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WITH ENDOGENOUS FINANCIAL LITERACY"**

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# Abstract

Ensuring sustainability and adequacy of pension systems, while dealing with economic and demographic challenges, is a key issue in retirement provision. A multi-pillar approach should be encouraged, hence it is fundamental to address the optimal design of second-pillar pension schemes. Moreover, households have trouble dealing with the financial industry and planning for retirement, given the low level of financial literacy around the world. Our contribution is to develop a model that investigates financial literacy and regulation by way of transparency, as a means to enhance investment choices of individuals in pension markets, taking into account their risk aversion preferences.

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# Introduction

Demographic and economic trends pose important policy challenges, affecting the financial sustainability of pay-as-you-go pension systems. As a consequence, several countries have implemented pension reforms over the last decades. Pension policies should be conceived in a long-term perspective, aiming at ensuring adequate retirement income while dealing with the financial sustainability of pension systems. Following a multi-pillar approach, which allows to implement a strategy of risk diversification by promoting the introduction of mandatory private pension schemes, the scope for funded pension systems should be widened. Moreover, the prevalent trend in many countries shows a transition towards defined-contribution rules. However, this poses a risk for household finances, exacerbated by a persistent environment of low asset returns that undermine the provision of adequate retirement income.

In addition, households rely less on social security systems and have to take on more responsibility for saving, investing and decumulating their assets, thus paying more attention to the design of their retirement plans. It raises some concerns about households' ability to deal with financial industry and planning for retirement, since the level of financial literacy is low around the world. Given that people are mandated to participate in the second pillar, supplementing the first one, and suffer from financial illiteracy, it is important to determine the optimal design of funded pension systems. Their regulation should address the issues that may arise. However, the literature has been low focused on the proper engineering of the second pillar.

We develop a theoretical model with the aim of optimizing the policy mix between regulation and financial literacy, in an institutional setting of funded pension schemes. The regulation of the pension fund industry is implemented by means of transparency, which affects the investment in financial literacy of consumers. The model goes through three sequential stages. In the first stage, the regulator, which takes action first, considers the impact of transparency on the financial literacy investment, in order to establish the level

of transparency featuring the market of pension funds. In the second stage, consumers optimize their life-cycle utility by choosing the investment in financial literacy, which is endogenous, taking into account the level of transparency established by the regulator. In the third stage, pension funds operate in the market, characterized by adverse selection.

The dissertation is organized as follows. Chapter 1 discusses the institutional framework of pension systems, dealing with their architecture, the fiscal sustainability issues that they face, the evolution of pension reforms over the last decades and the overview of funded private pension systems. Chapter 2 reviews the literature related to the rationale behind multi-pillar pension schemes, the transition towards funded pension systems through pension reforms, the regulation of funded pension systems and the financial literacy. Chapter 3 outlines the theoretical model: first, we analyze the investment in financial literacy of consumers, assuming no fees and no strategic behaviour of pension funds; then, we introduce an adverse selection problem in the market of pension funds, which behave strategically. Finally, we suggest a possible extension of the model by introducing a public option as additional regulation of the pension fund industry and we conclude the dissertation by describing the main findings that result from the model. Some detailed computations with reference to the model are included in appendix A and B.

# Chapter 1

## Institutional Framework

### 1.1 Architecture of pension systems

The design of pension systems differs widely across the countries. The figure 1.1 describes in Panel A the latest structure of mandatory pension schemes in OECD countries and other major economies belonging to the G20, in accordance with the latest legislation applying to future retirees. Panel B shows where that legislation is different for current retirees in OECD countries. According to the taxonomy outlined by OECD (2019b), retirement income is provided through different types of pension schemes:

1. First-tier schemes include mandatory pension schemes, which are independent of past earnings in calculating retirement income. They offer social protection in old age, preventing old-age poverty and ensuring some minimum living standards in retirement. They are provided by the public sector. There are three kinds of first-tier schemes:
  - Targeted plans provide higher benefits to poorer retirees, which meet some residence criteria to be eligible. The level of benefits may depend on income from other sources and assets. Almost all OECD countries have social safety nets of this kind. Nine OECD countries have targeted plans that entitle full-career workers with low earnings at 30% of the average wage.
  - Minimum pensions define a minimum for total lifetime or pension entitlements, referring to either a specific scheme or all schemes combined. They take into account only pension income without considering income from other sources. 17 OECD countries feature minimum pensions, while Chile and Italy are phasing them out.

- Basic pensions may be residence-based or contribution-based, hence the level of benefits may depend on the number of residence years or the number of contribution years, respectively. Seven OECD countries feature residence-based basic pensions, while Norway and Sweden are replacing them with targeted plans. Nine OECD countries have contribution-based basic pensions.
2. Second-tier schemes include mandatory earnings-related pension schemes. They help to smooth consumption and living standards between working life and retirement. Two OECD countries do not have second-tier schemes: Ireland and New Zealand, and also the United Kingdom is phasing it out. There are four kinds of second-tier schemes, which differ in public or private provider and in the way benefits are calculated:
- Defined benefit (DB) plans are provided by either the public sector as public pay-as-you-go (PAYG) schemes or the private sector as private occupational schemes. Pension benefits depend on the number of years of contributions, pensionable earnings and accrual rates expressed as a percentage of pensionable earnings. The retirement income is equal to the individual pensionable earnings multiplied by the accrual rate and the number of years of contributions.<sup>1</sup> 17 OECD countries have public DB plans, while 10 OECD countries are replacing them because of financial sustainability issues, but they still apply them to current pensioners. Three OECD countries have private DB plans, which are mandatory or quasi-mandatory.<sup>2</sup>
  - Funded defined contribution (FDC) plans may be publicly or privately managed. Contributions are collected in an individual account, they yield a return on investment and the accumulated capital is converted into a stream of monthly pension payments at retirement by means of an annuity divisor. The interest rate applied to contributions depends on financial market returns. Six OECD countries have mandatory private FDC plans and two OECD countries have quasi-mandatory private FDC plans. Three OECD countries have public FDC plans.

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<sup>1</sup>Pensionable earnings are based on entire career earnings in the majority of OECD countries. In few OECD countries, they are based on a small fraction of career earnings, such as the final years.

<sup>2</sup>Quasi-mandatory schemes are based on collective agreements with very high coverage rates with respect to the working-age population.

- Points schemes are publicly managed and provide a regular pension payment on the basis of earnings-based pension points, collected during working life and converted at retirement by means of a pension-point value. Five OECD countries have public points schemes.
  - Notional defined contribution (NDC) schemes are provided by the public sector and mimic FDC plans. Contributions are accumulated in an individual account and a notional rate of return is applied, but in reality collected contributions finance pension benefits of current retirees like PAYG schemes.<sup>3</sup> The notional accumulated capital is turned into a monthly pension income at retirement through a formula based on life expectancy. Five OECD countries have public NDC schemes.
3. Third-tier schemes include voluntary earnings-related pension schemes. They are privately managed and may be personal or employer-provided.

Figure 1.1: Structure of mandatory pension schemes in 44 countries

First tier						Second tier					
Residence-based		Contribution-based				Residence-based				Contribution-based	
Basic	Targeted	Basic	Minimum	Public	Private	Basic	Targeted	Basic	Minimum	Public	Private
Panel A. Latest legislation (applying to future retirees entering the labour market in 2018 at age 22)											
Australia	✓				FDC	Netherlands	✓				DB [q]
Austria			✓	DB		New Zealand	✓				
Belgium			✓	DB		Norway		✓		NDC	FDC
Canada	✓			DB		Poland			✓	NDC	
Chile	✓				FDC	Portugal			✓	DB	
Czech Republic		✓	✓	DB		Slovak Republic			✓	Points	
Denmark	✓	✓		FDC	FDC [q]	Slovenia			✓	DB	
Estonia		✓		Points	FDC	Spain			✓	DB	
Finland	✓			DB		Sweden		✓		NDC + FDC	FDC [q]
France			✓	DB + Points		Switzerland			✓	DB	DB
Germany		✓		Points		Turkey			✓	DB	
Greece	✓			DB		United Kingdom		✓			
Hungary			✓	DB		United States				DB	
Iceland	✓	✓			DB [q]						
Ireland		✓				Remaining G20 countries					
Israel	✓	✓			FDC	Argentina		✓	✓	DB	
Italy				NDC		Brazil			✓	DB	
Japan		✓		DB		China			✓	NDC + FDC	
Korea		✓		DB		India			✓	DB + FDC	
Latvia			✓	NDC + FDC		Indonesia			✓	DB + FDC	
Lithuania		✓		Points		Russian Federation		✓		Points	FDC
Luxembourg		✓	✓	DB		Saudi Arabia			✓	DB	
Mexico			✓		FDC	South Africa		✓			
Panel B. Current legislation where different from Panel A (applying to new retirees in 2018)											
Chile	✓		✓	DB	FDC	Mexico			✓	DB	
Estonia		✓		DB/Points	FDC	Norway	✓	✓		DB	FDC
Italy			✓	DB + NDC		Poland			✓	DB/NDC	
Latvia			✓	DB/NDC + FDC		Sweden	✓	✓		DB/NDC + FDC	FDC [q]
Lithuania		✓		DB/Points		United Kingdom		✓		DB	

Source: OECD (2019b)

<sup>3</sup>The notional interest rate may be equal to the rate of GDP growth, wage bill growth or earnings growth.

## 1.2 Fiscal sustainability

Countries all over the world face fiscal sustainability challenges, due to the legacy of the 2008 financial crisis and the macroeconomic context. Indeed, the sustainability of public finances is jeopardized by high public debt levels, moderate GDP growth and low inflation. Despite low interest rates that reduce financing costs for public debt, deleveraging is made harder in this context. Lessening public debt burdens and thus ensuring fiscal sustainability is important to support the economy in adverse scenarios (European Commission, 2016).

Ensuring fiscal sustainability is also important to deal with population ageing that affects age-related public expenditure, i.e., pensions, education, health care and long-term care. Over the long term, the demographic trends pose important policy challenges, because they reveal that the numbers and proportions of older people are growing as a result of declining fertility rates and increasing life expectancy.<sup>4</sup> The retirement of the baby-boom generation will accelerate the changes in the age structure of the population and undermine fiscal sustainability.<sup>5</sup> The figure 1.2 shows how the age structure of the EU population, separated by sex, is projected to change in the coming decades, comparing 2013 and 2060. Notwithstanding the demographic trends differ across EU Member States, the overall EU population is expected to be slightly larger in 2060 compared to 2013, increasing from 507 million to 523 million. This takes into account the projected increase of net migration flows.<sup>6</sup> However, the old-age dependency ratio is expected to increase from 27.8% to 50.1% and the working-age population is expected to decrease over the projection period.<sup>7</sup> This means that the EU population will continue to get older and that there will be only two working-age people for each elderly person. In 2013, the median age is 40 years old for males and 43 years old for females; in 2060, it is expected to be 45 years old for males and 47 years old for females (European Commission, 2015).

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<sup>4</sup>In OECD countries, the average fertility rate stands at 1.66. It is significantly lower than the natural replacement rate of 2.1, which is necessary to maintain the total population constant. The life expectancy of women and men aged 65 is 21.3 and 18.1 years respectively, on average across OECD countries. It is expected to increase by 3.9 years for women and 4.5 years for men by 2065 (OECD, 2019b).

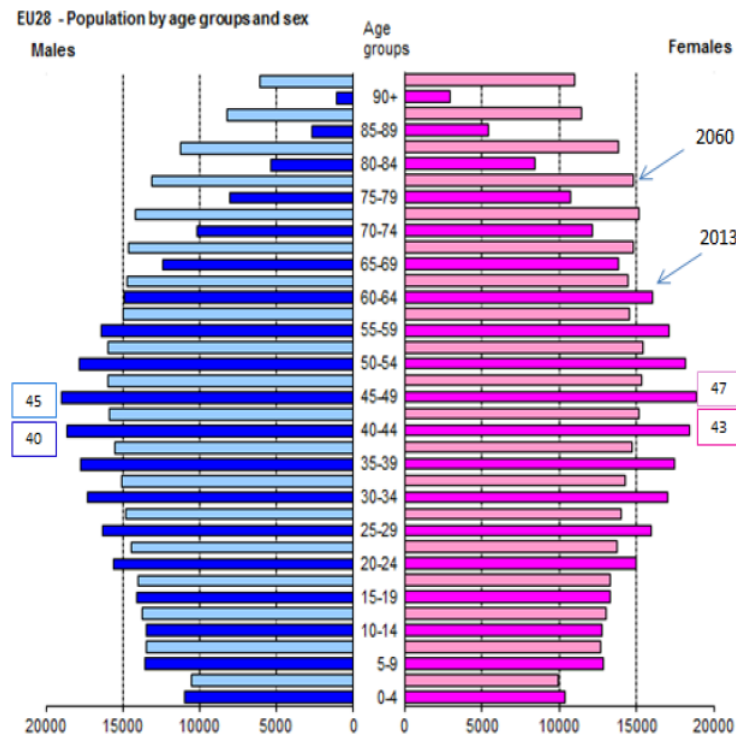
<sup>5</sup>Baby-boom generation defines people who were born between 1946 and 1964, when birth rates peaked.

<sup>6</sup>Net migration flows are the difference between migration inflows and outflows.

<sup>7</sup>The old-age dependency ratio is a demographic measure that compares elderly people, aged 65 years and over, to working-age people, aged 15 to 64 years. Looking at more recent data, the EU old-age dependency ratio is at 31% in 2019 and is projected to be at 57% in 2100.

European countries are slightly older compared to OECD countries and their projections broadly follow the OECD average: the number of elderly people is currently at 31% of working-age people, aged 20 to 64 years, and it is projected to be at 58% by 2060 (OECD, 2019b).

Figure 1.2: Age pyramid for the EU in 2013 and 2060



Source: European Commission (2015)

As a consequence of population ageing, the age-related public expenditure relative to GDP is projected to increase in the EU in the period between 2013 and 2060 under the baseline scenario, which focuses mostly on demographic developments. However, there is uncertainty as regards future developments and there are large differences across EU Member States. The variety among Member States depends mostly on the public pension expenditure because of different public pension arrangements. The public pension expenditure is projected to decline in the EU as a whole, after an increase at the beginning of the projection period, but its projections rely mainly on enacting pension reforms aimed at enhancing fiscal sustainability of pension systems and assuming no changes in pension legislation. However, decreasing public pension benefit ratios and decreasing coverage ratios because of increasing retirement age may trigger changes in pension policies and

thus an increase in public pension spending (European Commission, 2016).<sup>8</sup>

Pension reforms are necessary to address population ageing issues and ensure fiscal sustainability in the long run. In particular, population ageing affects public PAYG pension schemes, because the number of beneficiaries is expected to increase against an expected decrease in the number of contributors. These sustainability-enhancing pension reforms enable to contain future public pension spending, but they reduce the generosity of public pension schemes. Therefore, pension reforms should ensure not only fiscal sustainability, but also pension adequacy and social acceptability. Social or political sustainability of pension regimes would mitigate the excessive frequency of pension reforms and the legislative instability, which could cause counterproductive effects and greater uncertainty.

### 1.3 Pension reforms

The main objectives that should be pursued when designing or reforming a pension system are adequacy and sustainability. Adequacy ensures that a pension system provides reasonable living standards during retirement, preventing old-age poverty and delivering an adequate replacement rate.<sup>9</sup> Sustainability ensures that a pension system is financially sound in the long term.

Properly working pension systems allow to smooth consumption throughout the life cycle. Modigliani and Brumberg (1954) posited first that individuals use saving and borrowing to smooth intertemporal consumption profile, theorizing the life-cycle hypothesis. It describes consumption and saving habits of individuals throughout their lifetime, stating that they consume less than they earn during working life, thus saving and accumulating assets to support consumption during retirement. Therefore, consumers should make decisions on the basis of expected life-cycle income, not just yearly disposable income, thus moving away from Keynesian economics.

Reforming pension systems is a common priority around the world. Many countries have implemented several pension reforms over the last decades. The figure 1.3 shows the number of main pension reforms carried out by EU countries since the 1990's.<sup>10</sup> The

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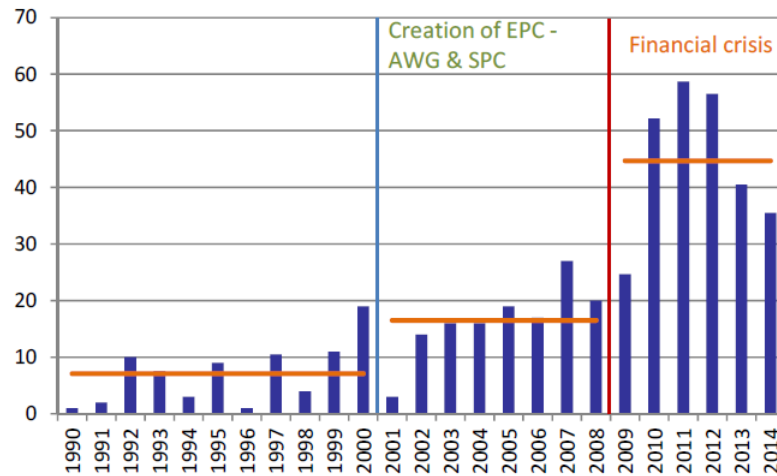
<sup>8</sup>The public pension benefit ratio compares average pensions, defined as total public pension expenditure divided by number of pensioners, to average wages. The coverage ratio compares the number of pensioners to the number of elderly people, aged 65 years and over.

<sup>9</sup>The replacement rate is defined as retirement income in relation to workers' pre-retirement earnings.

<sup>10</sup>Even though it does not include the more recent years, it gives a good overview of the evolution of

trend is growing, and the financial crisis and the sovereign debt crisis strongly boosted the intensity of pension measures (Carone et al., 2016). However, the pace of pension reforms has slowed down in recent years.

Figure 1.3: Number of pension reforms in the EU in period 1990-2014



Source: Carone et al. (2016)

Country-specific characteristics, such as demographic variables, labour market conditions and political environment, affect pension systems and determine differences among countries (Huitfeldt, 2020). Therefore, pension reforms vary significantly across countries, taking into account different pension arrangements and different needs. The choice about which type of pension reform is the most suitable for each country is highly country-specific (Nerlich and Schroth, 2018). Pension reforms may be parametric or systemic. Moreover, some countries have introduced automatic adjustment mechanisms that link key pension parameters to changes in life expectancy, in order to address longevity risk, although opposition against these mechanisms is growing.

Parametric reforms modify the pension system rules and parameters, such as retirement ages and pension benefits. Increasing the level of statutory retirement ages is the most common measure among EU countries to face fiscal sustainability challenges. Another measure is the change of the incentives to retire, for example by increasing the contributory period required to receive a full pension or by discouraging early retirement via penalties. These measures curtail eligibility. Many EU countries have additionally adopted measures that reduce pension benefits, for example by changing the pension calculation in such a way that pensionable earnings are extended and not restricted to best

pension reforms over the years, in particular following the financial crisis.

salaries. Other measures that curtail pension benefits concern the reduction of annual accrual rates, the shift towards less generous valorisation rules for past earnings with respect to changes in standard of living or the shift towards less generous indexation rules for pensions in payment that are fully or partially adjusted to prices instead of wages (Carone et al., 2016).<sup>11</sup> Measures that increase the statutory retirement age are expected to have a positive effect on the economic growth and the labour supply, thus mitigating the adverse macroeconomic implications of population ageing. Instead, measures that increase the contribution rate or reduce the benefit ratio are expected to worsen the adverse macroeconomic effects of population ageing (Nerlich and Schroth, 2018). Moreover, measures that further increase the contribution rate are unbearable if tax burdens are already high.

On the other hand, systemic reforms act radically on pension systems by introducing new pillars or by modifying the nature of public pension schemes. Several EU countries have enacted systemic pension reforms, alongside parametric ones. This is the case of Germany, Italy and Sweden since the 1990's, and Austria and Greece in more recent times. Many Eastern European countries, such as Bulgaria, Croatia, Cyprus, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia, have reformed their pension systems since the late 1990's, following a multi-pillar approach that promotes the introduction of mandatory private pension schemes, in spite of resulting in later reform reversals (Carone et al., 2016). Italy, Latvia, Poland and Sweden introduced NDC pension schemes. The Eastern Partnership countries, i.e., Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine, adopted systemic pension reforms lagging behind, learning from the experiences of Central and Eastern Europe, in order to prevent reform reversals, by following a gradual approach and ensuring societal consensus (Huitfeldt, 2020).

PAYG DB pension plans were predominant in the context of pension systems, expanding across OECD countries notably in the second half of the 20th century when population and economy grew fast. As a complement to public PAYG pension schemes, some OECD countries had funded DB occupational plans. However, there has been a movement from DB to DC pension plans over the last decades, in order to ensure financial sustainability.

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<sup>11</sup>Valorisation rules applied to past earnings take account of changes in standard of living between the accrual period of pension rights and the period pension rights are claimed. The growth of average earnings is the most widely used valorisation rate. Indexation rules refer to the growth of pensions in payment, which are more commonly indexed with price inflation.

This first occurred in Chile and Mexico that even substituted public PAYG schemes for mandatory funded private DC plans, and more recently in Estonia, Hungary, Poland, the Slovak Republic and Sweden that introduced these latter as top-up. However, some countries later abandoned them (OECD, 2019b).

The 2008 financial crisis pointed out the weaknesses in the design of pension systems. In the wake of the financial crisis, the number of pension system reforms accelerated and new short-term pension measures were immediately adopted dictated by the difficulties. However, some pension reforms gave subsequently rise to important reversals (OECD, 2019b). Since 2015, the pace of pension reforms in OECD countries has slowed down compared to previous years. One-fifth of OECD countries did not enact pension reforms (OECD, 2017b). The weak momentum in pension reforms is confirmed also in the following years, as a consequence of improving economic conditions. Moreover, some countries do not implement previously decided reforms or they partially reverse previously adopted reforms, because of easing public finances pressure. Under good economic times, governments are less willing to implement pension reforms, because political costs of pension reforms are borne in the short term while their benefits are enjoyed with a lag. However, the demographic challenges should be persistently addressed as population ageing is a long-term phenomenon and it is speeding up in most OECD countries. Over the last few years, most pension reforms have focused on promoting private pension savings, expanding coverage of pension schemes or loosening unpopular measures previously legislated by means of easing age requirements to get a pension or rising pension benefits (OECD, 2019b).

Pension reforms, aimed at improving pension system's long-term sustainability while maintaining an adequate level of future pensions, increase the role of pension funds. However, the public sector still remains strongly involved in pension systems across EU Member States. In an international perspective, OECD countries show on average a lower public pension expenditure than EU Member States (Carone et al., 2016).

## 1.4 Pension markets

In response to the rising burden of PAYG pension systems, funded private pension systems take a larger role in complementing pension income publicly provided (OECD, 2016). Over the last decade, there has been a growth of pension assets, regardless of a slight decrease in 2018 compared to the previous year. The payments of pension benefits,

which induce a decrease in pension assets, did not affect the overall increasing trend. At the end of 2018, accumulated pension assets amounted to USD 42.5 trillion in OECD countries, and their weighted average ratio to GDP was at 126%, using pension assets in each country as weights, in comparison to 49.7% in 2008. Pension funds collected the great majority of these pension assets, alongside other vehicles, such as pension insurance contracts offered by insurance companies or products provided by banks and investment companies. The amount of pension assets varies considerably across countries and more than 90% of the overall pension assets is concentrated in the hands of 7 out of 36 OECD countries, with the United States recording the largest amount. The growth of pension assets may be attributed to two main factors: the increase in the proportion of working-age people equipped with pension coverage and the increase in contribution rates. The proportion of individuals covered by funded private pension plans may be analyzed to fully understand the amount of savings for retirement in addition to public pension schemes. In the majority of OECD countries with mandatory funded private plans, the coverage is more than 70% of the working-age population and the growth of individuals with funded private pension plans recorded in the last decade is mainly due to countries that have recently adopted mandatory or auto-enrolment programmes.<sup>12</sup> Six OECD countries have voluntary funded private plans that cover more than half of the working-age population. The amount of accumulated pension assets depends on the contributions paid into funded private pension plans. In countries with mandatory or auto-enrolment programmes, the contribution rate is defined by regulation and it varies across countries (OECD, 2019a).

The lower the coverage of public pension schemes, the higher the development of private pension schemes. Moreover, their development is higher when there are mandatory participation and strong tax incentives for retirement savings. However, saving for retirement is low due to low levels of financial literacy, even when coverage of the working-age population is high (Rouzet et al., 2019).

There are several types of funded private pension plans: occupational plans, which in turn are DB or DC plans, and personal plans, which are DC plans. The access to occupational plans is provided through an employment relationship and they are set up by employers. In DB plans the risks are borne by plan sponsors, while in DC plans the risks are borne by individuals. Actually, there are also pension plans that are an hybrid

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<sup>12</sup>Automatic-enrolment plans, which are becoming increasingly popular, state that employers automatically enrol their employees in occupational pension plans, deciding the proportion of the salary to be contributed.

of DB and DC plans, which entail risk sharing between the parties. As confirmation of the shift from DB to DC pension plans, the percentage of pension assets in DB plans has decreased over the last decade. The transition from DB to DC pension plans may enhance the financial sustainability of pension systems, because it mitigates the risk of underfunded DB plans.<sup>13</sup> However, members of DC plans pay providers fees, which decrease the total amount of their pension assets and thus their benefit payments (OECD, 2019a). Moreover, members of DC plans are affected by the financial and longevity risk, hence enhancing their financial skills is becoming increasingly important (Rouzet et al., 2019).

The evolution of pension assets is driven by the performance of portfolio investment. Pension assets were mainly invested in bonds and equities, and their proportions varied greatly across countries, notwithstanding bonds were generally preferred. On average across OECD countries, funded private pension plans yielded a negative real rate of return net of investment expenses, equal to -3.2%, in 2018, probably because of the downturn on equity markets. Over a longer period, pension assets have yielded positive real investment returns in the majority of countries (OECD, 2019a).

The 2008 financial crisis and the subsequent recession not only undermined the sustainability of public finances, because of lower earnings and higher unemployment that reduced the contributions to PAYG pension systems, but they also deeply affected private funded pension systems. Pension assets strongly reduced by 23% in real terms in OECD countries during 2008, hence individuals lost a considerable amount of their retirement savings (Whitehouse, 2009).

The environment is characterized by persistently low interest rates over time, which may reflect low economic growth rates. This environment combined with increased life expectancy may undermine pension adequacy. Low interest rates have an impact on pension assets, because their returns are limited. They also increase liabilities, calculated as discounted future cash flows, of pension funds. Therefore, low long-term interest rates reduce future pension benefits of funded DC plans and threaten the solvency of funded DB plans. Investment opportunities are affected, because the risk profile of investment portfolios may be altered by buying higher-risk products, in order to meet benefit promises of DB pension funds (Antolin, Schich, and Yermo, 2011).

On average across OECD countries, pension payments from private pension plans

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<sup>13</sup>A plan is underfunded when its funding ratio is lower than 100%, because the value of assets does not cover the value of liabilities, defined as pension benefits promised.

amounted to 1.5% of GDP in 2015, in contrast to 8.0% of GDP of public pension expenditure. Although private-pension payments grew from 0.7% of GDP in 1990, they still represent a limited proportion of total pension spending. There are some exceptions, such as the Netherlands, in which private-pension payments accounted for 5.8% of GDP in 2015 (OECD, 2019b).

Therefore, notwithstanding the increased importance over time, funded private pension systems still play a marginal role across countries and they should be boosted. However, funded pension systems are not free of problems that may erode their benefits. Strengthening their regulatory framework encourages a more reliable operation, thus protecting members of private pension plans. Funded private pension systems should be properly designed, particularly when they are substitutes or complements to public pension systems, and mandatory (OECD, 2016).

# Chapter 2

## Literature Review

### 2.1 Multi-pillar pension schemes and funded pension reforms

It is almost a conventional wisdom that a pension system should be multi-pillar. Back in 1994, the World Bank (1994) had already stated that financial security in retirement would have been better ensured if governments had developed a system with three pillars:

1. a publicly managed first pillar with mandatory participation, providing basic pensions;
2. a privately managed second pillar with mandatory participation, supplementing them;
3. a voluntary third pillar.

The first pillar is financed on a pay-as-you-go (PAYG) basis: workers' contributions finance current pensions. The second and the third pillars are funded: workers' contributions are invested in the financial markets for own future pensions. Mixing a PAYG pension system and a funded pension system allows to reap the benefits and to offset the shortcomings of both. The two systems are exposed to different risks, hence it is optimal to complement the PAYG pension scheme with the funded pension scheme implementing a strategy of portfolio diversification.

The PAYG system is largely affected by the demographic risk, due to low fertility and rising longevity, which threatens its sustainability. The rate of return of the system depends on the growth rate of the salaries, but it typically fails to offset the negative

effect of higher dependency ratios<sup>1</sup>. On the other hand, the funded system is affected by the financial risk, exacerbated by financial crisis, and its rate of return depends on financial returns. In a stochastic framework, in which population growth, financial rate of return and wage growth are random, diversifying the risks through the combination of the two mechanisms is likely to be more efficient. To understand this point, let us consider Devolder and Melis (2015) who model the main risk factors in a risk-management perspective. By means of a mean-variance two-period model with two overlapping generations of workers and retirees existing at any given time, they determine the optimal fraction of contributions allocated to the two mechanisms to maximize the expected utility of the pension benefits received at retirement. Along the curve that contains all the optimal risk-return combinations, the choice depends on the individuals' preferences linked to the risk aversion coefficient. The optimal share to be invested in the funded pension scheme is found by the risk aversion coefficient, expected value and variance of both the rates of return of the PAYG system and the funded system. The demographic risk and the financial risk can be independent or correlated, and the impact of the correlation on the optimal share depends on the sign of the covariance and the degree of risk aversion. The longevity risk is not considered, since survival probabilities are assumed deterministic.

Pension systems need to be reformed in this regard. A pension reform is Pareto-optimal when its implementation does not inflict welfare losses to any individual in the economy. However, introducing a funded pillar when a PAYG scheme exists is not Pareto-improving, since it requires that the transition generations bear the transition costs. It may imply that either old pension obligations are not met or working age generations incur a double pension expenditure. The double burden arises because they have to simultaneously finance their pensions and their ancestors' ones: current workers continue to pay the contributions to fund the pensions of current retirees, but they also have to invest additional retirement savings to fund their own pensions. This results, for example, in a social security tax-rate increase. Otherwise, the government increases public debt, thus shifting part of the transition costs of the pension reform to the future generations repaying the debt and its servicing costs. Because of limited economic horizon of individuals, the latter strategy may generate major political consensus.

To analyze the optimal transition path from a PAYG pension system to a funded

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<sup>1</sup>The dependency ratio is a demographic measure that compares the dependent population, defined as people aged 0 to 14 years and over 65 years, to the working-age population, defined as people aged 15 to 64 years.

defined contribution system, we follow Bielecki et al. (2015) who consider an overlapping generations model with multiple cohorts of decreasing mortality rates and exogenous technological progress. Agents are subject to inter-temporal choices between consumption and savings, and intra-temporal choices between consumption and leisure. They maximize lifetime utility arising from consumption and leisure, measured as time not supplied to the labour market, subject to the budget constraint that takes a different form in the case of working age population or retired population. The government taxes consumption and income from capital and labour, but there is no capital income tax on obligatory savings for the funded pillar. The funded pillar is gradually introduced and the transition cohorts are compensated via an indexation scheme providing fiscal relief to face the additional tax increases that they experience. The indexation of pension benefits in excess arising from the positive difference between funded pillar's interest rate and PAYG system's indexation rate, defined as the wage growth rate, is a politically feasible instrument to phase in the reform. The costs of the reform are shifted to the future generations by means of implicit pension debt, which is the uncovered amount owed to them in the form of pension promises. The price of the implicit debt is determined exactly by the indexation of pensions. Future generations experience lower costs of servicing the debt compared to explicit debt.

As mentioned, pension reforms need to be politically sustainable. Introducing a funded pension system generates immediate costs, since working cohorts suffer a double burden, which will be eventually offset by delayed gains such as faster accumulation of capital and rise in total pension benefits. However, the reform may be exposed to the risk of policy reversal before society enjoys its benefits, thus moving back to the PAYG pension scheme, as it already happened in a number of countries. Beetsma et al. (2020) develop a stylized three-period overlapping-generations model without intra-cohort heterogeneity. Decisions are made under pure majority voting. They show that the funded pension system is not politically stable once introduced and currently alive cohorts provide political support to dismantling of the funded pension pillar, benefiting from capturing its assets accumulated and shifting the cost to the future cohorts. Individuals face a trade-off between a reduction in future pension benefits caused by eliminating the funded pillar that has a higher return and a reduction in current taxes financed by the government's appropriation of the pension assets, but the latter dominates the former for a majority of voters thus preferring asset capture. The introduction of the funded pension pillar will generate only welfare losses if it is dismantled before its benefits occur, hence credibility issues towards the pension

reform need to be addressed from the outset in order to avoid the risk of dismantling. The protection of property rights that prevents expropriating the pension assets also is key in maintaining a multi-pillar pension system.

The transition towards a multi-pillar pension system has been widely debated over the years, but the literature has been less focused on the proper engineering of the second pillar, which is of fundamental importance and a key issue of our discussion. In addition, it is necessary to establish a social security system with compulsory nature, because individuals do not make optimal decisions under uncertainty. The neoclassical economic theory assumes that individuals behave in a fully rational manner, are well-informed and are able to undertake complex economic calculations. However, in real life, individuals are not rational, have imperfect knowledge, and their decision-making process is biased, in accordance with the behavioural economic theory (Soukup, Maitah, and Svoboda, 2014). Therefore, given that people are mandated to participate in the second pillar and suffer from financial illiteracy, it is important to determine the optimal design of funded pension schemes.

## 2.2 Design and regulation of funded pension systems

The design of funded pension systems should be driven by some criteria (Price, 2018):

- efficiency, which relates to costs, investment returns and labour market impact;
- adequacy, which relates to the level of pension income;
- sustainability, which relates to the funding of defined benefit promises and affordability of given contributions;
- coverage, which relates to the percentage of population that is contributing and receiving pensions;
- security, which relates to the security of assets, the reliability of promised pensions and the role of a regulator and supervisor.

It may arise some synergies between different criteria, but there may also be some trade-offs, which are intrinsic in designing pension systems (Whitehouse et al., 2009).

Exploring the two main types of private pension schemes, Defined Benefit (DB) schemes promise a specific income at retirement, instead Defined Contribution (DC)

schemes depend on the amount of contributions and the fund's investment performance. The choice between DC and DB pension plans raises the issue on who is bearing the risks: members of DC pension schemes bear the risks as the pension provider or sponsor does not make promises on future payouts; vice versa, the pension provider or sponsor of DB pension schemes bears the risks as a specific benefit is promised on retirement. In particular, the pension provider or sponsor of DB pension schemes is affected by the risk of poor investment returns, changes in interest rate expectations or increases in longevity, which makes the promises not sustainable. DB pension plans are exposed to the longevity risk, because life expectancy may exceed its projections to the point that individuals outlive their assets. The prevalent trend in many countries shows a shift from DB towards DC pension plans, leaving members more exposed to inadequacy risk, i.e., the risk of having inadequate retirement income. The change from DB to DC pension schemes is supported by an environment with persistent low interest rates and higher life expectancy, which affects financial stability (Financial Stability Board Regional Consultative Group for Europe, 2017).

Personal pension plans are built on a DC scheme, while employer-sponsored pension plans used to be typically built on a DB scheme. As argued, DB pension plans may perform underfunding problems, leading not to meet pension promises, and pension reforms have tried to address them providing stronger incentives for individuals to save via DC pension plans. The increase in pension fund liabilities, due to increasing longevity, and the decrease in contributions, due to decreasing birth rates, bring out underfunding issues of DB pensions, both in PAYG and funded schemes. Cocco and Lopes (2011) deal with the important debate on the advantages and disadvantages of DB and DC pension plans and develop a dynamic life-cycle model of individual pension choices that is calibrated on UK data. The empirical analysis on the pension choices of individuals is consistent with the model predictions. Individuals choose to which pension plan they contribute among a DB plan with retirement benefits calculated as a proportion of average earnings, a DB plan with retirement benefits calculated as a proportion of final salary and a DC plan. These three plans correspond to the individual pension choices regarding the second-tier pension schemes in the UK: respectively, a state-provided DB pension plan, an employer-sponsored DB pension plan and a DC pension plan. There is a trade-off between the earnings risk of DB final-salary pension plans, as labour income is subject to transitory and permanent income shocks but the latter matters the most, and the investment risk of DC pension plans. The choice between DB and DC pension plans depends on individuals'

earnings characteristics: individuals facing larger variance of permanent income shocks are less likely to join the DB final-salary pension plan; vice versa, individuals facing higher expected real earnings growth are more likely to join the DB final-salary pension plan. Individuals self-select which pension funds to join according to their preferences and earnings characteristics, hence DB pension fund providers should adjust promised retirement benefits consequently. In addition, employer characteristics are important to the choice of joining employer-sponsored pension plans and employer-sponsored pension plans suffer of lower portability, so these plans are less attractive to individuals with lower levels of income and higher job mobility that are more likely to join the state-provided pension plan.

Financial markets are incomplete because they do not allow to trade between current generations and unborn generations, therefore allocation of risks could be inefficient. Collective DB pension plans allow to share risk across successive generations, while individual DC pension plans do not allow to exploit risk sharing between non-overlapping generations. On the other hand, some long-lived pension funds benefit from intergenerational risk sharing, carrying out trade in risk between non-overlapping generations and acting as a buffer against shocks. Risk is diversified across individuals' life cycle and across generations leading to a higher risk-bearing capacity. Individuals face human capital risk, interest rate risk, inflation risk, equity risk and longevity risk. As a result of enhanced diversification of risk, intergenerational risk sharing returns an *ex ante* welfare gain, but the first-best solution is achieved only if future generations are forced to participate in the risk-sharing contract. This is the rationale behind the existence of mandatory pension systems, both unfunded and funded. However, commitment problems may arise (Bovenberg and Mehlkopf, 2014).

As mentioned, collectively organized pension plans take advantage from intergenerational risk sharing, which implicitly assumes that pension funds have an infinite horizon. However, intergenerational risk sharing is threatened by discontinuity events, which are not infrequent as confirmed by the decline in the number of pension funds due to mergers, closures and liquidations. Discontinuity risk affects pension fund members, but it can have both a positive and negative impact on them, which depends strongly on the institutional setting. Triggers for discontinuity events in pension funds could be related to financial circumstances, such as solvency of the pension fund, and social circumstances, such as trust loss of members. Discontinuity risk can be mitigated by solvency requirements. The trust of members on the pension fund could be weakened by both a strong and weak

financial position. Indeed, in designing pension systems, a trade-off may arise between regulations, which need to be stricter to increase financial stability of the pension fund, and membership support (Alserda, Steenbeek, and van der Lecq, 2017).

Pension capital represents a large component of savings for many individuals around the world, mainly in countries with mandatory participation in funded pension systems. The retirement income is affected by the investment decisions of pension funds. However, the investment should be long-term oriented and focused on the members' best interest, and asset allocations should adequately reflect members' risk preferences, which are strongly heterogeneous. Members' risk preferences represent an important input in determining optimal pension asset allocations. Collectively organized pension plans differ from individual retirement accounts, because in the former members are required to share the same asset allocation. The asset allocations of collectively organized pension plans should reflect the collective risk attitude of their members. If such asset allocation does not match members' risk preferences, it is suboptimal and leads to significant welfare losses. In designing pension plans, members' preferences should be taken into consideration, even though choices for retirement savings are mostly made by delegation and so members do not need to be fully financially literate (Alserda, Dellaert, et al., 2019).

The pension policy is concerned on the reliability of pensions. Credibility problems, which arise when pension promises are not kept, mostly affected public pension systems as tax levels were not financially sustainable compared to the excessively generous promises made in the past decades. However, similar concerns arise in private pension systems too. The privatization of the social security system could be weakened by the problem of trust and raises up governance issues, given the incompleteness of the contractual arrangements. Pension arrangements are affected by three sources of risk: non-performance of pensions due to occurrences outside the control of individuals such as exposure to financial market risk, agency problems and poor information or defective decision-making capacity of individuals. Dealing effectively with these sources of risk is a premise for good governance. In particular, DB pension plans suffer from agency problems, because the majority of DB plans appoints trustees with a fiduciary duty to the beneficiaries, while DC pension plans are less affected by agency problems, since in the limiting case the individual is at the same time beneficiary, sponsor and asset manager, replacing external with internal agency problems: individual has to act in the best interest of his future self. DC pension plans are poorly insured against market fluctuations, but they allow for competition between pension plans. To improve the credibility of pensions in the private

sector, governance in DB pension plans could be made stricter by means of regulations, defining the role and responsibility of trustees. Moreover, in dealing with internal agency problems of DC pension plans, consumers' information on pension issues could be enhanced through education programmes and the role of collectives could be developed: it is socially inefficient that every individual is well informed and delegation to a benevolent expert could be better (Besley and Prat, 2005).

Using contract theory, Besley and Prat (2003) discuss about governance issues in pension funds, linking them to the contractual structures of DC and DB pension plans. They develop a simplified two-period model, fitting the institutional and financial structure of private occupational plans, with three players: sponsor, beneficiary and fund manager. Regarding residual claims, i.e., who owns the residual surplus or deficit of the pension fund, in a DB plan the sponsor is the residual claimant; instead, in a DC plan the beneficiary is the residual claimant bearing the full risk from the investment returns. Control rights give the authority to make decisions with regard to three areas: funding decisions, asset allocation and asset management that is outsourced to the fund manager. Under complete contracts, sponsor and beneficiary sign binding contracts on vigilance exerted on the fund manager and asset allocation, which both affect the investment returns, and if they are risk neutral, they are indifferent between DC and DB plans since the optimal governance structure is the same, otherwise the choice on which party should be the residual claimants depends on who is less risk averse. Typically, the sponsor is less risk averse, so DB plans are preferable. However, private pension plans are affected by incompleteness of contracts. Therefore, governance issues become relevant and the choice between DB and DC is driven by the necessity to match the governance structure with the incentives of the parties. Departing from the complete contracting benchmark, the authors proceed along three steps by assuming first that vigilance is non-contractible, second that asset allocation is non-contractible and finally that funding levels are non-contractible. Moreover, they assume that both parties are risk neutral. Vigilance exerted by sponsor and beneficiary has to be incentive compatible and only the residual claimant has an incentive to exert it, hence the party with the lower vigilance cost should be the residual claimant: consequently, the sponsor will offer a DB or DC plan. In the presence of multiple beneficiaries, a free-riding problem may arise in a DC plan since vigilance is public good, leading to a lower level of vigilance. The appointment of a strong and motivated trustee, who has the role of monitoring on behalf of the beneficiaries, may solve the free-riding problem among them. The optimal trustee profile could depend on the type of

scheme: professional outsiders, who are competent but motivated by external incentives such as career concerns, should be more used by DB plans; caring insiders, who have less investment expertise but have a direct stake in the pension plan and greater commitment to the beneficiaries, should be more used by DC plans. When the sponsor is responsible for asset allocation, a moral hazard problem may arise, leading to inefficient asset allocation, such as purchasing own stock and taking risk excessively. In DC plans, this happens because of the misalignment between the sponsor's allocation objectives and the goal of efficient allocation. Considering the possibility of insolvency, the sponsor has limited liability, hence asset allocation could be inefficient in DB plans too. Moreover, in DB plans with the possibility of insolvency the sponsor could have incentives for underfunding, thus reducing its contributions, while DC plans are not affected by issues of funding adequacy. In sum, the allocation of residual claims and control rights, which defines the governance structure of pension arrangements, is important to create incentives for good performance of private pension plans.

Strictly related to the credibility of pension funds, regulation and supervision play a fundamental role in ensuring the success of reforms towards funded pension systems managed by the private sector. Credibility, regulation and supervision are necessary to control risks and there is a strong boost to implement prudential regulation and efficient supervision, acting in the interests of beneficiaries. Bonasia and Napolitano (2007) use a CAPM time-varying model for pension asset returns in order to derive a credibility indicator of pension fund investment. Using a Markov switching model, credibility is modelled as a non-linear process subject to discrete regime shifts between states of low and high credibility. The credibility of pension funds is affected not only by fund management policy, but also by macroeconomic variables, such as fiscal and monetary policy: a contractionary monetary policy shock leads to higher credibility, for instance. The effects are asymmetric, depending on the two states of low and high credibility.

During the financial crisis of 2007 and the subsequent sovereign debt crisis in the Eurozone, the financial position of pension funds deteriorated all around the world. Moreover, persistent low interest rates contributed to the rise of funding deficits, since the present discounted value of pension promises exceeds the value of invested contributions. Kastelein and Romp (2018) use a canonical New-Keynesian closed economy dynamic general equilibrium model to analyze this issue. Financial adequacy of pension funds needs to be restored through suitable policies, such as increasing the required contributions with DB pension plans or writing down previously accumulated pension liabilities with DC

pension plans. DB pension funds have a distortionary effect on labour supply, as a result of the increase in contribution rates on labour income, and exacerbate economic fluctuations. Losses of pension wealth, on one hand, and distortions on the labour market, on the other, following the recovery from an unexpected shock to capital quality, bring to different preferences of workers, retirees and future generations about the optimal pension fund design.<sup>2</sup>

As mentioned, when liabilities exceed assets, pension funds face solvency problems. The latter can be addressed by means of risk sharing instruments, such as setting the pension premium over its actuarially fair price, suspending indexation to wage or price inflation, adjusting the asset mix, cutting accrued benefits. Using a sample of all Dutch occupational pension funds registered from 1993 to 2007, Bikker, Knaap, and Romp (2011) find that there is a positive, non-linear relation between the funding ratio, which compares the assets to the liabilities of pension funds, and the generosity of pension funds that grant new pension rights, but starting from the minimum ratio of 105%. Moreover, there is a positive correlation between the average age of members and the number of retirees of a pension fund and its generosity, which could probably be explained by their stronger influence and overrepresentation in labour unions. The size of pension funds also correlates positively with their generosity, possibly due to better scale efficiency.

Risk-based supervision should be introduced in the pension systems. Pension systems should ensure that contributors receive adequate replacement rates when they retire, such that the risk of receiving inadequate retirement income is mitigated. However, this goal is not explicitly defined in DC pension plans. In DB pension funds, capital requirements improve the solvency, thus reducing the possibility of missing pension promises. Instead, in DC pension funds, capital requirements may lead to increase the level of fees, without ensuring better pensions in the future; supervisors should focus on investment risk rather than operational risks, aiming at ensuring that pension fund management companies invest efficiently pension assets (Randle and Rudolph, 2014).

Operating efficiency plays an important role in providing optimal pensions. Operating costs of pension funds are divided in administrative and investment costs. Policies of pension funds should aim at minimizing such costs, since they erode future benefits. Using a sample of all Dutch pension funds registered from 1992 to 2009, Bikker (2013) finds

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<sup>2</sup>However, it should be taken into account that the tighter the link between contributions and pension benefits, the lower the distortionary effect on labour supply. In theory, the distortionary effect is less significant since pensions are deferred wages.

that there are significant scale economies and small pension funds benefit more from scale economies, because these depend on the size of pension funds: they decrease as pension fund size increases. Consolidation among smaller and medium-sized pension funds leads to a higher cost efficiency, since fixed costs decrease as pension fund size increases. An optimal scale exists when the average cost function is U-shaped. Upward-sloping right leg in this functional form results from large firm inefficiencies due to diseconomies of scale that prevail over monotonically declining fixed costs. When average cost function is monotonically decreasing, scale economies exist at any scale. The optimal scale for administrative costs increases over the sample period, while the optimal scale for investment costs remains constant over the sample period.

Individual retirement plans may be affected by high administrative costs. Indeed, private pension systems are expected to have higher administrative costs than public pension systems. This may raise a large objection concerning the privatization of social security systems (Mitchell, 1998).<sup>3</sup> High administrative costs may be explained by asymmetric information that features the market of pension funds, rather than imperfect competition. Competition among pension funds does not ensure efficient savings allocation. Consumers lack *ex ante* information and pension funds use marketing investments and short-term financial performances to signal their skills and attract individuals' pension contributions, improving market efficiency. However, signalling of asset-management skills is costly. Looking for policy solutions, market inefficiency is worsened by conduct regulation, such as cap to management fees and rules limiting costs or activities. On the other hand, social welfare is improved by structural regulations, such as introducing a public fund competing with private ones or a public-private scheme centralizing savings collection, allocating asset management to competitive funds through an efficient auction mechanism and leaving individuals free to opt-out (Greco, 2014).

Households make systematic mistakes in planning and saving for retirement, which is the rationale behind mandatory savings schemes. Indeed, households behave in a passive way to some extent, they do not change frequently their strategies, they join favourable plans slowly and they diversify their portfolios naively, adopting heuristics. On the other hand, DC pension plans require more responsibility in the decision making process for households (Benartzi and Thaler, 2007).

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<sup>3</sup>For example, Chile substituted a public DB pension plan for a mandatory funded private DC pension plan in 1981. However, it faced high administrative costs, which are still a problem, notwithstanding the later introduction of an auction mechanism (Barr and Diamond, 2016).

Mandatory pension systems are characterized by the rigidity of the demand for pension products. There is a misalignment between the incentives of the pension fund management companies, which focus excessively on short-term return maximization motivated by personal and reputational incentives, and the long-term objectives of the members. This misalignment should be solved and mandatory funded pension systems should offer life-cycle investment strategies acting as smart default options for individuals, since individuals are not able to make informed decisions related to long-term horizons. The supervisory of DC pension plans should aim to ensure that pension funds act in compliance with investment regulation; on the other hand, the supervisory of DB pension plans should aim to ensure that pension funds have enough resources to meet pension promises (Castañeda and Rudolph, 2011).

Considered that many individuals are not able to make active investment decisions, the design of default options has a great importance among policymakers. Investment strategies of default options need to pursue the long-term interest of individuals. The number of investment options provided has not to be excessive, because it may lead to information overload and bigger complexity, thus increasing the use of the default option by participants (Tapia and Yermo, 2007).

Using a behavioural contract theory approach, Bubb and Warrant (2020) develop two competing theories about how employers should design their retirement plans: an equilibrium model and a paternalistic employer model, which serves as a benchmark against which to assess the predictions of the equilibrium model. An employer-sponsored retirement plan is made up of a non-elective employer contribution, employer matching contributions proportional to workers' retirement savings and a default employee contribution rate. Workers are automatically enrolled in employer-sponsored retirement plans, but they can opt out if they do not want to participate. Firms offer labour contracts specifying a wage and a retirement plan and workers choose a contract among offers by maximizing their utility, given a time-inconsistent, present-bias factor. The authors call into question the employer acting as a paternalistic social planner and so designing retirement plan to maximize social welfare, because the delegation to employers of retirement plan design could result in perverse outcomes. Moreover, employer in designing a paternalistic retirement plan must have paternalistic motivations and significant market power, which is not satisfied given competition in the labour market. Employer-sponsored plans are subject to strict regulations, which would be not necessary if employers acted as paternalistic social planners. Empirically, the majority of employer-sponsored plans

complies with the predictions of the equilibrium model since they set default contribution rates strictly below the cap on employer matching contributions, whereas a minority of employer-sponsored plans sets default contribution rates at the cap on employer matching contributions in compliance with the paternalistic model. Empirically, the default savings rate in automatic enrolment plans is lower than the savings rate workers would have chosen opting in on their own, but it raises participation rates of workers who would not have opt in on their own. The equilibrium default choices minimize workers' savings and are lower than the minimum workers must contribute to get the full employer matching contributions.

Employers are intermediaries between retirement saving funds and savers. Employers acts as de facto market regulators through their retirement plan design. Default rules must be carefully designed, because they can lead to default bias such as weak participation in retirement savings. Savers benefit from employers' paternalism to the extent that employers serve savers' interests (Spiegler, 2015).

## 2.3 Financial literacy

The meaning of financial literacy involves a combination of financial knowledge, behaviour and attitudes. A financially literate individual is more able to handle everyday financial decisions regarding consumption, investments and savings. Financial literacy is necessary to make informed decisions about wealth accumulation, financial planning, debt and pensions. However, many people do not understand basic financial concepts and the level of financial literacy is low around the world: on average across G20 countries, the minimum target score defined as correctly answering 70% of the financial knowledge questions is achieved by less than half of adults (OECD, 2017a). Moreover, there is heterogeneity in levels of financial literacy across the population. Some evidences are, for instance: women are less financially literate than men; the profile of financial literacy along the life cycle is hump-shaped, meaning that young and elderly people are less financially literate; individuals with higher education are more financially savvy. This may suggest that financial education programs should be tailored to address specific groups (Lusardi and Mitchell, 2014).

Low levels of financial literacy raise concerns about households' ability to deal with financial industry and, particularly, with planning for retirement over the life cycle. Moreover, the evolving context, characterized by financial innovation and increasing markets

integration, on one hand, and by opportunity of living longer stressing the need of planning for a longer term, on the other, is becoming increasingly complex and highlights the importance of increasing financial sophistication. Using the Bank of Italy's Survey on Household Income and Wealth, Fornero and Monticone (2011) show that financial literacy positively and significantly affects the probability of participating in a pension fund. In this regard, public intervention aimed at improving the level of financial literacy is reasonable. Nudging jointly financial literacy and demographic literacy, which arises from the need to plan for the long term given the rising longevity, allows to design a more effective financial literacy program (Billari, Favero, and Saita, 2017).

On the other hand, Nolan and Doorley (2019), using data from the Irish Longitudinal Study on Ageing, find that there is no association between financial literacy and supplementary pension coverage, stressing the limited role for financial literacy over other determinants of participation in supplementary pension schemes such as income, education and employment type. However, they find that higher financial literacy is associated with higher total household wealth, greater expectations of income in retirement and lower financial stress.

Financial literacy may be considered a particular form of human capital accumulation. Therefore, some individuals are willing to invest in financial literacy while others may rationally choose not to invest in it. Financial markets are increasingly accessible, households face financial decisions increasingly complex and have a much greater responsibility. All these changes are increasingly requiring a financial literacy intervention. In particular, the pension environment is characterized by a trend toward disintermediation: workers and retirees rely less on Social Security and have to take on more responsibility for saving, investing, and decumulating their assets. This is consistent with the shift from employer-sponsored DB pension plans to DC pension plans and Individual Retirement Accounts. Individuals have to pay more attention to the design of their retirement plans, hence it is worth making financial literacy endogenous and integrating it in an intertemporal consumption model (Lusardi and Mitchell, 2014).

In this way, Jappelli and Padula (2013) integrate investment in financial literacy in an intertemporal consumption model. Consumers choose how much to invest to acquire financial literacy facing a trade-off between benefits, in terms of better investment opportunities and increasing net returns to saving, and costs, in terms of money, time and effort. Consumers allocate their income among consumption, saving and investment in financial literacy. Decision to acquire financial literacy and saving decisions depend on the

same factors, such as preference parameters, households' resources and costs of literacy. Reforms that develop private pension funds enhancing financial markets raise the incentive to invest in financial literacy. On the contrary, individuals living in countries with more generous public pension systems have less incentives to invest in financial literacy, showing lower levels of financial literacy.

Financial literacy affects economic preferences, whose two important domains are risk and time preferences. Risk preferences and time preferences are closely related to each other and are taken into account in financial decisions. By using a field experiment, an educational intervention on financial literacy addressed to students, aged 16 years on average, increases their risk aversion and patience in the aggregate, and the effect on both preferences is joint. Risk preferences are measured using certainty equivalents and time preferences are measured using future premium. The financial literacy intervention increases financial literacy, improving financial decisions of citizens. Individuals behave more frequently in a time-consistent manner. Larger improvements in financial literacy lead individuals to become less risk-averse, thus offsetting the increase in risk aversion without overcoming it. The financial literacy intervention is justified by the increasing complexity of financial decisions (Sutter et al., 2020).

The annual pension statement is a document that provides information on projected pension benefits to members of funded DC pension plans, in compliance with regulatory disclosure rules. It aims at enhancing member empowerment, improving members' level of knowledge and understanding, and encouraging members' action, especially in response to the risks that members bear under DC pension plans. Therefore, the pension statement may be considered as an integral component of the wider financial literacy programme (Antolin and Harrison, 2012).

In conclusion, financial literacy has a positive impact on retirement planning behaviour. Financial literacy is positively correlated with wealth accumulation over the life cycle, with likelihood to invest in the stock market, with returns from savings accounts and with propensity to plan for retirement, because financial literacy reduces costs of collecting and processing information and planning costs (van Rooji, Lusardi, and Alessie, 2012). However, financial literacy is expensive, there are direct, indirect and opportunity costs, which are likely high for both individuals and society. Moreover, financial education decays over time and Entorf and Hou (2018) find no clear evidence on the effectiveness of financial education interventions in increasing financial literacy levels. If the costs of financial literacy were too high, it could be better that households assume less respon-

sibility for their retirement plans giving way to regulation. There may be a trade-off between financial literacy and regulation: the former has interesting implications but it is not free of costs, the latter has some limits but it may also be effective in designing funded pension systems. This opens a debate about the role of financial literacy versus regulation. However, they may be complementary, not necessarily substitutes (Lusardi and Mitchell, 2014). The optimal policy mix between financial literacy and regulation should be investigated.

# Chapter 3

## Model

### 3.1 Investment in financial literacy

We start from the study of Jappelli and Padula (2013), who provide a model of intertemporal choice with endogenous saving and investment in financial information. They assume that consumers live for two periods: in period 0 consumers earn income  $y$  and in period 1 they live in retirement. In period 0, consumers allocate their income among consumption, investment in financial literacy and savings. Before entering the labour market at the beginning of period 0, consumers have an initial endowment of financial literacy  $\phi_0$ , which depreciates at a rate  $\delta$ . Consumers can buy financial literacy in period 0 at a cost  $p$  per unit, increasing the stock of financial literacy by  $\phi$ . Therefore, the stock of financial literacy evolves according to:

$$\phi_1 = (1 - \delta)\phi_0 + \phi \quad (3.1)$$

We assume that consumers are endowed with the same initial stock of financial literacy, hence what matters and draws a distinction among individuals is the subsequent investment in financial literacy.

Getting away from the model of Jappelli and Padula (2013), we assume that the amount of savings is exogenous and established by the regulator. It is consistent with the objective of studying the optimal design of the pension system's second pillar, for which consumers are forced to save a certain amount. Therefore, the investment in financial literacy is the only choice variable in the model. Financial literacy has both costs, in terms of time and monetary resources, and benefits, in terms of better investment opportunities, hence consumers face a trade-off in choosing how much financial literacy they acquire. We assume that the higher the investment in financial literacy the higher the probability of

acquiring a signal on the quality of financial products:

$$\pi(\phi) = \left( \frac{\phi}{1 + \phi} \right)^\alpha \quad (3.2)$$

where  $0 < \alpha < 1$  is the elasticity of the probability with respect to the investment in financial literacy, and we refer to  $\gamma = 1 - \alpha$  as the transparency factor. Investing in financial literacy raises the probability of getting the signal, though at a decreasing rate.<sup>1</sup> The marginal cost of financial literacy is the constant  $p$ , while the marginal return declines with investment in financial literacy. If consumers are not financially literate, the probability of getting the signal is zero. Moreover, the higher the transparency factor the higher the probability. Transparency may improve the effectiveness of financial literacy, because it facilitates the acquisition of information.

Consumers are forced to invest their savings in defined-contribution pension funds. We assume that the economy is made by an infinite number of individuals of mass 1. The institutional setting of the funded pension scheme is a competitive market of pension funds.<sup>2</sup> First of all, we assume that pension funds do not behave strategically and no pension-fund fees are charged to consumers. This will be our starting point for the subsequent development of the model.

At the beginning of period 1, saving  $s$  yields an interest rate factor. The interest rate factor is a random variable and is normally distributed,  $\tilde{R} \sim N(\mu, \sigma^2)$ . We assume, for the sake of simplicity, that there are only two financial products, which differ in mean and variance of the return of investment. A financial product provides a lower average return  $\mu_L$  but it is less risky  $\sigma_L^2$ . On the other hand, a financial product allows to gain a higher average return  $\mu_H > \mu_L$  but it is riskier  $\sigma_H^2 > \sigma_L^2$ .

With probability  $\pi(\phi)$ , informed consumers received a signal that allows them to perfectly distinguish the risk-return structure of financial products. Therefore, informed consumers choose the financial product that optimizes the risk-return trade-off according to their risk aversion. With probability  $1 - \pi(\phi)$ , uninformed consumers did not receive the signal and cannot distinguish between financial products. However, uninformed consumers

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<sup>1</sup>This is in line with the human capital literature, since financial literacy may be considered a particular form of investment in human capital. There are decreasing marginal returns to an additional investment in human capital.

<sup>2</sup>In a perfectly competitive market, consumers may switch between pension funds in order to maximize their expected pension. There are no barriers to entry and there is an infinite number of pension funds. Pension funds make zero expected profits, because new pension funds freely enter the market whenever profits are positive thus eliminating them in the long-run.

know that they will get high return-and-risk fund with probability  $\lambda$  and low return-and-risk fund with probability  $1 - \lambda$ . The figure 3.1 shows the sequential game, assuming that informed consumers optimize the risk-return trade-off by choosing the high risk-return product.

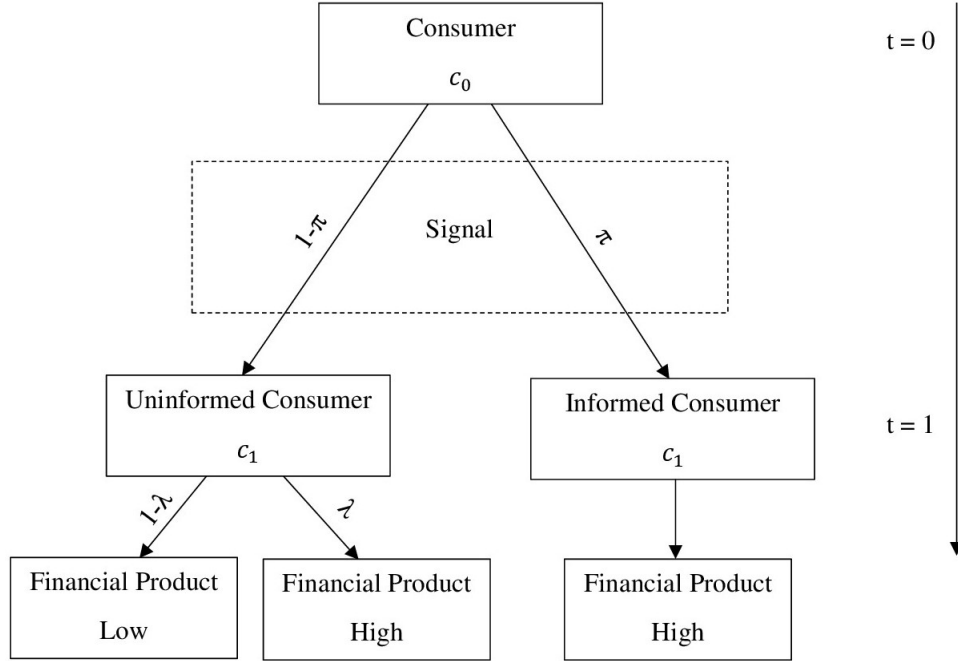


Figure 3.1: Sequential game

Consumers are risk averse and have a constant absolute risk aversion (CARA) utility function in each period  $t$ :

$$u(c_t) = -e^{-\rho c_t} \quad (3.3)$$

where  $\rho > 0$  is the constant absolute risk aversion coefficient. Consumers by choosing financial literacy investment maximize the following intertemporal utility function:

$$U = -e^{-\rho c_0} - \beta e^{-\rho c_1} \quad (3.4)$$

where  $0 < \beta < 1$  is the time discount factor. The optimization problem is subject to the time-contingent budget constraints:

$$c_0 + s + p\phi = y \quad \text{and} \quad c_1 = \tilde{R}s \quad (3.5)$$

Since the interest rate factor is uncertain,  $c_1$  gives a utility expressed as expected value,  $Eu(c_1)$ .<sup>3</sup> On the other hand,  $c_0$  is deterministic and  $u(c_0)$  is certain. Overall, consumers

<sup>3</sup>From moment generating function, the expected utility  $Eu(c_1)$  can be expressed in mean-variance terms as:  $-e^{-\rho[E(c_1) - \frac{1}{2}\rho \cdot Var(c_1)]}$ .

have to maximize:

$$\max_{\{\phi\}} c_0 + \beta \left[ E(c_1) - \frac{1}{2}\rho \cdot Var(c_1) \right] \quad (3.6)$$

where the first term in the square brackets is the mean and the second is the risk-premium. The linearization of the exponential function rules out the income effect.<sup>4</sup>

Solving by backward induction, we compute the risk aversion's threshold, as shown in appendix A:

$$\hat{\rho} = \frac{2(\mu_H - \mu_L)}{s(\sigma_H^2 - \sigma_L^2)} \quad (3.7)$$

Informed consumers choose the high return-and-risk product when their risk aversion coefficient is below the resulting threshold (3.7). On the other hand, informed consumers choose the low return-and-risk product when their risk aversion coefficient is above the threshold (3.7). Uninformed consumers are not able to choose, hence they receive an average of the two financial products according to the probability distribution. Uninformed consumers know the probability distribution of the two financial products, but they do not know which financial product they are buying. Therefore, there is a problem of incomplete information. Since pension funds are not strategic, they do not exploit the informational advantage that they have towards uninformed consumers.

We assume that the risk aversion is such that informed consumers choose the high return-and-risk fund and we compute the expected value and the variance of the consumption in period 1:<sup>5</sup>

$$E(c_1) = \pi(\phi) \cdot s\mu_H + (1 - \pi(\phi)) \cdot s[\lambda\mu_H + (1 - \lambda)\mu_L] \quad (3.8)$$

$$Var(c_1) = A(1 - A) \cdot s^2(\mu_H - \mu_L)^2 \quad (3.9)$$

where

$$A = \pi(\phi) + \lambda(1 - \pi(\phi)) \quad (3.10)$$

defines the mixture of the two probability distributions of receiving the high return-and-risk product, and  $0 \leq A \leq 1$ . We substitute the equations (3.5), (3.8) and (3.9) in (3.6) and compute the first order condition with respect to financial literacy investment  $\phi$ , thus obtaining:

$$\phi^* = \frac{\phi^\alpha \alpha \beta s(\mu_H - \mu_L)(1 - \lambda)[2 - \rho s(\mu_H - \mu_L)(1 - 2A)]}{2p(1 + \phi)^{\alpha+1}} \quad (3.11)$$

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<sup>4</sup>By optimizing (3.6) with respect to financial literacy investment, income  $y$  disappears. However, the income effect may be foreseeable: a higher income increases the optimal investment in financial literacy.

<sup>5</sup>The variance  $Var(c_1)$  is computed as:  $E(c_1^2) - [E(c_1)]^2$ .

which cannot be expressed in closed form and defines implicitly the optimal investment in financial literacy. The choice on how much to invest in financial literacy in period 0 is correlated with the probability of acquiring the signal and being informed. The term in the square brackets in the numerator of the (3.11)'s right-hand side has to be positive, otherwise the optimal investment in financial literacy would equal a negative number, but we are interested in positive financial literacy investments.<sup>6</sup>

In the same way, we analyse the case in which informed consumers choose the low return-and-risk fund according to their risk aversion. We compute the expected value and the variance of the consumption in period 1:

$$E(c_1) = \pi(\phi) \cdot s\mu_L + (1 - \pi(\phi)) \cdot s[\lambda\mu_H + (1 - \lambda)\mu_L] \quad (3.12)$$

$$Var(c_1) = B(1 - B) \cdot s^2(\mu_H - \mu_L)^2 \quad (3.13)$$

where

$$B = \pi(\phi) + (1 - \lambda)(1 - \pi(\phi)) \quad (3.14)$$

defines the mixture of the two probability distributions of receiving the low return-and-risk product, and  $0 \leq B \leq 1$ . We substitute the equations (3.5), (3.12) and (3.13) in (3.6) and compute the first order condition with respect to financial literacy investment  $\phi$ , thus obtaining:

$$\phi^* = \frac{\phi^\alpha \alpha \beta s(\mu_H - \mu_L) \lambda [\rho s(\mu_H - \mu_L)(2B - 1) - 2]}{2p(1 + \phi)^{\alpha+1}} \quad (3.15)$$

which defines implicitly the optimal investment in financial literacy. The term in the square brackets in the numerator of the (3.15)'s right-hand side has to be positive, otherwise the optimal investment in financial literacy would equal a negative number. When  $B \leq \frac{1}{2}$ , that term is negative, hence the optimal investment in financial literacy is zero in accordance with the Kuhn-Tucker conditions. From these arguments, we have the following proposition:

**Proposition 1.** *Consumers are very risk averse ( $\rho > \hat{\rho}$ ) and investing in financial literacy is risky: it does not mitigate the risk, but it may expose to further risks. When the probability of receiving the low return-and-risk product that they prefer is low ( $B \leq \frac{1}{2}$ ), consumers do not invest in financial literacy, while when the probability is high enough ( $B > \frac{1}{2}$ ), they acquire financial literacy because the investment is relatively less risky.*

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<sup>6</sup>When the equation (3.11) equals a negative number, the optimal investment in financial literacy is zero in accordance with the Kuhn-Tucker conditions.

In appendix B.1, we carry out a comparative statics analysis in order to study how the investment in financial literacy is affected by the parameters. The optimization process throughout the life cycle is shaped by consumer preferences, such as time discount rate and risk aversion. By the means of the model formulated in this way, we draw up some propositions about consumer choices with regard to the investment in financial literacy. We find that the more consumers are patient, which means a higher time discount factor, the more they invest in financial literacy. We find that the optimal investment in financial literacy depends on the costs for financial knowledge acquisition: the higher the price of financial literacy, the lower the investment in financial literacy.<sup>7</sup> We find that:

**Proposition 2.** *The investment in financial literacy depends on the risk aversion coefficient together with the probability of receiving the high or the low return-and-risk product. When consumers are not so much risk averse ( $\rho < \hat{\rho}$ ) and prefer the high return-and-risk product, a higher risk aversion reduces the investment in financial literacy if the probability of receiving it is low ( $A < \frac{1}{2}$ ), while a higher risk aversion increases the investment in financial literacy if the probability of receiving it is high enough ( $A > \frac{1}{2}$ ). When consumers are very risk averse ( $\rho > \hat{\rho}$ ) and prefer the low return-and-risk product, the investment in financial literacy increases with the risk aversion if the probability of receiving it is high enough ( $B > \frac{1}{2}$ ).*

*Proof.* See the appendix B.1, in particular the equations (B.12) and (B.26). ■

We need to distinguish between the parameters that are outside the control of the regulator and those that could be directly regulated by the government, such as transparency factor and savings allocated to defined-contribution pension funds:

**Proposition 3.** *When the probability of getting the signal is low ( $\pi(\phi) \leq \frac{1}{e}$ ), the higher the transparency the higher the financial literacy investment: the regulator that controls transparency may encourage financial literacy by enhancing transparency. However, when the probability is higher ( $\pi(\phi) > \frac{1}{e}$ ), a greater transparency might be counterproductive by decreasing the investment in financial literacy: since consumers have to pay to acquire financial literacy, they might prefer not to acquire it if transparency is already very high.*

*Proof.* See the appendix B.1, in particular the equations (B.7) and (B.21). ■

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<sup>7</sup>The price of financial literacy could be under the control of the regulator. For example, the government may reduce the cost of financial literacy services by means of subsidies.

**Proposition 4.** *The investment in financial literacy depends on the amount saved. When consumers are not so much risk averse ( $\rho < \hat{\rho}$ ) and prefer the high return-and-risk product, higher savings increase the investment in financial literacy if the probability of receiving it is high enough ( $A \geq \frac{1}{2}$ ). When consumers are very risk averse ( $\rho > \hat{\rho}$ ) and prefer the low return-and-risk product, higher savings increase the investment in financial literacy if the probability of receiving it is high enough ( $B > \frac{1}{2}$ ).*

*Proof.* See the appendix B.1, in particular the equations (B.9) and (B.23). ■

## 3.2 Market of pension funds with adverse selection

Now we remove the assumption that pension funds do not behave strategically, in order to study the working of the market of pension funds. A pension fund acts as an intermediary: it collects the contributions and invests them. A contractual relationship is established between consumers, called the principal, and pension funds, called the agent. Pension funds have some information that is not known to consumers and is already present before the contract is signed. The information concerns pension funds' skills, called the agent's type. Pension funds are interested in keeping their information private, trying to exploit their informational advantage. Therefore, there is asymmetric information and it may cause a market failure.<sup>8</sup>

We assume, for the sake of simplicity, that there are only two types of pension funds, which differ in their investment in skills  $\theta \in \{0, 1\}$  providing access to two distinct investment technologies. High-skill pension funds accumulate asset-management skills ( $\theta = 1$ ), hence they face some costs.<sup>9</sup> The investment in skills allows them to yield the high return  $\mu_H$  on average and to be rewarded with a higher management fee  $\omega_H$ , which is represented as a share of contributions  $s$ .<sup>10</sup> On the other hand, low-skill pension funds do not accumulate asset-management skills ( $\theta = 0$ ), yield the low average return  $\mu_L$  at most, and are rewarded with a lower management fee  $\omega_L < \omega_H$ . The pension fund's expected profit is

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<sup>8</sup>Asymmetric information affects the functioning of the real-world market of pension funds.

<sup>9</sup>A more sophisticated investment technology provides consumers access to higher expected returns, but pension funds face costs to get it, for example by hiring good asset managers that have to be adequately rewarded.

<sup>10</sup>The structure of pension-fund fees is complex. For the sake of simplicity, we assume that pension funds charge to customers only management fees.

represented as:

$$\Pi_i = \omega_i s - a(\theta) - c(\gamma)s \quad \text{with } i = L, H \quad (3.16)$$

where  $\omega_i s$  are accrued revenues,  $a(\theta)$  are skill-accumulation costs, and  $c(\gamma)s$  are transparency costs. Skill-accumulation costs are a function of the actual skills of the pension fund and cancel out when  $\theta = 0$ . They are fixed costs independent of the sum of savings allocated to the pension fund. Pension funds, regardless of their type, bear transparency costs to comply with the directives of the regulator. Transparency costs are independent of skills, and increasing with the transparency factor  $\gamma$  and the sum of managed savings  $s$ .<sup>11</sup> Let the average cost per unit  $c(\gamma) = k\gamma$ , with  $k > 0$  and  $c(\gamma) \in (0, 1)$ . Since we assume free entry and perfect competition among pension funds, their expected profit is zero. Therefore, we determine the pension funds' management fees as:

$$\omega_L s = c(\gamma)s \quad \text{and} \quad \omega_H s = a(\theta) + c(\gamma)s \quad (3.17)$$

so that accrued revenues cover outlays. These are the minimum prices that pension funds are willing to accept, depending on their investment in skills.

In the first place, pension funds enter the market and decide their investment in asset-management skills. Then, each consumer chooses a pension fund, on the basis of its risk aversion and investment in financial literacy.

With symmetric information, it would be easy to verify the skills of pension funds and the market would be efficient. In equilibrium, there would be no transparency costs, hence the low-skill funds' management fee would be zero and the high-skill funds' management fee would be equal to the skill-accumulation costs. In such a case, all consumers are informed, since they acquired financial literacy becoming able to observe funds' skills and distinguish high-skill pension funds from low-skill ones.

With asymmetric information, uninformed consumers cannot observe the skills of pension funds. Choosing to which pension fund uninformed consumers allocate their savings leads to an adverse selection problem. On the other hand, informed consumers can screen pension funds and overcome the adverse selection problem. Under imperfect information, low-skill pension funds pretend to be highly skilled, demanding the high management fee

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<sup>11</sup>Since the mass of individuals is equal to 1,  $s$  is also the aggregate of managed savings. Assuming that transparency costs increase with the sum of managed savings has economic sense, because they increase with the number of customers. For example, the MiFID questionnaire designed by the Markets in Financial Instruments Directive (MiFID) to fulfil transparency requirements is submitted to each customer.

$\omega_H$  without facing the skill-accumulation costs. Therefore, they make a positive profit by mimicking high-skill funds, instead uninformed consumers get the low average return although they paid the high management fee. As a consequence, uninformed consumers are willing to pay no more than an average price, equal to  $[(1 - \lambda)\omega_L + \lambda\omega_H]s$ .<sup>12</sup> The average price is lower than the minimum price high-skill funds are willing to accept, but higher than the minimum price low-skill funds are willing to accept, hence only low-skill pension funds will accept it. In equilibrium, uninformed consumers anticipate this and will offer no more than the low management fee  $\omega_L$ : only low-skill pension funds will operate in the market. Therefore, the equilibrium of the market of pension funds is Pareto-inefficient.

High-skill pension funds would like to convince uninformed consumers that their products yield a high return on average for real. However, simply telling it is not sufficient to obtain a higher price, otherwise all pension funds, also low-skill ones, would state their products are good.

In such a game, the equilibrium can be pooling when high- and low-skill pension funds choose the same strategy, or separating when high- and low-skill pension funds have different strategies. However, under perfect competition, a pooling equilibrium does not exist, because a contract based on one-size-fits-all is not robust to competition. Indeed, high-skill pension funds have to receive a fee high enough to cover skill-accumulation costs, but it generates an extra profit for low-skill pension funds because that fee is higher than their costs. As long as expected profits are positive, new funds enter as low-skill pension funds, because no fund is willing to be highly skilled. A separating equilibrium of the market of pension funds is a perfect Bayesian equilibrium.<sup>13</sup> Given consumers' beliefs, the separating equilibrium is characterized in this way: on the one hand, high-skill pension funds sell only to informed consumers, and on the other, low-skill pension funds sell to informed consumers if they are very risk averse or to uninformed consumers. Informed consumers are able to choose to which pension fund they allocate their savings on the basis of their risk aversion coefficient, while uninformed consumers can buy only the low return-and-risk product. However, when uninformed consumers are not so much risk averse and prefer the high return-and-risk product, their preferences cannot be fulfilled, otherwise they expose themselves to the risk of a low-skill pension fund that mimics high-skill ones.

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<sup>12</sup> $\lambda$  and  $1 - \lambda$  are the proportions of high-skill pension funds and low-skill pension funds in the economy, respectively.

<sup>13</sup>A perfect Bayesian equilibrium is a Nash equilibrium, because no pension fund has incentive to deviate unilaterally from its equilibrium strategy.

By including the management fees charged to consumers, the time-contingent budget constraints of the optimization problem become:

$$c_0 + s + p\phi = y \quad \text{and} \quad c_1 = \tilde{R}s(1 - \omega_i) \quad (3.18)$$

Proceeding by backward induction and in the same way as explained in appendix A, the risk aversion's threshold is:

$$\hat{\rho} = \frac{2[(1 - \omega_H)\mu_H - (1 - \omega_L)\mu_L]}{s[(1 - \omega_H)^2\sigma_H^2 - (1 - \omega_L)^2\sigma_L^2]} \quad (3.19)$$

In order that the high return-and-risk fund remains attractive to consumers, we set skill-accumulation costs  $a(\theta)$  low enough such that:

$$(1 - \omega_H)\mu_H > (1 - \omega_L)\mu_L \quad \text{and} \quad (1 - \omega_H)^2\sigma_H^2 > (1 - \omega_L)^2\sigma_L^2 \quad (3.20)$$

When the risk aversion coefficient is above the threshold (3.19), consumers are so risk averse that prefer the low return-and-risk fund. However, they are always satisfied because informed consumers would be able to distinguish and choose low-skill pension funds, while uninformed consumers can only bargain with low-skill pension funds in the market with adverse selection. Therefore, the expected value of the consumption in period 1 is certain,  $E(c_1) = s(1 - \omega_L)\mu_L$ , and there is no variance. As a result, consumers have no incentive to invest in financial literacy:

**Proposition 5.** *When consumers are very risk averse ( $\rho > \hat{\rho}$ ), the optimal investment in financial literacy is zero, because all consumers are willing to allocate their savings to low-skill pension funds that are the only ones to operate under adverse selection.*

*Proof.* This proposition follows from the classical lemon-market argument. ■

On the other hand, the case where the risk aversion coefficient is below the threshold (3.19) is interesting to explore. We compute the expected value and the variance of the consumption in period 1:

$$E(c_1) = \pi(\phi) \cdot s(1 - \omega_H)\mu_H + (1 - \pi(\phi)) \cdot s(1 - \omega_L)\mu_L \quad (3.21)$$

$$Var(c_1) = \pi(\phi)(1 - \pi(\phi)) \cdot s^2[(1 - \omega_H)\mu_H - (1 - \omega_L)\mu_L]^2 \quad (3.22)$$

For simplicity, we define:

$$\Delta = (1 - \omega_H)\mu_H - (1 - \omega_L)\mu_L \quad (3.23)$$

which is the yield spread net of the management fees between the high return-and-risk fund and the low return-and-risk fund, and  $\Delta > 0$ . We substitute the equations (3.18), (3.21) and (3.22) in (3.6) and compute the first order condition with respect to financial literacy investment  $\phi$ , thus obtaining:

$$\phi^* = \frac{(1 - \gamma)\beta s \Delta \pi(\phi)[2 - \rho s \Delta(1 - 2\pi(\phi))]}{2p(1 + \phi)} \quad (3.24)$$

which defines implicitly the optimal investment in financial literacy. The term in the square brackets in the numerator of the (3.24)'s right-hand side has to be positive, otherwise the optimal investment in financial literacy would equal a negative number. From these arguments, we have the following proposition:

**Proposition 6.** *When consumers are not so much risk averse ( $\rho < \hat{\rho}$ ), they are willing to invest in financial literacy in order to allocate their savings to high-skill pension funds.*

In appendix B.2, we carry out a comparative statics analysis in order to study how the investment in financial literacy is affected by the parameters, under adverse selection. We consider only the case in which the risk aversion coefficient is below the risk aversion's threshold (3.19): consumers are not so much risk averse and prefer the high return-and-risk product. Some comparative statics results previously found in appendix B.1 are confirmed. We find that:

**Proposition 7.** *The investment in financial literacy depends on the risk aversion coefficient together with the probability of getting the signal. A higher risk aversion reduces the investment in financial literacy if the probability of getting the signal is low ( $\pi(\phi) < \frac{1}{2}$ ), while a higher risk aversion increases the investment in financial literacy if the probability of getting the signal is high enough ( $\pi(\phi) > \frac{1}{2}$ ).*

*Proof.* See the appendix B.2, in particular the equation (B.40). ■

Looking at the parameters under the control of the regulator:

**Proposition 8.** *When the probability of getting the signal is high enough ( $\pi(\phi) > \frac{1}{2}$ ), the higher the transparency the lower the financial literacy investment: a greater transparency may be counterproductive by decreasing the investment in financial literacy, because consumers may prefer not to acquire it if transparency is already very high.*

*Proof.* See the appendix B.2, in particular the equation (B.35). ■

**Proposition 9.** *The investment in financial literacy depends on the amount saved. Higher savings increase the investment in financial literacy if the probability of getting the signal is high enough ( $\pi(\phi) \geq \frac{1}{2}$ ).*

*Proof.* See the appendix B.2, in particular the equation (B.37). ■

### 3.3 Regulation of pension funds

Summing up, the model goes through three sequential stages:

1. the regulator establishes policy instruments, such as provisions on transparency;
2. consumers choose how much to invest in financial literacy;
3. pension funds operate in the market.

The regulator may intervene in the market of pension funds by regulating transparency requirements.<sup>14</sup> Transparency is a form of regulation of the pension fund industry. It may be complementary to financial literacy because it increases the probability of getting the signal and being informed, as stated in (3.2). However, compliance with the provisions on transparency is costly and its costs are borne by pension funds. There is a trade-off between costs and benefits of transparency.

The regulator is responsible for ensuring the welfare of the population. Social welfare is determined by summing the utility function of consumers and the profit function of pension funds. Since the expected profit of pension funds is zero, the regulator has to maximize the intertemporal utility function (3.6) of consumers with respect to transparency factor in order to maximize the social welfare.

When the risk aversion coefficient is above the threshold (3.19), we find that the first order condition equals a negative number, hence the optimal level of transparency is zero in accordance with the Kuhn-Tucker conditions. From these arguments, we have the following proposition:

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<sup>14</sup>For example, Markets in Financial Instruments Directive (MiFID) is a legislative framework enforced in the European Union, which regulates financial markets and rules transparency requirements. MiFID II entered into force in January 2018, replacing the previous directive in operation across the European Union since 2007. It aims at standardizing practices and increasing transparency, so as to improve protection for investors and restore confidence, particularly after the 2008 financial crisis.

**Proposition 10.** *When consumers are very risk averse ( $\rho > \hat{\rho}$ ), the optimal level of transparency is zero, because all consumers are willing to allocate their savings to low-skill pension funds that are the only ones to operate under adverse selection.*

Considering the case where the risk aversion coefficient is below the threshold (3.19), we substitute the equations (3.18), (3.21) and (3.22) in (3.6) and compute the first order condition with respect to transparency factor  $\gamma$ , thus obtaining:

$$\gamma^* = 1 + \frac{\pi(\phi) \ln \pi(\phi) \Delta [2 - \rho s \Delta (1 - 2\pi(\phi))]}{2k\{\mu_L + (\mu_H - \mu_L)\pi(\phi)[1 - \rho s \Delta (1 - \pi(\phi))]\}} \quad (3.25)$$

which defines implicitly the optimal level of transparency. Since  $\gamma \in (0, 1)$ , the second term of the (3.25)'s right-hand side has to be negative, but bigger than  $-1$ . The term in the square brackets in the numerator has to be positive as stated in (3.24). Since  $\pi(\phi) \in [0, 1]$ ,  $\ln \pi(\phi)$  is a non-positive number. When  $\pi(\phi) = 1$ ,  $\ln \pi(\phi)$  is zero and thus the transparency factor equals 1. We set that the term in the square brackets in the denominator is positive, in order that the second term of the (3.25)'s right-hand side is always a negative number. Only the upper bound of  $\gamma$  matters, hence we ensure that  $\gamma$  does not overcome it. When the lower bound is not fulfilled and  $\gamma$  equals a negative number, the optimal level of transparency is zero in accordance with the Kuhn-Tucker conditions.

In appendix B.3, we carry out a comparative statics analysis in order to study how the transparency factor is affected by the parameters. We consider only the case in which the risk aversion coefficient is below the risk aversion's threshold (3.19): consumers are not so much risk averse and prefer the high return-and-risk product. We find that higher marginal costs of transparency and higher skill-accumulation costs reduce the level of transparency. Higher skill-accumulation costs mean that pension funds have lower incentives to be highly skilled. In addition, higher skill-accumulation costs lead to higher high-skill funds' management fee, charged to consumers. Therefore, the investment in the high return-and-risk product becomes less profitable, *ceteris paribus*. In such a case, consumers could prefer the low return-and-risk product, hence enhancing transparency could be not interesting. We find that a higher consumer risk aversion increases the level of transparency if the probability of getting the signal is high enough ( $\pi(\phi) \geq \frac{1}{2}$ ).

Transparency may improve the efficiency of the market of pension funds, but it does not overcome the adverse selection problem. Uninformed consumers still do not get access to the high return-and-risk fund and they might want it. We suggest a possible direction to address this issue: the introduction of a public pension fund that competes with private

ones in the market of pension funds. Introducing a public option is a form of structural regulation of pension funds. However, the public pension fund cannot yield the high return  $\mu_H$  on savings, but it is conceived to provide an average return, equal to  $(1 - \lambda)\mu_L + \lambda\mu_H$ , and to charge an average management fee, equal to  $(1 - \lambda)\omega_L + \lambda\omega_H$ .<sup>15</sup> By choosing the public option, uninformed consumers may have access to a higher expected return compared to the low return  $\mu_L$  that otherwise they would get from low-skill pension funds. This public pension fund may be more aligned with their risk aversion coefficient and their preferences, although they cannot get the high return-and-risk fund. Consumers that opt for the public pension fund do not have incentives to invest in financial literacy. This policy proposal may reduce the inefficiency of the market of pension funds arising from adverse selection, but it in turn may be affected by political agency problems. Indeed, the public pension fund may be benevolent or self-interested and tainted by corruption, depending on the quality of governance of public institutions. So again, there is a trade-off between costs and benefits of introducing a public option.

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<sup>15</sup>We imagine that a public asset manager cannot be as good as private asset managers oh high-skill pension funds.

# Conclusion

It is a conventional wisdom that financial literacy is a skill essential to participate in the current economy. Given its economic importance, many policy makers support with great enthusiasm financial literacy and financial education programmes that should improve awareness, financial knowledge and financial behaviour. Moreover, the implementation of methods aimed at protecting individuals from their financial illiteracy is an increasingly strong concern in response to the 2008 financial crisis. However, making everyone financially savvy is not feasible (Lusardi and Mitchell, 2014) and the effectiveness of financial education programmes has no clear evidence (Entorf and Hou, 2018).

To explore the role of regulation and financial literacy in funded pension systems, we considered a theoretical model. Our theoretical predictions emphasize that it is not obvious that making the entire population financially literate is the best way to build up an adequate retirement income. The policy mix between financial literacy and regulation by way of transparency has to be optimized, taking into account the arising trade-offs. On one hand, financial literacy has both costs, in terms of time and monetary resources, and benefits, in terms of better investment opportunities in line with risk aversion preferences of individuals. On the other, transparency increases the probability of being informed of individuals along with financial literacy, but it has costs borne by pension funds. The level of transparency established by the regulator affects the investment in financial literacy of individuals. We theoretically found that when the probability of being informed is low, a higher level of transparency may lead to a higher investment in financial literacy, hence the regulator may encourage financial literacy by enhancing transparency. However, when the probability of being informed is higher, a greater transparency may be counterproductive by decreasing the investment in financial literacy, because individuals may prefer not to acquire it if transparency is already very high.

Moreover, asset allocation strategies of pension funds have to be consistent with the risk appetite of individuals. The investment in financial literacy depends on the risk

aversion preferences along with the probability of being informed, which determines the ability of individuals of choosing the fund that optimizes their risk-return trade-off. We theoretically found that when the probability of being informed is low, a higher risk aversion may reduce the investment in financial literacy, while when the probability of being informed is higher, a higher risk aversion may increase the investment in financial literacy.

# Appendix A

## Risk Aversion Coefficient

This appendix shows how to compute the risk aversion's threshold (3.7), above and below which informed consumers choose the low and high return-and-risk product respectively. In period 1, consumers' utility is given by:

$$E(c_1) - \frac{1}{2}\rho \cdot Var(c_1) \quad (\text{A.1})$$

in which the first term is the mean and the second is the risk-premium. Substituting the budget constraint (3.5), we obtain:

$$sE(\tilde{R}) - \frac{1}{2}\rho s^2 \cdot Var(\tilde{R}) \quad (\text{A.2})$$

We compare risk-return combinations of the two financial products:

$$s\mu_H - \frac{1}{2}\rho s^2 \sigma_H^2 \quad \begin{matrix} \leq \\ \geq \end{matrix} \quad s\mu_L - \frac{1}{2}\rho s^2 \sigma_L^2 \quad (\text{A.3})$$

Informed consumers choose the high return-and-risk product when its risk-adjusted return is bigger than the risk-adjusted return of the low return-and-risk product, thus obtaining a higher utility. It happens when:

$$\rho < \frac{2(\mu_H - \mu_L)}{s(\sigma_H^2 - \sigma_L^2)} \quad (\text{A.4})$$

which identifies the risk aversion's threshold. Vice versa, informed consumers choose the low return-and-risk product when:

$$\rho > \frac{2(\mu_H - \mu_L)}{s(\sigma_H^2 - \sigma_L^2)} \quad (\text{A.5})$$

# Appendix B

## Comparative Statics Analysis

This appendix provides the comparative statics analysis, which determines the changes in the endogenous variable of the model as a result of the changes in the exogenous variables, under different scenarios.

### B.1 Financial literacy investment with zero pension-fund fees

We consider the case in which the risk aversion coefficient is below the risk aversion's threshold, as set out in (A.4). The first order condition with respect to financial literacy investment  $\phi$  is:

$$\frac{\alpha\beta s(\mu_H - \mu_L)(1 - \lambda)\pi(\phi)[2 - \rho s(\mu_H - \mu_L)(1 - 2A)]}{2\phi(1 + \phi)} - p = 0 \quad (\text{B.1})$$

We differentiate the equation (B.1) with respect to  $\phi$  and obtain:

$$f_\phi = \frac{\alpha\beta s(\mu_H - \mu_L)(1 - \lambda)\pi(\phi)}{2\phi^2(1 + \phi)^2} \cdot \{[-2\phi - (1 - \alpha)][2 - \rho s(\mu_H - \mu_L)(1 - 2A)] + 2\alpha\rho s(\mu_H - \mu_L)(1 - \lambda)\pi(\phi)\} \quad (\text{B.2})$$

In order to find a maximum, the second order condition requires that the equation (B.2) is negative. It is satisfied when:

$$\phi > \frac{\alpha\rho s(\mu_H - \mu_L)(1 - \lambda)\pi(\phi)}{2 - \rho s(\mu_H - \mu_L)(1 - 2A)} - \frac{1}{2}(1 - \alpha) \quad (\text{B.3})$$

The denominator of the first term of the (B.3)'s right-hand side has to be positive, otherwise the direction of the inequality would change and it would not have economic meaning

because  $\phi$  would be smaller than a negative number.<sup>1</sup> Moreover, if the denominator was not positive, the equation (3.11) would equal a negative number and it would not have economic meaning. This is always satisfied when  $A \geq \frac{1}{2}$ . The denominator is increasing as  $A$  gets larger. If  $A = 0$ , the denominator is positive when:<sup>2</sup>

$$\rho < \frac{2}{s(\mu_H - \mu_L)} \quad (\text{B.4})$$

By comparing (A.4) and (B.4), the latter is always satisfied when the right-hand side of (A.4) is smaller than the right-hand side of (B.4), i.e., when:

$$(\mu_H - \mu_L)^2 < (\sigma_H^2 - \sigma_L^2) \quad (\text{B.5})$$

It is a sufficient condition so that the equation (3.11) equals a positive number. To ensure that the second order condition is always satisfied, we study a sufficient condition such that the right-hand side of (B.3) is negative, considering that  $\phi$  has to be a non-negative number:

$$\rho < \frac{2(1 - \alpha)}{s(\mu_H - \mu_L)[2\alpha(1 - \lambda)\pi(\phi) + (1 - \alpha)(1 - 2A)]} \quad (\text{B.6})$$

This could be useful to restrict the range of variation of the parameters.<sup>3</sup>

We determine the comparative statics results by computing the total differential of the first order condition (B.1). The sign of the partial derivative of the first order condition with respect to each parameter is what we are interested in when assessing the effect of a change in a parameter on  $\phi$ , because the equation (B.2) has to be negative and is preceded by a negative sign.

The impact of a change in  $\alpha$  on  $\phi$  is calculated as:

$$\begin{aligned} \frac{\partial \phi}{\partial \alpha} = -\frac{1}{f_\phi} \cdot \frac{\beta s(\mu_H - \mu_L)(1 - \lambda)\pi(\phi)}{2\phi(1 + \phi)} \cdot \{(\ln \pi(\phi) + 1)[2 - \rho s(\mu_H - \mu_L)(1 - 2A)] \\ + 2\rho s(\mu_H - \mu_L)(1 - \lambda)\pi(\phi) \ln \pi(\phi)\} \end{aligned} \quad (\text{B.7})$$

which is negative when  $\pi(\phi) \leq \frac{1}{e}$ , but it is ambiguous when  $\pi(\phi) > \frac{1}{e}$ . The term in the square brackets has to be positive as stated in (B.3),  $\ln \pi(\phi)$  is a non-positive number since  $0 \leq \pi(\phi) \leq 1$ , and  $\ln \pi(\phi) + 1$  is positive if  $\pi(\phi) > \frac{1}{e}$  and negative if  $\pi(\phi) < \frac{1}{e}$ . A negative effect implies that the investment in financial literacy increases with the transparency

<sup>1</sup>The numerator of the first term of the (B.3)'s right-hand side is a positive number.

<sup>2</sup> $A = 0$  identifies the worst-case scenario.

<sup>3</sup>The denominator of the right-hand side of (B.6) has to be positive, otherwise the direction of the inequality would change.

factor  $\gamma = 1 - \alpha$ .

The impact of a change in  $\beta$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \beta} = -\frac{1}{f_\phi} \cdot \frac{\alpha s(\mu_H - \mu_L)(1 - \lambda)\pi(\phi)}{2\phi(1 + \phi)} \cdot [2 - \rho s(\mu_H - \mu_L)(1 - 2A)] \quad (\text{B.8})$$

which is positive, since the term in the square brackets has to be positive as stated in (B.3). Therefore, the investment in financial literacy increases with the time discount factor: the more consumers are patient, the more they invest in financial literacy.

The impact of a change in  $s$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial s} = -\frac{1}{f_\phi} \cdot \frac{\alpha \beta(\mu_H - \mu_L)(1 - \lambda)\pi(\phi)}{\phi(1 + \phi)} \cdot [1 - \rho s(\mu_H - \mu_L)(1 - 2A)] \quad (\text{B.9})$$

which is positive when  $A \geq \frac{1}{2}$ , but it is ambiguous when  $A < \frac{1}{2}$ .<sup>4</sup> The investment in financial literacy depends on the amount saved, but it cannot be concluded that higher savings lead always to higher stock of financial literacy.

The impact of a change in  $\mu_H$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \mu_H} = -\frac{1}{f_\phi} \cdot \frac{\alpha \beta s(1 - \lambda)\pi(\phi)}{\phi(1 + \phi)} \cdot [1 - \rho s(\mu_H - \mu_L)(1 - 2A)] \quad (\text{B.10})$$

which is positive when  $A \geq \frac{1}{2}$ , but it is ambiguous when  $A < \frac{1}{2}$ . Therefore, when  $A \geq \frac{1}{2}$ , a higher average return of the high return-and-risk product is associated with a higher investment in financial literacy.

The impact of a change in  $\mu_L$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \mu_L} = -\frac{1}{f_\phi} \cdot \frac{\alpha \beta s(1 - \lambda)\pi(\phi)}{\phi(1 + \phi)} \cdot [\rho s(\mu_H - \mu_L)(1 - 2A) - 1] \quad (\text{B.11})$$

which is negative when  $A \geq \frac{1}{2}$ , but it is ambiguous when  $A < \frac{1}{2}$ . As opposed to the impact of a change in  $\mu_H$  on  $\phi$ , when  $A \geq \frac{1}{2}$ , a higher average return of the low return-and-risk product is associated with a lower investment in financial literacy.

The impact of a change in  $\rho$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \rho} = -\frac{1}{f_\phi} \cdot \frac{\alpha \beta s^2(\mu_H - \mu_L)^2(1 - \lambda)\pi(\phi)}{2\phi(1 + \phi)} \cdot [-(1 - 2A)] \quad (\text{B.12})$$

which is positive when  $A > \frac{1}{2}$ , but it is negative when  $A < \frac{1}{2}$ . The investment in financial literacy depends on consumers' risk aversion together with the probability of receiving the high return-and-risk product: the more consumers are risk averse, the less they invest

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<sup>4</sup>If  $A = 0$ , the effect is positive when:  $\rho < \frac{1}{s(\mu_H - \mu_L)}$ . This is always satisfied when:  $2(\mu_H - \mu_L)^2 < (\sigma_H^2 - \sigma_L^2)$ .

in financial literacy if the probability  $A$  is not so high.

The impact of a change in  $\lambda$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \lambda} = -\frac{1}{f_\phi} \cdot \frac{\alpha \beta s(\mu_H - \mu_L) \pi(\phi)}{2\phi(1 + \phi)} \cdot [\rho s(\mu_H - \mu_L)(3 - 4A) - 2] \quad (\text{B.13})$$

which is negative when  $A \geq \frac{3}{4}$ , but it is ambiguous when  $A < \frac{3}{4}$ .<sup>5</sup> Thus, when the probability of receiving the high return-and-risk product is high, the higher the probability  $\lambda$  the lower the investment in financial literacy.

The impact of a change in  $p$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial p} = -\frac{1}{f_\phi} \cdot (-1) \quad (\text{B.14})$$

which is negative, hence a higher price of financial literacy reduces the investment in financial literacy.

We now consider the case in which the risk aversion coefficient is above the risk aversion's threshold, as set out in (A.5). The first order condition with respect to financial literacy investment  $\phi$  is:

$$\frac{\alpha \beta s(\mu_H - \mu_L) \lambda \pi(\phi) [\rho s(\mu_H - \mu_L)(2B - 1) - 2]}{2\phi(1 + \phi)} - p = 0 \quad (\text{B.15})$$

We differentiate the equation (B.15) with respect to  $\phi$  and obtain:

$$g_\phi = \frac{\alpha \beta s(\mu_H - \mu_L) \lambda \pi(\phi)}{2\phi^2(1 + \phi)^2} \cdot \{(-2\phi - 1)[\rho s(\mu_H - \mu_L)(2B - 1) - 2] + \alpha[\rho s(\mu_H - \mu_L)(2B - 1 + 2\pi(\phi)\lambda) - 2]\} \quad (\text{B.16})$$

In order to find a maximum, the second order condition requires that the equation (B.16) is negative. It is satisfied when:

$$\phi > \frac{\alpha[\rho s(\mu_H - \mu_L)(2B - 1 + 2\pi(\phi)\lambda) - 2]}{2[\rho s(\mu_H - \mu_L)(2B - 1) - 2]} - \frac{1}{2} \quad (\text{B.17})$$

The denominator of the first term of the (B.17)'s right-hand side has to be positive, otherwise the equation (3.15) would equal a negative number and it would not have economic meaning. The denominator is increasing as  $B$  gets larger. When  $B \leq \frac{1}{2}$ , the denominator is negative, hence we rule out this case and restrict the range of the parameters to  $B > \frac{1}{2}$ . The term in the square brackets in the numerator is bigger than

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<sup>5</sup>If  $A = 0$ , the effect is negative when:  $\rho < \frac{2}{3s(\mu_H - \mu_L)}$ . This is always satisfied when:  $3(\mu_H - \mu_L)^2 < (\sigma_H^2 - \sigma_L^2)$ .

the term in the square brackets in the denominator, hence the numerator is a positive number when the denominator is positive. If  $B > \frac{1}{2}$ , the denominator is positive when:

$$\rho > \frac{2}{s(\mu_H - \mu_L)(2B - 1)} \quad (\text{B.18})$$

By comparing (A.5) and (B.18), the latter is always satisfied when the right-hand side of (A.5) is bigger than the right-hand side of (B.18), i.e., when:

$$(\mu_H - \mu_L)^2(2B - 1) > (\sigma_H^2 - \sigma_L^2) \quad (\text{B.19})$$

It is a sufficient condition so that the equation (3.15) equals a positive number. To ensure that the second order condition is always satisfied, we study a sufficient condition such that the right-hand side of (B.17) is negative, considering that  $\phi$  has to be a non-negative number:

$$\rho > \frac{2(1 - \alpha)}{s(\mu_H - \mu_L)[(1 - \alpha)(2B - 1) - 2\alpha\lambda\pi(\phi)]} \quad (\text{B.20})$$

This could be useful to restrict the range of variation of the parameters.<sup>6</sup>

We carry out a comparative statics analysis. Since the equation (B.16) has to be negative and is preceded by a negative sign, the sign of the effect of a change in a parameter on  $\phi$  depends only on the sign of the partial derivative of the first order condition (B.15) with respect to each parameter.

The impact of a change in  $\alpha$  on  $\phi$  is calculated as:

$$\begin{aligned} \frac{\partial \phi}{\partial \alpha} = & -\frac{1}{g_\phi} \cdot \frac{\beta s(\mu_H - \mu_L)\lambda\pi(\phi)}{2\phi(1 + \phi)} \cdot \{(\ln \pi(\phi) + 1)[\rho s(\mu_H - \mu_L)(2B - 1) - 2] \\ & + 2\rho s(\mu_H - \mu_L)\lambda\pi(\phi) \ln \pi(\phi)\} \end{aligned} \quad (\text{B.21})$$

which is negative when  $\pi(\phi) \leq \frac{1}{e}$ , but it is ambiguous when  $\pi(\phi) > \frac{1}{e}$ . The term in the square brackets has to be positive as stated in (B.17),  $\ln \pi(\phi)$  is a non-positive number since  $0 \leq \pi(\phi) \leq 1$ , and  $\ln \pi(\phi) + 1$  is positive if  $\pi(\phi) > \frac{1}{e}$  and negative if  $\pi(\phi) < \frac{1}{e}$ . A negative effect implies that the investment in financial literacy increases with the transparency factor  $\gamma = 1 - \alpha$ .

The impact of a change in  $\beta$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \beta} = -\frac{1}{g_\phi} \cdot \frac{\alpha s(\mu_H - \mu_L)\lambda\pi(\phi)}{2\phi(1 + \phi)} \cdot [\rho s(\mu_H - \mu_L)(2B - 1) - 2] \quad (\text{B.22})$$

which is positive, since the term in the square brackets has to be positive as stated in (B.17). Therefore, the investment in financial literacy increases with the time discount

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<sup>6</sup>The denominator of the right-hand side of (B.20) has to be positive, otherwise the direction of the inequality would change.

factor: the more consumers are patient, the more they invest in financial literacy.

The impact of a change in  $s$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial s} = -\frac{1}{g_\phi} \cdot \frac{\alpha\beta(\mu_H - \mu_L)\lambda\pi(\phi)}{\phi(1 + \phi)} \cdot [\rho s(\mu_H - \mu_L)(2B - 1) - 1] \quad (\text{B.23})$$

which is positive, because the term in the square brackets is a positive number since it is bigger than the term in the square brackets in the denominator in (B.17). The investment in financial literacy depends on the amount saved, and higher savings lead to higher stock of financial literacy.

The impact of a change in  $\mu_H$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \mu_H} = -\frac{1}{g_\phi} \cdot \frac{\alpha\beta s\lambda\pi(\phi)}{\phi(1 + \phi)} \cdot [\rho s(\mu_H - \mu_L)(2B - 1) - 1] \quad (\text{B.24})$$

which is positive, because the term in the square brackets is a positive number since it is bigger than the term in the square brackets in the denominator in (B.17). Therefore, a higher average return of the high return-and-risk product is associated with a higher investment in financial literacy.

The impact of a change in  $\mu_L$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \mu_L} = -\frac{1}{g_\phi} \cdot \frac{\alpha\beta s(1 - \lambda)\pi(\phi)}{\phi(1 + \phi)} \cdot [1 - \rho s(\mu_H - \mu_L)(2B - 1)] \quad (\text{B.25})$$

which is negative, because the term in the square brackets is a negative number. As opposed to the impact of a change in  $\mu_H$  on  $\phi$ , a higher average return of the low return-and-risk product is associated with a lower investment in financial literacy.

The impact of a change in  $\rho$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \rho} = -\frac{1}{g_\phi} \cdot \frac{\alpha\beta s^2(\mu_H - \mu_L)^2\lambda\pi(\phi)}{2\phi(1 + \phi)} \cdot (2B - 1) \quad (\text{B.26})$$

which is positive, since  $B > \frac{1}{2}$ . The investment in financial literacy depends on consumers' risk aversion together with the probability of receiving the low return-and-risk product: the more consumers are risk averse, the more they invest in financial literacy if the probability  $B$  is high enough.

The impact of a change in  $\lambda$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \lambda} = -\frac{1}{g_\phi} \cdot \frac{\alpha\beta s(\mu_H - \mu_L)\pi(\phi)}{2\phi(1 + \phi)} \cdot [\rho s(\mu_H - \mu_L)(4B - 3) - 2] \quad (\text{B.27})$$

which is negative when  $\frac{1}{2} < B \leq \frac{3}{4}$ , but it is ambiguous when  $B > \frac{3}{4}$ .<sup>7</sup> Thus, when the probability of receiving the low return-and-risk product  $B \in (\frac{1}{2}, \frac{3}{4}]$ , the higher the

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<sup>7</sup>The effect is positive when:  $\rho > \frac{2}{s(\mu_H - \mu_L)(4B - 3)}$ . This is always satisfied when:  $(\mu_H - \mu_L)^2(4B - 3) > (\sigma_H^2 - \sigma_L^2)$ .

probability  $1 - \lambda$  the higher the investment in financial literacy.

The impact of a change in  $p$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial p} = -\frac{1}{g_\phi} \cdot (-1) \quad (\text{B.28})$$

which is negative, hence a higher price of financial literacy reduces the investment in financial literacy.

## B.2 Financial literacy investment under adverse selection

We consider only the case in which the risk aversion coefficient is below the risk aversion's threshold (3.19), because when it is above the risk aversion's threshold the optimal investment in financial literacy is zero. The first order condition with respect to financial literacy investment  $\phi$  is:

$$\frac{(1 - \gamma)\beta s \Delta \pi(\phi)[2 - \rho s \Delta(1 - 2\pi(\phi))]}{2\phi(1 + \phi)} - p = 0 \quad (\text{B.29})$$

We differentiate the equation (B.29) with respect to  $\phi$  and obtain:

$$h_\phi = \frac{(1 - \gamma)\beta s \Delta \pi(\phi)}{2\phi^2(1 + \phi)^2} \cdot \{(-2\phi - \gamma)[2 - \rho s \Delta(1 - 2\pi(\phi))] + 2(1 - \gamma)\rho s \Delta \pi(\phi)\} \quad (\text{B.30})$$

In order to find a maximum, the second order condition requires that the equation (B.30) is negative. It is satisfied when:

$$\phi > \frac{(1 - \gamma)\rho s \Delta \pi(\phi)}{2 - \rho s \Delta(1 - 2\pi(\phi))} - \frac{\gamma}{2} \quad (\text{B.31})$$

The denominator of the first term of the (B.31)'s right-hand side has to be positive, otherwise the equation (3.24) would equal a negative number and it would not have economic meaning. This is always satisfied when  $\pi(\phi) \geq \frac{1}{2}$ . The denominator is increasing as  $\pi(\phi)$  gets larger. If  $\pi(\phi) = 0$ , the denominator is positive when:<sup>8</sup>

$$\rho < \frac{2}{s\Delta} \quad (\text{B.32})$$

By comparing (3.19) and (B.32), the latter is always satisfied when the right-hand side of (3.19) is smaller than the right-hand side of (B.32), i.e., when:

$$\Delta^2 < [(1 - \omega_H)^2 \sigma_H^2 - (1 - \omega_L)^2 \sigma_L^2] \quad (\text{B.33})$$

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<sup>8</sup> $\pi(\phi) = 0$  identifies the worst-case scenario.

It is a sufficient condition so that the equation (3.24) equals a positive number. To ensure that the second order condition is always satisfied, we study a sufficient condition such that the right-hand side of (B.31) is negative, considering that  $\phi$  has to be a non-negative number:

$$\rho < \frac{2\gamma}{s\Delta[2(1-\gamma)\pi(\phi) + \gamma(1-2\pi(\phi))]} \quad (\text{B.34})$$

This could be useful to restrict the range of variation of the parameters.<sup>9</sup>

We determine the comparative statics results by computing the total differential of the first order condition (B.29). The sign of the partial derivative of the first order condition with respect to each parameter is what we are interested in when assessing the effect of a change in a parameter on  $\phi$ , because the equation (B.30) has to be negative and is preceded by a negative sign.

The impact of a change in  $\gamma$  on  $\phi$  is calculated as:

$$\begin{aligned} \frac{\partial \phi}{\partial \gamma} = & -\frac{1}{h_\phi} \cdot \frac{\beta s \pi(\phi)}{2\phi(1+\phi)} \cdot \{(\ln \pi(\phi) + 1)\Delta[\rho s \Delta(1-2\pi(\phi)) - 2] \\ & + 2k(1-\gamma)(\mu_H - \mu_L)[\rho s \Delta(1-2\pi(\phi)) - 1] + 2\rho s \Delta^2 \pi(\phi) \ln \pi(\phi)\} \end{aligned} \quad (\text{B.35})$$

which is negative when  $\pi(\phi) > \frac{1}{2}$ , but it is ambiguous when  $\pi(\phi) < \frac{1}{2}$ . The first term in the square brackets is negative as stated in (B.31),  $\ln \pi(\phi)$  is a non-positive number since  $\pi(\phi) \in [0, 1]$ , and  $\ln \pi(\phi) + 1$  is positive if  $\pi(\phi) > \frac{1}{e}$  and negative if  $\pi(\phi) < \frac{1}{e}$ . A negative effect implies that the investment in financial literacy decreases as the transparency factor increases.

The impact of a change in  $\beta$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \beta} = -\frac{1}{h_\phi} \cdot \frac{(1-\gamma)s\Delta\pi(\phi)}{2\phi(1+\phi)} \cdot [2 - \rho s \Delta(1-2\pi(\phi))] \quad (\text{B.36})$$

which is positive, since the term in the square brackets has to be positive as stated in (B.31). Therefore, the investment in financial literacy increases with the time discount factor: the more consumers are patient the more they invest in financial literacy.

The impact of a change in  $s$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial s} = -\frac{1}{h_\phi} \cdot \frac{(1-\gamma)\beta[(1-\omega_L)(\mu_H - \mu_L)]\pi(\phi)}{\phi(1+\phi)} \cdot [1 - \rho s \Delta(1-2\pi(\phi))] \quad (\text{B.37})$$

which is positive when  $\pi(\phi) \geq \frac{1}{2}$ , but it is ambiguous when  $\pi(\phi) < \frac{1}{2}$ . The investment in financial literacy depends on the amount saved, but it cannot be concluded that higher

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<sup>9</sup>The denominator of the right-hand side of (B.34) has to be positive, otherwise the direction of the inequality would change.

savings lead always to higher stock of financial literacy.

The impact of a change  $\mu_H$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \mu_H} = -\frac{1}{h_\phi} \cdot \frac{(1-\gamma)\beta s(1-\omega_H)\pi(\phi)}{\phi(1+\phi)} \cdot [1 - \rho s \Delta(1 - 2\pi(\phi))] \quad (\text{B.38})$$

which is positive when  $\pi(\phi) \geq \frac{1}{2}$ , but it is ambiguous when  $\pi(\phi) < \frac{1}{2}$ . Therefore, when  $\pi(\phi) \geq \frac{1}{2}$ , a higher average return of the high return-and-risk product is associated with a higher investment in financial literacy.

The impact of a change in  $\mu_L$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \mu_L} = -\frac{1}{h_\phi} \cdot \frac{(1-\gamma)\beta s(1-\omega_L)\pi(\phi)}{\phi(1+\phi)} \cdot [\rho s \Delta(1 - 2\pi(\phi)) - 1] \quad (\text{B.39})$$

which is negative when  $\pi(\phi) \geq \frac{1}{2}$ , but it is ambiguous when  $\pi(\phi) < \frac{1}{2}$ . As opposed to the impact of a change in  $\mu_H$  on  $\phi$ , when  $\pi(\phi) \geq \frac{1}{2}$ , a higher average return of the low return-and-risk product is associated with a lower investment in financial literacy.

The impact of a change in  $\rho$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \rho} = -\frac{1}{h_\phi} \cdot \frac{(1-\gamma)\beta s^2 \Delta^2 \pi(\phi)}{2\phi(1+\phi)} \cdot [-(1 - 2\pi(\phi))] \quad (\text{B.40})$$

which is positive when  $\pi(\phi) > \frac{1}{2}$ , but it is negative when  $\pi(\phi) < \frac{1}{2}$ . The investment in financial literacy depends on consumers' risk aversion together with the probability of getting the signal: the more consumers are risk averse, the less they invest in financial literacy if the probability of getting the signal is not so high.

The impact of a change in  $\omega_H$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \omega_H} = -\frac{1}{h_\phi} \cdot \frac{(1-\gamma)\beta s \mu_H \pi(\phi)}{\phi(1+\phi)} \cdot [\rho s \Delta(1 - 2\pi(\phi)) - 1] \quad (\text{B.41})$$

which is negative when  $\pi(\phi) \geq \frac{1}{2}$ , but it is ambiguous when  $\pi(\phi) < \frac{1}{2}$ . Therefore, when  $\pi(\phi) \geq \frac{1}{2}$ , a higher fee of the high return-and-risk fund is associated with a lower investment in financial literacy.

The impact of a change in  $\omega_L$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial \omega_L} = -\frac{1}{h_\phi} \cdot \frac{(1-\gamma)\beta s \mu_L \pi(\phi)}{\phi(1+\phi)} \cdot [1 - \rho s \Delta(1 - 2\pi(\phi))] \quad (\text{B.42})$$

which is positive when  $\pi(\phi) \geq \frac{1}{2}$ , but it is ambiguous when  $\pi(\phi) < \frac{1}{2}$ . As opposed to the impact of a change in  $\omega_H$  on  $\phi$ , when  $\pi(\phi) \geq \frac{1}{2}$ , a higher fee of the low return-and-risk fund is associated with a higher investment in financial literacy.

The impact of a change in  $p$  on  $\phi$  is calculated as:

$$\frac{\partial \phi}{\partial p} = -\frac{1}{h_\phi} \cdot (-1) \quad (\text{B.43})$$

which is negative, hence a higher price of financial literacy reduces the investment in financial literacy.

### B.3 Transparency factor

We consider only the case in which the risk aversion coefficient is below the risk aversion's threshold (3.19). The first order condition with respect to transparency factor  $\gamma$  is:

$$\beta s \left\{ -\pi(\phi) \ln \frac{\phi}{1+\phi} \Delta[2 - \rho s \Delta(1 - 2\pi(\phi))] - 2k\{\mu_L + (\mu_H - \mu_L)\pi(\phi)[1 - \rho s \Delta(1 - \pi(\phi))]\} \right\} = 0 \quad (\text{B.44})$$

We differentiate the equation (B.44) with respect to  $\gamma$  and obtain:

$$f_\gamma = \beta s \pi(\phi) \left\{ \left( \ln \frac{\phi}{1+\phi} \right)^2 \Delta[2 - \rho s \Delta(1 - 4\pi(\phi))] + 4k(\mu_H - \mu_L) \ln \frac{\phi}{1+\phi} [1 - \rho s \Delta(1 - 2\pi(\phi))] - 2k^2(\mu_H - \mu_L)^2 \rho s (1 - \pi(\phi)) \right\} \quad (\text{B.45})$$

In order to find a maximum, the second order condition requires that the equation (B.45) is negative. The first term in the square brackets is a positive number because it is bigger than the term in the square brackets in the numerator in (3.24).  $\ln \frac{\phi}{1+\phi}$  is a non-positive number. The second term in the square brackets is a positive number because it is bigger than the term in the square brackets in the denominator in (3.25).

We carry out a comparative statics analysis. Since the equation (B.45) has to be negative and is preceded by a negative sign, the sign of the effect of a change in a parameter on  $\gamma$  depends only on the sign of the partial derivative of the first order condition (B.44) with respect to each parameter.

The impact of a change in  $k$  on  $\gamma$  is calculated as:

$$\frac{\partial \gamma}{\partial k} = -\frac{1}{f_\gamma} \cdot 2\beta s \left\{ \pi(\phi) \ln \frac{\phi}{1+\phi} \gamma(\mu_H - \mu_L) [1 - \rho s \Delta(1 - 2(\pi(\phi)))] - \pi(\phi)(\mu_H - \mu_L) [1 - \rho s \Delta(1 - \pi(\phi))] - k\gamma(\mu_H - \mu_L)^2 \rho s \pi(\phi)(1 - \pi(\phi)) - \mu_L \right\} \quad (\text{B.46})$$

which is negative, because  $\ln \frac{\phi}{1+\phi}$  is a non-positive number, the first term in the square brackets is a positive number as stated in (B.45) and the second term in the square brackets is a positive number as stated in (3.25). Therefore, the higher the marginal costs of transparency, the lower the transparency factor.

The impact of a change in  $a(\theta)$  on  $\gamma$  is calculated as:

$$\frac{\partial \gamma}{\partial a(\theta)} = -\frac{1}{f_\gamma} \cdot 2\beta \mu_H \pi(\phi) \left\{ \ln \frac{\phi}{1+\phi} [1 - \rho s \Delta(1 - 2\pi(\phi))] - (\mu_H - \mu_L) \rho s (1 - \pi(\phi)) \right\} \quad (\text{B.47})$$

which is negative, because  $\ln \frac{\phi}{1+\phi}$  is a non-positive number and the in the square brackets is a positive number as stated in (B.45). Therefore, the higher the skill-accumulation

costs, the lower the transparency factor.

The impact of a change in  $\rho$  on  $\gamma$  is calculated as:

$$\frac{\partial \gamma}{\partial \rho} = -\frac{1}{f_\gamma} \cdot \beta s^2 \Delta \pi(\phi) \left[ \ln \frac{\phi}{1+\phi} \Delta(1 - 2\pi(\phi)) + 2k(\mu_H - \mu_L)(1 - \pi(\phi)) \right] \quad (\text{B.48})$$

which is positive when  $\pi(\phi) \geq \frac{1}{2}$  since  $\ln \frac{\phi}{1+\phi}$  is a non-positive number, but it is ambiguous when  $\pi(\phi) < \frac{1}{2}$ . The higher the consumer risk aversion, the higher the transparency factor if the probability of getting the signal is high enough.

The impact of a change in  $\mu_H$  on  $\gamma$  is calculated as:

$$\begin{aligned} \frac{\partial \gamma}{\partial \mu_H} = -\frac{1}{f_\gamma} \cdot 2\beta s \pi(\phi) \Big\{ & -\ln \frac{\phi}{1+\phi} (1 - \omega_H) [1 - \rho s \Delta(1 - 2\pi(\phi))] \\ & - k \{ 1 - \rho s (1 - \pi(\phi)) [(1 - \omega_H)(\mu_H - \mu_L) + \Delta] \} \Big\} \quad (\text{B.49}) \end{aligned}$$

which is ambiguous.

The impact of a change in  $\mu_L$  on  $\gamma$  is calculated as:

$$\begin{aligned} \frac{\partial \gamma}{\partial \mu_L} = -\frac{1}{f_\gamma} \cdot 2\beta s \Big\{ & \pi(\phi) \ln \frac{\phi}{1+\phi} (1 - \omega_L) [1 - \rho s \Delta(1 - 2\pi(\phi))] \\ & - k(1 - \pi(\phi)) \{ 1 + \rho s \pi(\phi) [(1 - \omega_L)(\mu_H - \mu_L) + \Delta] \} \Big\} \quad (\text{B.50}) \end{aligned}$$

which is negative, because  $\ln \frac{\phi}{1+\phi}$  is a non-positive number and the first term in the square brackets is a positive number as stated in (B.45). A higher average return of the low return-and-risk product is associated with a lower transparency factor.

The impact of a change in  $s$  on  $\gamma$  is calculated as:

$$\begin{aligned} \frac{\partial \gamma}{\partial s} = -\frac{1}{f_\gamma} \cdot 2\beta \Big\{ & -\pi(\phi) \ln \frac{\phi}{1+\phi} (1 - k\gamma)(\mu_H - \mu_L) [1 - \rho s \Delta(1 - 2\pi(\phi))] \\ & - k(\mu_H - \mu_L) \pi(\phi) \{ 1 - \rho s (1 - \pi(\phi)) [(1 - k\gamma)(\mu_H - \mu_L) + \Delta] \} - k\mu_L \Big\} \quad (\text{B.51}) \end{aligned}$$

which is ambiguous.

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