ to $\alpha_{t_{ret}} = \frac{t'}{t_{ret}-1}$ for $t = t', \dots, t_{ret}$
- constantly equal to $\frac{t'}{t_{ret}-1}$ for $t = t_{ret} + 1, \dots, T$

Namely, initial-class income (and living) conditions become less and less important in affecting individual survival probabilities throughout the second working-life period, and this effect is assumed to stabilize and remain constant after individuals choose to retire.

Representative individuals, belonging to social class j , maximize expected discounted lifetime utility with respect to within-period consumption (c_t), within-period leisure (l_t) and notably retirement age t_{ret} . Expected discounted lifetime utility at (just before) the beginning of life, i.e. at time $t = 0$, reads as follows:

$$E_0 \left[\sum_{t=1}^T \beta^{t-1} \left[\prod_{k=1}^t \psi_{k,j} \right] U_{t,j}(c_{t,j}, l_{t,j}) \right]$$

where $j = j_I$ from $t = 1$ to $t = t'$, and $j = j_F$ from $t = t' + 1$ to $t = T$; β is the subjective time discount factor; $\psi_{t,j}$ is the conditional survival probability from age $t - 1$ to age t for an individual belonging to social class j (with $j = L, M, H$), with $\psi_{1,L} = \psi_{1,M} = \psi_{1,H} = 1$.

The within-period utility function has the CES form:

$$U_{t,j}(c_t, l_t) = \frac{1}{1-\rho} (c_t^{1-\sigma} + \gamma_{t,j} l_t^{1-\sigma})^{\frac{1-\rho}{1-\sigma}} \quad \text{for } t = 1, \dots, T$$

where $\frac{1}{\rho}$ is the intertemporal elasticity of substitution between consumption of different years, $\frac{1}{\sigma}$ is the intratemporal elasticity of substitution between consumption and leisure, and $\gamma_{t,j}$ represents the time-varying leisure preference parameter. The leisure preference parameter is generally increasing over time and inversely proportional to individual survival probabilities

$(\psi_{t,j})$.⁹ Specifically, the leisure preference parameter is kept constant during the initial phase of lifetime, and increases after a given period (denoted by \tilde{t}) in lifetime:¹⁰

$$\begin{aligned}\gamma_{t,j} &= 1 && \text{for } t = 1, \dots, \tilde{t} \\ \gamma_{t,j} &= \left(\frac{1}{\psi_{t,j}} - \left(\frac{1}{\psi_{\tilde{t},j}} - 1\right)\right)^\theta && \text{for } t = \tilde{t} + 1, \dots, T\end{aligned}$$

In every period t individuals are provided with a given time endowment \bar{T} , and choose consumption c_t and labor supply $\bar{T} - l_t$. Individuals belonging to a given class j work and receive a wage $w_{t,j}$ for each unit of time spent working, namely a gross labor income $w_{t,j}(\bar{T} - l_t)$, at every age t (if alive), until retirement at age t_{ret} . While working, individuals pay social security contributions at a rate h out of their labor income. The only role of government in the model consists of running an unfunded social security system, consequently no other types of income taxation are considered. As individuals decide to retire at t_{ret} , labor supply falls to zero in all subsequent periods ($l_t = \bar{T}$), and they receive a pension benefit p_{t,j_I,j_F} at every age t (if alive) until death at T . The within-period budget constraint of a given individual belonging to social class j_I at every age t from $t = 1$ until t' , and shifting to class j_F from $t' + 1$ onwards therefore reads as follows:

$$A_{t+1} = A_t(1 + r_t) + (1 - h)w_{t,j_I}(1 + g)^{t-1}(1 + sw_{j_I})^{t-1}(\bar{T} - l_t) - c_t \quad \text{for } t = 1, \dots, t'$$

$$A_{t+1} = A_t(1 + r_t) + (1 - h)w_{t,j_F}(1 + g)^{t-1}(1 + sw_{j_F})^{t-1}(\bar{T} - l_t) - c_t \quad \text{for } t = t' + 1, \dots, t_{ret} - 1$$

$$A_{t+1} = A_t(1 + r_t) + p_{t,j_I,j_F} - c_t \quad \text{for } t = t_{ret}, \dots, T$$

where A_t represents the beginning-of-period asset holdings of the individual aged t . All agents are assumed to be borrowing constrained:

$$A_t \geq 0 \quad \text{for } t = 1, \dots, T$$

A further assumption is that there is no bequest motive, so that individuals do not leave any bequest in case they live until age T : $A_{T+1} = 0$. In case an individual dies before reaching age T , all accumulated assets (accidental bequests) are assumed to be destroyed and provide no utility to other

⁹Survival probabilities in the model are deemed as proxies for health conditions of individuals. As individuals become older, survival probabilities decline, reflecting worse health conditions. Moreover, at every age individuals with higher income face higher survival probabilities. Assuming that the leisure preference parameter is inversely proportional to survival probabilities therefore implies that utility from leisure, and disutility from work, plausibly increase as individuals grow older, and are higher (on average) for poorer individuals.

¹⁰This assumption allows having utility from leisure (disutility from work) constant when individuals are younger, and increasing with age as they grow older. This assumption implies that individuals in the model retire at reasonable ages also without social security.

individuals who are still alive.¹¹ In addition to individuals being borrowing constrained, the model has two other main sources of market incompleteness. Firstly, annuity markets are assumed to be missing, in line with what is generally claimed by the literature.¹² Secondly, class-specific labor income risks are uninsurable in the market.

4.2.2 The Italian Pension System

Before the introduction of the Amato reform (in the following, “old” regime) the Italian pension system was an unfunded Defined Benefit (DB) scheme, in which pensions were based on wages earned in the last five years of working life (only on last year’s wage for public sector employees). Individuals were allowed to retire after 35 years of work and contribution to social security (20 years for public sector employees), or alternatively when they reached 60 years (55 for females) with at least 15 years of contribution. Pension benefits were computed by applying to the average wage over the last five working years a “replacement rate” (denoted by RR) equal to the so-called “accrual rate” (denoted by $acrate$) multiplied by years of work and contribution. The accrual rate was equal to 2% for most (low and middle) income levels, up to a given income threshold beyond which it gradually decreased. The maximum possible replacement rate was equal to 80% (corresponding to 2% accrual rate for 40 years of work) for individuals working 40 years or more.¹³ The contribution rate under the old regime was equal to 24%. Denoting gross labor income in every period t , i.e. $w_{t,j}(1+g)^{t-1}(1+sw_j)^{t-1}(\bar{T}-l_t)$, as $W_{t,j}$, with j representing the income class ($j = j_F$ since normally $t_{ret} > t' + 5$), the old pension benefit formula (for a private-sector employee) can be represented as follows:

$$p_{Old} = RR \cdot \frac{\sum_{t=t_{ret}-5}^{t_{ret}-1} W_{t,j}}{5}$$

¹¹Assuming away unintended bequests in steady state greatly improves the computational manageability of the model. However, this assumption implies a restrictive condition, that is all agents in the economy start their (economic) life with the same amount of assets (i.e. no initial assets at all), regardless of their initial social class. Alternative assumptions regarding accidental bequests may involve redistributing unintended bequests to all or some of the surviving generations according to some criteria, e.g. in a lump-sum fashion or proportionally to wealth conditions of the survivors.

¹²This is particularly true of Italy, where the annuity market has a very small size (Guazzarotti and Tommasino, 2008). The absence of annuity markets in general implies in particular the absence of privately provided annuities yielding wage-based returns, that are instead typically publicly provided through PAYG Defined Benefit pension systems.

¹³According to the statutory accrual rate schedule before 1993, the $acrate$ schedule in the model is equal to 2% for agents with low and middle final income, and it is subdivided into three values 1.5%, 1.25%, 1%, for higher income bands.

$$RR = \begin{cases} (t_{ret} - 1) \cdot acrate & \text{for } t_{ret} - 1 \leq 40 \\ 0.8 & \text{for } t_{ret} - 1 > 40 \end{cases}$$

The 1992 Amato reform basically tightened the rules of the pension system through parametric variations, while keeping unchanged its Defined-Benefit nature. After the Amato reform pension benefits would be computed by applying the replacement rate (*acrate* multiplied by years of work and contribution) to the average of all wages earned throughout the entire working life. The contribution rate was raised at 27%.

The 1995 Dini reform changed the Italian pension system to a greater extent, by turning it from DB into Notional Defined Contribution (NDC). Under this “new” regime, pension benefits are determined based on social security contributions paid in during the whole working life, that are “notionally” (i.e. fictitiously) capitalized at a rate that is linked to the growth rate of the economy during working life (depending on the growth rate of productivity and population). The amount accumulated in this way at retirement is turned into annuities through multiplying it by annuity rates (“transformation coefficients”, denoted by *tc*). Dini reform allowed individuals to choose their retirement age from any age between 57 and 65 years (with a minimum required number of years of contribution). Annuity rates are constant across all income classes, vary according to the age at which an individual chooses to retire (the higher the retirement age, the greater the annuity rate, and the greater the pension benefit, *ceteris paribus*), and are periodically revised in order to account for changes in the (average) life expectancy of population. Individuals under the new regime may also choose to retire after 65: in this case the annuity rate (transformation coefficient) used in the benefit rule remains constant thereafter, and equal to the annuity rate applied in case of retirement at 65. The contribution rate, currently in force, was set at 33%. The new pension benefit formula (for a private-sector employee) can be represented as follows:

$$p_{New} = tc \cdot \left[\sum_{t=1}^{t_{ret}-1} (0.33) \cdot W_{t,j} \cdot [(1+g) \cdot (1+m)]^{t_{ret}-t} \right]$$

where $j = j_I$ from $t = 1$ to $t = t'$, and $j = j_F$ from $t = t' + 1$ to $t = t_{ret} - 1$, and where *tc* is increasing with retirement age from 0.047 when retiring at 57 (corresponding to $t_{ret} = 37$ in the model) to 0.061 when retiring at 65 or more (corresponding to $t_{ret} \geq 45$ in the model).¹⁴

¹⁴A transition period was set by law: whoever at the end of 1995 had contributed for more than 18 years, is not affected by Dini reform; for whomever entered the labor market after 1995, Dini reform fully applies; for those having contributed to social security for less than 18 years at the end of 1995, a mixed regime applies, with pension determined pro-rata (proportionally to time spent contributing before and after 1995).

The system introduced by the 1992 Amato reform is not considered in the following analysis. Because that regime provided pension benefits based on all working-life wages (within a DB scheme), from a risk-insurance perspective its properties are basically the same as those of the new regime introduced by the 1995 Dini reform, which provides pension benefits based on all working-life contributions and thus wages (within a NDC scheme).

4.3 Calibration and Optimization Problem

The exogenous parameters of the model are assigned specific values resulting from calibration aiming to replicate some stylized facts of the Italian economy, notably lifetime labor and consumption paths of individuals. The benchmark economy utilized in the calibration is the Italian economy under the old pension system (before the 1992 Amato reform), since the new system is still in a transition phase. While applying the main *statutory* features of the old regime, the average replacement rate across income classes used in the calibration (81.6%) approximately matches the *actual* average replacement rate enjoyed at retirement by individuals in Italy under the old system.¹⁵

The baseline calibration is characterized as follows (see Table 5.1). All representative individuals are assumed to enter the economy when 21 years old (reflecting the real average entry age in the labor market in Italy), that corresponds to the first lifetime period ($t = 1$) in the model. Agents entering the economy belong to an initial low, middle or high income class. Individuals initially belonging to the low, middle and high income class make up respectively 20%, 60% and 20% of the population, representing the lowest quintile, the second to fourth quintile and the highest quintile of the Italian income distribution.¹⁶ Assets held by all individuals of all classes at the beginning

¹⁵The actual average replacement rate was indeed above 80% (OECD, 2007). The Italian pension system in the past decades was particularly advantageous to pensioners, e.g. due to opportunities of early retirement, so that the actual replacement rate under the old scenario was higher than the one statutorily set.

¹⁶Social classes in the model are based on the subdivision of Italian households by deciles and quintiles of income, as reported by the Bank of Italy “Supplements to the Statistical Bulletin” from 1989 to 2006. The two lowest income deciles (the first quintile) constitute the “low” class in the model, deciles from the third to the eighth (second to fourth quintile) the “middle” class, the two highest deciles (the fifth quintile) the “high” class. Percentages 20%, 60% and 20% therefore represent the steady-state proportions of different social classes in the economy. Since available data consider deciles and quintiles of income, Italian households have not been grouped into classes of equal size (i.e. 1/3, 1/3, 1/3). As a consequence of the 1/5, 3/5, 1/5 distribution, better insights may emerge regarding the redistributive impacts of pension reforms on the poorest as well as on the richest individuals in society.

of their (economic) life are assumed to be equal to zero: $A_1 = 0$. During working life individuals are assumed to stochastically shift to the “final” social class j_F (different or equal to the initial class j_I) at $t = t' + 1 = 21$.¹⁷ Individuals stochastically move across social classes according to a social mobility matrix (SM), that is computed based on two-year transition matrices by deciles of income reported by the Bank of Italy “Supplements to the Statistical Bulletin” from 1989 to 2006. Since the transition period $t' + 1$ has been set at 21, SM (reported in Table 4.1) is a twenty-year social mobility matrix derived from the average (“stationary”) two-year transition matrix (see the Appendix for details), and representing the twenty-year transition probabilities for low-, middle- and high-income individuals from the initial class j_I to the final class j_F .

		j_F		
		L	M	H
j_I	L	0.2155	0.5988	0.1869
	M	0.1993	0.6009	0.2006
	H	0.1871	0.5999	0.2133

Table 4.1: Social mobility matrix SM

This shift is assumed to occur only once, for the sake of simplicity and without loss of generality.¹⁸

All individuals in the model live at most for $T = 80$ periods (corresponding to 100 years in real life), surviving from every period to the next with a certain (conditional) survival probability. Individuals belonging to different social classes face different conditional survival probabilities ($\phi_{t,L}$, $\phi_{t,M}$, $\phi_{t,H}$), estimated according to available evidence (Costa, Leombruni and Richiardi,

¹⁷Since the average observed working life spans approximately 40 years, the value for $t' + 1$ is chosen so as to be roughly halfway over the working life of individuals.

¹⁸This simplifying assumption serves for the sake of much easier computational manageability: considering one shift yields 9 final (“ex-interim”) individual types, whereas considering e.g. twenty shifts (every two years) during a 40-year working life would yield approximately 3.5 billion final types. The simplification causes no loss of generality for a few reasons. First, the twenty-year social mobility matrix SM incorporates all two-year transition matrices. Second, the social mobility matrix is assumed to be exogenous, uncorrelated with wage processes, and independent of endogenous labor effort. Third, from an ex-ante perspective what really matters (to the aims of the paper) is the essential feature of intra-generational social move, affecting the lifetime riskiness individuals are confronted with, irrespective of how many times such move may occur.

2008) on life expectancy of different social and income groups in Italy (see the Appendix for details). Population mass of the whole economy in every period is normalized to one, thus the yearly population growth rate (denoted by m) is equal to zero, in line with both recent demographic trends and demographic projections for Italy.¹⁹

Based on econometric analysis of Italian real wages and financial market returns of assets held by Italian households (see the Appendix for details) between 1990 and 2004, the model processes underlying real wages $w_{t,L}$, $w_{t,M}$ and $w_{t,H}$ and financial market returns r_t can be represented as follows:

$$\begin{aligned} w_{t,L} &= 52.5959 + 1.6251 \cdot w_{t-1,L} - 1.0573 \cdot w_{t-1,M} + 0.1155 \cdot w_{t-1,H} + \varepsilon_{t,L} \\ w_{t,M} &= 94.7884 + 0.8490 \cdot w_{t-1,L} - 0.3671 \cdot w_{t-1,M} + 0.0321 \cdot w_{t-1,H} + \varepsilon_{t,M} \\ w_{t,H} &= 155.5886 - 0.4432 \cdot w_{t-1,L} + 0.1204 \cdot w_{t-1,M} + 0.3547 \cdot w_{t-1,H} + \varepsilon_{t,H} \\ r_t &= 0.0656 + \varepsilon_t^r \end{aligned}$$

The deterministic yearly growth rate (denoted by g) of aggregate real wages is assumed to be zero. This is in line with the average yearly growth rate of aggregate real compensations per employee in Italy during the period 1990-2004, that was approximately equal to -0.04% (OECD, 2008). Considering a partial equilibrium model with constant deterministic (zero) growth of aggregate wages and population, the whole analysis throughout the paper will focus on steady state individuals of different social classes, all belonging to one single representative generation living from $t = 1$ to $t = T$. The only source of deterministic wage variation through time in the model is a cohort-specific component tracking changes in wages due to career dynamics, namely to seniority-driven (contractual) increases in wages. By approximation based on available data (OECD, 2008; Rosolia and Torrini, 2007), the average yearly “seniority” growth rate of real wages, denoted by sw , is set at the constant level 2% . The representative individuals belonging to the representative generation (cohort) considered in the model thus enjoy a deterministic growth of wages equalling 2% per period, *on average* across income classes. This aggregate value is then decomposed into three values for different social classes, based on different income dynamics of social groups (quintiles), reported by the Bank of Italy “Supplements to the Statistical Bulletin” from 1989 to 2006. The resulting seniority growth rates of real wages for “low” (sw_L), “middle” (sw_M) and “high” (sw_H) social class

¹⁹According to the demographic balance of the Italian National Institute of Statistics (Istat), the Italian population in the 1990-2004 period experienced an average yearly population growth rate equal to 0.15% , and demographic projections for the 2007-2051 period (under the “central” scenario) forecast an average yearly population growth rate close to zero (0.1%).

are respectively $sw_L = 0.0178$, $sw_M = 0.02$ and $sw_H = 0.0252$, implying steeper career dynamics for individuals with higher earnings.²⁰

Preference parameters are assumed to be the same for all individuals belonging to different social groups. The calibrated values assigned to the main preference parameters are in line with values commonly used in the literature.²¹ The time-profile of the leisure preference parameter γ_t resulting from values assigned to θ (90) and \tilde{t} (36) is such that on average individuals in the calibrated model are willing to retire at an age that matches the actual retirement age in the presence of social security.

Based on the reported parameter values, the calibrated model resulting from simulations reproduces the following stylized facts of the Italian economy, with reference to the *average* behaviors of individuals initially belonging to different social classes (respectively low, middle, high). The calibrated average lifetime consumption path increases in line with wage growth (at an average rate equal to $sw = 2\%$) during working life, and drops around retirement. The simulated average consumption drop²² at retirement under the *actual* old pension system in the model lies between 4% and 5%, and is comparable to the average drop empirically measured for Italy under the old regime (Battistin et al. 2009; Miniaci, Monfardini and Weber, 2010). Moreover, the calibration yields an average working-life labor supply profile that is (approximately) equal to the normalized value of 1 in each working-life period until retirement (t_{ret}), and constantly equal to zero after retirement.²³ In the calibrated model, the average retirement choice is $t_{ret} = 36$, corresponding to 56 years in real life. Individuals in the calibrated model under the *actual*

²⁰The per-period *cohort-specific* seniority growth rates are considered as steady-state values, constant across the whole working life of individuals and throughout all subsequent cohorts. Therefore they are also consistent with an *aggregate* growth of real wages (g) equal to zero.

²¹Although the literature does not provide estimates for the elasticity of intertemporal substitution in Italy, the value assigned to ρ (1.0001) lies in ranges that are suggested by various studies, such as between 0.5 and 1.5 (Battistin et al. 2009). The subjective time discount factor β (0.96) is in line with values commonly referred to Italy in the literature, ranging from lower values, e.g. 0.9 in Ventura (2003), to higher values, e.g. 0.985 in Fonseca and Sopraseuth (2005). The value assigned to the reciprocal of the intratemporal elasticity of substitution σ (0.999) is very close to 1, implying that consumption and leisure in the calibrated model are substitutable to a very little extent. This is in line with the fact that some consumption goods are substitutes and other consumption goods are complements with leisure.

²²Analogously to Battistin et al. (2009), consumption drop is measured as the percentage variation between the average consumption level in the 10 years before retirement and the average consumption level in the 10 years after retirement.

²³A labor supply constantly equal to (approximately) 1 in the model allows individuals to obtain labor earnings (while working) that coincide with wage rates in the model economy.

Parameters	Symbol	Value
<i>Demographic and macroeconomic parameters</i>		
Maximum possible life length	T	80
Growth rate of population	m	0
Stationary mean of low wages	μ_{w_L}	29.034
Stationary mean of middle wages	μ_{w_M}	92.967
Stationary mean of high wages	μ_{w_H}	238.515
Stationary mean of market returns	μ_r	0.066
Stationary variance of low wages	$\sigma_{w_L}^2$	3.998
Stationary variance of middle wages	$\sigma_{w_M}^2$	2.769
Stationary variance of high wages	$\sigma_{w_H}^2$	23.568
Stationary variance of market returns	σ_r^2	0.018
Aggregate growth rate of wages	g	0
Seniority growth rate of low wages	sw_L	0.018
Seniority growth rate of middle wages	sw_M	0.02
Seniority growth rate of high wages	sw_H	0.025
<i>Preference parameters</i>		
Subjective time discount factor	β	0.96
Reciprocal of the intertemporal elasticity of substitution	ρ	1.0001
Reciprocal of the intratemporal elasticity of substitution	σ	0.999
Parameters in the leisure preference formula	θ	90
$\gamma_{t,j} = (\frac{1}{\psi_{t,j}} - (\frac{1}{\psi_{\tilde{t},j}} - 1))^\theta$	\tilde{t}	36

Table 4.2: Calibration

old pension system therefore choose to retire as soon as they are statutorily allowed to (i.e. after 35 years of work and contribution). This retirement choice in the model approximately matches the actual average retirement age of Italian workers under the old pension regime, around their mid-50s mainly due to favorable eligibility conditions.²⁴ Hereafter in the paper, all ages are expressed in terms of model periods, while the corresponding real-life ages equal the model ages plus 20.

²⁴This early average retirement age in the calibrated model is due to the generous *actual* replacement rate used in the benchmark economy. Since the estimated (OECD, 2007) actual replacement rate under the Italian old regime is higher than the one statutorily provided, individuals on average are potentially induced to retire earlier. The average optimal retirement age in the calibrated model ($t_{ret} = 36$) is indeed lower than the optimal retirement age of individuals subject to the *statutory* features (notably, statutory replacement rate) of the old regime, as reported in Table 4.4.

Based on the calibrated model, the solution to the corresponding optimization problem for the representative individuals belonging to a given initial social class (low, middle or high) when entering the economy at age $t = 1$, consists of a sequence of optimally chosen values for consumption ($\{c_t^*\}_{t=1}^T$) and leisure ($\{l_t^*\}_{t=1}^T$), as well as the optimal retirement age (t_{ret}), maximizing the individuals' expected discounted lifetime utility, conditioned on labor being no longer supplied in all subsequent periods after retirement.²⁵

4.4 Findings

In order to assess welfare consequences for social groups in the economy under different Italian pension systems, simulations are performed by applying to the model social security schemes reproducing the statutory features of the “old” and the “new” regime. Particularly, the *statutory* replacement rate is considered under the old pension system, instead of the *actual* one used in the model calibration. The two schemes can also be compared against a setting without social security, applied to the Italian economy in the model. The main statutory features of the different settings considered hereafter in the paper are represented in Table 5.2.

	Contribution rate h	Pension benefit p_t
<i>Old regime</i>	0.24	$[(t_{ret} - 1) \cdot acrate] \cdot \frac{\sum_{t=t_{ret}-5}^{t_{ret}-1} W_{t,j}}{5}$
<i>New regime</i>	0.33	$tc \cdot [\sum_{t=1}^{t_{ret}-1} (0.33) \cdot W_{t,j} \cdot [(1+g) \cdot (1+m)]^{t_{ret}-t}]$
<i>No social security</i>	0	0

Table 4.3: Statutory features of the schemes considered in the analysis

²⁵As in Geron (2010), solutions are found by numerically simulating the calibrated model, specifically through running 1000 simulations. Optimal individual behaviors thus depend on the specific simulated realizations of stochastic variables in each period t . Consequently, lifetime profiles for consumption and leisure ($\{c_t^*\}_{t=1}^T$ and $\{l_t^*\}_{t=1}^T$) of individuals are derived as the average across 1000 different paths. For the sake of computational simplification, the optimal retirement age t_{ret} for different individual types in the model is instead derived from an “ex-ante” (respectively, “ex-interim”) perspective, as the age maximizing the expected discounted lifetime utility (respectively, the residual expected discounted utility from the period when social mobility occurs onwards) namely the value function at the beginning of life (respectively, the value function when shifting to the final social class).

The steady-state analysis requires a “fair” (i.e. budget-neutral) comparison to be carried out between alternative scenarios. To this end, the social security budget is forced to balance in every period (thus it cannot run deficits nor surpluses) by artificially changing statutory policy parameters under both pension systems, namely the accrual rate *acrate* under the old system and the annuity rate *tc* under the new system, for every level of the respective contribution rate *h*.²⁶ Notably, while being artificially changed to ensure budget balance, the accrual rate under the old regime in the model still follows a progressive schedule, in that it is kept lower for high-income bands, preserving the ratio between the statutory accrual rate of higher income bands and the statutory accrual rate of low-and-middle income bands.

Comparisons in the paper are performed either from an *ex-ante* or from an *ex-interim* perspective. In the former case, individual welfare under alternative scenarios is based on the expected discounted lifetime utility (that is the value function evaluated at the beginning of life, at time $t = 1$) when individuals only know the income class they initially belong to.²⁷ In the latter case, individual welfare under alternative scenarios is evaluated based on the expected discounted utility after turning from the initial to the final social class (namely the value function evaluated at time $t = t' + 1 = 21$, as individuals have just shifted to the new social class) when individuals “ex-interim” find out the final class they have ended up in. Adopting the *ex-ante* (respectively, the *ex-interim*) perspective, the results of the comparisons are expressed in terms of “*Compensating Variation*” (CV), defined as the amount of assets that should be given to individuals in a setting e.g. with social security, just before starting their life (respectively, just before moving to the final class), in order to let them benefit from the same level of *ex-ante* (respectively, *ex-interim*) expected discounted utility as they would enjoy in the other setting e.g. without social security. In all comparisons between alternative settings, each *ex-ante* Compensating Variation is normalized by the average wage in the economy in the first model period; each *ex-interim* Compensating Variation is normalized by the wage earned in period $t = 21$ within the initial (low, middle or high) income class to which the individual belongs in period $t = 20$.²⁸

²⁶Both the replacement rate (under the old regime) and the annuity rates (under the new regime) are thus treated as functions of the statutory contribution rate *h* (24% under the old scheme, 33% under the new scheme).

²⁷The “ex-ante” perspective, as defined in the paper, therefore corresponds to a sort of “ex-interim” perspective at time $t = 1$.

²⁸Consequently, for a given individual starting in social class j_I and ending in social class j_F , passing from a setting (e.g. without social security) to another setting (e.g. with social security), the *ex-ante* CV (evaluated at $t = 0$) is normalized by w_1 with

Results from simulations are analyzed by distinguishing between the *ex-ante* perspective on the one hand, with 3 possible types of individuals initially belonging to the low, middle, or high income class (denoted by *Low*, *Middle*, *High*); on the other hand, the *ex-interim* perspective, with 9 possible types of individuals resulting from all possible combinations of j_I and j_F (denoted by *LowLow*, *LowMiddle*, *LowHigh*, *MiddleLow*, *MiddleMiddle*, *MiddleHigh*, *HighLow*, *HighMiddle*, *HighHigh*).

4.4.1 Individual Behavior

Optimal retirement ages (expressed in model periods) in the setting without social security (budget-balanced by definition) and in the settings with budget-balanced old and new regimes, respectively denoted by $t_{ret,NoSS}$, $t_{ret,Old}$ and $t_{ret,New}$, are reported in Table 4.4.

	Individual type	$t_{ret,NoSS}$	$t_{ret,Old}$	$t_{ret,New}$
<i>Ex-ante</i>	Low	60	60	60
	Middle	50	38	38
	High	46	42	42
<i>Ex-interim</i>	LowLow	58	36	36
	LowMiddle	60	60	60
	LowHigh	60	60	60
	MiddleLow	46	42	42
	MiddleMiddle	56	36	36
	MiddleHigh	60	60	60
	HighLow	46	42	42
	HighMiddle	46	42	42
	HighHigh	56	36	36

Table 4.4: Optimal retirement age under no social security, old pension system and new pension system

Considering the optimal retirement ages under social security (both the old and the new system) from an *ex-interim* perspective as reported in Table 4.4, it can be noticed that individuals undergoing a shift to a higher income class in the second working-life period tend to work as long as possible,

$w_1 = 0.2 \cdot w_{1,L} + 0.6 \cdot w_{1,M} + 0.2 \cdot w_{1,H}$, i.e. the expected (average) value of wages in the economy in the first model period; the *ex-interim* CV (evaluated at $t = 20$) is instead normalized by w_{21,j_I} , i.e. the value of wages earned in period $t = 21$ by the same class as the one to which the considered individual belonged in the first 20 periods. This is due to the *ex-interim* CV being expressed in terms of assets that are evaluated at time $t = 20$, thus reflecting the initial wage levels w_{t,j_I} for $t = 1, \dots, 20$.

plausibly due to more a favorable level and particularly to a more favorable growth rate of labor income (i.e. to a higher seniority wage growth rate $sw_{j_F} > sw_{j_I}$) inducing them to choose to work longer at the margin, as theoretically argued e.g. by Ljungqvist and Sargent (2010). Individuals who remain in the same labor income class, on the contrary, tend to retire as soon as possible, thus benefitting from social security in the absence of any change in their seniority wage growth rate. Finally, individuals undergoing a shift towards a lower income class turn out to work a few more years than the statutory minimum contributory period, plausibly aiming to accumulate more savings before retiring in order to counteract the decrease in both the level and the growth rate of labor income in the final working-life period. In the absence of social security, retirement behavior from an *ex-interim* perspective is qualitatively the same as in the social-security scenario, while quantitatively differing in that individuals, as expected, tend to work longer in order to compensate for the absence of a social security system providing pension benefits.

Optimal retirement ages from an *ex-ante* perspective as reported in Table 4.4 further suggest that individuals in the absence of social security, as expected, on average tend to work for a longer period than in the presence of social security (both the old and the new system). The *ex-ante* optimal behavior of individuals starting their economic life in a given initial class, is mainly driven by the *ex-interim* optimal behavior of this class after shifting to the middle class, because of substantially higher ex-ante probabilities of moving to the middle class in the second working-life period (according to the social mobility matrix SM).

4.4.2 Elimination of Social Security

The first issue to be tackled is the investigation of whether the suppression of a budget-balanced social security scheme in the Italian economy is potentially welfare improving, and how different social groups would be consequently affected. To this end, welfare comparisons are performed, both from an *ex-ante* and from an *ex-interim* perspective, in order to assess whether pension systems as the old and the new Italian regime are welfare-increasing or welfare-decreasing with respect to a setting without social security, for different types of individuals initially (namely from time $t = 1$) belonging to one of the three social classes (in the *ex-ante* analysis) or belonging to one of the nine possible types after varying social condition at $t' + 1 = 21$ (in the *ex-interim* analysis). The Compensating Variation to be given to an individual passing from a setting with no social security to a setting with a balanced old (respectively, new) scheme is denoted by CV_NoSS_Old (re-

spectively, CV_NoSS_New). In case the Compensating Variation turns out to be positive, it means that passing to the alternative setting, e.g. introducing a social security system, is welfare-decreasing. Compensating Variations for the old and the new regime with respect to the reference setup without social security are reported in Table 4.5. In performing all of the comparisons in the paper, the macroeconomic (wages and financial market returns) and demographic setting is kept the same across different scenarios.

	Individual type	CV_NoSS_Old	CV_NoSS_New
<i>Ex-ante</i>	Low	1.0653	15.7598
	Middle	2.1236	5.3167
	High	3.4776	40.6307
<i>Ex-interim</i>	LowLow	-0.0839	-0.1233
	LowMiddle	19.6738	32.9683
	LowHigh	42.3681	46.3580
	MiddleLow	-0.0246	-0.0204
	MiddleMiddle	-0.0274	1.5715
	MiddleHigh	13.2381	14.4778
	HighLow	-0.7070	-0.2900
	HighMiddle	-0.8514	-0.4944
	HighHigh	-0.6822	1.3926

Table 4.5: CV, NoSS vs Old system CV_NoSS_Old , NoSS vs New system CV_NoSS_New [$CV > 0$ implies social security worsening individual welfare]

As reported in Table 4.5, from an *ex-ante* perspective individuals belonging to all initial social classes are worse-off after the introduction of social security (both the old and the new system), whereas from an *ex-interim* perspective (namely when information on own final type is disclosed) some social groups are better off after the introduction of social security. The reason is that ex-ante welfare measures take into account social security contributions paid in during the whole working life, including the first t' (20) years (before shifting to another class), while ex-interim welfare measures consider only contributions paid in from time $t' + 1$ (21) until retirement. Since the contribution rate under the new regime (33%) is greater than the one under the old regime (24%), the ex-ante welfare loss from introducing social security is bigger under the new system (ex-ante CV_NoSS_New is generally greater than CV_NoSS_Old).²⁹ The ex-interim welfare measures suggest that individuals

²⁹Overall, the main reason why the introduction of balanced social security decreases ex-ante welfare of all individuals (that is their welfare measured over their whole lifetime), is plausibly linked to the implicit return on the social security “asset” being lower than

shifting to a lower labor income class are better-off after the introduction of social security, whereas individuals shifting to a higher labor income class suffer an ex-interim welfare loss. Indeed, individuals improving their social conditions accumulate relatively lower assets during the first part of working life (before shifting to the final class), whereas in the second part of working life (after shifting to the final class) they earn relatively higher income (both in level and growth rate) and are forced to pay higher contributions. Consequently, they prefer retiring later (see Table 4.4), so as to benefit longer from higher income, save more and provide for themselves after retirement, without relying on any social security scheme.³⁰ Based on an analogous (converse) reasoning, individuals worsening their social conditions tend to retire earlier and benefit from a social security system. Social security from an ex-interim perspective seems therefore to act as a sort of “insurance” tool that *implicitly* redistributes towards individuals undergoing a worsening (or, under the old system, not facing an improvement) of their social conditions during working life.³¹ It is however worth noticing that the magnitude of the ex-interim welfare gains from social security (namely the absolute value of negative Compensating Variations) for some individual types is on average substantially lower than the magnitude of ex-interim welfare losses from social security (namely the value of positive Compensating Variations) for the other individual types in the economy.

the average return on financial assets. The (cohort-specific) growth rate of real wages in the model economy is indeed at most $sw_H = 2.5\%$ for highest-income individuals, while the mean value of financial market returns is 6.56%. In general, the bigger the rate h at which individuals are forced to invest in the social security “asset” during their whole working life (particularly when they are younger and possibly more liquidity-constrained), the larger the welfare loss they may suffer. A related reason for social security being welfare-decreasing in the model is the fact that the contribution rate h is compulsorily constant over the whole working life (Hurst and Willen, 2007).

³⁰Moreover, under the new regime, pension benefits of individuals shifting to a higher final class are based also on lower wages earned in the first working-life period, so that from an ex-interim perspective pensions are perceived as less than proportional with respect to contributions paid in from time 21 onwards. Under the old regime, pension benefits for only individuals with high final income are negatively affected by the progressive schedule of the accrual rate.

³¹Individuals remaining in the same class throughout their whole working life are unambiguously better off from an ex-interim perspective under the old regime. Under the new regime they may instead be worse off (*MiddleMiddle*, *HighHigh*) plausibly because contributions are paid from time 21 onwards, in exchange for pension benefits depending also on wages earned in the first working-life period (from $t = 1$ to $t = 20$), under substantial growth rates (sw_M and sw_H) of middle-income and high-income-class wages and thus contributions. Expected benefits from an ex-interim perspective may then be perceived as disproportionately low as compared to contributions paid in during the second working-life period.

4.4.3 Comparison between Different Schemes

After analyzing the welfare effects of social security in the Italian economy, comparisons are performed between the old and the new system, both considered under the budget-balance restriction for the sake of comparability.³² The main purpose of this analysis is to investigate variations in risk-insurance properties of the Italian social security system after the introduction of the major pension reforms in the 1990s. While applied to the Italian institutional setting, the following analysis basically considers on the one hand a typical DB system, with benefits based on the last working-life earnings and the statutory replacement rate following a progressive schedule, on the other hand a notional DC system, with benefits based on all working-life contributions (thus wages) and therefore in principle more actuarially fair and less redistributive.

The Compensating Variation to individuals subject to reforms passing from the (budget-balanced) old to the (budget-balanced) new regime is denoted by CV_{Old_New} . Values of CV_{Old_New} for different types of individuals from both an ex-ante and an ex-interim perspective are reported in Table 4.6.

	Individual type	CV_{Old_New}	$CV_{Old_New_Equalized}$
<i>Ex-ante</i>	Low	15.7165	16.3490
	Middle	5.3167	5.6724
	High	40.5581	43.3866
<i>Ex-interim</i>	LowLow	2.0339	-0.0839
	LowMiddle	7.0088	-0.00005
	LowHigh	20.1611	-0.00002
	MiddleLow	0.1110	-0.0091
	MiddleMiddle	1.9018	-0.0142
	MiddleHigh	6.3206	-0.00001
	HighLow	0.1059	-0.0060
	HighMiddle	0.7473	-0.0025
	HighHigh	2.0563	-0.0031

Table 4.6: CV, Old vs New system CV_{Old_New} , and Old vs New system with equalized lifetime transfers $CV_{Old_New_Equalized}$ [$CV > 0$ implies the new pension system worsening individual welfare]

The shift from the old to the new pension regime turns out to be welfare-

³²The accrual rate $acrate$ under the old system and the annuity rate tc under the new system are varied in each simulation in order to constantly fulfill within-period financial balancing of government budget.

decreasing in all instances, both from an *ex-ante* and from an *ex-interim* perspective. The reason is that the old pension system provides on average more favorable net lifetime transfers (i.e. social security contributions and pension benefits), in particular individuals during working life are charged a lower contribution rate (24% instead of 33%) out of every unit of labor income.³³ Notably, from an *ex-interim* perspective individuals starting their economic life in the low-income class suffer a greater welfare loss as compared to individuals starting in other classes, and more generally individuals improving their social condition during working life turn out to suffer greater *ex-interim* welfare losses when passing from the old to the new regime. This is due to the fact that their pension benefits under the new NDC regime (based on all working life contributions) depend also on wages earned in the initial working-life period when belonging to the initial lower-income class, whereas their pension benefits under the old DB regime (depending only on the last working-life wages) do not reflect the initial lower income level.

These comparisons are influenced by the fact that the old and the new regime are characterized by different contribution rates and pension benefit levels. Moreover, individuals under alternative budget-balanced regimes may consequently make different optimal choices (consumption and leisure, notably retirement, choices). In order to merely focus on changes in risk-insurance properties, welfare comparisons across regimes should not be affected by variations in net lifetime transfers and differences in individual behaviors. Differences in lifetime transfers can be eliminated through exogenously equalizing the contribution rate as well as pension benefit levels across the two regimes. While keeping budget-balance restrictions, the contribution rate under both systems is set at the old-regime level ($h = 0.24$). The new-regime annuity rate (tc) is also exogenously set, in each simulation, at a level ensuring not only the balance of government budget but also the equality (in *ex-ante* and *ex-interim* expected value) of new pension benefit levels to the benefits provided under the old scheme. After exogenously eliminating differences in contributions and (expected) pensions across the two schemes, endogenous variations in individual behavior are consequently minimized (almost nullified) in magnitude. The only remaining welfare-variation component from an *ex-ante* and from an *ex-interim* perspective, is therefore the one related to “risk insurance”.³⁴

³³From both an *ex-ante* and an *ex-interim* individual perspective, a bigger size of the social security “asset” in which individuals are forced to invest (namely a higher required contribution rate) implies on average a decrease in their welfare.

³⁴Due to different benefit formulas considering different series of risky labor earnings (the last working-life wages under the old DB system, all working-life wages under the new NDC system), a significant risk-related welfare variation across systems is represented

The Compensating Variation to individuals passing from the (budget-balanced) old to the new regime, under the above hypothesis of equalization of (expected) net lifetime transfers across systems, is hereafter denoted by *CV_Old_New_Equalized*. Values of *CV_Old_New_Equalized* for different types of individuals from both an ex-ante and an ex-interim perspective are reported in Table 4.6. Under the transfer-equalization assumption, the shift from the old to the new pension regime turns out to be welfare-decreasing for all initial types of individuals from an *ex-ante* welfare perspective. From an *ex-interim* perspective instead individuals belonging to all classes enjoy a small welfare gain under the new pension scheme as compared to the old regime.

On the one hand the new pension regime, by basing the computation of pension benefits on a longer series of wages, performs a better “wage-risk diversification”: it causes a reduction in the variance of pension benefits, namely an increase in the probability of mean benefit values occurring (and a corresponding decrease in the probability of tail values occurring), thus resulting in risk-averse individuals enjoying a welfare increase. On the other hand, by linking more strictly the wages earned during working life (more generally, the individual “human capital”) and the pension benefits received after retirement (due to a benefit formula based on *all* working-life wages), the new system may potentially increase the overall uncertainty facing individuals throughout their lifetime: due to this higher “wage-benefit correlation”, individuals under the new regime may experience a welfare decrease.³⁵ These qualitatively opposite effects are two facets of the risk-related effects of social security, with the former increasing and the latter decreasing risk insurance.

The welfare gains enjoyed in *ex-interim* terms (that is in expected terms after shifting to the final social class) suggest that the better “wage-risk diversification” properties of the new regime tend to prevail over the “wage-benefit correlation” effects after uncertainty on class shift is revealed, namely

by different (ex-ante and ex-interim) *probabilities* of ending up with various benefit levels, given the same mean expected (respectively, in ex-ante and ex-interim terms) pension level (Geron, 2010).

³⁵Besides being influenced by the riskiness of financial market returns, the overall lifetime uncertainty facing individuals is affected by the variance of wages and the variance of pension benefits, as well as by their correlation: the more these two latter sources of uncertainty are correlated with each other, the higher the increase in the overall lifetime uncertainty. Through an improved “wage-risk diversification”, the new regime may decrease the variance of pension benefits and consequently the overall degree of lifetime uncertainty. However, since the new regime relates wages (labor income) and pension benefits to a higher extent than the old system does, it may possibly augment the overall degree of uncertainty.

after most working-life variability has been resolved.³⁶ The pooling of a longer series of risky final-class wages under the new regime causes an expected reduction in the variance of pension benefits, thereby providing some valuable insurance against class-specific income shocks.

The welfare loss in *ex-ante* terms seems instead to suggest that the higher “wage-benefit correlation” induced by the new regime tends to outweigh its “wage-risk diversification” properties when all uncertainty on both the initial-class wages and (notably) on class-shift is still confronting individuals at the beginning of lifetime. Evaluated from an *ex-ante* perspective, pension benefits under the new system not only incorporate risky wages earned in the final working-life period (from time $t' + 1 = 21$ until retirement) but also the risky wages earned in the initial working-life period (from time 1 until $t' = 20$) as well as the stochastic move to another social class after time 20 (which represents the most relevant source of working-life uncertainty); pension benefits under the old regime instead *ex-ante* reflect only uncertainty on the last (five) years’ wages before retirement. The higher degree of correlation between pension benefits and *all* working-life risky variables (human capital) determines a higher overall lifetime uncertainty, causing individuals to experience an *ex-ante* welfare loss when passing from the old to the new regime, *ceteris paribus* (i.e. with other components of welfare variations being neutralized). From this perspective, the investment in the social security asset is therefore more valuable, the less it is correlated to human capital. A lower correlation between these two assets (as it occurs under the old DB system with respect to the new NDC system) yields a better lifetime “portfolio” diversification, and thus increases *ex-ante* risk insurance.

On the whole, the new regime slightly improves the mere risk-insurance properties of social security only from an *ex-interim* perspective, whereas in *ex-ante* terms the increase in the overall lifetime riskiness outweighs the reduction in pension variability thereby causing a welfare loss. Moreover, the average magnitude of the *ex-ante* welfare loss (namely *ex-ante* values of *CV_Old_New_Equalized*) is substantially larger than the average magnitude of the *ex-interim* welfare gains (namely *ex-interim* absolute values of *CV_Old_New_Equalized*). Interestingly, the *ex-interim* purely risk-insurance welfare gains to the new system (expressed by the absolute values of *ex-interim CV_Old_New_Equalized*) are generally outweighed in magnitude also by the *ex-interim* welfare losses to the new system resulting (mainly) from differences in net lifetime transfers across regimes (values of *ex-interim*

³⁶The bulk of uncertainty on individual human capital (for which labor earnings and thus wages may be considered as proxies) is represented by the stochastic social-class shift. Uncertainty on class-specific wages is indeed relatively smaller than riskiness involved in moving across different classes.

CV_{Old_New} in Table 4.6): transfer effects are arguably more important in driving ex-interim welfare variations across alternative systems than risk-insurance effects.

Risk-insurance effects of social security

As previously argued, the higher “wage-benefit correlation” under the new system negatively affects individual welfare, by increasing uncertainty over the whole lifetime. Based on values resulting from simulations, Table 4.7 reports the correlation coefficient (ρ_{WP}) between the discounted flow of all working-life wages on the one hand and pension benefits at retirement on the other hand, under the old (ρ_{WP_Old}) and the new (ρ_{WP_New}) regime, for individuals initially belonging to the low, middle and high income class. Values of ρ_{WP_New} are indeed greater than ρ_{WP_Old} for each initial social class.

	Individual type	ρ_{WP_Old}	ρ_{WP_New}
<i>Ex-ante</i>	Low	0.8714	0.9359
	Middle	0.8759	0.9283
	High	0.8782	0.9358

Table 4.7: Simulated overall wage-pension correlation, under Old and New system [Correlation coefficient between the discounted flow of working-life wages and pension benefits]

The risk-insurance effect due to “wage-risk diversification” ultimately results from the variance of pension benefits (σ_P^2) being lower under the new pension regime ($\sigma_{P_New}^2$) than under the old regime ($\sigma_{P_Old}^2$), in ex-ante expected terms for each initial social class, as reported in Table 4.8.

	Individual type	$\sigma_{P_Old}^2$	$\sigma_{P_New}^2$
<i>Ex-ante</i>	Low	0.0367	0.0335
	Middle	0.0363	0.0334
	High	0.0362	0.0330

Table 4.8: Simulated variance of pension benefits, from ex-ante perspective, under Old and New system [Values are normalized by the average wage in the economy in the first model period]

Ex-ante welfare measures incorporate all lifetime uncertainty, notably the greatest source of working-life uncertainty that is stochastic social mobility. Therefore a higher correlation of all working-life wages (proxies for individual “human capital”) with pension benefits ($\rho_{WP_New} > \rho_{WP_Old}$) consider-

ably increases lifetime riskiness, and this effect ex-ante prevails over wage-risk diversification, resulting in ex-ante welfare losses to the new system. *Ex-interim* measures instead incorporate only a minor part of the working-life uncertainty (since stochastic social mobility has already been resolved), consequently the higher residual riskiness due to higher correlation between final-class wages and benefits is dominated by the reduction in pension variability ($\sigma_{P_New}^2 < \sigma_{P_Old}^2$) due to better wage-risk pooling, yielding ex-interim welfare gains to the new system.

The ex-interim preponderance of the “wage-risk diversification” effect over the “wage-benefit correlation” effect may become even bigger as the welfare comparison is performed later in lifetime, namely as a greater amount of uncertainty is revealed and “left behind”. For instance, by comparing the old and the new pension system under equalized net lifetime transfers, the ex-interim welfare gain to the new system becomes slightly larger in case the welfare comparison is carried out at $t = 30$ instead of $t = 20$, as reported in Table 4.9. Values of *CV_Old_New_Equalized_20* in Table 4.9, expressing the (equalized-transfers) ex-interim welfare comparisons between the old and the new regime as evaluated at $t = 20$ (the same as ex-interim *CV_Old_New_Equalized* in Table 4.6), are indeed lower in absolute value than the respective values of *CV_Old_New_Equalized_30*, expressing the (equalized-transfers) ex-interim welfare comparisons between the old and the new regime as evaluated at $t = 30$. When postponing the time of the comparison, welfare measures incorporate less residual uncertainty, consequently the increase in the overall uncertainty under the new regime due to the “wage-benefit correlation” effect becomes smaller.

Evaluating explicit redistribution

Besides issues related to wage-risk diversification and wage-benefit correlation, a further source of insurance may be provided specifically under the old DB regime. The old system was indeed explicitly designed to provide intra-generational redistribution (ex-ante risk insurance) by means of a progressive accrual rate (lower for higher bands of final earnings, while remaining constant for low and middle final-income bands). An evaluation of the magnitude of the explicit redistribution component under the old regime can be performed by computing the Compensating Variation (*CV_Old_OldNoRed*) to individuals passing from the (budget-balanced) progressive old system (*Old*) to the (budget-balanced) old system without redistribution (*OldNoRed*), as reported in Table 4.10.³⁷ It is clear from this analysis that individuals finally

³⁷Explicit redistribution is exogenously eliminated (in the alternative *OldNoRed* scenario) by imposing a constant accrual rate throughout all classes (including the high-

<i>Ex-interim</i>	<i>CV_Old_New_Equalized_20</i>	<i>CV_Old_New_Equalized_30</i>
Individual type		
LowLow	-0.0839	-0.1023
LowMiddle	-0.00005	-0.00008
LowHigh	-0.00002	-0.00003
MiddleLow	-0.0091	-0.0157
MiddleMiddle	-0.0142	-0.0229
MiddleHigh	-0.00001	-0.00002
HighLow	-0.0060	-0.0071
HighMiddle	-0.0025	-0.0036
HighHigh	-0.0031	-0.0050

Table 4.9: Ex-interim CV, Old vs New system with equalized lifetime transfers, evaluated at $t = 20$ (*CV_Old_New_Equalized_20*) and at $t = 30$ (*CV_Old_New_Equalized_30*) [$CV < 0$ implies the new pension system increasing individual welfare. A higher absolute value of negative CV implies a larger welfare gain to the new pension system.]

ending up in the high-income class under the old regime are better off without redistribution. On the contrary, as expected, individuals ending up in the low and middle social class under the old regime are better off with redistribution, since they are benefited by a budget-balanced progressive system wherein the accrual rate schedule becomes progressive only for high-income bands.

	Individual type	<i>CV_Old_OldNoRed</i>
<i>Ex-interim</i>	LowLow	0.4489
	LowMiddle	0.0017
	LowHigh	-0.0057
	MiddleLow	0.0640
	MiddleMiddle	0.4065
	MiddleHigh	-0.0018
	HighLow	0.0435
	HighMiddle	0.0911
	HighHigh	-0.5992

Table 4.10: $CV > 0$ implies the old system without redistribution worsening individual welfare

income class), namely by taking away its progressivity.

4.4.4 Optimal Social Security

The analysis finally focuses on the optimal *size* of the social security system, for different social classes both from an ex-ante and from an ex-interim perspective. The optimal size of the pension system is defined as the contribution rate (denoted by h^*) which maximizes individuals' welfare (in either *ex-ante* or *ex-interim* terms) while satisfying social security budget balance condition. Table 4.11 reports the optimal size of the contribution rate (thus, of social security) for different types of individuals in the model under both the old (h_{Old}^*) and the new (h_{New}^*) pension system, along with their corresponding optimal retirement ages ($t_{ret,Old}^*$ and $t_{ret,New}^*$).

	Individual type	h_{Old}^*	$t_{ret,Old}^*$	h_{New}^*	$t_{ret,New}^*$
<i>Ex-ante</i>	Low	0	60	0	60
	Middle	0.01	46	0.01	46
	High	0.01	42	0.01	42
<i>Ex-interim</i>	LowLow	0.35	36	0.3	36
	LowMiddle	0	60	0	60
	LowHigh	0	60	0	60
	MiddleLow	0.15	42	0.15	42
	MiddleMiddle	0.35	36	0	56
	MiddleHigh	0	60	0	60
	HighLow	0.2	42	0.2	42
	HighMiddle	0.15	42	0.15	42
	HighHigh	0.35	36	0	56

Table 4.11: Optimal size of social security, under old (h_{Old}^*) and new (h_{New}^*) pension system, with respective optimal retirement ages ($t_{ret,Old}^*$ and $t_{ret,New}^*$)

From an *ex-ante* perspective, under both the old and the new regime, only initially middle- and high-income individuals prefer a positive though very small ($h^* = 1\%$) social security system, whereas the initially low-income individuals prefer not to rely on any mandatory scheme. This seems to suggest that particularly those individuals who are more likely to improve their social condition during working life are better off without social security and by choosing a late retirement age, from an ex-ante perspective (that is before discovering the class in which they finally end up).³⁸ From an *ex-interim* perspective (that is after the final social condition is known),

³⁸In steady state the social mobility *SM* matrix implies that individuals starting their economic life in the low-income class are more likely to shift to a higher class, whereas individuals initially belonging to the middle- and particularly high-income class are more likely to either remain in the same class or worsen their condition during working life.

those individuals who improve their social conditions during working life prefer no social security system and late retirement, whereas individuals who experience a worsening (or, under the old regime, not an improvement) of social conditions wish to have a sizeable social security system (both old DB and new NDC scheme) and retire earlier, in accordance with the previous reasoning on Table 4.5. Notably individuals shifting to a higher labor income class accumulate relatively lower assets during the first part of working life, while in the second working-life period they earn higher income. Under social security these individuals would thus be forced also to pay higher contributions in the second part of working life. Consequently, they do not wish to rely on any social security scheme, instead they decide to work longer, earn (and save) more and self-insure for the old age.³⁹ Overall, from an ex-interim perspective the (potentially redistributive) public mandatory scheme favors individuals whose conditions worsen (or, in some cases, do not improve) during working life, who therefore wish to introduce a social security system as an additional asset to counterbalance adverse social mobility. It is finally worth stressing that *LowLow*-type individuals under both the old and the new regime (as well as *MiddleMiddle* and *HighHigh* types under the old regime) would prefer a social security system with a size (respectively, 35% and 30%) that is very close to the one currently in force in Italy (33%).

4.5 Conclusions

This paper has investigated and compared the risk-insurance properties of a typical DB scheme providing pension benefits based on the last working-life wages, and a typical NDC scheme providing pension benefits based on all working-life contributions (thus wages), in the light of the Italian pension reforms introduced in the 1990s. This goal has been pursued by using simulations from life-cycle models of heterogeneous agents within different income classes, belonging to one representative generation in steady state, in a partial equilibrium economy in the presence of mortality risk, idiosyncratic (class-specific) uncertainty on wages, stochastic intra-generational social mobility, and aggregate uncertainty on financial market returns.

³⁹From an ex-interim perspective, individuals improving their social conditions during working life may perceive pension benefits under the new system as disproportionately low with respect to contributions paid in during the second working-life period, since the benefit rule takes into account also lower wages earned during the first working-life period. Notably, under the new regime even some individual types remaining in the same class throughout their whole working life (*MiddleMiddle*, *HighHigh*) prefer a setting without social security, in accordance with the reasoning on Table 4.5.

By applying the main features of the Italian pension system to a calibrated model representing stylized facts of the Italian economy, the paper has carried out comparisons between the old DB pension system and the new NDC system (respectively, before and after reforms in the mid 1990s), based on welfare measures from both an *ex-ante* perspective (i.e. when individuals only know their initial social class) and an *ex-interim* perspective (i.e. after shifting to the final social class). While applied to the Italian institutional framework, the analysis can be straightforwardly generalized to a comparison between a typical DB progressive scheme on the one hand, and a typical Notional DC actuarially fair scheme on the other hand. After exogenously eliminating differences in net lifetime transfers across regimes (namely from a pure risk-insurance perspective) the new NDC regime proves to slightly increase *ex-interim* welfare by improving the *ex-interim* risk-insurance properties of social security for all individual types, but from an *ex-ante* perspective the new system is substantially welfare-decreasing for all initial classes. These results are basically due to the new regime providing pension benefits based on all working-life risky wages, as opposed to the old regime providing pension benefits based on only the final working-life wages. As a consequence, the effect caused by the new regime (with respect to the old one) is twofold:

- increase in the correlation between pensions and working-life wages (“human capital”), augmenting the degree of riskiness faced *ex-ante* by all individuals over their lifetime. This effect prevails from an *ex-ante* perspective, as all lifetime uncertainty is not resolved, and causes the *ex-ante* welfare loss.
- better wage-risk diversification (due to pooling of a longer series of risky wages), reducing the variance of pension benefits. This effect prevails from an *ex-interim* perspective, as most working-life variability (notably, stochastic social mobility) has been resolved, and drives the *ex-interim* welfare gain.

Interestingly, the *ex-interim* risk-insurance welfare gains are relatively small in magnitude as compared to *ex-ante* welfare losses. Moreover, *ex-interim* purely risk-insurance welfare gains to the new regime are also outweighed in magnitude by welfare losses to the new regime resulting from differences in net lifetime transfers (particularly in contributions) favoring the old system.

The paper has also analyzed the overall welfare effects resulting from social security in the model economy. The introduction of a budget-balanced social security system reproducing both the old and the new Italian pension

scheme has been shown to decrease ex-ante welfare of individuals belonging to all initial social classes in the model. From an ex-interim perspective, all individuals shifting to a lower labor-income class enjoy a slight ex-interim welfare improvement from the introduction of social security; individuals shifting to a higher labor-income class instead suffer a substantial ex-interim welfare loss plausibly resulting from pensions being less attractive with respect to earning a higher income and providing for themselves in the old age. Social security may therefore act as an implicit “insurance” tool for individuals undergoing a worsening (or, under the old system, not facing an improvement) of their social conditions during working life, although to a relatively little extent. In accordance with these findings, the optimal size of both the old and the new Italian pension system turns out to be significantly positive only from an ex-interim perspective for individuals whose income conditions worsen (or, under the old system, do not improve) during working life.

Overall, risk-insurance effects of social security seem to cause (*ex-ante* and *ex-interim*) welfare gains only to a minor extent. In particular, the introduction of the new pension system may worsen risk-insurance properties of social security, since it possibly causes an ex-ante increase in the total amount of uncertainty confronting individuals over their whole lifetime.

Future research will need to go more in depth and check the robustness of the above results to different specifications of preference and (particularly) risk-related parameters. Building on the previous findings, future analysis will also investigate further the risk-insurance properties of social security in the light of the correlation between human capital and pensions. To this aim, it will notably focus on comparing DB and NDC systems with ideal (redistributive) flat-rate schemes.

4.6 Appendix

4.6.1 Data and Methodology

Stochastic processes for real market returns and wages have been estimated by considering available historical series for Italy over the period 1990-2004. The reason why a relatively short time span is considered, is that for the period 1990-2004 almost all needed data are available. In order to get better econometric estimates, data have been taken at a quarterly frequency.

As for data sources, data on aggregate wages (w_t) have been found in the OECD (2008) data set, by using the OECD entry “Compensation per employee in total economy”, since it is a measure of gross wages in the overall economy (comprising both public and private sector). The series of wages by income class $w_{t,L}$ (for the first quintile of income), $w_{t,M}$ (for the second, third and fourth quintile of income) and $w_{t,H}$ (for the fifth quintile of income), that are not available in data, have been estimated by applying to the series of average wages (w_t) the yearly ratios of respectively low, middle and high income levels to the average income level, as reported by income quintiles in the Bank of Italy “Supplements to the Statistical Bulletin” from 1989 to 2006.⁴⁰

Average market returns (r_t) are computed as the weighted average of historical returns on three major financial assets held by Italian households: government bonds, corporate bonds issued by Italian banks, and stocks issued by Italian companies (both listed and not listed).

Returns on government bonds have been computed as the (non-weighted) average yield on two main types of Italian government bonds, namely short-term bonds (BOT - Italian T-bills) and medium-to-long-term bonds (BTP - Italian T-bonds). As for returns on BOTs the source is the “Ministero dell’Economia” web site, providing BOT returns at issue. As regards BTPs return, the “Rendistato” yield is utilized: it is computed by the Bank of Italy, and reflects the average market performance of BTPs traded on the Electronic Bond and Government Securities Market (MOT) of the Italian Stock Exchange.

Returns on corporate bonds issued by banks constitute a great majority of all Italian corporate bonds. Their return is reported by the “Rendiob” yield; it is computed by the Bank of Italy, and reflects the average market performance

⁴⁰Income levels reported by the Bank of Italy consider not only labor income but also other sources, notably capital income. Since particularly financial assets in Italy are highly concentrated at the top of the distribution (Mazzaferro and Toso, 2009), the estimated series of wages $w_{t,L}$, $w_{t,M}$ and $w_{t,H}$ are plausibly more right-skewed and dispersed than they would be if they were estimated based on only labor income levels.

of corporate bonds issued by banks and traded on the Electronic Bond and Government Securities Market (MOT) of the Italian Stock Exchange. The “Rendiob” index is available only from the end of the 1980s to 2004.

As for stocks, shares of listed companies have been deemed as representative of shares of all Italian companies. Average returns on stocks have been computed using the COMIT Performance - Total Return index, which includes total returns (both prices and dividends) of all shares listed on the Stock Electronic Market (MTA) of the Italian Stock Exchange.

All of the three above mentioned types of returns have then been weighted considering the yearly portfolio composition of Italian households reported by the Bank of Italy (2007), referring to the period 1995 through 2006. Weights are computed as percentages of “Italian government bonds”, “Italian corporate bonds issued by banks” and “listed shares issued by residents” in a simplified portfolio held by Italian households, namely a portfolio made up of only those three categories of securities. In the absence of data on portfolio composition relative to the 1990-1994 period, weights for returns in those years have been assumed to be the same as those in year 1995. Moreover, when considering observations at a quarterly frequency, the yearly weights are assumed to be the same throughout all quarters of every year.

All collected wages and financial market returns have been finally expressed in real terms by correcting them for historical inflation growth rates, reported in OECD (2008), so as to obtain the values based on which estimates for $w_{L,t}$, $w_{M,t}$, $w_{H,t}$ and r_t in the model have been carried out.

Data used to compute the aggregate growth rate (g) of real wages in Italy in different historical periods have been found in OECD (2008) data source. The aggregate yearly “seniority” wage growth rate (sw) has been computed as the difference between two terms: the approximate yearly average growth rate of real wages earned by a specific cohort from 1976 to 2004 (Italian workers entering the labor market in 1976 when 21/22 years old); minus the average yearly aggregate growth rate of wages in Italy in period 1976-2004. Computing this difference is aimed at obtaining a cohort-specific measure of “seniority” wage growth, by having cohort-specific wage growth through time net of aggregate growth wage in the economy (i.e. affecting all cohorts). This measure is then assumed to stay constant through time in the model. This means that the crucial underlying assumption is that seniority wage growth profiles for all generations are the same as the (two-year) cohort that entered labor market in 1976. This assumption rests on the fact that in the available data the wage career profile of that cohort was tracked for the longest time span, with respect to other - subsequent - cohorts: therefore, the obtained measure for sw is in some sense more “complete”, as it reflects an almost entire working career, by taking into account the greatest (available) number

of years. Data on the wage dynamics of cohort that entered labor market in 1976 have been deduced by a rough analysis of data reported by Rosolia and Torrini (2007). The decomposition of the aggregate sw rate into “low” (sw_L), “middle” (sw_M) and “high” (sw_H) by class of income has been carried out based on different income dynamics (average growth rate) through time for different classes (quintiles or deciles of income) in Italy, as reported by the Bank of Italy “Supplements to the Statistical Bulletin” from 1989 to 2006. In particular, assuming that sw_M coincides with the average rate $sw = 2\%$, sw_L and sw_H (respectively 1.78% and 2.52%) have been computed by applying to the average sw the weights (respectively 0.89 and 1.26) that correspond to ratios of growth rates of respectively low and high income to the growth rate of middle income.

Data on social security contribution rates (h) have been found at INPS (National Institute of social security) web site. Estimates on the actual replacement rate under the old pension system are reported in OECD (2007).

All demographic data and projections are provided by the yearly demographic balance of Istat (National Institute of Statistics) web site.

4.6.2 Technical Appendix

Social classes in the model are based on the subdivision of Italian households by deciles (or quintiles) of income, as reported by the Bank of Italy “Supplements to the Statistical Bulletin” from 1989 to 2006. The two lowest deciles (the first quintile) make up the “low” class, deciles from third to eighth (quintiles from second to fourth) make up the “middle” class, the two highest deciles (the highest quintile) constitute the “high” class. The social mobility matrix, according to which individuals stochastically move across social classes, is computed based on two-year transition matrices by deciles of income reported by the Bank of Italy “Supplements to the Statistical Bulletin” from 1989 to 2006. Since the transition period ($t' + 1$) has been set at 21, the matrix resulting from the above computations needs to be a twenty-year social mobility matrix (SM), representing the transition probabilities for low-, middle- and high-income individuals from the initial class j_I to the final class j_F (Table 4.12).

The twenty-year social mobility matrix (SM) in the model has been derived from a “steady-state” two-year transition matrix (sm) computed by averaging out across all two-year social mobility matrices reported by the Bank of Italy “Supplements to the Statistical Bulletin” from 1989 to 2006. Therefore $SM = sm^{(20)} = sm^{(10)}$. The computed average two-year transition matrix (from any period t to $t + 2$) is reported in Table 4.13.

		L	j_F M	H
	L	0.2155	0.5988	0.1869
j_I	M	0.1993	0.6009	0.2006
	H	0.1871	0.5999	0.2133

Table 4.12: 20-year social mobility matrix SM

		L	$t + 2$ M	H
	L	0.7126	0.2828	0.0048
t	M	0.0928	0.8075	0.1000
	H	0.0091	0.2944	0.6964

Table 4.13: Average 2-year social mobility matrix sm

Individuals belonging to different social classes face different class-specific conditional survival probabilities, denoted by $\phi_{t,L}$, $\phi_{t,M}$ and $\phi_{t,H}$. Data on class-specific probabilities are not available, so they have been set up based on available estimated life expectancy of different social and income groups in Italy. The starting point is the sequence of conditional survival probabilities $\{\phi_t\}_{t=1}^T$, representing the weighted average of survival probabilities per cohort of all Italian males and females in 2004 (one of the last years for which data are available, in line with the 1990-2004 time span of macroeconomic data), as reported by the yearly demographic balance of Istat (Italian National Institute of Statistics). Denoting by D_L , D_M and D_H the estimated average life expectancy (Costa, Leombruni and Richiardi, 2008) respectively for low, middle and high income class, it holds that:

$$D_j = \sum_{t=1}^T t \cdot \prod_{q=1}^{t-1} (\delta_j \phi_q) [1 - (\delta_j \phi_t)]$$

Solving the above equation for δ_j , separately for each $j = L, M, H$, class-specific conditional survival probabilities $\phi_{t,j}$ by class j have been derived as:

$$\phi_{t,j} = \delta_j \phi_t \quad \text{for } t = 1, \dots, T$$

with δ_L , δ_M and δ_H having been found out to respectively equal 0.9994, 1.0001 and 1.0004, implying (not surprisingly) that the lower the income class, the lower the level of lifetime conditional survival probabilities.

Econometric analysis on Italian wages and market returns suggests that

the processes underlying wages ($w_{t,L}$, $w_{t,M}$ and $w_{t,H}$) and market returns (r_t) can be represented as follows, with standard errors reported in parentheses:

$$\begin{aligned}
 w_{t,L} &= 52.5959 + 1.6251 \cdot w_{t-1,L} - 1.0573 \cdot w_{t-1,M} + 0.1155 \cdot w_{t-1,H} + \varepsilon_{t,L} \\
 &\quad (9.7243) \quad (0.2105) \quad (0.1970) \quad (0.0563) \\
 w_{t,M} &= 94.7884 + 0.8490 \cdot w_{t-1,L} - 0.3671 \cdot w_{t-1,M} + 0.0321 \cdot w_{t-1,H} + \varepsilon_{t,M} \\
 &\quad (12.4785) \quad (0.2701) \quad (0.2528) \quad (0.0722) \\
 w_{t,H} &= 155.5886 - 0.4432 \cdot w_{t-1,L} + 0.1204 \cdot w_{t-1,M} + 0.3547 \cdot w_{t-1,H} + \varepsilon_{t,H} \\
 &\quad (45.5318) \quad (0.9856) \quad (0.9225) \quad (0.2636) \\
 r_t &= 0.0656 + \varepsilon_t^r \\
 &\quad (0.0178)
 \end{aligned}$$

Therefore, the processes can be overall considered as a VAR process, with mean (μ) and variance (Σ) equal to:

$$\mu = \begin{bmatrix} 29.0341 \\ 92.9666 \\ 238.5152 \\ 0.0656 \end{bmatrix}$$

$$\Sigma = \begin{bmatrix} 3.9983 & 2.6196 & -5.0280 & -0.0603 \\ 2.6196 & 2.7694 & -0.3042 & -0.0070 \\ -5.0280 & -0.3042 & 23.5680 & 0.2976 \\ -0.0603 & -0.0070 & 0.2976 & 0.0180 \end{bmatrix}$$

suggesting there may exist a correlation between wages and market returns.

The stationary (unconditional) distributions of the above variables are as follows:

$$\begin{aligned}
 w^L &\sim N(29.0341, 3.9983) \\
 w^M &\sim N(92.9666, 2.7694) \\
 w^H &\sim N(238.5152, 23.5680) \\
 r &\sim N(0.0656, 0.0180)
 \end{aligned}$$

The error terms $\varepsilon_{t,L}$, $\varepsilon_{t,M}$ and $\varepsilon_{t,H}$, as well as ε_t^r , are jointly distributed as a multi-variate normal:

$$\varepsilon_t \sim N(0, \Sigma')$$

with error covariance matrix

$$\Sigma' = \begin{bmatrix} 0.8439 & 0.5871 & -1.9703 & -0.0603 \\ 0.5871 & 1.3897 & 1.7645 & -0.0070 \\ -1.9703 & 1.7645 & 18.5021 & 0.2976 \\ -0.0603 & -0.0070 & 0.2977 & 0.0180 \end{bmatrix}$$

Considering the calibrated model, the solution is based on optimization following finite-horizon stochastic dynamic programming. Since an analytical solution to the optimization problem can not be obtained, simulations have been run in order to solve the problem numerically. These simulations have been performed in Matlab. Since wages ($w_{t,L}$, $w_{t,M}$, $w_{t,H}$) and market returns (r_t) are stochastic variables, a randomization has been performed by letting the software program randomly draw 1000 values for $w_{t,L}$, $w_{t,M}$ and $w_{t,H}$ as well as for r_t in every period t . Consequently, 1000 optimal assets (thus consumption) and leisure paths have been obtained, as well as 1000 pension benefit levels. The individuals' optimal paths have been finally derived from averaging out across the 1000 simulated paths in every period.

Low wages, middle wages, high wages and financial market returns in the model have been discretized into three states each (thus making up nine states overall for wages and three for market returns) in order to numerically solve the optimization problem. Like wages, pension benefits have been accordingly discretized into nine possible states. Stochastic processes for wages and financial market returns have been approximated by Markov chains through the Tauchen procedure (Tauchen, 1986) so as to be discretized.⁴¹ This procedure yields stationary transition matrices for all wage groups and market returns, representing the conditional probabilities of passing from one state of the world in a given period t to another state of the world in the subsequent period $t + 1$. The resulting stationary transition matrices of low wages and market returns (PWLR), middle wages and market returns (PWMR), high wages and market returns (PWHR) are reported as follows:⁴²

⁴¹Markov-chain approximation has been applied also to financial returns, although they do not follow a Markov chain since they turn out to be serially uncorrelated from estimations.

⁴²Each of these matrices has 9-by-9 dimension, resulting from combination of 3 discrete states for (respectively low, middle or high) wages and 3 discrete states for financial returns.

$$PWLR = \begin{bmatrix} 0.1262 & 0.5791 & 0.1652 & 0.0481 & 0.0725 & 0.0053 & 0.0000 & 0.0000 & 0.0000 \\ 0.1221 & 0.5579 & 0.1625 & 0.0521 & 0.0937 & 0.0087 & 0.0000 & 0.0000 & 0.0000 \\ 0.1183 & 0.5330 & 0.1594 & 0.0558 & 0.1186 & 0.0129 & 0.0000 & 0.0000 & 0.0000 \\ 0.0132 & 0.0769 & 0.0361 & 0.1314 & 0.4971 & 0.1237 & 0.0295 & 0.0775 & 0.0144 \\ 0.0161 & 0.0830 & 0.0333 & 0.1298 & 0.5016 & 0.1283 & 0.0282 & 0.0670 & 0.0126 \\ 0.0179 & 0.0935 & 0.0345 & 0.1253 & 0.4962 & 0.1294 & 0.0310 & 0.0619 & 0.0100 \\ 0.0000 & 0.0000 & 0.0000 & 0.0151 & 0.1370 & 0.0630 & 0.1590 & 0.5145 & 0.1104 \\ 0.0000 & 0.0000 & 0.0000 & 0.0104 & 0.1090 & 0.0589 & 0.1637 & 0.5425 & 0.1144 \\ 0.0000 & 0.0000 & 0.0000 & 0.0061 & 0.0813 & 0.0533 & 0.1681 & 0.5702 & 0.1202 \end{bmatrix}$$

$$PWMR = \begin{bmatrix} 0.0535 & 0.2078 & 0.0577 & 0.0898 & 0.3363 & 0.0876 & 0.0309 & 0.1074 & 0.0267 \\ 0.0708 & 0.2752 & 0.0768 & 0.0814 & 0.2994 & 0.0753 & 0.0221 & 0.0769 & 0.0191 \\ 0.0829 & 0.3233 & 0.0912 & 0.0780 & 0.2821 & 0.0688 & 0.0132 & 0.0462 & 0.0115 \\ 0.0184 & 0.0748 & 0.0216 & 0.1236 & 0.4625 & 0.1236 & 0.0321 & 0.1142 & 0.0291 \\ 0.0263 & 0.1042 & 0.0293 & 0.1253 & 0.4690 & 0.1254 & 0.0225 & 0.0783 & 0.0195 \\ 0.0397 & 0.1546 & 0.0423 & 0.1171 & 0.4381 & 0.1173 & 0.0173 & 0.0589 & 0.0143 \\ 0.0173 & 0.0696 & 0.0209 & 0.0785 & 0.3005 & 0.0812 & 0.0782 & 0.2814 & 0.0708 \\ 0.0259 & 0.1040 & 0.0312 & 0.0862 & 0.3240 & 0.0857 & 0.0620 & 0.2235 & 0.0565 \\ 0.0332 & 0.1336 & 0.0396 & 0.0974 & 0.3608 & 0.0943 & 0.0436 & 0.1572 & 0.0399 \end{bmatrix}$$

$$PWHR = \begin{bmatrix} 0.1286 & 0.2721 & 0.0251 & 0.0454 & 0.3718 & 0.1358 & 0.0001 & 0.0076 & 0.0130 \\ 0.1280 & 0.2694 & 0.0247 & 0.0460 & 0.3743 & 0.1359 & 0.0001 & 0.0079 & 0.0133 \\ 0.1281 & 0.2698 & 0.0247 & 0.0459 & 0.3740 & 0.1360 & 0.0001 & 0.0078 & 0.0132 \\ 0.0611 & 0.0733 & 0.0033 & 0.1097 & 0.5042 & 0.1092 & 0.0033 & 0.0740 & 0.0610 \\ 0.0597 & 0.0708 & 0.0031 & 0.1109 & 0.5041 & 0.1080 & 0.0035 & 0.0766 & 0.0623 \\ 0.0584 & 0.0683 & 0.0029 & 0.1121 & 0.5040 & 0.1069 & 0.0036 & 0.0792 & 0.0635 \\ 0.0122 & 0.0070 & 0.0001 & 0.1358 & 0.3660 & 0.0439 & 0.0262 & 0.2787 & 0.1295 \\ 0.0121 & 0.0069 & 0.0001 & 0.1357 & 0.3650 & 0.0436 & 0.0264 & 0.2798 & 0.1297 \\ 0.0118 & 0.0067 & 0.0001 & 0.1355 & 0.3625 & 0.0431 & 0.0268 & 0.2824 & 0.1303 \end{bmatrix}$$

In numerically solving the optimization problem the choice variables for individuals in every period t are represented by leisure (l_t) and asset holdings at the beginning of the next period (A_{t+1}). The assets variable has been discretized into a triple exponential grid of points representing different values for asset holdings of individuals. The number of grid points is 20, with the minimum grid value for assets being 0 (individuals cannot borrow in the model economy), and the maximum grid value being 500.

In most simulations within-period time endowment (\bar{T}) has been normalized to 2. This normalization of the per-period time endowment to two units

turns out to be useful in calibrating the model for computational reasons. Within-period leisure in the model, l_t , has been discretized so as to take on 10 possible grid values, triple-exponentially spaced from zero to (mostly) 2. In the baseline calibrated model individuals choose to work approximately 1 unit of time (enjoying approximately 1 time unit of leisure) during working life, whereas they enjoy the whole time endowment after retirement. The maximum allowed retirement age in the model has been realistically assumed to be at $t = 60$, corresponding to 80 real-life years. Therefore optimal retirement ages have been truncated at 60 when endogenously exceeding this threshold.

Since all variables are discretized in order to solve the optimization problem, the corresponding simulated paths for consumption, assets and leisure are obtained by interpolating (through the *spline* method) across the discrete values resulting from the optimization.

4.7 References

Aiyagari, S.R. (1994), “Uninsured Idiosyncratic Risk and Aggregate Saving”, *The Quarterly Journal of Economics* **109(3)**, 659-84.

Bank of Italy (2007), Household Wealth in Italy 1995-2005 - Supplements to the Statistical Bulletin, <http://www.bancaditalia.it/statistiche/>

Battistin, E., A. Brugiavini, E. Rettore and G. Weber (2009), “The Retirement Consumption Puzzle: Evidence from a Regression Discontinuity Approach”, *American Economic Review* **99(5)**, 2209-2226.

Baxter, M. (2001), “Social Security as a Financial Asset: Gender-Specific Risks and Returns”, Working paper, NBER, Cambridge, MA.

Bewley, T. (1986), “Stationary monetary equilibrium with a continuum of independently fluctuating consumers”, in H. Werner and A. Mas-Colell, eds., *Contributions to Mathematical Economics in Honor of Gerard Debreu*, North-Holland, Amsterdam, 79-102.

Borella, M. (2001), “Social Security Systems and the Distribution of Income: an Application to the Italian Case”, Working paper, Center for Research on Pensions and Welfare Policies, Turin, Italy.

Cardarelli, R. and N. Sartor (2000), “Generational Accounting for Italy”, in Bank of Italy, eds., *Fiscal Sustainability*, Rome, 501-57.

Conde-Ruiz, J.I. and P. Profeta (2004), “What Social Security: Beveridgean or Bismarckian?”, Meeting paper, Society for Economic Dynamics, University of Connecticut, Storrs, CT.

Conde-Ruiz, J.I. and P. Profeta (2007), “The Redistributive Design of Social Security Systems”, *Economic Journal* **117**, 686-712.

Conesa, J.C. and D. Krueger (1999), “Social Security Reform with Heterogeneous Agents”, *Review of Economic Dynamics* **2**, 757-95.

Costa, G., R. Leombruni and M. Richiardi (2008), “Aspettative di vita, lavori usuranti e equità del sistema previdenziale. Prime evidenze dal Work Histories Italian Panel”, Working paper, Laboratorio Riccardo Revelli, Turin, Italy.

Fehr, H. and C. Habermann (2008), “Risk Sharing and Efficiency Implications of Progressive Pension Arrangements”, *Scandinavian Journal of Economics* **110(2)**, 419-443.

Feldstein, M. S. and J.B. Liebman (2001), “Social Security”, Working paper, NBER, Cambridge, MA.

Fonseca, R. and T. Sopraseuth (2005), “Welfare Effects of Social Security Reforms Across Europe: the Case of France and Italy”, Working paper, Centre for Studies in Economics and Finance, Salerno, Italy.

Fuster, L., A. Imrohoroglu and S. Imrohoroglu (2007), “Elimination of Social Security in a Dynastic Framework”, *Review of Economic Studies* **74(1)**,

113-145.

Geron, D. (2010), "Social Security Incidence under Uncertainty: Assessing Italian Reforms", *mimeo*, Department of Economics, University of Padova, Italy.

Guazzarotti, G. and P. Tommasino (2008), "The Annuity Market in an Evolving Pension System: Lessons from Italy", Working paper, Center for Research on Pensions and Welfare Policies, Turin, Italy.

Huggett, M. and G. Ventura (1999), "On the Distributional Effects of Social Security Reform", *Review of Economic Dynamics* **2(3)**, 498-531.

Hurst, E. and P. Willen (2007), "Social security and unsecured debt", *Journal of Public Economics* **91(7-8)**, 1273-1297.

Koethenbueger, M., P. Poutvaara and P. Profeta (2008), "Why are more redistributive social security systems smaller? A median voter approach", *Oxford Economic Papers* **60(2)**, 275-292.

Lindbeck, A. and M. Persson (2003), "The Gains from Pension Reform", *Journal of Economic Literature* **41(1)**, 74-112.

Ljungqvist, L. and T.J. Sargent (2010), "Career Length: Effects of Curvature of Earnings Profiles, Earnings Shocks, and Social Security", Discussion Paper, CEPR, London, UK.

Mazzaferro, C. and S. Toso (2009), "The Distribution of Total Wealth in Italy: 1991-2002", *Review of Income and Wealth* **55(3)**, 779-802.

McCarthy, D. (2003), "A Lifecycle Analysis of Defined Benefit Pension Plans", Working Paper, Michigan Retirement Research Center, University of Michigan, Ann Arbor, MI.

Miniaci, R., C. Monfardini and G. Weber (2010), "How does consumption change upon retirement?", *Empirical Economics* **38(2)**, 257-280.

Nishiyama, S. and K. Smetters (2007), "Does Social Security Privatization Produce Efficiency Gains?", *The Quarterly Journal of Economics* **122(4)**, 1677-1719.

Nishiyama, S. and K. Smetters (2008), "The Optimal Design of Social Security Benefits", Working Paper, Michigan Retirement Research Center, University of Michigan, Ann Arbor, MI.

OECD (2007), Pensions at a Glance: Public Policies across OECD Countries - 2007 Edition, <http://lysander.sourceoecd.org>

OECD (2008), OECD Economic Outlook: Annual and quarterly data Vol 2008 Issue 1, <http://puck.sourceoecd.org>

Rosolia, A. and R. Torrini (2007), "The Generation Gap: Relative Earnings of Young and Old Workers in Italy", Working paper, Bank of Italy, Rome.

Storesletten, K., C.I. Telmer and A. Yaron (1999), "The Risk-sharing Implications of Alternative Social Security Arrangements", *Carnegie-Rochester*

Conference Series on Public Policy **50**, 213-259.

Tauchen, G. (1986), "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions", *Economic Letters* **20**, 177-81.

Ventura, L. (2003), "Direct Measures of Time Preference", *Economic and Social Review* **34(3)**, 293-310.

Chapter 5

Severance Pay or Pension Funds?

Devis Geron
Department of Economics, University of Padova

Abstract

The paper aims to analyze the determinants of the individual choice of contributing to pension funds, by evaluating the effects of the latest reform of social security in Italy, converting the severance pay scheme (the so-called *TFR*) into a fully funded scheme of pension funds. The model describes the behavior of a representative agent belonging to a representative generation in steady state, in a partial equilibrium setting with mortality risk as well as uncertainty on wages and financial market returns. Investing in riskier but potentially more rewarding pension funds, paying out annuities from retirement onwards, turns out to be slightly welfare improving with respect to contributing to a severance pay scheme eventually paying out a lump-sum amount. Interestingly, the optimal mix of the two schemes would maintain a small fraction of severance pay. The welfare-based value of insurance provided by private annuities from pension funds is relatively low, mainly due to *a*) the pre-existence of (sizeable) public annuities, and *b*) the convenience of investing considerable resources in financial markets upon retirement.

5.1 Introduction

In the last decades, most developed countries have experienced substantial changes both in the demographic structure and in the growth rates of the economy. As a result, the prospective financial sustainability of social security systems is put at risk, inducing many countries to reform public Pay-As-You-Go (PAYG) pension systems and to supplement (or partially substitute) them with fully funded complementary private pension schemes.

Italy is quite a neat example of this trend. In order to reduce the projected imbalance of social security, two main reforms were introduced in Italy during the early 1990s, turning the public PAYG system from a Defined Benefit (DB) to a Notional Defined Contribution (NDC) scheme, and considerably reducing the prospective replacement rates that it will be plausibly capable of providing.¹ A further pension reform, the so-called Maroni reform introduced in Italy in 2004 (implemented in 2007), was aimed at boosting the fully funded pension pillar, by providing fiscal incentives for workers choosing to invest their severance pay contributions (“*Trattamento di Fine Rapporto*”, TFR) into private Defined Contribution (DC) pension funds.²

The reform basically lets agents choose between investing in a (almost) safe asset paying out a lump-sum amount at the end of employment (severance pay scheme), and a riskier but potentially more rewarding asset that provides annuities from retirement onwards (pension funds). Important drivers of this choice, among others, appear to be the risk-aversion of workers and their preference towards more liquid assets, both potentially favoring the investment of contributions in the severance pay scheme (Cesari, Grande and Panetta, 2008). Conversely, an important argument in favor of pension funds is the provision of annuities that may otherwise be difficult to find in the market, protecting against the longevity risk, namely the risk of workers outliving their savings after retirement (Barr and Diamond, 2006). In fact, annuity markets are actually narrow in real economies. In particular the size of the Italian annuity market is currently tiny (Guazzarotti and Tommasino, 2008).

Such narrowness of annuity markets seemingly contradicts predictions of the traditional life cycle model, according to which individuals facing uncer-

¹The average gross replacement rate of private-sector employees, for instance, is projected to decrease from around 70% in 2010 to roughly 50% in 2060 (Covip, 2008).

²In Italy the value of assets in private pension funds as a percentage of GDP (3.3% in 2007) is still by far among the lowest levels in OECD countries (OECD, 2009). Despite the favorable fiscal conditions provided by the Maroni reform, relatively few workers chose to switch contribution from TFR to pension funds: by 2008 this choice was made by approximately 1/3 of private sector employees, according to Cesaratto (2011).

tain lifespan and without a bequest motive should fully annuitize their wealth (Yaari, 1965).³ The main explanations provided by the literature for this “annuity puzzle” are: low yields on annuities (also due to costs related to adverse selection); presence of a bequest motive (Friedman and Warshawsky, 1990); alternative risky investments that are more attractive than annuities, in case of labor supply flexibility (Benitez-Silva, 2003, building on Bodie, Merton and Samuelson, 1992); pre-existence of annuitized wealth, notably public pension wealth; general availability of nominal annuities not hedging against inflation risk; irreversibility of the annuity investment combined with retirees being liquidity constrained and facing uncertainty about future expenditure needs (Brown and Warshawsky, 2004). As specifically regards the payment form of accumulated pension capital at retirement, empirical studies have also confirmed that workers tend to choose lump-sum over annuitized payments, with few exceptions (Bütler and Teppa, 2007), which reveals an underlying general demand for liquid retirement assets. Therefore, as in many countries fully funded complementary private pension schemes are becoming ever more important, a key issue is whether (and to what extent) annuitization should be mandated.

This paper evaluates the individual behavior in contributing to supplementary private schemes, in the light of the analysis of the welfare consequences from the 2004 Italian pension reform. The main goal is to investigate the determinants of this behavior, particularly by focusing on the role of different payout forms at retirement, i.e. either lump-sum or annuities. The concurrent presence of both alternatives makes Italy an appropriate case study to the purposes of this paper.

The paper uses simulations from a life-cycle model of a representative agent belonging to a representative generation in steady state, within a partial equilibrium setting with mortality risk and uncertainty on factor returns. By applying the main features of the Italian public NDC pension system (the so-called “first pillar”, as modified by the 1995 reform) to a calibrated model reproducing stylized facts of the Italian economy, the paper performs a welfare comparison between the scenario where the representative individual chooses to contribute to the severance pay scheme on the one hand, and the scenario where the individual contributes to pension funds on the other hand (the so-called “second pillar”). Based on this comparison, the investment in the fully funded DC pension scheme turns out to be slightly preferred. In case pension funds are assumed to pay out benefits after retirement in a lump-sum

³Annuitization provides insurance against the risk of outliving one’s savings, as well as insurance against the risk of dying with assets that have not been consumed while alive. Moreover, the return on annuities also yields a mortality premium, reflecting the possibility that the individual dies before receiving future payments.

fashion (instead of annuities), *ceteris paribus*, the welfare gain to the complementary fully funded pension scheme is even larger. Pension funds are then assumed to provide the same risk-return combination as the severance pay asset, so that the analysis boils down to a comparison between annuities and lump-sum payments. In this case the previous relations reverse in that contributions are preferably kept with the severance pay scheme rather than being invested in pension funds. These findings suggest firstly that the risk-return combination of pension funds is potentially preferable, and acts as the unique driver of the overall individual preference towards pension funds. Secondly, the longevity-risk insurance effect is outweighed by preference towards more liquid retirement assets. Consistently with these intuitions, the optimal mix of the two schemes turns out to lean towards pension funds, while however preserving a small fraction of contributions within the severance pay fund. Investigating more in depth the specific individual choice between lump-sum and annuitized payout within pension funds, it turns out (in line with the above findings) that individuals prefer receiving most of the funds' capital in lump-sum fashion upon retirement. The pre-existence of sizeable annuitized wealth in the form of the public pension system proves to play an important role in "crowding out" a substantial part of the individual demand for private annuities. This implies that additional longevity-risk insurance from private annuities is valued relatively less than the opportunity of immediately cashing out most of the pension funds' capital. Another key factor explaining the low demand for annuities is the relative welfare gain to individuals from investing considerable resources out of the lump-sum payout in rewarding financial markets upon retirement.

The paper is organized as follows. Section 2 presents the model and the institutional framework. Section 3 illustrates the policy experiments that are considered, and presents the main findings. Section 4 concludes. A final Appendix provides more technical details on the calibration and the simulation method.

5.2 Model and Institutional Framework

5.2.1 Model

As in Geron (2010), the paper considers a steady-state partial equilibrium model in a discrete time setting (every period in the model corresponds to one year in real life), representing an economy where stochastic wages and financial returns are exogenously determined by foreign markets. The pre-tax income of individuals in the economy in every period t is thus determined

by a stochastic real average market return r_t on their savings (government bonds, corporate bonds, stocks) and by a stochastic real wage w_t earned during working life. The model considers yearly average wage growth, both at the aggregate level (growth rate of labor productivity g) and at the cohort-specific level (seniority wage growth sw). Both growth rates are assumed to be constant and to enter the model as exogenous deterministic trends that are applied to the underlying stochastic dynamics of wages w_t .

Individuals in the economy live from age 1 to at most T years, surviving at every age t (with $t = 1, \dots, T$) to age $t+1$ with a given (age-dependent) conditional survival probability. The economy in every period is populated by T generations, each consisting of an infinite number of agents.⁴ Total population mass is assumed to grow at a deterministic constant rate m . Individuals ex-ante (i.e. at time $t = 0$, prior to entering the economy) maximize expected discounted lifetime utility with respect to within-period consumption and within-period leisure:

$$E_0 \left[\sum_{t=1}^T \beta^{t-1} \left[\prod_{k=1}^t \psi_k \right] U_t(c_t, l_t) \right]$$

where β in the above formula is the subjective time discount factor; ψ_t is the conditional survival probability from age $t-1$ to t , with $\psi_1 = 1$ and $\psi_{T+1} = 0$; c_t and l_t are respectively consumption and leisure entering the utility function of agents at age t . The within-period utility function takes the CES form:

$$U_t(c_t, l_t) = \frac{1}{1-\rho} (c_t^{1-\sigma} + \gamma_t l_t^{1-\sigma})^{\frac{1-\rho}{1-\sigma}}$$

where $\frac{1}{\rho}$ is the intertemporal elasticity of substitution between consumption of different years, $\frac{1}{\sigma}$ is the intratemporal elasticity of substitution between consumption and leisure, and γ_t represents the time-varying leisure preference parameter following the formula:

$$\begin{aligned} \gamma_t &= 1 && \text{for } t = 1, \dots, \tilde{t} \\ \gamma_t &= \left(\frac{1}{\psi_t} - \left(\frac{1}{\psi_{\tilde{t}}} - 1 \right) \right)^\theta && \text{for } t = \tilde{t} + 1, \dots, T \end{aligned}$$

The leisure preference parameter is constant (normalized to 1) until a given period \tilde{t} in lifetime, and increases thereafter. This assumption represents the utility from leisure (disutility from work) as being constant during

⁴In each period, a constant fraction of individuals passes from each age to the next (respectively, dies) according to constant survival probabilities (respectively, according to constant mortality probabilities). Since the model is considered in steady state under the assumption of partial equilibrium, the whole analysis throughout the paper will focus on a single representative individual belonging to a representative generation, instead of considering all overlapping generations through time. With reference to this single representative individual, both time periods and the individual's age are denoted by t (with $t = 1, \dots, T$).

the initial part of working life when individuals are younger, and then increasing when individuals are older and less healthy.⁵

In every period t individuals are provided with a given time endowment \bar{T} , and choose consumption c_t and labor supply $\bar{T} - l_t$. Individuals work and receive a wage w_t for each unit of time spent working, i.e. overall $w_t(\bar{T} - l_t)$, at every age t (if alive) until they endogenously choose to retire at age t_{ret} . After retiring individuals are assumed to no longer go back to work in subsequent periods. While working, individuals pay in social security contributions at a rate h out of their gross labor income. After retirement they receive a public pension benefit p_t (linked to their working-life wages) at every age t if alive until death at T . During working life individuals are also mandatorily required to contribute at a rate h' out of their labor income, either to their firm-based severance pay scheme (namely, the termination indemnity) or to external private pension funds. Accordingly, after retirement individuals enjoy an additional source of income, consisting of either a lump-sum amount at t_{ret} (the severance pay, denoted by SP) or a further annuitized payment at every age t if alive until death at T (the complementary private pension from pension funds, denoted by PF_t).

Denoting gross labor income in every period t , i.e. $w_t(1+g)^{t-1}(1+sw)^{t-1}(\bar{T} - l_t)$, as W_t , in case the additional working-life contributions (paid at rate h') are left by the firm-based severance pay scheme, the within-period budget constraint of a given individual at every age t would read as follows:

$$\begin{aligned} A_{t+1} &= A_t(1+r_t) + (1-h-h')W_t - c_t & \text{for } t = 1, \dots, t_{ret} - 1 \\ A_{t+1} &= A_t(1+r_t) + p_t + SP - c_t & \text{for } t = t_{ret} \\ A_{t+1} &= A_t(1+r_t) + p_t - c_t & \text{for } t = t_{ret} + 1, \dots, T \end{aligned}$$

In case the additional working-life contributions (paid at rate h') are instead invested in the private fully funded pillar (pension funds), the within-period budget constraint would read as follows:

$$\begin{aligned} A_{t+1} &= A_t(1+r_t) + (1-h-h')W_t - c_t & \text{for } t = 1, \dots, t_{ret} - 1 \\ A_{t+1} &= A_t(1+r_t) + p_t + PF_t - c_t & \text{for } t = t_{ret}, \dots, T \end{aligned}$$

In the above formulas A_t represents the beginning-of-period asset holdings of the individual aged t .

Agents are assumed to be borrowing constrained:

$$A_t \geq 0 \quad \text{for } t = 1, \dots, T$$

⁵Survival probabilities in the model can be considered as a proxy for individual health conditions, worsening as individuals become older. The leisure preference parameter is therefore assumed to be inversely proportional to survival probabilities (from a given age onwards).

The model assumes there is no bequest motive, therefore for individuals living until the last possible age T it holds that $A_{T+1} = 0$. Accidental bequests of individuals dying before reaching age T are assumed to be destroyed and provide no utility to other living individuals.⁶

Markets in the model are assumed to be incomplete. Firstly, agents are borrowing constrained. Secondly, annuity markets are assumed to be missing, except for complementary private pensions.

5.2.2 Institutional Framework

The Italian public pension scheme considered in the model reproduces the main features of the system introduced by the so-called Dini reform in 1995. The Dini reform transformed the Italian public PAYG pension system from a DB into a NDC scheme. Pension benefits under this regime are computed by “notionally”, i.e. fictitiously, capitalizing social security contributions at a rate that is linked to the growth rate of the economy during working life (depending on the growth rate of productivity and population, respectively denoted by g and m in the model). The amount accumulated in this way at retirement is turned into annuities through multiplying it by statutory annuity rates (so called “transformation coefficients”, denoted by tc). Individuals are allowed to choose their retirement age (denoted by t_{ret} in the model) from any age between 57 and 65 real-life years (corresponding to respectively 37 and 45 years in the model), with a minimum required number of years of contribution.⁷ Annuity rates vary according to the age at which an individual chooses to retire: the higher the retirement age, the greater the annuity rate, and the greater the pension benefit.⁸ The contribution rate (denoted by h in the model) currently in force is 33%. Denoting gross labor income in every period t , namely $w_t(1+g)^{t-1}(1+sw)^{t-1}(\bar{T}-l_t)$, as W_t , the formula of the public pension benefit annuity can be represented as follows:

⁶This assumption is made for the sake of considerable computational simplification. Alternative assumptions regarding accidental bequests may involve redistributing unintended bequests to all or some of the surviving generations according to some criteria, e.g. in a lump-sum fashion or proportionally to wealth conditions of the survivors.

⁷Each age t in the model corresponds to age $t+20$ in real life. Hereafter in the paper, retirement age t_{ret} is expressed in terms of *model* periods. Corresponding real-life age therefore equals the model age plus 20.

⁸Individuals may also choose to retire after 65 real-life years: in this case the annuity rate (transformation coefficient) used in the benefit rule remains constant thereafter, and equal to the annuity rate applied in case of retirement at 65. The 1995 reform also provided that statutory transformation coefficients should be revised every ten years, in order to account for changes in the (average) life expectancy of population, however the first actual revision occurred in 2010 instead of 2005.

$$p = tc \cdot \left\{ \sum_{t=1}^{t_{ret}-1} h \cdot W_t \cdot [(1+g) \cdot (1+m)]^{t_{ret}-t} \right\}$$

where tc is increasing with retirement age, from 0.047 when $t_{ret} = 37$ to 0.061 when $t_{ret} \geq 45$.⁹

The latest reform introduced in Italy in 2004, the so-called Maroni reform, largely preserved the public pension system *à la* Dini, by only applying some marginal changes (such as a gradual increase in the minimum retirement age, from 60 years in 2008 to 62 years in 2014 onwards) that are not considered in the model. The Maroni reform affected more deeply the private pension pillar, in that it provided fiscal incentives for workers to invest their severance pay contributions into pension funds, on an individual voluntary basis.¹⁰ The reform (as detailed by the application law in 2005, and actually implemented as of 2007), provided that workers would have to choose whether to leave their future contributions for severance pay (so-called “*Trattamento di Fine Rapporto*”, TFR) by their firm-based saving fund, or to (irreversibly) devote those contributions to fiscally-favored investment in complementary pension schemes (the private fully funded DC pension pillar).¹¹ The contribution rate to both schemes (denoted by h' in the model) is 6.91% of gross labor earnings.¹²

Contributions to the TFR fund yield a (nearly) safe return equalling a fixed 1.5% nominal rate plus 75% of the inflation rate; the revaluated total amount is paid out in a lump-sum fashion at retirement (or upon leaving the firm). For the sake of simplicity the *real* return on severance pay contribu-

⁹A transition period for the 1995 reform was set by law. Whoever at the end of 1995 had contributed for more than 18 years, is not affected by the Dini reform; for whomever entered the labor market after 1995, Dini reform fully applies; for those having contributed to social security for less than 18 years at the end of 1995, a mixed regime applies, with pensions determined pro-rata (proportionally to time spent contributing before and after 1995). The paper does not consider this transition phase, and only focuses on the fully applied Dini regime.

¹⁰The paper however does *not* consider fiscal incentives to investment in pension funds, since the focus is only on comparing the very features of alternative schemes, abstracting from taxation favoring specific investment forms over others.

¹¹This choice has to be made within six months from employment. The choice of leaving the TFR contributions with the firm can be reconsidered in the future, whereas the investment of contributions in pension funds is irreversible. The paper does *not* consider scenarios where individuals pay in contributions to the TFR scheme until a certain working-life period and in pension funds thereafter, since individuals in the model are only allowed to invest in one of the two alternatives during their whole working life.

¹²The statutory contribution rate to the TFR scheme is indeed 6.91%. This same amount can be alternatively diverted to pension funds, based on individual choice. The paper only focuses on these two scenarios, without considering any further investment in pension funds. In reality, besides possibly diverting the mandatory TFR payment, additional contributions to the fully funded pension pillar can be voluntarily paid by both employees and employers.

tions, denoted by r_{SP} , is treated in the model as a *fixed* (i.e. completely safe) return amounting to 0.55%, given its very low variance derived from a mere 25% of the (usually fairly stable) inflation rate.¹³

The severance pay (SP) received at retirement can be therefore represented as follows:

$$SP = \sum_{t=1}^{t_{ret}-1} h' \cdot W_t \cdot (1 + r_{SP})^{t_{ret}-t}$$

Contributions to private pension funds (PF) instead yield a risky financial market return (the average financial return denoted by r_t in the model); the capitalized total amount is paid out in the form of annuities from retirement onwards.¹⁴ The annuity rate for private pensions (denoted by tc' in the model) is actuarially determined as inversely depending on conditional survival probabilities (denoted by ψ_t in the model) discounted at rate \bar{r} :

$$tc' = \left(\sum_{t=t_{ret}}^T \frac{\prod_{k=t_{ret}}^t \psi_k}{(1+\bar{r})^{t-t_{ret}}} \right)^{-1}$$

As expected, tc' is increasing with retirement age, for instance it equals 0.0374 when $t_{ret} = 37$, and 0.0502 when $t_{ret} = 45$. The discount rate \bar{r} used for private pension annuities in the model is zero.¹⁵

¹³Denoting by inf_t the inflation rate in period t , the *nominal* return on TFR contributions measured in period t would equal $0.015 + (0.75 \cdot inf_t)$, and the corresponding *real* return would thus approximately equal $0.015 - (0.25 \cdot inf_t)$. Since all variables in the model are expressed in real terms and there is no inflation, for the sake of simplicity, the per-period inflation rate is assumed to be constant and is equalized to the average inflation rate in period 1990-2004 (consistently with the reference period for other macroeconomic data used in the paper), that is about 3.8%. Consequently, r_{SP} in the paper is a fixed return rate equal to $0.015 - (0.25 \cdot 0.038) = 0.0055 = 0.55\%$. Such simplifying assumption of constant r_{SP} is quite realistic, since the series of real returns obtained by applying the 1990-2004 series of inflation rates shows a very low variability. Defining R_t as the real severance pay yield, $0.015 - (0.25 \cdot inf_t)$, with reference to actual 1990-2004 data, the sample variance of R_t is indeed 0.000017. This variance value equals 0.3% of the R_t sample mean (0.0055), and just 0.4% of the variance of the risky financial market returns in the model (0.004).

¹⁴Law provisions after the 2004 reform mandate annuitization of at least half of a worker's pension fund capital. The baseline model in the paper considers complete annuitization under pension funds. This assumption is relaxed in further analysis allowing for individual choice on the optimal annuitization share within pension funds.

¹⁵In this paper, competition among different private pension funds is not explicitly taken into account, therefore the second pension pillar resembles the functioning of a single government-operated pension fund. Moreover, pension fund managers actually may also choose to insure themselves against default risk. Consequently, the discount rate \bar{r} is assumed to be zero, reflecting the absence of risk in the payment of private pensions. Following the previous reasoning, administrative costs of pension funds are also assumed to equal zero in the model, while actual administrative costs in the real world tend to be higher under fully funded than under PAYG pension schemes (Lindbeck and Persson, 2003).

The private pension benefit annuity can be represented as follows:

$$PF = tc' \cdot \left\{ \sum_{t=1}^{t_{ret}-1} h' \cdot W_t \cdot \left[\prod_{k=t}^{t_{ret}-1} (1 + r_k) \right] \right\}$$

Basically the stylized Italian pension system reproduced in the paper consists of the mandatory public first pillar, supplemented by the mandatory part of the private second pillar (constituted by one of the two alternative schemes, i.e. either the severance pay saving fund or pension funds, based on individual choice).

5.2.3 Calibration and Optimization Problem

The main parameters of the model, notably those preference-related, are assigned specific values resulting from calibration aiming to replicate stylized facts of the Italian economy, notably lifetime labor and consumption paths of individuals, as in Geron (2010).¹⁶

The baseline calibration is characterized as reported in Table 5.1. The representative individual is assumed to enter the economy when 21 years old, corresponding to the first lifetime period ($t = 1$) in the model. This reflects the real average entry age in the labor market in Italy. Assets held by individuals at the beginning of their (economic) life are assumed to be equal to zero: $A_1 = 0$. The representative individual lives at most T periods, equalized to 80 in the model (i.e. when 100 years old in real life), surviving from every period to the next with a certain (conditional) survival probability.¹⁷ Population mass of the whole economy in every period is normalized to one, i.e. yearly population growth rate (denoted by m) is equal to zero. This is in line with recent demographic trends and with demographic projections for Italy.¹⁸

Econometric analysis on Italian real wages and financial market returns between 1990 and 2004 (for further details see the Appendix) is the same as in Geron (2010). The estimated processes underlying wages w_t and market returns r_t can be represented as follows (standard errors in parentheses):

¹⁶The benchmark economy utilized in the calibration is the Italian economy under the old pension system, i.e. the pension regime before the introduction of the Amato reform in 1992, since the Dini regime is undergoing a long transition phase.

¹⁷The sequence of conditional survival probabilities $\{\psi_t\}_{t=1}^T$ is computed as the weighted average of survival probabilities per cohort of Italian males and females in 2004, reported by the yearly demographic balance of Istat (Italian National Institute of Statistics). The year 2004 is one of the last years for which data are available, and is in line with the 1990-2004 time span of macroeconomic data utilized in the calibration.

¹⁸According to the Istat demographic balance, the Italian population in the 1990-2004 period has experienced an average yearly population growth rate equal to 0.15%. Istat demographic projections for the 2007-2051 period, under the so-called “central” scenario, forecast an average yearly population growth rate close to zero, namely 0.1%.

$$w_t = \underset{(10.273)}{35.253} + \underset{(0.103)}{0.645} \cdot w_{t-1} + ew_t$$

where ew_t is the error term, normally, identically and independently distributed with mean zero and variance (denoted by σ_w^2) estimated to equal 2.436;

$$r_t = \underset{(0.008)}{0.054} + er_t$$

where er_t is the error term, normally, identically and independently distributed with mean zero and variance (denoted by σ_r^2) estimated to equal 0.004. The covariance between the error terms (denoted by σ_{wr}) is estimated to equal 0.03.

The deterministic yearly growth rate (denoted by g) of aggregate real wages is assumed to be zero. This is in line with the average yearly growth rate of aggregate real compensations per employee in period 1990-2004, that was roughly zero.¹⁹ The only source of deterministic wage variation through time is a cohort-specific component tracking changes in wages due to career dynamics, namely to seniority-driven (contractual) increases in wages. This per-period *cohort-specific* “seniority” growth rate in real wages, denoted by sw , is set at 2% (for further details see the Appendix) and is assumed to remain constant across the entire individual working life, as well as throughout all subsequent cohorts, so that it is also consistent with an *aggregate* growth of real wages (g) equal to zero.²⁰

Based on the calibrated model, the solution to the corresponding optimization problem for the representative individual entering the economy at age $t = 1$ is a sequence of optimally chosen values for consumption ($\{c_t^*\}_{t=1}^T$) and leisure ($\{l_t^*\}_{t=1}^T$), as well as the optimal retirement age t_{ret} , maximizing the individual’s expected discounted lifetime utility (measured at time $t = 0$). Solutions are found by numerically simulating (1000 times) the calibrated model. Therefore optimal individual behavior is state-contingent, namely depending on the specific simulated realizations of stochastic variables in each period t . Consequently, lifetime profiles for consumption and leisure ($\{c_t^*\}_{t=1}^T$ and $\{l_t^*\}_{t=1}^T$) result from averaging across 1000 different paths.²¹

¹⁹According to OECD (2008) data for Italy, average growth rate of real compensations in 1990-2004 was approximately equal to -0.04% .

²⁰As a consequence of the above assumptions, the representative individual belonging to the representative generation (cohort) considered in the model enjoys a deterministic growth of wages by 2% per period.

²¹For the sake of computational simplification, the optimal retirement age t_{ret} is instead computed from an ex-ante perspective, as the age maximizing the expected discounted lifetime utility (namely the value function at the beginning of life).

Parameters	Symbol	Value
Demographic and macroeconomic parameters		
<i>Maximum possible life length</i>	T	80
<i>Growth rate of population</i>	m	0
<i>Variance of wages error term</i>	σ_w^2	2.436
<i>Variance of market returns error term</i>	σ_r^2	0.004
<i>Covariance of wages and market returns error terms</i>	σ_{wr}	0.03
<i>Aggregate growth rate of wages</i>	g	0
<i>Seniority growth rate of wages</i>	sw	0.02
Preference parameters		
<i>Subjective time discount factor</i>	β	0.96
<i>Reciprocal of the intertemporal elasticity of substitution</i>	ρ	1.0001
<i>Reciprocal of the intratemporal elasticity of substitution</i>	σ	0.999
<i>Parameters in the leisure preference formula</i>	θ	90
$\gamma_t = \left(\frac{1}{\psi_t} - \left(\frac{1}{\psi_{\bar{t}}} - 1\right)\right)^\theta$	\tilde{t}	35

Table 5.1: Calibration

5.3 Findings

In order to evaluate the individual choice of investing in the fully funded pension pillar (in the light of the 2004 Italian pension reform), comparisons are performed between different scenarios. The main *statutory* features of the schemes considered in the paper are represented in Table 5.2.

The analysis of a steady-state setting with a representative individual belonging to one representative generation requires considering balanced-budget scenarios. To this end, the social security budget is forced to balance in every period (thus it cannot run either deficits or surpluses) by artificially changing a *statutory* policy parameter, namely the public-pension annuity rate tc , for every given level of the relative contribution rate h .

Comparisons in the paper are carried out by analyzing different settings, from an ex-ante welfare perspective. Firstly the reference scenarios are considered, namely the firm-based severance pay saving scheme (*SP*) and the fully funded scheme based on pension funds (*PF*). Secondly, the analysis goes more in depth by considering a hypothetical fully funded scheme paying out financially capitalized contributions in a lump-sum fashion (*LumpsumPF*) on the one hand, and a hypothetical annuity-based fully funded scheme where contributions yield the same fixed (non-stochastic) return rate r_{SP} as the severance pay scheme (*FixedratePF*). All of these four schemes enter the model

	Payout form	Benefit
<i>Public pension (I pillar)</i>	annuity	$tc \cdot \{\sum_{t=1}^{t_{ret}-1} (0.33) \cdot W_t\}$
<i>Private pension (II pillar) from pension funds - PF</i>	annuity	$tc' \cdot \{\sum_{t=1}^{t_{ret}-1} (0.0691) \cdot W_t \cdot [\prod_{k=t}^{t_{ret}-1} (1 + r_k)]\}$ with $tc' = \frac{1}{\sum_{t=t_{ret}}^T \prod_{k=t_{ret}}^t \psi_k}$
<i>Severance pay - SP</i>	lump-sum	$\sum_{t=1}^{t_{ret}-1} (0.0691) \cdot W_t \cdot (1.0055)^{t_{ret}-t}$

Table 5.2: Schemes considered in the paper

on top of the public first-pillar pension system.²²

The results from comparing couples of settings are expressed in terms of “*Compensating Variation*” (CV), defined as the amount of assets that should be given to individuals in a setting (e.g. with individuals contributing to pension funds) before the beginning of their life, in order to let them benefit from the same level of ex-ante expected discounted lifetime utility as they would enjoy in the other setting (e.g. with individuals contributing to the severance pay scheme). Hereafter in the paper, all comparisons between alternative settings are expressed in terms of Compensating Variation normalized by the average wage in the first model period.²³ The main results of the paper (Compensating Variations as well as outcomes from optimality analysis) are summarized in Table 5.3.

²²In comparing different scenarios, the macroeconomic (basically, w_t and r_t in every model period t) and demographic backdrop remains the same, with the only difference being the institutional features under each alternative setting.

²³The comparison measures, computed in terms of assets, are expressed relative to the average individual wage. In particular, the first-period wage is considered because it is drawn from the stationary (i.e. “steady-state”) distribution of wages in the model.

Compensating Variations	
SP vs PF	-0.0568
SP vs $LumpsumPF$	-0.2148
SP vs $FixedratePF$	0.1682
Optimal mix of SP and PF	
SP: α^*	0.07
PF: $(1 - \alpha^*)$	0.93
Optimal mix of payout forms within PF	
Annuity: δ^*	0.15
Lump-sum: $(1 - \delta^*)$	0.85

Table 5.3: Main results [Compensating Variations relative to comparisons (*settingA* vs *settingB*). $CV > 0$ ($CV < 0$) implies *settingB* worsening (improving) individual welfare with respect to *settingA*]

5.3.1 Comparison between Severance Pay and Pension Funds

Considering the optimal retirement ages under different schemes (reported in Table 5.4), it turns out that when individuals opt for leaving their contributions by the firm-based scheme, they wish to retire slightly later than they would when investing in pension funds. This is plausibly due to the return on pension funds being riskier but *on average* substantially more rewarding than the return on the severance pay saving fund, which induces individuals to work longer in order to accumulate a higher amount of severance pay savings.²⁴ On the other hand, lump-sum payment induces individuals on average to retire earlier than annuitized pensions, for any given risk-return combination.²⁵ This results from the need to work longer to accumulate a higher amount of capital, in case it is annuitized and earned gradually later, instead of being immediately received at retirement.

From simulations the resulting Compensating Variation (denoted by $CV_{SP,PF}$) to be given to the representative individual passing from a setting with the severance pay scheme to a setting with pension funds (both in addition to

²⁴The (assumedly) fixed return on severance pay (r_{SP}) is 0.55%, whereas the *average* expected financial market return earned from investing in pension funds is 5.4%.

²⁵Since *FixedratePF* is equivalent to a severance pay scheme paying out annuities after retirement, it is apparent from Table 5.4 that individuals under either severance pay or pension funds tend to retire slightly earlier with lump-sum than with annuitized payment of the respective accumulated amount at retirement.

	Optimal t_{ret}
SP	39
PF	38
$LumpsumPF$	37
$FixedratePF$	40

Table 5.4: Retirement ages under different settings

the first public pillar) turns out to equal -0.0568 (relative to the first-period wage in the economy), as reported in Table 5.3. The negative sign of CV_{SP_PF} implies that investing contributions in pension funds causes a higher individual lifetime welfare than investing in the firm-based scheme. In order to shed light on this general finding, additional comparisons between alternative settings are performed as follows, allowing a deeper understanding of the role played by the relative convenience of different risk-return profiles and (particularly) different payout methods.

5.3.2 Risk-return Combination and Payout Form

Further comparisons are performed between the setting with individuals contributing to the severance pay scheme, and *a*) the setting with individuals investing in pension funds paying out benefits in a lump-sum fashion ($CV_{SP_LumpsumPF}$) or *b*) the setting with individuals investing in annuity-based pension funds yielding a fixed return rate equal to the severance pay return ($CV_{SP_FixedratePF}$).

From the first comparison, it turns out that the ex-ante welfare gain from shifting to pension funds increases when pensions are provided in lump-sum form upon retirement: $CV_{SP_LumpsumPF}$ is indeed negative and larger in absolute value than CV_{SP_PF} , as reported in Table 5.3. This implies that the preference towards the more liquid lump-sum payment prevails over the longevity-risk insurance provided by annuitized benefits. Consequently, the previous general finding expressed by CV_{SP_PF} (pension funds are overall slightly preferred to severance pay) is *uniquely* driven by the more favorable risk-return combination of the private fully funded pillar reproduced in the model. The fact that the pension fund portfolio is more “efficient” (i.e. provides a better risk-return combination) than the severance pay fund, depends on the substantially higher expected financial return of the former outweighing the lower riskiness of the latter in driving ex-ante welfare gains.²⁶

²⁶In case the discount rate \bar{r} used for private pensions were assumed to equal the (almost) safe r_{SP} return (instead of being set at zero), these results would be qualitatively confirmed and quantitatively strengthened, since the annuity rate (tc') and thus benefits from pension

From the second comparison, individual preference towards earlier liquidity is further confirmed by $CV_{SP_FixedratePF}$ being positive. The positive sign of $CV_{SP_FixedratePF}$ means indeed that, after equalizing the risk-return properties of the two schemes (to the severance pay risk-return combination), paying out the same capitalized amount in the form of annuities decreases individual welfare with respect to paying it out in the lump-sum form.

From an overall analysis of all the above findings, it is therefore apparent that the “efficiency effect” (higher expected return relative to riskiness) of pension funds outweighs even the preference towards more liquid retirement assets, since the investment in annuity-based pension funds is generally preferred to the investment in the lump-sum-based severance pay saving fund (CV_{SP_PF} is negative).

While the severance pay scheme is beneficial to individuals by providing the whole accrued amount immediately at retirement, this effect is thus dominated by pension funds providing a preferred risk-return combination. Such outcome clearly emerges also by analyzing a hypothetical scenario where individuals are allowed to invest in a *mix* of the two schemes. Under this scenario, individuals in the model can choose the optimal share α^* to be invested in the severance pay scheme out of the overall mandatory contribution rate (h'), and thus the corresponding portion $1 - \alpha^*$ of h' to be invested in pension funds. Under this assumption α^* turns out to equal 0.07, implying that the optimal investment mix consists of 7% in the severance pay scheme and 93% in pension funds. A combination of the two schemes, thus of their respective advantages (earlier liquidity and higher financial reward), may therefore increase individual welfare with respect to the (statutory) setting requiring workers to invest in only one of the two assets (at a time). In particular, consistently with the previous findings, the optimal combination shows a clear prevalence (93%) of financially rewarding pension funds, although a minor fraction (7%) would still be kept within the more liquid severance pay scheme, so as to receive a (small) part of the capitalized amount immediately at retirement.²⁷

5.3.3 Optimal Payout Mix in Pension Funds

As suggested by Compensating Variations reported in Table 5.3, individuals prefer earlier lump-sum payment over the annuitization of benefits. In order to evaluate more in depth the preference of individuals towards alternative

funds would increase in value, *ceteris paribus*.

²⁷Under the optimal-mix scenario individuals choose to retire at 38, namely at the same age as under pure pension funds, in accordance with the prevalence of this scheme within the optimal mix.

payout forms, while abstracting from differences in risk-return combinations, further analysis aims at investigating the optimal mix of lump-sum and annuity payments from pension funds.²⁸ To this end, the accumulated pension fund capital is assumed to be possibly paid partly (by a share δ) as annuities from retirement onwards and partly (by a share $1 - \delta$) immediately in lump-sum fashion at retirement. Under this scenario, it turns out that the optimal share of annuitization (δ^*) amounts to 15%, and the corresponding optimal lump-sum share ($1 - \delta^*$) equals 85%.²⁹ This implies that individuals would like to annuitize a minor (though positive) portion of the accumulated pension capital at retirement, consistently with the previously highlighted preference towards earlier liquidity. Such predominant underlying demand for liquid retirement assets is consistent with what is often reported in the literature, regarding the actual preference of most workers for lump-sum payout over annuities.

The clear (85%) tendency towards lump-sum payments may be striking at first. Annuitization provides indeed retirees with insurance against two qualitatively opposite risks (Brown and Warshawsky, 2004): the risk of outliving one's savings (the so-called longevity risk), and the risk of dying with assets that have not been consumed while alive (due to self-insuring by setting aside more than enough wealth). Moreover, annuities yield a mortality premium (due to the individual possibly dying before receiving future payments) besides the risk-free rate. The preference towards lump-sum cash-out may be due to several reasons, some of which are based on rational economic grounds, some others relate to individuals' financial illiteracy or behavioral biases (Brown, 2009). In life-cycle models of rational agents, as the one adopted in this paper, only the first type of reasons is to be taken into account. In particular, the previously reported low level (15%) of the optimal share of annuitization is due to the following factors:

- the pre-existence of annuitized wealth provided by the public PAYG social security pillar;
- the subjective discounting of future streams of annuitized income, as well as the potential attractiveness of alternative risky investments after retirement;

²⁸The relevance of this analysis also relates to the fact that in many cases workers participating in (especially DC) pension funds are offered the opportunity of receiving a share of their accrued pension claims immediately upon retirement. Notably, the Italian law provides workers with the opportunity of receiving up to 50% of benefits from pension funds in a lump-sum fashion.

²⁹The optimal retirement age in this case equals 37, namely the same age as under purely lump-sum pension funds (see Table 5.4).

- the payout schedule of the annuity investment, yielding a fixed stream of income from retirement onwards.

Generally, as sources of annuitized wealth already exist in the individual's portfolio, the value of incremental annuity payments decreases (Brown and Warshawsky, 2004), so that individuals may be willing to forgo (totally or partly) additional annuities in exchange for (substantial) immediate payments. This argument can be shown by artificially changing the size of the public pension system in the model, so as to completely eliminate (as an extreme case) the first pillar. By exogenously setting the public-system contribution rate h to zero, the optimal annuitization share δ^* of the pension funds' capital becomes 50% instead of 15%.³⁰ This implies that private annuities do increase individual welfare through their insurance properties, nevertheless their importance relatively decreases and is generally overshadowed by preference towards earlier liquidity as long as individuals already benefit from sizable annuitized wealth (namely, the public pension system with contribution rate $h = 0.33$). The partial "crowding-out" effect caused by pre-existing public pensions (in principle, actuarially fair annuities under a NDC system) over private annuities therefore acts as a key determinant of the limited recourse to the latter, accounting for 35% non-annuitized wealth within pension funds.³¹

Subjective intertemporal discounting (implicit within the time discount factor β in the model) may also play a relevant role in evaluating a future stream of annuities with respect to lump-sum payment received immediately upon leaving the job (Warner and Pleeter, 2001). The more patient individuals are, the higher the value they indeed attach to future streams of income. For instance if the subjective time discount factor β (calibrated as 0.96) were assumedly set to 1, the optimal annuitization share within pension funds δ^* would increase to 31%. Intuitively, assuming a unitary value for β implies supposing no subjective preference for present over future consumption, so

³⁰The optimal retirement age in this case equals 46. Individuals in the absence of the main source of retirement benefits (namely the public pillar) tend to retire later than under the alternative scenarios.

³¹A related issue is the optimal size of either of the two alternative schemes supplementing the public pension system. Assuming that individuals are allowed to voluntarily choose how much to contribute to the private second pillar, under either SP or PF, it turns out that the optimal size (i.e. the contribution rate) of both the severance pay scheme (h_{SP}^*) and pension funds (h_{PF}^*) is zero (with individuals choosing to retire at a later age, that is 42, than in the presence of a complementary private fund). Also this individual preference for no supplementary scheme whatsoever is apparently due to the considerable size of the mandatory public pillar, which "crowds out" additional private saving for retirement of any type.

that individuals attach a higher value (than in the baseline case) to any additional stream of annuities from retirement onwards, *ceteris paribus*.

Analogously, the risk-free discount rate (\bar{r} , set at zero in the model, and usually relatively low in fact) used to compute the annuity rate for private pensions (tc') may also contribute to explaining the preference for lump-sum payout, particularly if the discount rate considered by individuals is higher than \bar{r} . Individuals may indeed be better off by receiving (most of) the pension-funds capitalized amount in lump-sum fashion immediately upon retirement, and by subsequently investing it in financial markets gaining a higher expected rate than the risk-free yield. Under the hypothesis of 100% lump-sum payout from pension funds, model-predicted individual behavior after retirement would optimally invest a sizeable portion of the accumulated assets (notably, a portion of the lump-sum payout greater than the corresponding per-period annuity) in the financial markets, thereby gaining risky returns at rate r_t *on average* equal to 5.4%. Therefore, annuitization would generally impose a constraint on individual saving behavior after retirement.³² This point can be clearly illustrated by hypothetically assuming that the discount rate for computing annuities equals the average financial market return (namely $\bar{r} = 0.054$): in this case the optimal annuitization share δ^* considerably increases to 68%.³³ Such finding suggests that the relative financial convenience of annuities with respect to alternative risky investments (made out of the lump-sum payout) upon retirement plays an important role in driving the individual demand for annuities.

A related reason why demand for additional (private) annuities can be relatively low is due to the annuity investment usually paying out a constant stream of income (as it is the case under most pension schemes). Therefore individuals after retirement are potentially liquidity constrained, while also facing future financial uncertainty (Brown and Warshawsky, 2004). Specifically, retirees in the model face a further constraint imposed by annuitization on individual behavior. Under 100% lump-sum payout from pension funds, individuals would indeed optimally choose to follow a decreasing (instead of constant) consumption path from retirement onwards, notably by consum-

³²Pension schemes impose a (relatively high) taxation on individuals during working life. This causes individuals in the model to save very little (almost nothing) while working, and optimally start to save significantly at retirement (as taxation no longer affects individual behavior), notably by investing a sizeable portion of the lump-sum payout in financially rewarding markets.

³³Only in case the capital accumulated in pension funds at retirement were allowed to be re-invested in financial markets, a higher discount rate reflecting financial market returns would be used for computing annuities. The assumption of $\bar{r} = 0.054$ is therefore artificially introduced uniquely to isolate this specific effect on individuals' demand for annuitization.

ing more than the corresponding per-period annuity in the initial part of their retirement period, and less than the corresponding per-period annuity in the final part.³⁴ Consequently annuities, through providing a fixed stream of income uniformly spread over the post-retirement period, negatively affect individual welfare thereby partially offsetting the positive longevity-risk insurance impact.

5.4 Conclusions

The paper investigates the individual choice of investing in pension funds, in the light of the 2004 pension reform in Italy. Workers can choose to divert contributions from the firm-based severance pay scheme to the investment in pension funds (namely, in typical private fully funded DC pension schemes). In comparing the relative convenience of the former with respect to the latter, after allowing for their different risk-return properties (respectively nearly risk-free with low return and riskier with an expected higher return), the main issue that is considered regards their different forms of payout at retirement (respectively lump-sum and annuities). The analysis is performed by using simulations from a life-cycle model of a representative agent belonging to a representative generation in steady state, within a partial equilibrium setting with mortality risk and uncertainty on factor returns. The model is calibrated so as to reproduce stylized facts of the Italian economy.

Investing in the fully funded pension-funds scheme turns out to be slightly welfare-improving with respect to the firm-based saving fund. This welfare gain even increases in case pension funds are assumed to pay out benefits after retirement in a lump-sum fashion (instead of annuities), all the rest being equal. These findings suggest that the long-term (“steady-state”) risk-return combination of pension funds is potentially largely preferable to that offered by the severance pay scheme, and as such it is the crucial driver of the general welfare gain from the former with respect to the latter. Furthermore, in driving (ex-ante) utility variations the longevity-risk insurance effect is outweighed in magnitude by preference towards earlier liquidity, which adds to the “annuity puzzle” debate. Consistently with the previous findings, the optimal mix of the two schemes turns out to mostly consist of pension funds, while however keeping a small fraction of contributions with the severance

³⁴Consumption during working life is substantially affected by mandatory pension contributions, so that it basically coincides with net-of-tax labor income (savings being nearly zero). After retirement (as distortions from mandatory contribution are absent), saving and consumption paths may be optimally determined by individuals receiving lump-sum payout.

pay scheme. In order to investigate more in depth individual preferences between lump-sum and annuitized payment, the analysis focuses on the optimal combination of the two alternative payout forms within pension funds (thus abstracting from differences in risk-return properties with respect to the severance pay scheme). Under this scenario, individuals turn out to prefer obtaining most of the pension funds' capital in lump-sum fashion at retirement. Crucial determinants of this outcome are *a)* the pre-existence of sizeable annuitized wealth from the public social security system, that is shown to "crowd out" a significant portion of the potential demand for additional private annuities; *b)* the relative financial convenience of alternative risky investments made out of the lump-sum payout upon retirement.

Future research will delve into the above findings, firstly by focusing on the optimal combination of the public and private pension pillars, namely on the optimal size of the public and private contribution rates. This analysis may shed further light on the role played by the public pillar in crowding out supplementary pension schemes. Next research steps will also investigate the risk-return conditions under which the investment in pension funds is no longer preferred to the severance pay scheme, as a way to check the robustness of the first general outcome from welfare comparisons in this paper. Finally, the hypothesis of allowing for re-investment of pension-funds capital after retirement (thereby potentially yielding variable annuities, linked to financial market yields) will be considered in order to further evaluate the relative convenience of annuitization with respect to lump-sum payout.

5.5 Appendix

5.5.1 Data and Methodology

Stochastic processes for real market returns and wages have been estimated by considering available historical series for Italy over the period 1990-2004. The reason why a relatively short time span is considered is that for period 1990-2004 almost all needed data are available. In order to obtain better estimates from an econometric point of view, data have been taken at a quarterly frequency.

As for data sources, data on wages have been found in the OECD (2008) data set, with “Compensation per employee in total economy” being the OECD entry that has been utilized, since it is a measure of gross wages in the overall economy (comprising both public and private sector). Average market returns are computed as the weighted average of historical returns on three major financial assets held by Italian households: government bonds, corporate bonds issued by Italian banks, and listed shares issued by Italian companies.

Returns on government bonds have been computed as the non-weighted average yield on two main types of Italian government bonds, namely short-term bonds (BOT - Italian T-bills) and medium-to-long-term bonds (BTP - Italian T-bonds). As for returns on BOTs the source is the “Ministero dell’Economia” web site, providing BOT returns at issue. As regards BTPs return, the Bank of Italy “Rendistato” yield is utilized, since it reflects the average market performance of BTPs traded on the Electronic Bond and Government Securities Market (MOT) of the Italian Stock Exchange.

Returns on corporate bonds issued by banks constitute the great majority of all Italian corporate bonds. Their return is reported by the Bank of Italy “Rendiob” yield, reflecting the average market performance of corporate bonds issued by banks and traded on the Electronic Bond and Government Securities Market (MOT) of the Italian Stock Exchange. The “Rendiob” index is available only from the end of the 1980s to 2004.

As for stocks, average returns on listed shares have been computed using the COMIT Performance - Total Return index, which includes total returns (both prices and dividends) of all shares listed on the Stock Electronic Market (MTA) of the Italian Stock Exchange.

All of the three above mentioned types of returns have then been weighted considering the yearly portfolio composition of Italian households reported by the Bank of Italy (2007), referring to the period 1995 through 2006. Weights are computed as percentages of “Italian government bonds”, “Italian corporate bonds issued by banks” and “listed shares issued by residents” in a

simplified portfolio held by Italian households, namely a portfolio made up of only those three categories of securities. In the absence of data on portfolio composition relative to the 1990-1994 period, weights for returns in those years have been assumed to be the same as those in year 1995. Moreover, when considering observations at a quarterly frequency, the yearly weights are assumed to be the same throughout all quarters of every year.

All collected wages and financial market returns have been finally expressed in real terms by correcting them for historical inflation growth rates, reported in OECD (2008), so as to obtain the values based on which estimates for w_t and r_t in the model have been carried out.

From the preliminary econometric analysis of data on wages and market returns, it turns out that a statistically significant specification of processes underlying data is as follows:

$$w_t = 35.253 + 0.645w_{t-1} + ew_t$$

$$r_t = 0.054 + er_t$$

The stationary normal distributions of wages and returns processes are as follows:

$$w \sim N(99.332, 4.172)$$

$$r \sim N(0.054, 0.004)$$

Data used to compute the aggregate growth rate (g) of real wages in Italy in different historical periods have been found in OECD (2008) data source. The average yearly "seniority" wage growth rate sw has been computed as the difference between two terms: the approximate yearly average growth rate of real wages earned by a specific cohort from 1976 to 2004 (Italian workers entering the labor market in 1976 when 21/22 years old); minus the average yearly aggregate growth rate of wages in Italy throughout the period 1976-2004. Computing this difference is aimed at obtaining a cohort-specific measure of "seniority" wage growth. This measure is then assumed to stay constant through time, and through generations, in the model. Data on aggregate wages have been collected from OECD (2008) data base; data on the wage dynamics of the cohort that entered the labor market in 1976 have been deduced from evidence reported by Rosolia and Torrini (2007).

Information about the institutional features of the Italian public pension system, as well as information about the TFR (severance pay) scheme, have been found at INPS (National Institute of social security) web site.

All demographic data and projections are provided by the yearly demographic balance of Istat (National Institute of Statistics) web site.

5.5.2 Optimization Problem and Simulation Procedure

The model solution is based on optimization following finite-horizon stochastic dynamic programming. Since an analytical solution to the optimization problem can not be obtained, simulations have been run in order to solve the problem numerically. These simulations have been performed by utilizing the numerical simulation software program Matlab.

In order to take into account the fact that wages (w) and market returns (r) are stochastic variables, a randomization has been performed by letting the software program randomly draw 1000 values for w_t and r_t in every period t . Consequently, 1000 optimal assets (thus consumption) and leisure paths have been obtained, as well as 1000 pension benefit levels.

Wages and market returns in the model have been discretized into three grid values (corresponding to “low”, “mean” and “high” state) each, in order to numerically solve the optimization problem. Specifically, stochastic processes for wages and financial market returns (autoregressive and serially uncorrelated, respectively) have been approximated by Markov chains through the Tauchen procedure (Tauchen, 1986) so as to be discretized.³⁵ This procedure yields stationary transition matrices (representing the conditional probabilities of passing from one state of the world in a given period t to another state of the world in the subsequent period $t + 1$) for both wages and market returns. As in Geron (2010), the (slight) correlation between the stochastic component of wages and market returns is considered in the procedure, so that overall there are *a*) one transition matrix for wages (denoted by PW) and *b*) nine transition matrices for market returns (denoted by PR_{ij}) conditional on realizations of the i – *th* grid value for w at time $t - 1$ and the j – *th* grid value for w at time t . These matrices are reported as follows.

$$PW = \begin{bmatrix} 0.6479 & 0.3507 & 0.0014 \\ 0.0953 & 0.8094 & 0.0953 \\ 0.0014 & 0.3507 & 0.6480 \end{bmatrix}$$

$$PR_{11} = \begin{bmatrix} 0.2438 & 0.6604 & 0.0958 \\ 0.2438 & 0.6604 & 0.0958 \\ 0.2438 & 0.6604 & 0.0958 \end{bmatrix}$$

$$PR_{12} = \begin{bmatrix} 0.0598 & 0.6116 & 0.3286 \\ 0.0598 & 0.6116 & 0.3286 \\ 0.0598 & 0.6116 & 0.3286 \end{bmatrix}$$

³⁵Markov-chain approximation has been applied also to financial returns, although they do not follow a Markov chain since they turn out to be serially uncorrelated from estimations.

$$PR13 = \begin{bmatrix} 0.0078 & 0.3300 & 0.6622 \\ 0.0078 & 0.3300 & 0.6622 \\ 0.0078 & 0.3300 & 0.6622 \end{bmatrix}$$

$$PR21 = \begin{bmatrix} 0.4452 & 0.5235 & 0.0313 \\ 0.4452 & 0.5235 & 0.0313 \\ 0.4452 & 0.5235 & 0.0313 \end{bmatrix}$$

$$PR22 = \begin{bmatrix} 0.1587 & 0.6827 & 0.1587 \\ 0.1587 & 0.6827 & 0.1587 \\ 0.1587 & 0.6827 & 0.1587 \end{bmatrix}$$

$$PR23 = \begin{bmatrix} 0.0313 & 0.5235 & 0.4452 \\ 0.0313 & 0.5235 & 0.4452 \\ 0.0313 & 0.5235 & 0.4452 \end{bmatrix}$$

$$PR31 = \begin{bmatrix} 0.6622 & 0.3300 & 0.0078 \\ 0.6622 & 0.3300 & 0.0078 \\ 0.6622 & 0.3300 & 0.0078 \end{bmatrix}$$

$$PR32 = \begin{bmatrix} 0.3286 & 0.6116 & 0.0598 \\ 0.3286 & 0.6116 & 0.0598 \\ 0.3286 & 0.6116 & 0.0598 \end{bmatrix}$$

$$PR33 = \begin{bmatrix} 0.0958 & 0.6604 & 0.2438 \\ 0.0958 & 0.6604 & 0.2438 \\ 0.0958 & 0.6604 & 0.2438 \end{bmatrix}$$

Both public and private pension benefits have been discretized into 12 possible states. The choice of using 12 instead of just 3 discrete states for pensions meets the aim of capturing the considerable variability of (particularly) private pensions, that incorporate both wage risks and market return risks.

In numerically solving the optimization problem the choice variables for the individual in every period t are represented by leisure (l_t) and asset holdings at the beginning of the next period (A_{t+1}). The latter variable has been discretized into an exponential grid of points representing different values for asset holdings of individuals. The number of grid points is 10, with the minimum grid value for assets being 0 (individuals cannot borrow in the model economy), and the maximum grid value being 500.

In most simulations within-period time endowment (\bar{T}) has been normalized to 2. This normalization of the per-period time endowment to two units turns out to be useful in calibrating the model for computational reasons.

Within-period leisure in the model, l_t , has been discretized so as to take on 5 possible grid values, triple-exponentially spaced from zero to (mostly) 2. In the baseline calibrated model individuals choose to work approximately 1 unit of time (enjoying 1 time unit of leisure) during working life, whereas they enjoy the whole time endowment from retirement onwards.

Since all variables are discretized in order to solve the optimization problem, the corresponding simulated paths for consumption, assets and leisure are obtained by interpolating (through the *spline* method) across the discrete values resulting from the simulation-based optimization.

5.6 References

Barr, N. and P.A. Diamond (2006), “The Economics of Pensions”, *Oxford Review of Economic Policy* **22**(1), 15-39.

Benitez-Silva, H. (2003), “The Annuity Puzzle Revisited”, Working paper, University of Michigan, Michigan Retirement Research Center, Ann Arbor, MI.

Bodie, Z., R.C. Merton and W.F. Samuelson (1992), “Labor supply flexibility and portfolio choice in a life cycle model”, *Journal of Economic Dynamics and Control* **16**, 427-449.

Brown, J.R. (2009), “Understanding the Role of Annuities in Retirement Planning”, in A. Lusardi, eds., *Overcoming the Saving Slump*, University of Chicago Press, Chicago, IL, pp. 178-206.

Brown, J.R. and M.J. Warshawsky (2004), “Longevity Insured Retirement Distributions from Pension Plans: Market and Regulatory Issues”, in W. Gale, J. Shoven and M. Warshawsky, eds., *Private Pensions and Public Policies*, Brookings Institution, Washington, D.C., pp. 332-369.

Bütler, M. and F. Teppa (2007), “The Choice between an Annuity and a Lump Sum: Results from Swiss Pension Funds”, *Journal of Public Economics* **91**(10), 1944-1966.

Cesaratto, S. (2011), “The Macroeconomics of the Pension Fund Reform and the Case of the TFR Reform in Italy”, *Intervention. European Journal of Economics and Economic Policies*, forthcoming.

Cesari, R., G. Grandi and F. Panetta (2008), “Supplementary Pension Schemes in Italy: Features, Development and Opportunities for Workers”, *Giornale degli Economisti e Annali di Economia* **67**(1), 21-73.

Covip (2008), Relazione per l'Anno 2008, <http://www.covip.it/?cat=35>

Friedman, B.M. and M.J. Warshawsky (1990), “The Cost of Annuities: Implications for Saving Behavior and Bequests”, *The Quarterly Journal of Economics* **105**(1), 135-154.

Geron, D. (2010), “Social Security Incidence under Uncertainty: Assessing Italian Reforms”, *mimeo*, Department of Economics, University of Padova, Italy.

Guazzarotti, G. and P. Tommasino (2008), “The Annuity Market in an Evolving Pension System: Lessons from Italy”, Working paper, Center for Research on Pensions and Welfare Policies, Turin, Italy.

Lindbeck, A. and M. Persson (2003), “The Gains from Pension Reform”, *Journal of Economic Literature* **41**(1), 74-112.

OECD (2008), OECD Economic Outlook: Annual and quarterly data Vol 2008 Issue 1, <http://puck.sourceoecd.org>

OECD (2009), Pensions at a Glance: Retirement-Income Systems in OECD Countries, <http://lysander.sourceoecd.org>

Rosolia, A. and R. Torrini (2007), "The Generation Gap: Relative Earnings of Young and Old Workers in Italy", Working paper, Bank of Italy, Rome.

Tauchen, G. (1986), "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions", *Economic Letters* **20**, 177-81.

Warner, J.T. and S. Pleeter (2001), "The Personal Discount Rate: Evidence from Military Downsizing Programs", *American Economic Review* **91(1)**, 33-53.

Yaari, M.E. (1965), "Uncertain Lifetime, Life Insurance, and the Theory of the Consumer", *Review of Economic Studies* **32(2)**, 137-150.