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Future of Work and Pension Design
Portuguese Pension System

Pedro Miguel da Silva Santos Almeida

Dissertation presented as partial requirement for obtaining the Master's degree in Information Management

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FUTURE OF WORK AND PENSION DESIGN

by

Pedro Miguel da Silva Santos Almeida

Dissertation presented as a partial requirement for obtaining the Master's degree in Information Management, with a specialisation in Knowledge Management and Business Intelligence

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ABSTRACT

The new forms of work, as such as Crowdworking and Freelancer jobs, driven by the technologies advances and globalization are introducing more frequent career breaks as well as higher variations on the worker's income which are incompatible with the current old-age protection system in Portugal. Most of the studies performed in Portugal are around the sustainability of the pension scheme and focus mainly on the parametric changes. Only a few studies are reflecting a redesign pension scheme like the Notional Defined Contribution (NDC) implemented in Sweden, Italy and Poland. The objective of this study is to propose a new design of a pension model within the new context of the future of work. The paper analyzes the impact of the future of work on the current Portuguese DB pension model and other existent pension models by simulating pension entitlements based on different career breaks and pensionable salaries oscillations. The results of the study confirmed the inadequacy of the actual Portuguese DB pension model for non-standard workers, and a worker with multiple breaks on the service could have a significant loss on the retirement pension entitlement. The study also confirmed that other standalone design models as the Notional Defined Contribution, Cash Balance, Defined Contribution, and the Systems Points would provide the same inadequacy levels for non-standard workers. We concluded that Beveridge and Bismarck's plans complement each other, and an optimal model within the future of work would have to be based on both characteristics of a Beveridge and Bismarck models with the same level of importance. The study shows evidence that moving away from the existing DB pension model to a multi-model, a first sub-model like a DB plan not linked to the contributive career - a Pure Beveridge model - with the objective of “redistribution” and “poverty relief”, and a second sub-model like a Bismarck plan (DC or Cash Balance type) with the objective of “consumption smoothing” and “insurance” would improve the adequacy and fairness of the pension retirement for the non-standard workers.

KEYWORDS

Future of Work; Pension Design; Pension Schemes; Social Security Systems, Digital Era.

ABSTRACTO

As novas formas de trabalho, como a prestação de serviços por aplicativo ou trabalho de freelancers, impulsionadas pelos avanços da tecnologia e pela globalização, vêm introduzindo interrupções de carreira mais frequentes, bem como maiores variações nos rendimentos do trabalhador, que são incompatíveis com o atual sistema de pensões público em Portugal. A maioria dos estudos realizados em Portugal, gira em torno da sustentabilidade do regime de pensões publico e incide principalmente nas alterações paramétricas. Apenas alguns estudos analisam o impacto de mudanças estruturais no atual modelo de pensões em Portugal, como o modelo de "Notional Defined Contribuiton" (NDC) implementado na Suécia, Itália e Polónia. O principal objetivo deste estudo, é propor um novo desenho de um modelo de pensões em Portugal dentro do novo contexto do futuro do trabalho. O estudo analisa o impacto do futuro do trabalho no atual modelo de português e noutros modelos existentes, simulando direitos de pensão de reforma baseado em diferentes cenários de interrupções contributivas e oscilações de salários, durante a carreira contributiva. Os resultados confirmam a inadequação do atual modelo português de pensões para as novas formas de trabalho, e um trabalhador com múltiplas interrupções contributivas pode ter uma perda significativa na sua pensão de reforma. O estudo também confirmou que outros modelos como a NDC, "Cash Balance", Contribuição Definida e o Sistema de pontos têm os mesmos níveis de inadequação de que o modelo de pensões em Portugal relativamente às novas formas de trabalho. Concluímos que os planos do tipo "Beveridge" e "Bismarck" se complementam, e um modelo de pensões ótimo teria necessariamente ter ambas as características de um modelo de Beveridge e Bismarck com o mesmo grau de importância. A principal recomendação do estudo é a alteração do atual modelo de pensões de BD, para um múltiplo modelo, um primeiro submodelo de plano de BD, mas não vinculado à carreia contributiva, como um modelo Puro de Beveridge em que a principal objetivos é garantir um rendimento mínimo e a redistributividade de financiamento do sistema, complementado com um segundo modelo Bismarck (tipo DC ou Cash Balance) vinculado à carreira contributiva, e em que principal objetivo é suavizar impacto no rendimento perdido devido ao evento de reforma e proteger contra o risco de reforma. O estudo demonstra que adotando ambas características "Beveridgean" e "Bismarkian" iria permitir melhores níveis de adequação das pensões de reforma para as novas formas de trabalho.

PALAVRAS CHAVES

Trabalhos do Futuro; Desenho Pensões; Plano de Pensões; Sistemas de Segurança Social, Era digital.

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1. INTRODUCTION

The Portuguese pension system is based on three pillars of differing importance: the dominant earnings-related old-age state pension system (first pillar), the occupational pension provision (second pillar), and the personal pension provision (third pillar). The first pillar combines an earnings-related, defined benefit (DB), mandatory public scheme, comprising two separate but convergent schemes, with minor special systems for lawyers and solicitors (CPAS) and older bank employees (J. M. Bravo, 2015) (J.M. Bravo, 2016). Private-sector workers are covered by pensions within the general social security scheme (Regime Geral da Segurança Social (RGSS)). Public servants enrolled before December 2005 are covered by pensions within the former civil service pension scheme (Caixa Geral de Aposentações (CGA)), that has been closed to new entrants since 2006 and new civil servants contribute to the general scheme. Yet, the CGA will continue to operate for most of the 21st century.

Contributory state pensions are financed on a pay-as-you-go (PAYG) basis by social contributions paid by both the employer and employee, complemented by a small fraction of the value-added tax (social VAT). Additionally, the state system includes non-contributory means-tested first-tier pension benefits, top-up minimum contributory benefits, and several targeted assistance programs, fully funded by general taxes, aimed at protecting those with short contribution periods or low pension entitlements more generally against old-age poverty. The state pension scheme comprises old age, early retirement, disability, and survivors' pensions. Together with supplementary benefits, it was designed to guarantee the maintenance of an appropriate standard of living after retirement and in the event of disability or death (J. M. Bravo, 2018) (OECD, 2019).

The actual Portuguese DB pension model might have been a good fit within the dynamics of work, economic environment and the demographic population at the time of implementation. The declining of the old-age dependency ratio, primarily due to the ageing of the Portuguese population resulting from a decline in fertility and an increase in life expectancy, and the economic changes over the last decades (low economic growth, low labour productivity and salaries growth) have been putting pressure on the long term sustainability of this funding model (Bravo J.M. & Coelho E., 2020). As a result of this continuous demographic and economic changes, there were several reforms to the social security system in Portugal introduced in 1993, 2000, 2002 and 2007. Nevertheless, all these reforms were parametric changes (e.g., adjusting the qualifying conditions, indexing retirement age to life expectancy automatically, introducing the sustainability factor, modifying the bonus/penalties for late/early retirement) instead of structural changes, designed to provide short-public finance alleviation without solving the system's long-term sustainability, adequacy and fairness problems (Ayuso, M., Bravo, J. M., and Holzmann, 2020) (J.M. Bravo, 2015) (J.M. Bravo, 2016) (J. M. Bravo, 2018) (Jorge M. Bravo & Herce, 2020).

In earnings-related pension schemes, benefits are closely linked to individual employment histories, wages and contributions. Unemployment periods and other voluntary or involuntary career breaks (e.g., part-time employment, layoff, termination of fixed-term contracts, parental leave, childbearing, childrearing, illness/disability, studying, military service, housekeeping without raising children or general inactivity periods) have long-term scarring effects on future labour market possibilities and earnings, permanently affecting workers' retirement income and the pension system financial sustainability (Jorge M. Bravo & Herce, 2020). Empirical evidence suggests that unemployment breaks are the type of career interruption that is more harmful to an employee's future wage prospects and,

consequently, to pension benefits (e.g., (Bruce, D., & Schuetze, 2004) (Cooper, 2014); (Schmieder, J., von Wachter, T., & Bender, 2014)).

In recent years, there has been a trend away from the standard full-time permanent employment relationship that receives the greatest labour and social security protection towards non-standard more flexible work arrangements, typically receiving less protection such as temporary employment, part-time jobs, self-employment, teleworking, and nomadic working. The increasing flexibilisation of the labour market weakens the protection of the standard model. The growing importance and diversity of the non-standard forms of labour challenge the concept of work, the income replacement nature of most work-related social security schemes and the financial basis for these schemes (employee and employer social contributions), including the determination of the (principal) employer who is responsible, e.g., for paying contributions and deciding on unemployment (Schoukens & Barrio, 2017).

The population challenged to adapt since many tasks are continually being automated, and new higher-value tasks are emerging, requiring new skills. These changes will inevitably be unsettling for many, and we will expect many redundancies in the workforce and breaks on contributed careers for many workers (The World Bank, 2019). All of this will have a massive impact on the actual model of the public pension system in Portugal. There is a clear need to rethink the Social Security System not only in Portugal but worldwide due to the disruption caused by the "Future of Work". The risk of unemployment is the most challenge component of the social security systems for the non-standard form of work in Europe. However, other risks as such as sickness, disability and old-age also represent significant challenges for current social security structure (Avlijas, 2019).

Actual demographics and economic indicators, alongside with the arising of new forms of working arrangements incompatible with the old-age protection system, are solid pieces of evidence for an urgent need to redesign the actual Portuguese pension model in order to continue to provide social protection and a minimum guaranteed income replacement to all Portuguese citizens. Most of the studies performed in Portugal are around the sustainability of the pension scheme despite the urgency of redesign the pension scheme in Portugal. In all currently available literature, only a few studies are reflecting a redesign pension scheme like the Notional Defined Contribution (NDC) implemented in Sweden, Italy and Poland. Even more disquieting is the almost absence of studies related to the impact of the future of work in the Portuguese Social Security System, with just a hand of studies performed in Portugal (Jorge M. Bravo & Herce, 2020).

A social security system protects the population against various risks as such as unemployment, sickness, maternity leave, disability, death, and retirement. In this paper, we focused only on the old-age risk and the main challenges that the Portuguese social security system will face in order to provide an alternative old-age income from the workers with non-standard forms of employment. Nevertheless, it is important to stress that there is also an urgent need to redesign and rethink the other protection coverages provide by the Portuguese social security as such as unemployment, sickness and disability coverage for the non-standard workers.

The objective of this paper is designing a new pension model to provide post-retirement income security to all Portuguese citizens within the new context of future of work, gain insights, and contribute to the current academic discussions for a necessary change on the design/structure of the current Portuguese pension model. In order to do so, we answered the following research questions:

1) Why doesn't the current Portuguese pension scheme fit well within the context of the future of work?

2) Are there other pension models already design that better of the actual Portuguese DB pension model?

3) How should the Portuguese pension scheme design to fit within the context of the future of work?

We used an exploratory research design based on the multi-case study method to provide insights and understand the impact of the non-standard form of work on the current pension scheme in Portugal.

The results confirmed the inadequacy of the actual Portuguese DB pension model for non-standard workers, and we reached the same conclusion as Bravo, i.e., a worker with multiple breaks on the service could have a significant loss on the retirement pension entitlement. The study also confirmed that other standalone design models as the Notional Defined Contribution, Cash Balance, Defined Contribution, and the Systems Points would provide the same inadequacy levels for non-standard workers, but with different fairness levels. However, combining two pension models into one single model, a first "Beveridge" pension model, like a DB plan but not related to the pensionable service, and a second "Bismarck" pension model, like a cash balance plan, would provide a much better adequacy, fairness and distributiveness (within the same generation) levels for non-standard workers compared with the current Portuguese DB model. Therefore, we concluded that Beveridge and Bismarck's plans complement each other, and an optimal model within the future of work would have both characteristics of a Beveridge and Bismarck model with the same level of importance, and this is in line with the framework design by the OECD – a first-tier – distributiveness and poverty relief plus a second-tier – consumption smooth and insurance.

The significant contribution of this paper was to confirm that there is a better alternative path to solve the problems of the actual Portuguese pension model besides parametric changes and provide some insights for a model adequate for non-standard workers. Although there is still a long way to reach the optimal pension model in Portugal, this paper jointly with other existent few papers in Portugal suggests some insights and evidence that it is possible to create a universal pension model for all Portuguese citizens. Maybe we could be even more ambitious and create a master pension model functional worldwide.

The paper involves four main sections; the first section is chapter 2 – Literature Review, and this chapter is where we defined our tools and our base start for our study. We started by defining the principles of the social security systems and the importance of design the pension scheme around objectives and principles established to be the first step of design a pension scheme. Next, we define the two known economic concepts around the pension schemes and the two social security models – Bismarck and Beveridge – inspired by most countries on the design of their pension model. We also emphasised the importance of the pension tiers, with the first-tier design focus mainly on poverty relief and redistributive principles, and the second tier on the consumption smooth and insurance principles. Based on this, we described the taxonomy used by the OECD based on this framework. After setting the framework used on the design of the pension schemes around the world, we identified the fragilities of the actual models on the context of the ageing population and economic changes driven by globalisation and technologies advances, and the problems facing the public pension schemes

around the world inclusive Portugal. We highlighted a few changes made by some countries since their first introduction of the pension scheme in order to answer the factors of ageing and economic volatility and the insufficiency of these changes. Finally, we defined the context of the future of work and the reason why the future of work is adding even more pressure to the already fragile Social Security Systems around the world, including Portugal.

The second section, we described the methodology used in our study, and this based on the tools described in the previous section. Here we defined our path to answer the research questions and eventually reach the proposed objective of our study, which is to design “an optimal” model within the context of future of work.

The third section highlighted the findings and insights, and the fourth section synthesises the conclusions of our research study.

Finally, the last section of the study highlights the limitations and recommendation for future studies related to the pension model design in Portugal.

2. LITERATURE REVIEW

2.1. SOCIAL SECURITY FRAMEWORK

Social Security Principles

The principles of the social security system are consumption smoothing, insurance, redistribution and poverty relief. Consumption smoothing is the principle to save in higher-income moments to lower-income moments and have a stable path of consumption. Insurance is a principle of protection against uncertain and unexpected events. Redistribution within generations by paying adequate pensions to lower earns and across generations by "*promoting transfer from the future to the current generation by setting a lower contribution rate in the early stages, expecting that future generations will have higher wages due to economic growth and productivity increases".* Poverty relief is a principle of guarantee minimum income security for thus unable to save enough. These are the main principles in designing a social security system (Cunha, 2017).

Economic concepts of pension schemes

The main objective of a pension model is to replace the earnings income lost due to the retirement event. Therefore, it is fundamental to understand the economic concepts around retirement when designing a pension model. There are two known economic concepts to seek security during old age:

- "*To store current production by storing part of the current output for future use*";
- "*When an individual exchange current production for a claim on future production*."

The first economic concept is inadequate for most consumptions needs except for housing since it is expensive, it does not deal with uncertainty, and it cannot apply to services deriving from human capital. The alternative for pension models is the second economic concept, which there are two possible ways of structuring a pension scheme around it. *Funded Scheme* and *Pay-As-You-Go (PAYG) scheme* - both schemes are "*pay-as-you-go financed pension systems*" since the pensions/post-retirement benefits paid to its members linked to the contributions or taxes paid by the members during their active lifetime. In a *Funded Scheme*, there is an established pension fund were contributions made by employers and employees are accumulating during working lifetime to secure an old-age pension. In the *PAYG schemes*, a vested right to receive a pension at retirement age is guaranteed by tax payments during the active period. The taxes finance the pensions of the current pensioners, i.e., the active members pay the pension to inactive members in exchange for a right to receive an old-age pension (Barr, 2000).

Bismarck and Beveridge models

Most of the pension schemes worldwide implemented based on the second economic concept (pay-as-you-go-financed public-pension schemes), and they classified into two basic models – the Bismarck model (continental) and the Beveridge model (Anglo-Saxon) (Kolmar, 2007). The Bismarck model created by Otto von Bismarck German chancellor between 1862-1890. He introduced an old-age social insurance program in Germany and considered the first social security scheme in the world. The pension paid directly linked to the contributions made by members during the working lifetime based on their salary or wages (Ignacio Conde-Ruiz & Gonzalez, 2014), and the objective of

Bismarck model was to provide well-being on workers and to stimulate the economy of German. The Beveridge model created by William Henry Beveridge, a British economist that wrote a report in 1942 about "Social Insurance and Allied Service" (the Beveridge Report). This report was the foundation of the social security scheme in the United Kingdom in the year 1945. The social security scheme designed by Beveridge covered all population (Universal), based on a flat-benefit, and mainly financed through tax payments. The objective of this social protection system was to answer the demands of the consequence of the great depression in the 30s (Klitzke, 2016). The Beveridge model design primarily based on the principles of poverty relief and redistribution, the Bismarck model primarily designed based on principles consumption smoothing and insurance, and based on the literature review, these are the two main models used as a base model by most countries on the design of their social protection systems.

Table 1 - The first juncture: Bismarck vs Beveridge

	Formation (before/around WWI)		Reconstitution (after WWII)	
Germany	**Bismarckian**	**1889** blue-collar "invalidity" insurance **1911** white-collar pension insurance	**1949** restoration law (pre-war scheme)	**Bismarckian**
Italy		**1919** blue-collar insurance **1939** white-collar insurance	**1950** no income limit **1952** two-tier pension	
France		**1910** contributory (workers & peasants)	**1945** régime general	
Switzerland		-	**1946** universal earnings-related pension	
Netherlands		**1913** old-age insurance for workers	**1947** means-tested pension **1956** universal flat-rate basic pension	**Beveridgian**
Great Britain	**Beveridgian**	**1908** means-tested flat-rate pension **1925** contributory old-age pension	**1946** basic old-age and widow pension	
Sweden		**1913** basic minimum pension with means-tested supplement	**1946** tax-financed basic old-age and widow pension	
Denmark		**1891** means-tested old-age assistance	**1956** tax-financed National Pension	

Source: Flora, 1987: Appendix Vol. IV; Immergut et al. 2007; GOSPE – Project country chapters.

The table 1 shows the first Western European countries introducing their social security systems based on these two models before and around the first world war(WWI) and after the second world war(WWII). Germany, Italy and France set up a social security system classified as Bismarck pension system and Switzerland short after the second war. Denmark, Sweden and Great-Britain established Beveridge type pension system. The Netherlands started with a Bismarck type pension system due to a post-war crisis and later moved to a Beveridge system as a universal basic pension (Ebbinghaus, 2009). Later in the 1950s and the 1960s, some countries (such as Sweden, Finland, Norway and Canada) initially cluster in the Beveridge model moved in the direction of a Bismarck model by topping their basic pension schemes with a second-tier financed by contributions and linked to earnings or wages. With the maturation of the second tier, the importance of the basic pension in these countries declined gradually. Therefore, the public pension schemes in these countries become more like the Bismarck model. There are also countries belonging to the Bismarck cluster that

expanded the coverage of their pension and established components of minimum protection similar to the Beveridge model (Schludi, 2005).

In Portugal, the first social welfare implemented during the Dictatorship was created based on the Bismarck model in the form of mandatory social insurances - the law no. 1884/35 of 16th March 1935. Only until 1984, the social welfare switched to the actual universal scheme based on the Beveridge model with the Law No. 28/84 of 14th August; This law implemented two regimes – the contributory public regime and the non-contributory regime. The contributory public regime is mandatory based on a distribution system covering all employees and self-employed workers. There is a minimum number of required years of contribution to have a right to receive an old-age benefit. The non-contributory regime provides a minimum guaranteed benefit for all old age citizens not covered by the public system or for those who do not meet the conditions to have a pension by the public system. (Manuel, Sofia, Sónia, Manuel, & Vaz-paralta, 2006).

In summary, and based on the scientific literature, somehow, there is a general perception that the European social security systems can be cluster between Bismarck and Beveridge model despite considerable differences between them. However, currently, most of the European countries do not follow a pure form of these two systems, and variations among countries can be found (Ismarck & Of, 2008).

The taxonomy of social security schemes

The design of a pension plan starts by agreeing on the objectives based on the principles of Social Security, and then proceed with instruments to model the pension scheme to achieve the established objectives (Barr, 2000).

Based on the principle of Social Security principles, in 1994, the World Bank provide a Conceptual Framework (Annex 2) and defined a Social Security classification - "three-pillar" system - between "*a publicly managed system with mandatory participation and the limited goal of reducing poverty among the old [first pillar]; a privately managed mandatory savings system [second pillar]; and voluntary savings [third pillar]*" (The World Bank, 1994).

Barnes also sorted the typology of the pension models in terms of principles (Barr, 2000):

1) The first-tier pension intended primarily to provide poverty relief, it is mandatory through usually publicly organised and PAYG system, and its form can vary widely;
2) the second tier provides consumption smoothing, it can be in principle be publicly or privately manage, funded or PAYG system, and it may or may not integrated into the first tier, and
3) the third tier is private, funded, or voluntary intend to increase the range of individual choice.

In the year 2005, the OECD developed a taxonomy based on the principles and objectives of each part of the pension system. It divided the countries based on two frameworks with two mandatory tiers – a redistributive part based on the social security principles of poverty relief and an insurance part based on the principle of consumption smoothing and insurance. "***Redistributive components*** *of pension systems designed to ensure that pensioners achieve some absolute, minimum standard of*

*living**. Insurance components** designed to achieve some target standard of living in retirement compared with that when working"* (OECD, 2005).

All pension schemes design in the OECD countries includes a first tier around the poverty relief principle but with different structures. There are four types of design the "first tier -redistributive schemes" – "*social assistance"*, "*separate targeted retirement-income programs*", "*basic pension schemes*" and "*minimum pensions within earning related plans"*. All these programs are mandatory and public pension schemes. The basic pension the benefit is a flat benefit paid to every pensioner independently of receiving other incomes from other sources, or it depends only on years of work (but not on the past earnings). Other sources of retirement income do not affect the entitlement of the basic pension. The Targeted plans pay a higher benefit to the poorer pensioners and a reduced benefit to better-off retirees, i.e., this type of plans based on a redistribution of benefits by reducing the benefit amount to wealthy pensioners and increasing benefits to needy pensioners. The minimum pension is like targeted plans since there is a level guarantee of pension income; however, the eligibility and conditions are different. In general, pensioners to be eligible to receive the benefit required a minimum number of years of contributions. Lastly, there are the countries which only provides a universal social-assistance in which cover those who are not eligible to receive an old-age pension by the public pension scheme.

The objective of the second tier is to ensure a similar quality of life as during the active life period. There are different models to cover the second tier (J.M. Bravo, 2015).

Defined Benefit plans (DB plans)

Most of the countries have purely defined benefit plan (DB), and this is the case of Portugal. In general, this type of plan, the benefit is defined based on a constant accrual rate linked to the years of service (contributions) and earnings or wages. The contributions made by the active members, usually in the form of tax payments, are used to pay the current pensioners, and therefore not saved or invested.

Defined Contributions plans (DC plans)

The next common type of pension scheme is defined contribution plan (DC). In this type of scheme, each worker has an individual account with the contributions saved and invested for capitalisation, and the accumulated capital at retirement age converted into an annuity income and, in rare situations, to a Lump sum payment. The DC schemes organised in several ways, for example, in Australia, employers required to cover their employees via an industry-wide fund or a financial services company. In Hungary, Mexico and Poland, the employees choose a pension provider without employment participation, and in Sweden, employees required to contribute to a mandatory individual account. Most of the countries with a mandatory DC plan also have another type of scheme as such as point system or the rate of return that individual accounts earn as complementary to guarantee minimum retirement protection.

"Points Systems"

Some countries do not structure their pension scheme either as a simple DB or DC plan. The first case is where the pension schemes organised as "points systems" – this is the case of the public pension schemes in France, German and Slovak. The workers credited points based on their contributions linked to their average earnings, and at retirement, the sum of the points multiplied by a pension-point value to convert into a pension income. The retirement benefit depends on the value point at retirement age.

Notional Contribution plans (NDC)

There are also the notional-accounts schemes – the Public schemes of Italy, Norway, Poland, Sweden and Latvia. The yearly contributions made by actives as well the interest on the contributions recorded on an individual accumulated notional account that exists on the books of the managing institution. At retirement, each accumulated account converted into a pension income based on a notional actuarial conversion factor reflecting the life expectancy at the time of retirement. The contributions paid by the active members used to pay the current pensioners, but in this case, the contributions linked to the retirement benefit, and there is a "notional" rate return on the assets. In this type of plan differs from the simple DB plans, since the demographic and economic changes over time are reflected in the final retirement benefit by adjusting the notional return for economic fluctuations or adjusting the actuarial annuity factor for demographic fluctuations. Usually, countries introduce a guaranteed minimum pension since unlikely the DB plans an adequate benefit not guaranteed at retirement age (Holzmann, R., 2006) (Alho, J., Bravo, J. M. & Palmer, 2013) (Alho, J., Bravo, J. M. & Palmer, 2013) (Holzmann, 2017) (J. M. & E. M. de F. Bravo, 2018) (J. M. Bravo, 2019)

Cash Balance Plans

Finally, the mandatory contributions to Swiss occupational plans are cash balance plans which is like the DC plan, but there is a minimum interest guarantee on the contributions made to the pension fund.

In Portugal, the Social Security Framework Law (Law no. 4/2007 of 16th January) delineates the actual design of the Portuguese Social Security System (annexe 3). The social security system based on three pillars – the Citizenship Social Protection System, the Providential System and the complementary system; The first-tier based on the poverty relief and redistribution guaranteed by the Citizenship Social Protection System included in the subsystem solidarity supplement (targeted plan), and by the Providential System with a minimum pension guaranteed after 15 years of contribution; the second tier based on consumption smoothing and insurance is covered by the Providential System which is a defined benefit plan (DB). (OECD, 2019). Table 2 shows the OECD multi-pillar pension taxonomy of social security schemes inclusive of Portugal.

Table 2 - Multipillar Pension Taxonomy classification by the OECD

Tier: function	First-tier: universal coverage, redistributive				Second-tier: mandatory, insurance		
Provision	Public				Public	Private	
Type	Social assistance	Targeted	Basic	Minimum	Type	DB	DC
Australia		√					√
Austria		√			DB		
Belgium		√		√	DB		
Canada		√	√		DB		
Czech Republic	√		√	√	DB		
Denmark		√	√		DB/DC		√
Finland		√			DB		
France		√		√	DB+points		
Germany	√				Points		
Greece		√		√	DB		
Hungary				√	DB		√
Iceland		√				√	
Ireland		√	√				
Italy	√				NDC		
Japan			√		DB		
Korea			√		DB		
Luxembourg			√	√	DB		
Mexico		√					√
Netherlands	√		√			√	
New Zealand			√				
Norway		√	√		Points		
Poland				√	NDC		√
Portugal		√		√	DB		
Slovak Republic				√	Points		
Spain				√	DB		
Sweden		√			NDC	√	√
Switzerland		√		√	DB	CB	
Turkey		√		√	DB		
United Kingdom		√	√	√	DB		
United States		√			DB		

Source: OECD; DB = Defined Benefit, DC = Defined Contribution, CB = Cash Balance, and Points = Points System.

Despite the variety of social security schemes, globally, all schemes were designed based on the social security principles and used tools created mainly by social security programs initially established in Germany and the UK. Furthermore, with the right questions and the proper conceptual framework template, each government had modelled their schemes based on pre-defined objectives and the instruments used to achieve the objectives- the Bismarck versus Beveridge models or a mix between the two models (Barr, 2000).

2.2. THE PROBLEM - GLOBALLY

Nicolas Barr (2000) differentiates risk and uncertainty as to "*the risk, the probability of potential outcomes is known or estimable, with uncertainty it is not.*" This distinction is crucial since we can actuarially measure the risk but not the uncertainty. Public and private pension schemes face both risks and uncertainties. Barr then identifies two sorts of uncertainty*: "Macroeconomic shocks"* and *"Demographic shocks"* (Barr, 2000). Indeed, these two factors were the initiators of challenging the sustainability of pension schemes in Western Europe, starting in the 1970s and onwards. The economic crisis in the 1970s, together with ongoing demographic alterations, had damaged several government budgets. The financing of public pension schemes, in particular, the pay-as-you-go systems prevalent in the Bismarck and Beveridge systems went under pressure started first in the UK, and later in Italy and Sweden with the public deficit crisis in earlier 1990s (Ebbinghaus, 2009). Many countries introduced reforms on their pension schemes in order to maintain sustainable their pension schemes and many countries have undertaken significant reforms, and others are now experiencing a similar process (Ignacio Conde-Ruiz & Gonzalez, 2014).

(Feldstein, 2001) Feldstein predicted the taxes to pay the future benefits would need to rise sharply due to the ageing of the European population. Feldstein stated that this is not a temporary issue but a permanent issue. The tax rate will have to rise by about 50 per cent in most countries with even more significant increase in some countries if no changes made to the structure of the existing PAYG schemes (Feldstein, 2001). Based on Ignacio and Gonzalez, there is no doubt that the ageing population is damaging hard the Pays-As-You-Go (Ignacio Conde-Ruiz & Gonzalez, 2014). Based on Schuldi, the economic pressure will be more severe on the public pension schemes since the demographic changes will lead to massive ageing of the population from 2020 onwards. He mentioned two significant demographics changes – the increasing life expectancy and declining fertility rates with more substantial incidence within western Europe. Both Beveridge and Bismarck models are highly vulnerable to these demographic changes. Both models have the pension paid to pensioners based on the contributions (in the form of tax) paid by the active members, and therefore when the ratio between actives and pensioners declines, i.e., there are fewer actives to pay the pensions in payment to the pensioners, the system will come under pressure. (Schludi, 2005).

What have done Western Europe countries to solve the problem?

Despite all the changes observed in the public pension systems started in the 1970s and onwards, in Western European countries, only a few countries such as Sweden and Italy performed structural changes on the public system by moving to a notional defined benefit (NDC) and reorganised their system thoroughly to make them more sustainable for the future. Sweden was the unique country that moved from a basic pension plus earnings-related second pension (Beveridge type) to a contributory earnings-related (Bismarck Type) but keeping universal. Furthermore, Sweden and Denmark introduced funded pensions in the first tier as a mandatory public pension. Italy did not introduce the funded part as done by Sweden but instead transferred the mandatory end-of-service pay ("TFR" plans) into a private pension. In Germany, the birth of the first Bismarck social security scheme introduced a new layer in the public system, the voluntary personal pension ("Riester") and promoted collective occupational pension. The rationality is that due to demographic changes, the principle of consumption smoothing the inspiration of the Bismarck design is not meet any longer, and therefore, the need to introduce a second layer on the public pension scheme to fill the gap. In

countries with the occupational second tiers, Switzerland and the Netherlands, the pension reform has been less pronounced, but it is in the political agenda. (Ebbinghaus, 2009). In conclusion, in Western European countries, there has been a transformation on the public schemes, and as mentioned by Ebbinghaus, despite all the changes, "*Yet, in the long-run these institutional changes may be the first step towards a more substantial change in the public-private mix to come in the future.*" (Ebbinghaus, 2009).

2.3. THE PROBLEM IN PORTUGAL

Portugal is also facing the same issues as other countries in Western Europe since the Bismarck and the Beveridge models inspire the Portuguese social security model. In the past, there were several amendments to the social security framework based on Law No. 28/84 of 14th August. Table 4 illustrates the main reforms performed to the public pension scheme in Portugal since 1990.

Table 3 - Main reforms to the public pension scheme in Portugal

Retirement age	Convergence between men and women at 65 (1999)	Retirement age raised to 66 and linked to life expectancy (2014)	
Accrual period	Minimum years of contributions for a pension raised from 10 to 15 years (1993)	Number of years after which accrual stops increased from 37 to 40 years (1999)	Bonus of 10% per year of late retirement for those with more than 40 years of contributions (1999)
Benefit formula	Reference wage: best 10 out of last 15 years (1993)	Accrual rate set at 2% (previously 2.2%) (1999)	Reference wage: extended to 40 years and accrual rates set between 2% and 2.3% depending on wage level (2002)
Sustainability factor	Introduction (2007)	Abolishment for retirement from normal retirement age (2014)	
Early retirement	Access to the long-term unemployed from age 55 with 20 years of contributions (1999)	Raised from age 54 to 55 (2007)	Early retirement suspended (2012) re-enacted in 2015 but at age 60
Penalty	4.5% per year of anticipation (1999)	6% per year of anticipation (2007)	
Civil servant	Start convergence of rules with general regime (1999)	Closed for new entrants (2006)	

Source: OECD report (2019)

However, all these modifications were at a parametric level, rather structural level. (Manuel et al., 2006). The actual structure of the social security system in Portugal maintains the PAYG structure where the pillars of this model are firmly based on the equilibrium between the numbers of taxpayers and the number of pensioners (to be more precise, between the number of contributors and pensions) which heavily depend on the dynamics of the population size and its age structure (old-age dependency ratio). A report issued by OECD in the year 2019 related to the old-age pension system in Portugal, among all OECD countries, Portugal is the country with the most significant decline (in percentage) in the size of active population between 2015 and 2045, putting even more pressure to the actual, and already fragile, public pension scheme in Portugal.

At the national level, the studies remote to the 1990s just a few years from the implementation of social security based on the Beveridge model. Consequently, similar to other countries, the sustainability of the PAYG schemes has been studied and discussed for several years and exists several

studies on this theme in Portugal appointing for the urgency of redesigned the public pension scheme in Portugal (OECD, 2019).

In 1995, Mendes questioned the implementation of the universal social security inspired by the Beveridge model in 1984 due to demographic and employment trends in Portugal. He anticipated the maturation of the Beveridge model by just observed other countries that adopted the Beveridge model earlier than Portugal and were facing issues with the public pension sustainability. Mendes predicted a significant increase in the tax contributions paid by the active members to the current pensioners, which would not permit individuals and employers to contribute for the second and the third pillar of the pension system (Mendes, 1995). In 1997, due to the crisis and bankruptcy of the European Social Security schemes, Silva performed a research study which confirmed the previous study related to the maturation of the PAYG schemes. According to Silva, the Portuguese social security system is mature, and it would not be sustainable in the long term due mainly to two factors – due to demographic pressure – decrease on the fertility rates and increase on the life expectancy, and due to the reform on education (extension in years of the mandatory scholarship) which delay the start of the active life for Portuguese citizens (Silva, 1997). In 2004, Pereira Da Silva foresaw the probability of the population aged over 65 would be increased by 70 per cent in the years between 2000 and 2050. At the same time, he predicts that the proportion of age under 15 will remain constant, decreasing from 20 per cent in 2000 to 19 per cent in 2019. The data projections revealed a significant divergence between the evolution of pensioners and active members threatening the equilibrium of the PAYG scheme in Portugal. He concluded the study that in order to ensure the sustainability of the public pension scheme after the year 2050, significant changes need to be made to the actual public pension system in Portugal (Pereira Da Silva, Tomé Calado, & Medeiros Garcia, 2004). In 2006, Rodrigues concluded that population ageing is causing severe risk to the sustainability of public pension schemes and increases taxes to finance the public pension system would be inevitable if no changes in the current social security system would be performed at the structural level. In the last couple of years, several studies appear stressing the urgency for the need for immediate structural changes in the public pension scheme in Portugal (Rodrigues & Pereira, 2006).

In recent years, Portugal has implemented numerous (temporary and permanent) parametric pension reforms aimed at reducing public pension expenditures, with little margin for addressing income adequacy concerns in an already highly aged society. The main policy initiatives were driven by the short-term need for fiscal consolidation rather than by a long-term prospect for the design of pension systems. Parametric reforms include: (i) the introduction of a sustainability factor in the pension formula; (ii) an increase in the statutory retirement age; (iii) moving from best years to lifetime average earnings; (iv) a new indexation mechanism linked to prices and real GDP growth; (v) the introduction of bonuses for late retirement and penalties for early retirement; (vi) suspension of early-retirement regimes; (vii) nominal pension cuts; and (viii) means-testing for non-contributory benefits; (ix) convergence of rules between RGSS and CGA regimes. Long-term projections show that systems are not sustainable from the economic, financial and demographic point of review, and despite the several waves of pension reforms made over the last 20 years, the population ageing and economic changes driven by social and technological changes in the labour market will continue to impact the public pension schemes and change the living conditions for pensioners (J.M. Bravo, 2012) (J. M. Bravo, 2012) (Jorge Miguel Bravo, Afonso, & Guerreiro, 2013) (Bravo, J. M., Guerreiro, G., Afonso, 2014) (J. M. Bravo, 2017).

2.4. THE FUTURE OF WORK – ADDING MORE PRESSURE

Standard and non-standard form of work

Adding even more pressure to the public pension models is the rapid transformation of the working framework driving by the technological advances and globalisation. The standard working model, used as a base for a pension design, is moving from full-time work under an open-ended employment contract to atypical forms of work with features incompatible with actual pension designs (Schoukens & Barrio, 2017). Three main characteristics define a standard form of work: i) **direct employment relationship** where there is a clear distinction of bilateral relation between a single employer and employee; ii) **Labour stability** where the work arrangements are for an indefinite period and only terminates under particular situation regulated by labour law, and iii) **Income Security** where the employee receives a fixed income paid regularly by the employer in exchange for their services. The actual design of the public pension scheme is strongly correlated with these three concepts. i.e., the majority of the public pension schemes are structured as an income replacement under the perception that the standard of work is the primary income source. The future of work is challenging somehow these three concepts where there is no clear distinction between a direct single relationship employer and employee, the income made by the employee along the work career is unpredictable as well the duration of the work assignments (Schoukens & Barrio, 2017).

The non-standard forms of work have the following issues related to old-age protection coverage due to the lack of one or all of the three main features that define the standard form of work (Runde & Milner, 2018) (ILO, 2019):

- *Labour stability*: Unstable work careers, discontinuous careers and short working hours resulting in inadequate coverage or limited benefits. Pension schemes often require minimum years of contributions for eligibility to receive a retirement benefit, and therefore individual covered by the atypical work forms are usually pushed out of social security system, even though they may accumulate over time a multitude of fixed/part-time work assignments but not enough to be eligible for social insurance purposes;

- *Income Security*: Usually, lower earnings and with high variance on the earnings. Often, insurance-based and non-contributory benefits co-exist, and individuals can access only the latter (e.g. only basic pension and not earnings-related).

- *Direct single employer relationship*: Difficulty to have a clear distinction between employer and the employee, and this is a central element of any social security systems for paying dues (financing); Who should be liable for the employer contributions if an employer is not well identified? Self-employed can choose to declare lower-contribution base, but also received lower benefit entitlement;

- *Portability*: lack of regulation to ensure labour market mobility. Acquired entitlements lost during a change in employment status or job (e.g. following a transition from dependent to self-employment when rights differ across employment statuses, or between jobs if they tied to a specific employment relationship). Additionally, some activities do not rise to pension entitlements (e.g. self-employment in many jurisdictions and casual or irregular work in some);

- Taxation of pensions: The current "Exempt-Exempt-Taxed" ("EET") regime adopted in most countries, where both contributions and returns on investment are exempted from taxation while benefits are treated as taxable income upon withdrawal, and the increasing mobility of retirees challenges the traditional deferred taxation are motivating significant tax arbitrage across countries (J. M. Bravo, 2016) (J. M. Bravo, 2018).

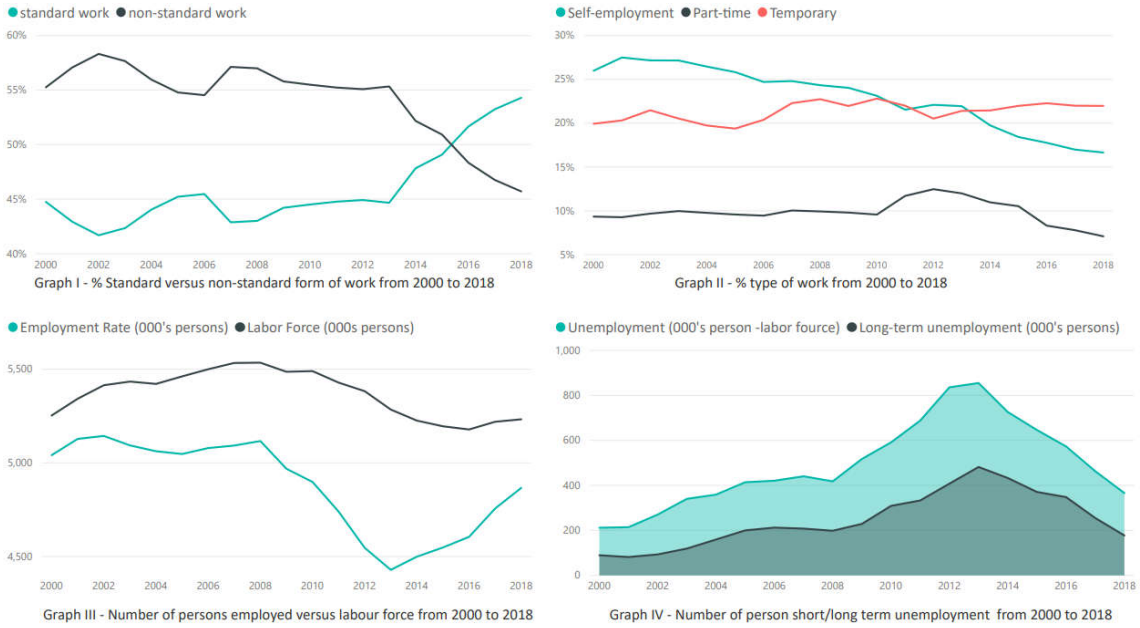
Bismarck versus Beveridge models

Analysed the effect of the non-standard forms on the Bismarck versus Beveridge models, there is a general perception that there is limited and lower access for the "non-standard workers" in the Bismarck systems since the benefit is linked directly to the contributions paid based on the salaries; therefore, with more frequent career breaks and lower wages. On the other side, the Beveridge systems better designed to deal with the impact of the effects of the non-standard forms of work since the benefit is usually a flat-rate benefit. Although this may be true, however, most of the countries do not have a pure "Beveridge model", and usually there is a second-tier with private-scheme with a high level of benefits, where in most situations, the non-standard of workers not protected by this second-tier. Additionally, it is questionable where Beveridge systems, with an increase on more frequent breaks of work and lower salaries, might be not financed only by taxes without the support of work contributions. Furthermore, this brings to another issue about the fairness of the traditional forms of work financing the first-tier universal schemes almost entirely(Schoukens & Barrio, 2017).

Non-standard forms of work in Portugal

Atypical forms of work as such as temporary work, part-time work and self-employment represent already a third of all type of employment relationship in the OECD countries (Schoukens & Barrio, 2017). However, many other forms of non-standard of work are emerging as such as platforms workers, flexible or on-call contacts that also challenge the pension structures worldwide. In this paper, the focus is on two types of non-standard of the wok - "Temporary employment" and Self-employment" since these are the predominant type of non-standard workers in Portugal.

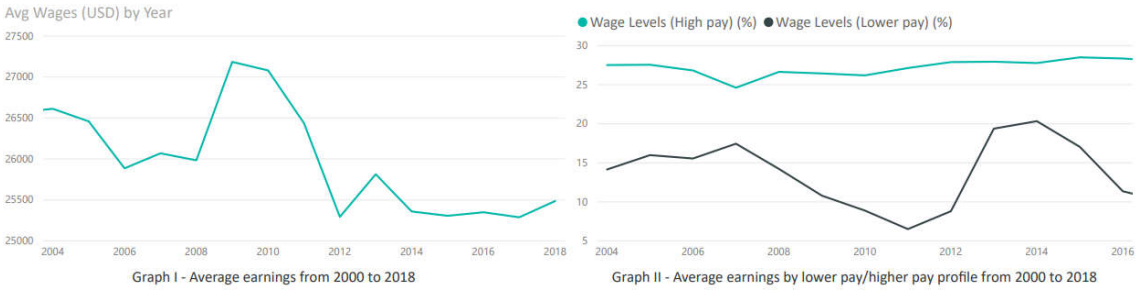
Figure 1 - Portugal Data – Employment



Source: OECD

In the dashboard above based on data produced by the OECD for Portugal, there is a steep decrease in the non-standard forms of work (self-employment, part-time and temporary workers), from the year 2012 and onwards (graph II), but this decrease linked to the unemployment rate that affected more the non-standard workers as shown in graph IV. This explicit shows evidence that the interruptions of work affect more the non-standard types of work. Based on data, the self-employment workers are the most affected by the decrease in the employment rate (graph I). The non-standard workers represent almost 45% of the employment in the year 2018.

Figure 2 - Portugal Data - Earnings



Source: OECD

The two graphs above represent the incidence of low pay workers (earning less than two-thirds of median earnings) and high payment workers (earnings more than one-and-a-half time median earnings) of full-time employees. The overall decrease on the average earnings (graph I) matches with the decrease of the average earnings of the lower-earnings profile. The higher-earnings profile maintains a constant or a slight increase in the average earnings over the years. The decrease of lower pay workers likely correlated to the self-employed workers and temporary workers, usually with lower earnings or with more fluctuations over the years than the standard forms of work.

Insights from OECD

In 2019, the OECD suggested two basic concepts to tackle some of the challenges facing the old-age social protection for the non-standard forms of work. The OECD suggested tying entitlements to individual workers rather than specific employment relationships or to do the opposite and untie benefits from contributions. The first concept, OECD suggested, "Individualisation of social protection" similar to the NDC plans as implemented by several countries like Sweden, Italy and Poland. On this type of plan, social protection contributions made by workers, employers or the state on the worker behalf linked to an individual notional account – this measure would tackle the high variations of the salaries as well combining incomes from different sources. Additionally, this concept preserves rights during job changes and career breaks and would solve the "*double contribution problem*". On the other hand, since this is an individual use, this solution would not incorporate the risk-sharing fundamental for any insurance, therefore, would not protect against catastrophic risks as such disability. Additionally, it is not the right solution for many low-income workers and part-time workers unless the government would sponsor lower-income workers. The second concept of untying social protection from the employment relationship would be by making Social Security more Universal – untie retirement benefits to contributions, i.e. adopt a pure Beveridge model for all citizens. It is the type of solution there is the risk of crowding out employer contributions (OECD, 2019).

2.5. WHAT RESEARCH DONE IN PORTUGAL TO SOLVE THE PROBLEM?

There were few research papers published in the last 15 years to assess the long-term sustainability of the Portuguese Pension System empirically, and most of them focused on parametric changes, despite the fact, as concluded from recent research papers, that the Portuguese Pension System will not be sustainable with the current PAYG design.

Rodrigues measured the long-term financial sustainability of the public pension system in Portugal and evaluated various reform options in a dynamic general equilibrium framework. The study found that there are limits to what can be achieved through parametric reforms of the PAYG system. Indeed, to ensure long-term financial sustainability, as well as the adequacy of pension income, a public second pillar needs to be erected once the first pillar is significantly scaled back. Reforming the PAYG system cannot go much further than solving an estimated 47.6% of the problem of financial sustainability. Even if the PAYG pillar were financially sustainable in the long term, setting up a second pillar would be advised (Rodrigues & Pereira, 2006).

Pina Manso analysed the impact of a simulated transition to an NDC scheme on the Pension System in Portugal. The results suggest that even after two decades of parametric reforms and pension adjustments, there is still a deeply rooted sustainability problem in the Portuguese Pension System. The thesis used a Dynamic Microsimulation Model (DYNAPOR) to analyse the impact of a transition from a traditional Defined Benefit Pay-As-You-Go pension scheme to a Notional Defined Contribution system on both the financial and the social sustainability of the pension system in Portugal. The results showed that while the NDC scenarios outperform the DB-PAYG system in terms of financial sustainability, it does so at the cost of the social component. The various features of the NDC pension

system are proven to be essential in both reducing expenditure and improving adequacy and poverty relief (Rodrigues & Pereira, 2006).

Bravo & Herce (2020) investigate the effect of single and multiple unemployment spells on the lifetime pension entitlements of earnings-related contributory pension schemes, considering the timing and duration of breaks, alternative lifecycle labour earnings profiles, scarring and restoration effects on labour market re-entry, the existence of pension credits and pension accruals for periods spent outside the labour market, longevity heterogeneity, and the accumulation and decumulation redistributive features of the pension scheme. Pension entitlements are estimated using a backwards-looking simulation approach based on the actual Portuguese public pension system rules and stylized labour market profiles identified in the SHARE Job Episodes Panel data using a sequence analysis. Longevity heterogeneity is modelled using a stochastic mortality model with a frailty model. The authors show that the timing and duration of unemployment periods is critical, that scarring effects amplify pension wealth losses, that minimum pension provisions, pension credits and pension scheme redistributive features can partially mitigate the impact of unemployment periods on future entitlements, and that in the presence of positive correlation between lifetime income and longevity career breaks amplify the asymmetry in the distribution of pension entitlements across income groups.

Based on the report issued by the European Commission in 2018, developing a comprehensive national strategy on the extension of working life and the consolidation of a sustainable pension system should be a priority, and the government priority of poverty alleviation should continue (European Comission, 2018). As such, the present is one of the last opportunities to reform the public pension system in Portugal meaningfully. The modernisation of this system is a structural reform that can no longer be postponed (Rodrigues & Pereira, 2006).

There is clear evidence of the need for further research studies on the optimal design of the old-age retirement protection coverage in the context of the future of work, and this is the primary purpose of this paper by analysing different pension designs for Portugal having in mind the future of work context.

3. METHODOLOGY

In this section, we describe the path of our academic research. First, we started to define our goals by express our research questions, next and according to the established goals of our study, we selected the research method and finally, we designed a research path to carry out the aims of our study. Therefore, we divided this section into three subsections – research questions, research method and research design.

3.1. RESEARCH QUESTIONS

This research paper aims to investigate the impact of the non-standard forms of work in the actual Portuguese pension model and generate insights for a new pension model design in Portugal. We aimed to reach our goals by answer the following three research questions:

1) Why doesn't the current Portuguese pension scheme fit well within the context of the future of work?

2) Are there other pension models already design that better of the actual Portuguese DB pension model?

3) How should the Portuguese pension scheme design to fit within the context of the future of work?

By answer these three questions, we first find the gaps of the old-age protection coverage in Portugal for those with non-standard forms of employment, and with the second and third questions, we gained insights for an answer to the challenges presented by the first question.

3.2. RESEARCH METHOD

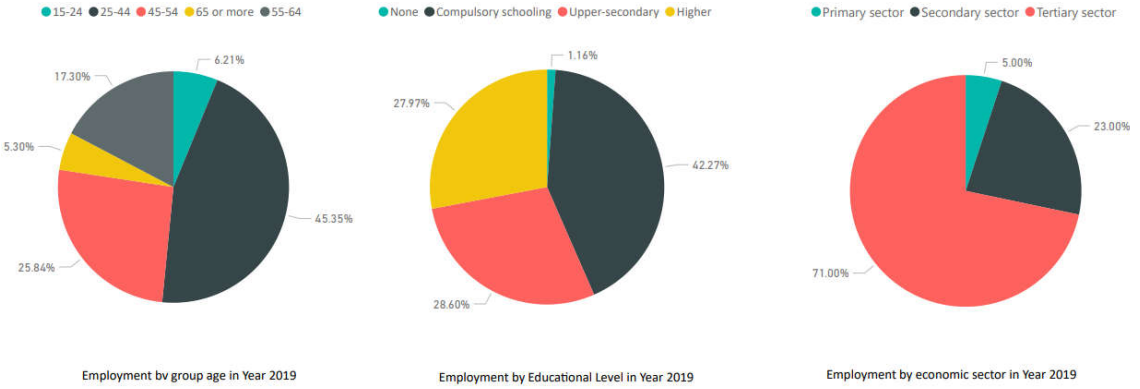
Our study intended to provide insights and new ideas to support an old-age protection coverage adequate for non-standard forms of works. Consequently, we used an exploratory research study based on a case study method to find the answers to our research questions. A case study is preferable when a "how" or "why" question asked about a current set of events over which the investigator has little or no control, and the case study often used to assess public policies (Yin, 2009) (Herce & Bravo, 2017).

3.3. RESEARCH DESIGN

We considered besides the current Defined Benefit (DB) Portuguese pension model other four pension models for this study. The first model is like the pension model used in Sweden - Notional Defined Contribution (NDC). The second model is a mirror of the pension model used in Swiss, with a DB plan (Basic Plan) plus a cash balance plan. The third model is a floor offset, i.e. it is DC plan but with minimum benefit set up like a DB plan. Finally, the fourth model is a Points Systems like the plan used in Germany (details of these four plans described in annexe 1). We considered these four models since all these plans covered most of the current pension designs worldwide. Then, we defined two cases studies: the "*typical average worker*" in Portugal based on the standard form of work and the "*atypical average worker*" based on the non-standard agreement of employment. As defined in the literature review, the standard of work based on three features; direct employment relationship, Labour stability and Income Security, and the non-standard of work somehow lack some or all these three features.

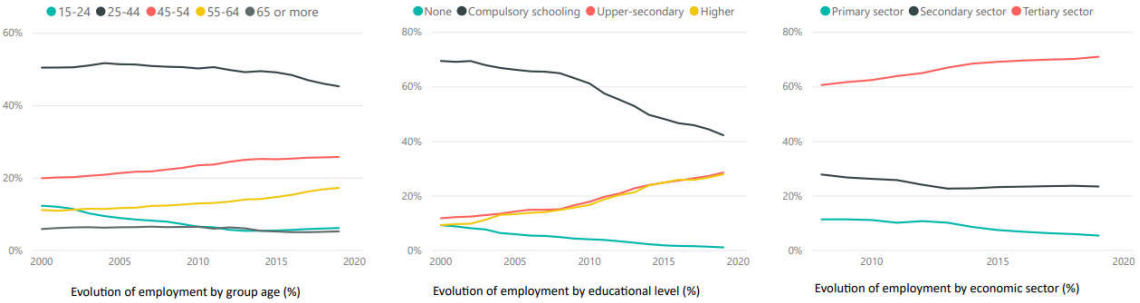
Therefore, it is expected more interruptions on the service and higher variations in earnings through all active career for non-standard workers.

Figure 3 - Statistic Portugal data –employment profile in Portugal



Source: PORDATA

Figure 4 - Statistic Portugal data –employment evolution in Portugal



Source: PORDATA

The statistics data for Portugal shows most of the worker's age ranges between age 25 to age 44, and despite a slight decrease from the year 2015 still is 45% of the total employed data in the year 2019. The higher education level of the employed data increased, and employees with compulsory schooling decreased over the past years. Based on these data statistics, we assumed the average worker in Portugal to be born on 1st January 1985 with high education level, working on the tertiary sector. The first date of employment to be on 1st January 2012 at age 27. We assumed to be a male for simplification purposes—this profile used in both study cases – the standard worker and non-standard worker. We also defined two earnings profiles for the non-standard worker: the "lower earnings" profile with three ranges of pensionable salary - national minimum wage, 0.5 and 0.75 of average earnings worker (MNW, 0.5 AW and 0.75 AW) - and the "higher earnings" profile with also three ranges of pensionable salary - 1.5, 2 and 3 of the average earning workers (1.5 AW, 2 AW and 3 AW). The different pensionable salaries range served to analyses the impact on the pension models due to the high variance on the pensionable salaries for the non-standard workers.

The first case study used as a baseline scenario based on the average earnings worker without interruptions of service, i.e. with full pensionable service of 40 years until the retirement age of 66.5 years. The other case study for the non-standard workers based on the interruptions varying between 1 to 5 years, at the beginning of career (from at age 35), middle of career (from age 45), end of career

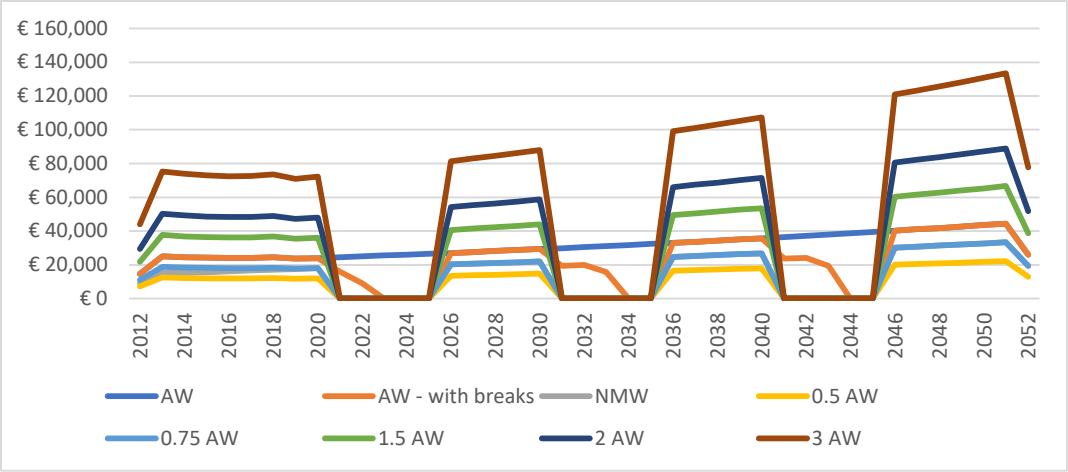
(from age 55) and multiple breaks during all career. Additionally, the simulations on the interruptions of work based on the following two scenarios:

- Baseline scenario: the post-interruption earnings resume of that of the worker who has not suffered a career breaker.

- Convergent scenario: assumes a loss of 10% of each year of interruption on the post-interruption wage salary, and then catch-up with the baseline scenario in five years.

Finally, the study also simulated the impact of breaks of work for an average worker covered by the social security unemployment program (please see Annexe 1) compared for those with the same length of breaks but not covered by the unemployment program. Then, we applied the assumed pension models to all these earnings profiles and scenarios.

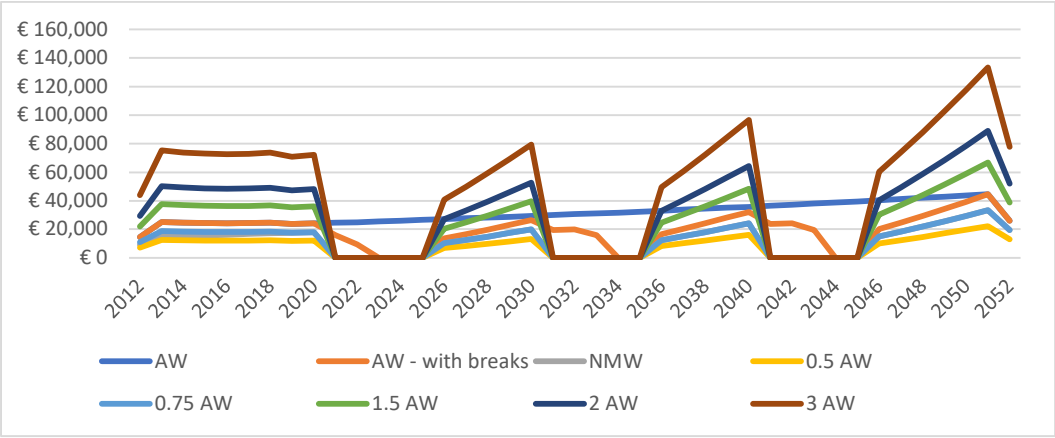
Figure 5 – Baseline scenario - multi breaks



Source: Source: Author's preparation; Notes: AW-=Average Wage, NMW= National Minimum Wage.

Figure 4 and Figure 5 represents the multiple breaks with a duration of 5 years for the different earnings profiles for the baseline scenario and or the convergent scenario, respectively.

Figure 6 – Convergent scenario - multi breaks



Source: Source: Author's preparation; Notes: AW-=Average Wage, NMW= National Minimum Wage.

The simulation-based on the following assumptions:

Economic assumptions:

Based on the forecast of the European Central Bank, the inflation for five years is around 1.80 % p.a. (ECB, 2020); therefore, we assumed an inflation rate of 1.75% p.a. The study also assumes a real salary increases assumption of 2.00% p.a. and a pension increase of 1.50% p.a.

The study assumes that all contributions are used to pay directly the current pensioners, therefore no investment return on the contributions by the active members to sponsor the old-age benefit. However, we assumed an investment return of 2.90% p.a. on the accumulated contributions for the DC model considered in this study. Based on a survey performed by Willis Towers Watson at December 2019, the historical returns for one year have been 8.2% p.a., three years have been 2.7% p.a. and five years have been 2.3% p.a. for the pension funds in Portugal.

Demographic assumptions:

The study assumes all profiles arrive at retirement age, i.e., assumes no decrements before the assumed retirement age of 66.50 years for simplification purposes. The post-retirement mortality assumed is the "U94M2020" mortality table providing an expected future lifetime of 18.26 years for a male at age 66.50 years. The UP-94 mortality table established under the Retirement Plan Experience Committee in the US to develop a recommendation for an uninsured pensioner mortality table (SOA, 1994). The study assumes the UP94 projected to 2020 is appropriate for a Portuguese population and for the purpose of the objective of the research study with pension simulations. However, for pension policy, the issue of the correct estimation of the future life expectancy is also amplified when ex-ante differences in mortality are observed, the longevity improvements are not homogenous across socioeconomic groups, there is high lifespan inequality at retirement, and subjective mortality beliefs differ significantly from objective longevity measures, translating into implicit intragenerational tax/subsidy effects and ineffective financial planning (Ayuso et al., 2017a,b; 2020; Bravo et al., 2020). The study does not provide sensitivity analyses and not reflect the impact of these factors on the pension entitlements.

Plan rules and assumed contributions to sponsor the retirement risk:

The assumed contributions to sponsor old-age benefit is 20.21% for average worker of the total 34,75% contribution to the Portuguese social security and 17.21% of the total of 29.60% for non-standard workers (the same as self-employed workers) (ssa.gov, 2018).

The plan rules for the assumed pension models and respective parameters of the models are described on Annexe 1 as well as the Portuguese social security unemployment program.

Criteria to interpret the results

The criteria for interpreting the results based on two measures – replacement ratio and actuarial fairness. The replacement ratio used in the pension field to measure how effectively a pension model generates a retirement income to replace earnings (OECD). The replacement ratio is the ratio between the retirement benefit and the pensionable salary at retirement age. The actuarial fairness, as defined by the OECD, requires that the present value of lifetime contributions equals the present value of

lifetime benefits (OECD, 2020). In this study, we defined "actuarial fairness" measure to be a percentage of the old-age pension generated by the pension model, and the variance between the "fair" retirement pension, estimated by dividing the total accumulated tax paid during a lifetime at retirement age by the expected future lifetime, and the retirement pension, as calculated by the pension model. The highest of the "actuarial fairness" measure means the taxpayer is receiving a benefit much more favourable than the benefit he/she would receive based on his/her accumulated contributions to the system—the closest to zero this measure is the fairness is the pension entitlement. In summary, the replacement ratio measure for the adequacy of the pension model and the actuarial fairness measure the fair balance indices between the contributions and the benefits as well as the distributiveness levels of the pension model.

The study also compared the baseline scenario without work interruptions with simulated scenarios (and profiles) to measure the impact on the interruptions of work.

Criteria to interpret the results – mathematical equations

In general terms, a simple retirement accrual benefit for a DB plan is a constant accrual rate, a, for each year of service. The pension entitlement benefit is as follows:

$$DB = N \times a \times w_{ref}$$

Where N is the number of contributions years, and w_{ref} is the reference wage at the retirement age used for pension purposes. The reference wages depend on how past wages are revalued:

$$w_{ref} = \frac{\sum_{i=1}^{N} w_i \, (1 + x_i)^{N-i}}{N}$$

Where, w_i is individual earnings in year i, and x_i is the average rate at which earnings from the year i are revaluated. Therefore, the formula of the pension benefit under a simple DB plan can be rewritten as follows by replacing the w_{ref} using the formula above:

$$DB = \sum_{i=1}^{N} w_i \, (1 + x_i)^{N-i} a$$

Defining ρ_i as the growth rate of an individual's wages, the replacement ratio at retirement age for the DB plan is defined as follows:

$$RR_{DB} = \sum_{i=1}^{N} \left(\frac{(1 + x_i}{1 + \rho_i} \right)^{N-i} a$$

Under a Point systems type of plan, the pension points are calculated by dividing contributions by the cost of the pension point (k). The pension retirement benefit depends on the value of a point at the time of retirement, v. The number of points acquired at each period is equal to $\frac{c \, w_i}{K_i}$ where c is the contribution rate; therefore, the pension benefit for a pension system type of plan can be written as follows:

$$PP = \sum_{i=1}^{N} \frac{c \, w_i \, v_N}{K_i}$$

The pension point cost and the value of the points are revaluated by indexation rates defined by the plan. Defining parameter, u, as the indexation rate for pension cost, and parameter, n, for indexation rate for pension values, such as $K_{i+1} = K_i\,(1 + u_i)$, and $V_{i+1} = V_i\,(1 + n_i)$, we can rewrite the pension benefit for a point system as follows:

$$PP = \sum_{i=1}^{N} cw_i(1 + u_i)^{N-i} \frac{v_N}{k_N}$$

And the replacement ratio defined as follows:

$$RR_{PP} = \sum_{i=1}^{N} \left(\frac{(1 + u_i}{1 + \rho_i}\right)^{N-i} c \frac{v_N}{k_N}$$

The Notional accounts work like points, but the unit value is express in currency rather than in the number of points. Inflows are equal to contributions (in currency), i.e., wages multiplied by the contribution rate. The notional capital is increased each year by the notional interest rate, r. At retirement, the accumulated notional capital is divided by a notional actuarial annuity factor, A_N as defined by the plan rules. The pension benefit for NDC defined as follows:

$$NDC = \sum_{i=1}^{N} \frac{cw_i(1 + r_i)^{N-i}}{A_N}$$

and the replacement ratio is:

$$RR_{NDC} = \sum_{i=1}^{N} \left(\frac{(1 + u_i}{1 + \rho_i}\right)^{N-i} \frac{c}{A_N}$$

The DC works similarly with the NDC plan. However, the contributions (in currency) made during the year are capitalized by the actual interest rates depending on the investment strategy, return assets, instead of established notional rate r, and the annuity factor is based on the market conditions at retirement age, instead of a notional annuity factor.

The accumulated contributions made to the social security systems at retirement age are as follows:

$$AC_{Ret} = \sum_{i=1}^{N} cw_i(1 + Cap_i)^{N-i}$$

Where, Cap_i is the capitalization of the contributions made by the pensioner during the active life. In the cases where the contributions are made in the form of taxes, and not capitalized, the Cap_i is null on the formula above.

The estimated "fair" benefit at retirement obtains by dividing the accumulated contributions (in the form of tax payments) through all active lifetime by the expected future lifetime at retirement age, a_{ret} based on the assumed mortality decrements.

$$Estimated\text{Fair}PensionBenefit = \frac{AC_{Ret}}{a_{ret}}$$

The "actuarial fairness" measured used on this paper is the retirement pension benefit defined by the model divided by the estimated pension fair benefit based on the accumulated contributions or tax paid, i.e.

$$\text{Actuarial Fairness Measure} = \frac{Pension\ Benefit\ (generated\ by\ the\ pension\ model)}{Estimated\ \text{Fair}\ Pension\ Benefit}$$

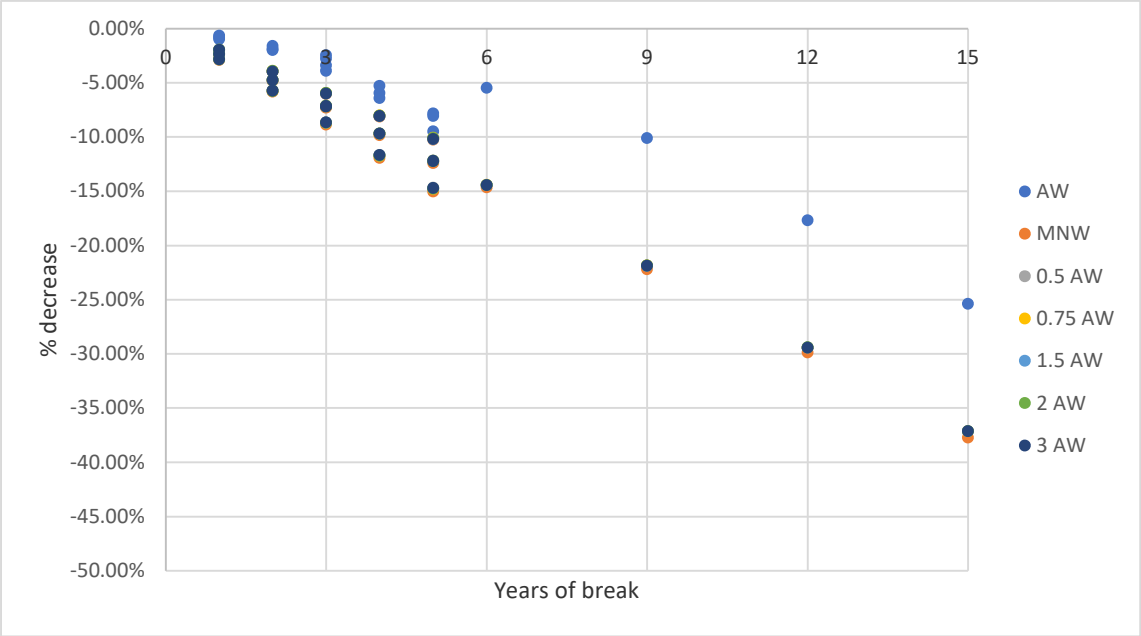
(Boulhol, 2019)

4. RESULTS AND DISCUSSION

Why doesn't the current Portuguese pension scheme fit well within the context of the future of work?

The graph in figure 7 shows the percentage reduction in the old-age benefit comparing with the average worker that did not suffer work interruptions during the active life. The modelling assumes that post-interruption earnings resume of that of the worker who has not suffered a career breaker.

Figure 7 - Impact on the old-age benefit (Baseline scenario)

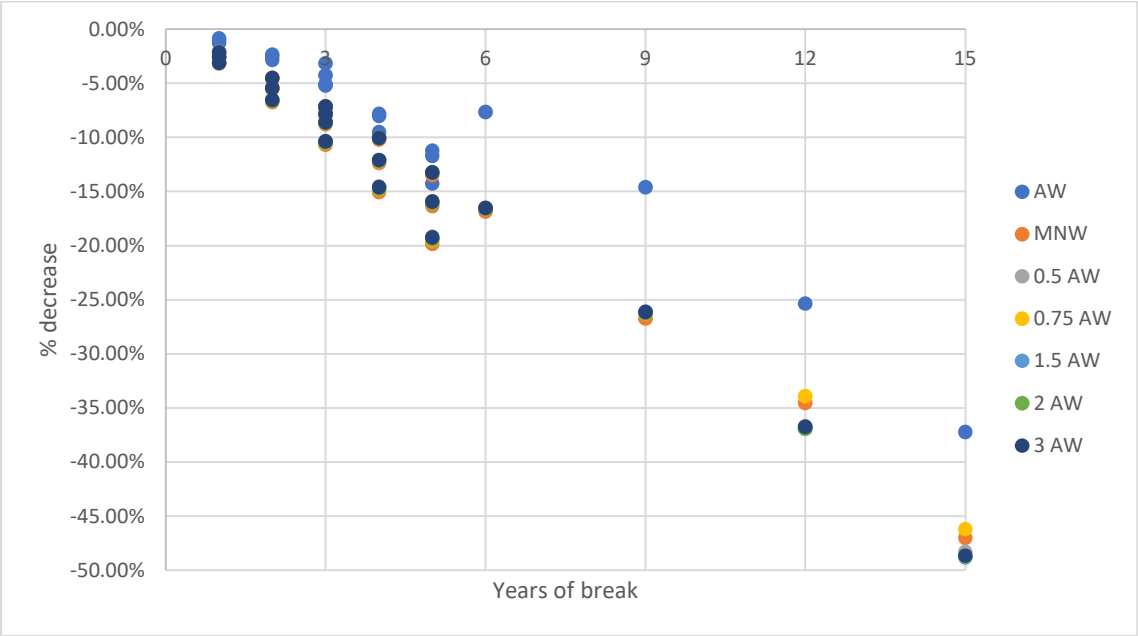


Source: Source: Author's preparation; Notes: AW-=Average Wage, NMW= National Minimum Wage.

The longer the period of a career break, the higher is the reduction on the old-age pension entitlement. For the nonstandard workers that have an interruption of 15 years will lose 37% of the old-age pension against 25% of the average worker covered by the unemployment program. As expected, the longer the break of service, the higher is the reduction impact on the old-age pension entitlement. The average worker covered by the unemployment program, the old-age pension can be reduced by 1% to 25% as the interruption increase from 1 to 15 years, and for workers not covered by unemployment for all earnings profiles, the old-pension entitlement reduced between 2% to 35% as the interruption increase from 1 to 15 years. The gap between the worker protected by the unemployment program and the worker not protected by the unemployment program increases significantly after five years of break. The difference in the wage salaries has little impact since we assumed the post-interruption earnings resume of that of the worker who has not suffered a career breaker.

The second graph below assumes a loss of 10% of each year of interruption on the post-interruption wage salary, and then catch-up with the baseline scenario in five years.

Figure 8 - impact on the old-age benefit (convergent scenario)



Source: Source: Author's preparation; Notes: AW-=Average Wage, NMW= National Minimum Wage.

Identical to the first scenario, smaller breaks have little impact on the old-age pension entitlements. However, after three years of interruption, the pension entitlement can be reduced by 5% with three years break to 37% with 15 years break for workers covered by unemployment program and from 8% with three years breaks to 49% with 15 years break for workers not covered by unemployment program for all profile's earnings.

There is an evidence for the inadequacy of the actual Portuguese pension model for nonstandard workers with more frequent interruptions on their career compared with the standard workers, and in this case, these workers could lose between 2% to 50% of the pension entitlement depending on the length of interruptions. There is also evidence for nonstandard workers not covered by the unemployment program that can lose more than 5% to 12% compared with average workers with the same length of periods breaks during the active life.

In summary, the study reaches the same conclusion has Bravo (Herce & Bravo, 2017). The existence of contribution credits arrangements somehow protects workers from losing pension entitlements, and the multiple breaks have a higher impact than the single breaks, more frequent interruptions have a more significant impact on the pension entitlements, and the actual DB system is inadequate for nonstandard workers.

Are other models better off than the DB model of applied by the Portuguese old-age pension scheme?

The tables below show the percentage of reduction on the old-age pension entitlements based on the Baseline scenario and the "convergent earnings" scenario.

Table 4 - Reduction on pension entitlements by model – Baseline Scenario

1 yr multiple breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan	0%	-2%	-7%	-7%	-7%	-7%	-7%	-7%
NDC Plan	0%	-2%	-7%	-7%	-7%	-7%	-7%	-7%
Basic Pension + Cash Balance	0%	-4%	-7%	-7%	-7%	-7%	-7%	-7%
Floor Offset Plan (DC)	0%	-3%	-7%	-7%	-7%	-7%	-7%	-7%
Points Systems	0%	-2%	-7%	-7%	-7%	-7%	-7%	-7%

2 yrs multiple breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan	0%	-5%	-15%	-14%	-14%	-14%	-14%	-14%
NDC Plan	0%	-5%	-15%	-14%	-14%	-14%	-14%	-14%
Basic Pension + Cash Balance	0%	-9%	-14%	-14%	-14%	-14%	-14%	-14%
Floor Offset Plan	0%	-6%	-15%	-14%	-14%	-14%	-14%	-14%
Points Systems	0%	-5%	-14%	-14%	-14%	-15%	-15%	-15%

3 yrs multiple breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan	0%	-10%	-22%	-22%	-22%	-22%	-22%	-22%
NDC Plan	0%	-9%	-22%	-22%	-22%	-22%	-22%	-22%
Basic Pension + Cash Balance	0%	-14%	-21%	-20%	-21%	-22%	-21%	-21%
Floor Offset Plan (DC)	0%	-10%	-22%	-22%	-22%	-22%	-22%	-22%
Points Systems	0%	-10%	-21%	-21%	-21%	-22%	-22%	-22%

4 yrs multiple breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan	0%	-18%	-30%	-29%	-29%	-29%	-29%	-29%
NDC Plan	0%	-16%	-30%	-29%	-29%	-29%	-29%	-29%
Basic Pension + Cash Balance	0%	-21%	-28%	-27%	-28%	-29%	-28%	-28%
Floor Offset Plan (DC)	0%	-18%	-30%	-29%	-29%	-29%	-29%	-29%
Points Systems	0%	-17%	-29%	-29%	-29%	-30%	-30%	-30%

5 yrs multiple breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan	0%	-25%	-38%	-37%	-37%	-37%	-37%	-37%
NDC Plan	0%	-22%	-38%	-37%	-37%	-37%	-37%	-37%
Basic Pension + Cash Balance	0%	-28%	-36%	-34%	-35%	-36%	-35%	-35%
Floor Offset Plan (DC)	0%	-26%	-38%	-37%	-37%	-37%	-37%	-37%
Points Systems	0%	-25%	-37%	-37%	-37%	-37%	-37%	-37%

Source: Author's preparation; Notes: DB=Defined Benefit; NDC=Notional Defined Contribution; DC (or FDC)=Funded Defined Contribution; AW-=Average Wage, NMW= National Minimum Wage.

The loss of pension entitlement is lower for the average worker since the study assumed that the Portuguese unemployment program does not cover the nonstandard worker. All the models have similar losses on the pension entitlements—the same situation for the "convergent" scenario, as shown below. However, for the "Points Systems" there is a maximum loss reduction of 37% for higher earnings profile because of the ceiling amount. In summary, the other pension models like the current DB Portuguese pension model shows evidence of significant pension entitlement losses for the nonstandard workers and biased differences between the average workers and nonstandard workers.

Table 5 - Reduction on pension entitlements by model – Convergent Scenario

1 yr multiple breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan	0%	-3%	-8%	-8%	-8%	-8%	-8%	-8%
NDC Plan	0%	-3%	-8%	-8%	-8%	-8%	-8%	-8%
Basic Pension + Cash Balance	0%	-5%	-8%	-7%	-8%	-8%	-7%	-7%
Floor Offset Plan (DC)	0%	-3%	-8%	-8%	-8%	-8%	-8%	-8%
Points Systems	0%	-3%	-8%	-8%	-8%	-7%	-7%	-7%

2 yrs multiple breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan	0%	-8%	-17%	-17%	-17%	-17%	-17%	-17%
NDC Plan	0%	-7%	-17%	-17%	-17%	-17%	-17%	-17%
Basic Pension + Cash Balance	0%	-11%	-16%	-16%	-16%	-16%	-16%	-15%
Floor Offset Plan	0%	-8%	-17%	-17%	-17%	-17%	-17%	-17%
Points Systems	0%	-8%	-16%	-16%	-16%	-15%	-15%	-15%

3 yrs multiple breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan	0%	-15%	-27%	-26%	-26%	-26%	-26%	-26%
NDC Plan	0%	-13%	-27%	-26%	-26%	-26%	-26%	-26%
Basic Pension + Cash Balance	0%	-19%	-26%	-24%	-26%	-26%	-25%	-23%
Floor Offset Plan (DC)	0%	-15%	-27%	-26%	-26%	-26%	-26%	-26%
Points Systems	0%	-14%	-26%	-26%	-26%	-22%	-22%	-22%

4 yrs multiple breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan	0%	-25%	-35%	-37%	-34%	-37%	-37%	-37%
NDC Plan	0%	-22%	-38%	-37%	-37%	-37%	-37%	-37%
Basic Pension + Cash Balance	0%	-30%	-37%	-34%	-36%	-36%	-34%	-32%
Floor Offset Plan (DC)	0%	-26%	-38%	-37%	-37%	-37%	-37%	-37%
Points Systems	0%	-26%	-37%	-37%	-37%	-30%	-30%	-30%

5 yrs multiple breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan	0%	-37%	-47%	-48%	-46%	-49%	-49%	-49%
NDC Plan	0%	-33%	-50%	-49%	-49%	-49%	-49%	-49%
Basic Pension + Cash Balance	0%	-43%	-49%	-44%	-48%	-47%	-45%	-40%
Floor Offset Plan (DC)	0%	-38%	-50%	-49%	-49%	-49%	-49%	-49%
Points Systems	0%	-38%	-50%	-50%	-50%	-37%	-37%	-37%

Source: Author's preparation; Notes: DB=Defined Benefit, NDC=Notional Defined Contribution, DC (or FDC)=Funded Defined Contribution; AW-=Average Wage, NMW= National Minimum Wage.

How should be the Portuguese pension scheme design to fit within the context of the future of work?

The adequacy of a pension model measured by the level of replacement ratio, i.e., lower replacement ratio measures imply an inadequate pension model, and higher replacement ratios better the adequacy of the pension model. On the other hand, the actuarial fairness, as described in section three, measures the fairness between the contributions and the benefit of the pension model. Lower the actuarial fairness measure better is the balance between the inflows and outflows of the pension model, and higher is the actuarial fairness measure more unbalanced is the link between outflows and inflows of the pension model. Therefore, the best model should have the maximum replacement ratio and the minimum actuarial fairness measures, and it is the balance between these two measures that we may find the optimal pension model. Additionally, higher actuarial fairness measures for lower earnings profiles and lower actuarial fairness measures for higher profile earnings implies a distributiveness feature of a pension model within generations.

The current replacement ratios and actuarial fairness measures of the DB Portuguese model for the different profiles assuming no interruptions in work are as follows:

Table 6 – Measures scores for the current Portuguese DB plan by profile

Profile	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan							
Replacement Ratio	46%	45%	50%	46%	45%	45%	44%
Actuarial Fairness	96%	131%	149%	132%	127%	124%	120%

Source: Author's preparation; Notes: DB=Defined Benefit; Measure Score defined on section 3.2.; AW-=Average Wage, NMW= National Minimum Wage.

The actuarial fairness measure for the average worker is lower compared with the other profiles due to the slightly higher contributions rates during active life period. There is little redistribution within generations in the DB Portuguese model since the variance of the actuarial fairness measures between higher earnings profiles, and lower earnings profile is minimal. However, the actuarial fairness measures are considerably higher for all earnings profile putting in cause the sustainability of the actual pension model. In summary, the major issue of the DB pension model in Portugal is the considerable higher actuarial fairness measures between all profiles and low levels of redistribution within the same generation. Therefore, the first step to design a pension model adequate for nonstandard and standard workers is to have lower actuarial fairness measures for higher earnings profiles and increase the levels of redistribution within the same generation.

What would be the actuarial fairness for other pension models with the same replacement ratio measures as the DB plan of Portugal for the average worker?

The models are easily adjusted to obtain the same replacement ratio measure of the current DB Portuguese DB plan by readjusting the parameters of each pension model for the average worker.

For the NDC pension model, a replacement ratio of 46% attained for an average worker by setting up the notional asset return to 3% and discount rate used on the notional conversion factor to 3.25% instead of the assumed hypothetical discount rate of 3.00%.

Table 7 – Comparison measures scores by profile (DB versus NDC)

Breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan								
Replacement Ratio	46%	46%	45%	50%	46%	45%	45%	44%
Actuarial Fairness	96%	96%	131%	149%	132%	127%	124%	120%
NDC Plan								
Replacement Ratio	46%	46%	38%	39%	39%	39%	39%	39%
Actuarial Fairness	88%	88%	84%	86%	86%	86%	86%	86%

Source: Author's preparation; Notes: Pure DB=the current Portuguese Defined Benefit plan; NDC plan = Notional Defined Plan; Measure scores defined on section 3.2.; AW-=Average Wage, NMW= National Minimum Wage.

The actuarial fairness slightly improved for the average worker but not sufficiently enough to be considered a significant advantage. However, for the nonstandard workers, the actuarial fairness measures improved considerable, but the replacement ratio measure decrease between 5 to 10 basis points. The redistributive level within generations by analysed the difference in variances of the actuarial fairness measures between profiles is inexistent on this type of model.

For the DC pension model, a replacement ratio of 46% attained for an average worker by assuming a return on assets by 2.90% p.a.

Table 8 – Comparison measures scores by profile (DB versus DC)

Breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan								
Replacement Ratio	46%	46%	45%	50%	46%	45%	45%	44%
Actuarial Fairness	96%	96%	131%	149%	132%	127%	124%	120%
Floor Offset Plan (DC)								
Replacement Ratio	46%	46%	38%	39%	39%	39%	39%	39%
Actuarial Fairness	20%	20%	20%	20%	20%	20%	20%	20%

Source: Author's preparation; Notes: Pure DB=the current Portuguese Defined Benefit plan; DC (or FDC) plan = Funded Contribution Defined Plan; Measure scores defined on section 3.2.; AW-=Average Wage, NMW= National Minimum Wage.

There is evidence that the DC model is a pension design more attractive than the DB model in terms of sustainability because it has shallow actuarial fairness measures for all profiles. The reason is that the risk is within the workers. The 20% actuarial fairness is due mostly due to the difference between the actuarial factor used to convert the accumulated contributions into an annuity and the expected average lifetime of an individual at age 66.5 years. Like the NDC model, the replacement ratio is lower for nonstandard works compared with the Portuguese DB plan, and the redistribution within a generation is inexistent. However, the most significant advantage for the DC plan is the contributions made by the taxpayers are invested and consequently capitalised, and the contributions under the NDC used directly to pay the pension to the current pensioners. This has an impact of around 70% increase on the actuarial fairness measure.

For the Swiss pension model, a replacement ratio of 46% attained for an average worker by changing the minimum pension factor to 1.65 (parameter of the Basic Plan).

Table 9 – Comparison measures scores by profile (DB versus Basic Plan+Cash Balance Plan)

	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Actual DB Plan								
Replacement Ratio	46%	46%	47%	53%	48%	43%	40%	35%
Actuarial Fairness	97%	97%	139%	164%	140%	117%	101%	77%
Swiss Plan - Basic Pension+Cash Balance								
Replacement Ratio	46%	46%	50%	60%	51%	40%	37%	32%
Actuarial Fairness	66%	66%	109%	147%	107%	65%	51%	30%

Source: Author's preparation; Notes: Pure DB=the current Portuguese Defined Benefit plan; Measure scores defined on section 3.2.; AW-=Average Wage, NMW= National Minimum Wage.

There is evidence that the Swiss model is better compared with the DB Portuguese model by scoring high on all measures. The replacement ratio measures are higher for lower earnings than for higher earnings. The actuarial fairness measures are significantly better comparing with the DB Portuguese model, and there is a better equilibrium between replacement ratio and actuarial fairness measures. For higher earnings, the replacement ratio is lower compared with the Portuguese DB plan because of the maximum pension limit on the basic pension.

For the Points System, a replacement ratio of 46% attained for the average worker by changing the pension value to 16.75 euros.

Table 10– Comparison measures scores by profile (DB versus Basic Plan + Points Systems)

Breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan								
Replacement Ratio	46%	46%	45%	50%	46%	45%	45%	44%
Actuarial Fairness	96%	96%	131%	149%	132%	127%	124%	120%
Points Systems								
Replacement Ratio	46%	46%	45%	46%	46%	31%	23%	16%
Actuarial Fairness	97%	97%	131%	131%	131%	100%	100%	100%

Source: Author's preparation; Notes: Pure DB=the current Portuguese Defined Benefit plan; Measure scores defined on section 3.2.; AW-=Average Wage, NMW= National Minimum Wage.

The results for the points system pension models are identical to the DB Portuguese plan for all profiles except for the higher earnings because of the ceiling, but this also gives the possibility for higher-earning profiles to save the excess in a private pension scheme.

In summary, somehow all models were better off than the actual DB Portuguese model in terms of actuarial fairness measures, but in terms of adequacy, the DB Portuguese model is slighter better than the other models except for the Swiss model for lower earnings profile and the average worker.

Could we change the parameters of the DB Portuguese model to improve the actuarial fairness and keep the same replacement ratio for average workers?

The answer is yes. By setting up higher accrual rates for the 1st tier from 2.30% p.a. to 2.50% p.a. and lower accrual rates for the 3rd tier, 4th tier and 5th tier from 2.20%, 2.10%, 2.00% to 2.00%, 1.50% and 0.75%, respectively.

Table 11 – Comparison measures scores by profile (Actual DB versus DB with new parameters)

Breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan								
Replacement Ratio	46%	46%	45%	50%	46%	45%	45%	44%
Actuarial Fairness	96%	96%	131%	149%	132%	127%	124%	120%
Pure DB plan - new accrual rates								
Replacement Ratio	46%	46%	47%	53%	48%	43%	40%	35%
Actuarial Fairness	97%	97%	139%	164%	140%	117%	101%	77%

Source: Author's preparation; Notes: DB= Defined Benefit plan; Measure scores defined on section 3.2.; AW-=Average Wage, NMW= National Minimum Wage.

Changing the DB plan for higher rates for lower tiers and lower rates for higher tiers would improve the actuarial fairness levels for higher profile earners and the redistributive levels within generations but still with very high actuarial fairness measures producing an unbalance scenario between contribution (inflows) and benefit (outflows) of the model in the long term. The replacement ratio decreased for higher earnings profiles from 5 to 10 basis points. With these parameters for the DB plan, the replacement ratio measures are like the Swiss models, but the actuarial fairness measures for the Swiss models are still considerably lower than the DB model as shown in the figure above making the Swiss model much more attractive.

Table 12 – Comparison measures scores by profile (DB with new parameters versus Cash Balance)

Breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Pure DB plan								
Replacement Ratio	46%	46%	47%	53%	48%	43%	40%	35%
Actuarial Fairness	97%	97%	139%	164%	140%	117%	101%	77%
Basic Pension + Cash Balance								
Replacement Ratio	46%	46%	49%	58%	50%	41%	38%	34%
Actuarial Fairness	47%	47%	81%	109%	79%	48%	38%	22%

Source: Author's preparation; Notes: DB= New Defined Benefit plan; Measure scores defined on section 3.2.; AW-=Average Wage, NMW= National Minimum Wage.

The reason for lower replacement ratio for the Swiss plan is the limit of the Basic Pension as the figure below illustrates.

Table 13 – Replacement Ratio by sub-Plan (Swiss model= Basic Pension + Cash Balance)

Replacement Ratio	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Basic Plan	23%	23%	27%	35%	27%	18%	15%	11%
Cash Balance	23%	23%	22%	23%	23%	23%	23%	23%
Total	46%	46%	49%	58%	50%	41%	38%	34%

Source: Author's preparation; Notes: Basic Plan= Defined Benefit type plan; Replacement Ratio defined on section 3.2.; AW-=Average Wage, NMW= National Minimum Wage.

Based on the above, there is evidence that the Swiss model is a better start for an optimal model with a better balance between replacement ratio and actuarial fairness. The next question to support us on the quest for an optimal model would be: *What is the reason for the Swiss model to be better off than the other models?*

The Swiss model integrated with two sub-models, the first model a DB plan (Basic Plan) and a second model a cash balance plan. Both sub-models complement each other. The figure below shows the replacement ratio and actuarial fairness measures separately for each sub-model.

Table 14 – Measure score for Swiss plan (Basic Pension + Cash Balance)

Breaks of work impact	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Basic Plan								
Replacement Ratio	23%	23%	27%	35%	27%	18%	15%	11%
Actuarial Fairness	95%	95%	223%	319%	220%	116%	82%	30%
Cash Balance								
Replacement Ratio	23%	23%	22%	23%	23%	23%	23%	23%
Actuarial Fairness	19%	19%	19%	19%	19%	19%	19%	19%

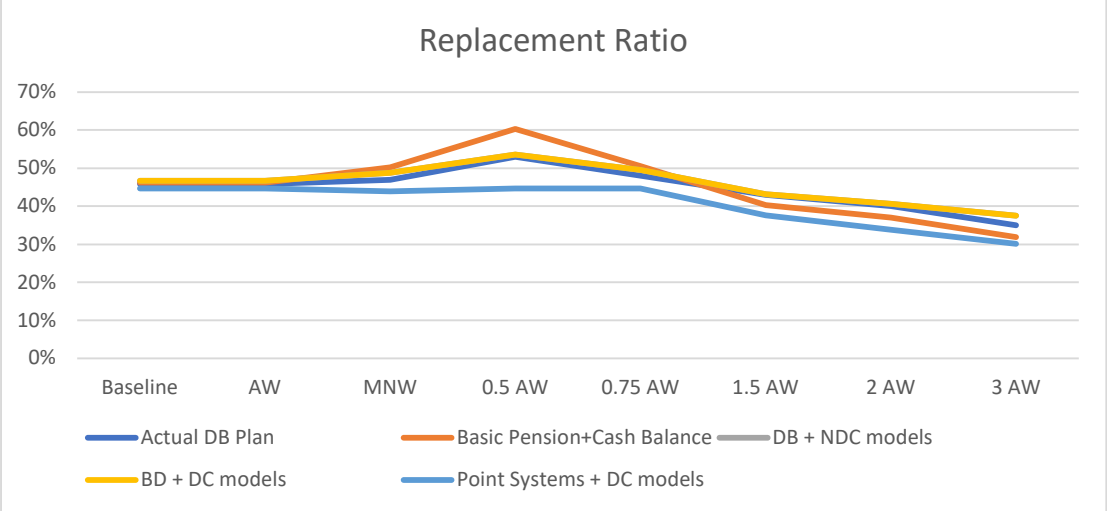
Source: Author's preparation; Basic Plan= Defined Benefit type plan; Measure scores defined on section 3.2.; AW-=Average Wage, NMW= National Minimum Wage.

The cash balance alone would behave exactly like the DC or NDC pension models without redistribution within the generation and with lower replacement ratios compared with the DB Portuguese model. The sub-model Basic pension (DB type of model) introduced by the Swiss model increased the replacement ratio and provided the retribution feature important for any social security coverage. These two sub-models combined as a single model have better measures as the DB plan and all other models alone or with a minimum pension guarantee.

What would happen if we combine the models?

There is evidence that combining the models will have the same effect as the combined swiss model; therefore, the optimal model will be likely a combination of two or more pension models. The second model always behaves as a constant for all profiles and a first model providing the redistribution feature to the model.

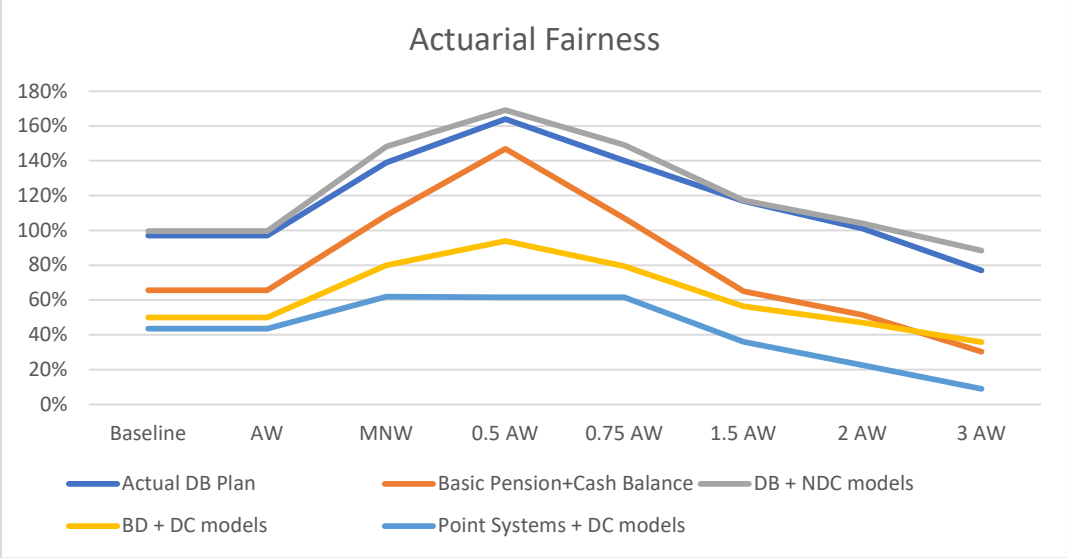
Figure 9 – Replacement Ratio measure by model and profile



Source: Author's preparation; DB= Defined Benefit; DC=Defined Contribution; AW-=Average Wage, NDC= Notional Defined Contribution; NMW= National Minimum Wage; Replacement Ratio measure defined on section 3.2.

The combination of the "BD+DC" models and the "DB+NDC" have the same replacement ratio, but the actuarial fairness is different since, under the NDC plan, the savings are not capitalised. The replacement ratio measure for the combination of the "Points systems + DC models" are the lowest, but the actuarial fairness measure is also the lowest.

Figure 10 – Actuarial Fairness measure by model and profile



Source: Author's preparation; DB= Defined Benefit; DC=Defined Contribution; AW-=Average Wage, NDC= Notional Defined Contribution; NMW= National Minimum Wage; Actuarial Fairness measure defined on section 3.2.

The Swiss model still is the most balanced models with a better equilibrium between the replacement ratio and actuarial measures, but this does not mean that the other combined other models would be considered out the equation since by adjusting the parameters of all other combined models maybe we could get better results. Maybe we should take a mathematical approach, and this is just an optimal problem with the objective function being the combined pension models.

For illustration purposes, the Swiss model is used in order to provide an answer to the third research question related to the design of the pension model within future of work, but other combination of models could be used with the right parameters. The next two questions would be:

What adjustment needs to be made to the model to have more adequate levels for nonstandard workers? Could we perform an adjustment to one of the sub-models in order to compensate to loss old age pension entitlement due to interruptions of work?

By adjusting the Basic Plan (the DB sub-model) from a Basic Pension to Target Benefit as defined in the literature review but the target benefit depending only on the average pensionable salary, i.e. not depending on the pensionable service, the model would obtain much better adequacy measure for nonstandard workers.

The table below shows a comparison of the replacement ratio and actuarial fairness measures between the actual DB Portuguese plan and the combined Target plan (DB type) and the Cash Balance plan.

Table 15 – Comparison measures scores by profile (Actual DB Portuguese plan versus Newly Targeted Plan + Cash Balance)

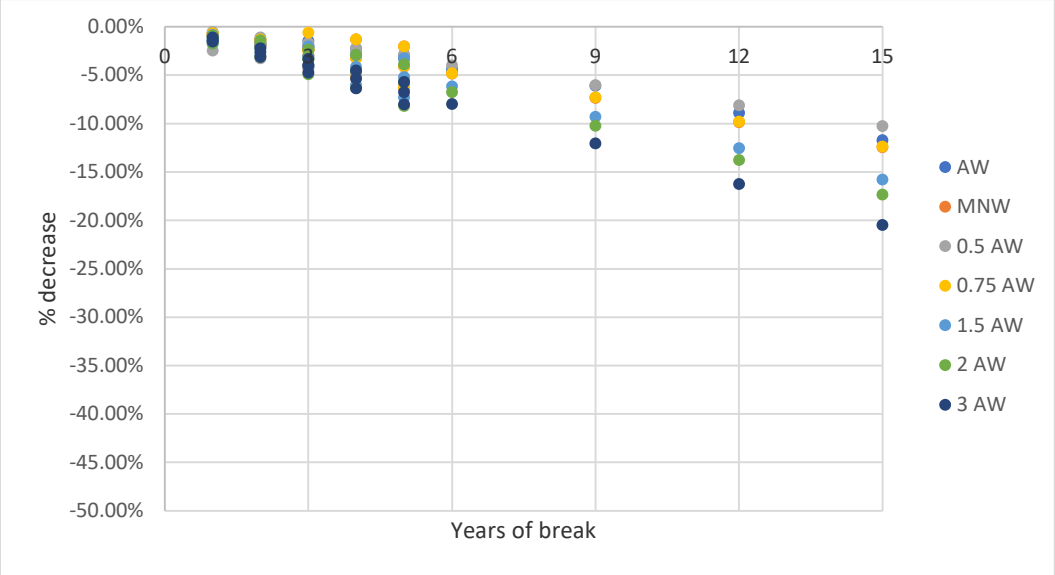
	Baseline	AW	MNW	0.5 AW	0.75 AW	1.5 AW	2 AW	3 AW
Actual DB Plan								
Replacement Ratio	46%	46%	47%	53%	48%	43%	40%	35%
Actuarial Fairness	97%	97%	139%	164%	140%	117%	101%	77%
Swiss Plan - Basic Pension+Cash Balance								
Replacement Ratio	52%	51%	56%	69%	57%	44%	40%	34%
Actuarial Fairness	86%	85%	139%	186%	137%	85%	68%	42%

Source: Author's preparation; Notes: Actual DB= Current Portuguese Defined Benefit plan; Measure scores defined on section 3.2.; AW-=Average Wage, NMW= National Minimum Wage.

The actuarial fairness measures are slightly higher for lower earnings profile but much lower for Higher earnings profiles. In the other hand, the replacement ratio is higher for all profiles except for higher-profile earnings which are similar.

Based on this model, the impact on the nonstandard works would be as follows:

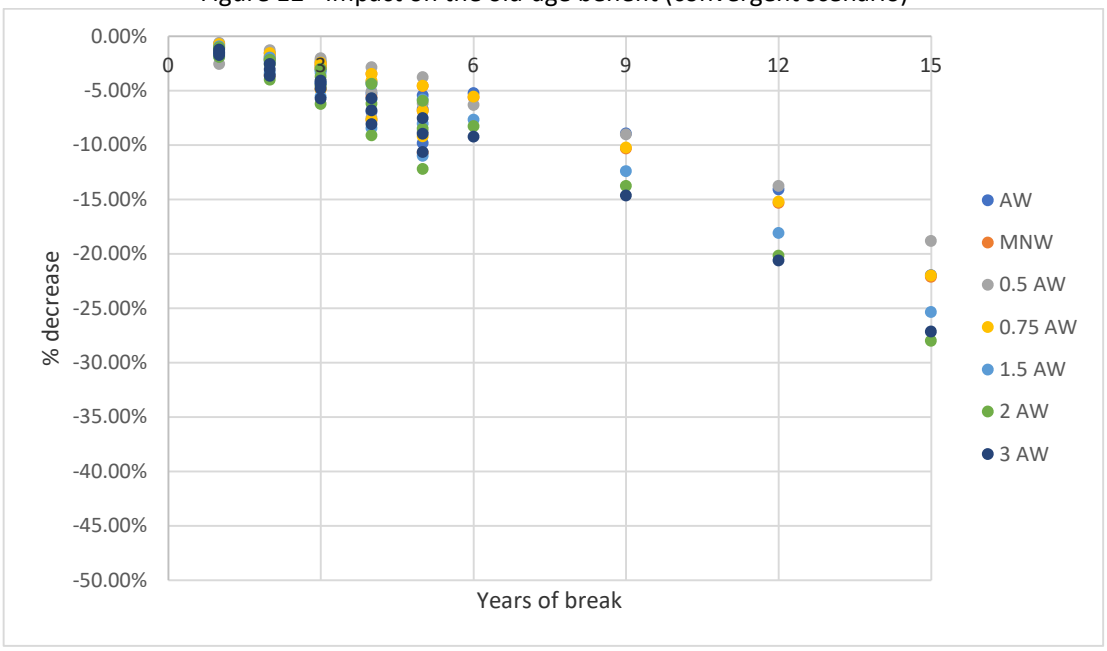
Figure 11 - Impact on the old-age benefit (Baseline scenario)



Source: Source: Author's preparation; Notes: AW-=Average Wage, NMW= National Minimum Wage.

The pension entitlement loss under this scenario for lower earnings is 10% with 15 years of multiple interruption service compared with the 25% for the actual DB plan. For higher earnings, the loss would vary between 15% to 20% but still must more acceptable compared with the current pension Portuguese model. The results would also be more satisfactory than the actual Portuguese model assuming a loss of 10% of each year of interruption on the post-interruption wage salary, and then catch-up with the baseline scenario in five years. The loss for higher earnings profile is between 25% to 27%, and for lower earnings profiles would be lower than 25% with 15 years multiple breaks.

Figure 12 - Impact on the old-age benefit (convergent scenario)



Source: Source: Author's preparation; Notes: AW-=Average Wage, NMW= National Minimum Wage.

Therefore, the adjusted Swiss plan model could be a candidate pension model for standard and nonstandard worker keeping the same and, in some cases, better adequacy levels compared with the actual DB Portuguese model, but with much better fairness levels. The model could be further improved for nonstandard workers by removing the fix retirement age and let the individual decided the age of retirement based on the progression of the adequacy of the old-age pension entitlement, and open the possibility of partially receiving the old-age pension instead full pension and continue to contribute to accumulated vested rights into the future. These two features are already established in the Sweden pension model.

By answer the third research question, the results show that there are ways to design a pension model within the future of work. However, the pension model would at least to have the following three features in order to be adequate for nonstandard workers:

- A model should be a combination of two sub-models. A first-tier model with DB type, and second-tier model with DC/NDC or cash balance type in order to achieve a fair balance between actuarial fairness and replacement ratio measures; The cash balance would be preferable since the contributions are invested and consequently capitalised, and there is a minimum guarantee return on the accumulated contributions.
- The first-tier model DB should not be designed around the pensionable service and should design like a pure beverage model; The second-tier models designed like a Bismarck model.
- The normal retirement age should be flexible and introduced the concept of partial retirement and allow to continue to contribute to the system like the Sweden model.

The combination of these three features would provide a better equilibrium to the pension model, and the model would become more resilient to pension entitlement losses due to interruptions of work.

5. CONCLUSIONS

This work aimed to design an old-age pension model in Portugal that would be adequate for nonstandard workers. Based on the literature review, most of the academic research studies have been around sustainability, and most of the studies focused on the impact of changing the parameters of the Portuguese pension model. Studies related to the impact on beneficiaries pension considering the future of work in the Portuguese pension model is scarcer with exceptions like the study performed by Bravo with the impact of interruptions of work in the retirement pension entitlement.

We started our study by answer our first research question – *Why doesn't the current Portuguese pension scheme fit well within the context of the future of work?* The research results arrived at the same conclusion has Bravo, the current Portuguese pension system is inadequate for nonstandard workers with more frequent interruptions in their active career. The loss of the old-age pension entitlement could be from 5% to 50% compared with a worker without breaks, and this decrease on the pension entitlement is uniform for all earnings profiles. The results also show that for the same interruption period length there is a difference from 5% to 12% of decrease on the pension entitlement between a nonstandard worker compared to an average worker covered by the social security unemployment program.

The next step of the journey was to understand the effect of interruption of work on other pension models considered for this study – Defined Contribution (DC), Notional Defined Contribution (NDC), Points Systems and the Swiss model with a combination of two models - Defined Benefit (the basic plan) and a Cash Balance plan. The study concluded that all these pension models had the same levels of inadequacy for the nonstandard workers as the current Portuguese DB plan with a slight difference between higher profile earnings.

Once the study concluded that the DB Portuguese actual system and other pension models were not adequate for nonstandard workers, we went on our pursuit to answer the third research question –

How should the Portuguese pension scheme design in order to fit within the context of the future of work? - we studied close each of the pension models considered in the study and tried to understand what pension model would be a better fit for an average standard worker and the reasons for that. We used two measures – replacement ratio and actuarial fairness. The replacement ratio to measure the adequacy of the pension model, i.e., the higher the replacement ratio measures, the most adequate is the pension model. The actuarial fairness is determined to measure the fairness related to the link between contributions and benefits of the pension model. The lowest the actuarial fairness measure the fairest is the pension model related to the link between the contributions and benefits. Additionally, the actuarial fairness measure also the levels of distributiveness of the model within the same generation. The pension model is a redistributive model when scores higher actuarial fairness measures for lower-earning profiles in detriment to the higher-earning profiles. We set the replacement ratio target to be equal to the current replacement ratio of the DB Portuguese model for an average worker in Portugal which is around 46%. Next, we adjusted the parameters of each pension model to reach a replacement ratio target of 46% for an average worker and compared the performance measures against the measures of the Portuguese pension model. In line with the study performed by Pina, the NDC model is more sustainable than the Portuguese model but with lower adequacy levels for nonstandard workers profiles due to lower contribution rates. Additionally, there is no redistribution within the generation for the NDC model. The DC plan had similar adequacy level like the NDC but with the best actuarial fairness measures compared with all the models in the study

since the risk is fully transferred to the citizens and therefore, not fully adequate for a protection social security system. The points systems, as used in Germany, was very close to the measures of the DB Portuguese model for average workers and lower earnings profiles. For higher earnings profiles, the adequacy levels reduced but also an increase in the sustainability levels due to the ceilings amounts. The pension model that had better measures scores was the Swiss model with the adequacy levels in line with the Portuguese model and, in the same cases, better for lower earnings profiles, and with a much long-term sustainability level. This pension model also scored high related to redistributive levels within the same generation. In summary, we concluded that would be an advantage for Portugal to analysed other structures, and pension models design that would provide the same current levels of adequacy but with better fairness levels, i.e., we concluded that exists pension models better than the current DB Portuguese model. The biggest weakness of the actual DB Portuguese is very high actuarial fairness measures and lowest levels redistribution within the same generations. We concluded that by readjust the parameters giving higher accrual rates to the first tiers and lower rates to higher tiers, the actual model could reach better results but still with unsustainability levels compared with the Swiss model and other models.

The Swiss model was the better fit for average workers since the pension model is a combination of two sub-models plans- a DB type of plan plus a cash balance plan. The cash balance standalone plan would provide the same measures as the NDC/DC models with no redistribution levels within the same generation and with slighter lower adequacy levels. The cash balance model was balanced by introducing of a sub-model with DB nature reaching better adequacy and distributiveness levels. We concluded that combined two plans – one first plan like a Beverage type model and second plan, to complement the first plan, like a Bismarck type of plan would improve the adequacy and fairness levels of the model.

The final step of the journey was readjusting the Basic Plan of the Swiss model not to be a function of the pensionable service. By making this adjustment to the model, we were able to reach an adequate model for nonstandard workers. The loss of pension entitlement decreased significantly due to interruptions of work and with much less impact for lower-earning profiles. Therefore, in line with the literature review, we concluded that a model with two tiers – the first tier a pure Beveridge model with higher benefits for lower earnings profile to compensate the lowest access to the Bismarck plan, and a second-tier as Bismarck plan would be a better start for the ideal pension model. Of course, the parameters should be chosen in order to minimise the actuarial fairness once a replacement ratio target is defined and correlated with the economic and demographic factors.

In summary, we learned the following:

Why doesn't the current Portuguese pension scheme fit well within the context of the future of work?

- Baseline Scenario: The average worker covered by the unemployment insurance, the old-age pension can be reduced by 1% to 25% as the interruption increase from 1 to 15 years, and for workers not covered by unemployment insurance, the old-pension entitlement reduced between 2% to 35% as the interruption increase from 1 to 15 years for all profile's earnings.

- Convergent scenario: The pension entitlement can be reduced by 5% with three years break to 37% with 15 years break for workers covered by unemployment insurance and from 8% with three years breaks to 49% with 15 years break for workers not covered by unemployment insurance for all profile's earnings.

Are other models better off than the DB model of applied by the Portuguese old-age pension scheme?

- All models (NDC Plan, Swiss plan, DC plan, and Point systems) had an impact on the pension entitlement as the DB Portuguese plan. The losses vary between 2% to 37% for the baseline scenario and between 3% to 49% for the convergent scenario.

How should be the Portuguese pension scheme design to fit within the context of the future of work?

- The replacement ratio and actuarial fairness used to measure the performance of the models. The replacement ratio indicated the adequacy of the pension model and the actuarial fairness shows the fair balance indices between the contributions and the benefits as well as the distributiveness levels of the pension model. The results show evidence that all four models used in the study have better measures that the Portuguese DB plan.

- The study shows that the performance of the models based on the two defined measures is easily adjusted by fine-tuning the parameters of the model. The DB Portuguese model would improve the actuarial fairness levels for higher profile earners and the redistributive levels within generations by setting up higher accrual rates for the 1st tier from 2.30% p.a. to 2.50% p.a. and lower accrual rates for the 3rd tier, 4th tier and 5th tier from 2.20%, 2.10%, 2.00% to 2.00%, 1.50% and 0.75%, respectively. Nevertheless, still with very high actuarial fairness measures producing an unbalance scenario between contribution (inflows) and benefit (outflows) of the model in the long term.

- The combination of the "BD+DC" models and the "DB+NDC" have the same replacement ratio, but the actuarial fairness is different since, under the NDC plan, the savings are not capitalized. The study shows evidence that by capitalized the contributions wold decrease between 65% to 70% the actuarial fairness measure.

- The "Swiss" model was the most balanced model with a better equilibrium between the replacement ratio and actuarial measures. The Swiss models based on a DB benefit (Basic Plan) plus a Cash Balance plan. Furthermore, the Swiss model obtained better adequacy measure for nonstandard workers by changing the basic plan to target benefit. The target benefit designed based on the average pensionable salary and not dependent on the pensionable service. The pension entitlement loss under the basic scenario for lower earnings is 10% with 15 years of multiple interruption service compared with the 25% for the actual DB plan. For higher earnings, the loss would vary between 15% to 20% but still must more acceptable compared with the current pension Portuguese model. The results are also more satisfactory for the convergent scenario where the loss for higher earnings profile is between 25% to 27%, and for lower earnings profiles would be lower than 25% with 15 years multiple breaks compared with the loss of 49% for the current DB model.

Based on the empirical results summarized above, we concluded the following:

1) **All standalone pension models are alike related to adequacy levels** (i.e. with the same replacement ratio measures) by adjusting the parameters—the difference between the models found in the sustainability levels and the respective actuarial fairness measures. The Cash Balance, DC and NDC plans are not redistributive within the same generation, and in general score lower in terms of actuarial fairness measures compare with DB plan and systems points, but this depends on the parameters. The DC or Cash Balance have better measures related to actuarial fairness since the contributions invested and consequently capitalised. The DB plans efficiently designed to introduce the redistributive feature within generations and increase the adequacy level for lower-earning profiles.

2) **A standalone pension model performs worse than a multiple pension model**. A model should have at least two sub-models with different types – Beveridge and Bismarck models. The integration of the two models would increase the adequacy and sustainability levels.

3) **The Bismarck and Beveridge model complement each other** and incorporating these two models into a single model with the optimal parameters would provide the four main principles of a pension model – poverty relief; redistribution, insurance and consumption smooth.

4) **Multiple models with at least two tiers could be more adequate for nonstandard workers**; however, the first sub-model DB plan should not be linked to the pensionable service like a Pure Beveridge model – a flat benefit and the second plan should be like a Bismarck plan.

5) **The contributions for the second-tier model benefits should be invested** - this has a decreasing effect of around 65% to 70% on the actuarial fairness measure.

6) **A mathematical approach should be taken in analysed the parameters of a pension model,** and maybe this resumes to an optimisation problem to find the optimal parameters for pension model - *What are the best parameters for each model in order to maximise the replacement ratio and minimise the actuarial fairness?*

7) **The parameters should be correlated with the economic and demographic factors** – the main drivers of the sustainability of the pension model;

The pension model could be further improved for nonstandard workers by removing the fix retirement age (that was used as an assumption) and let the individual decided the age of retirement based on the progression of the adequacy of the old-age pension entitlement, and open the possibility of partially receiving the old-age pension instead full pension and continue to contribute to accumulated vested rights into the future.

Having in mind the objectives of the study, propose a new design of a pension model within the new context of future of work, the main recommendations based on the conclusions of the study, would be as follows:

Paper conclusion	Recommendation change to the first-tier model of the public pension model	Effect
1. The Bismarck and Beveridge model complement each other; 2. Multiple models with at least two tiers could be adequate for nonstandard workers; 3. The contributions for the second-tier model benefits should be invested	Change the actual single DB plan to a multi-model with the first model to be a flat benefit (pure Beveridge plan) with a replacement ratio target between 35% to 40% and a second model to be a Cash Balance plan with a minimum guarantee return rate. The tax paid by the participant members redistributed between the two models, i.e., part of the tax payment would be to sponsor the flat benefit, and the other amount invested as a form of a contribution to the Cash Balance Plan.	This measure would improve the fairness related to the link between the contributions and benefit of the model and the adequacy levels for the nonstandard form of work.
4. A mathematical approach should be taken in analyzing the parameters of a pension model; 5. The parameters should be correlated with the economic and demographic factors	The parameters of the model should be based on a mathematical "optimal" problem. Established an objective pension based on the adequacy and fairness measures, and find out the parameter that maximizes the objective function. The parameters should be strongly correlated with demographic and economic factor.	This measure would improve the robustness of the pension models against demographic and economic shocks.

In Portugal, most of the discussions have been around parameters of the current DB pension model. However, there are already some investigators/professionals of the pension field like Bravo that are challenging the pension professionals to start to have a different perspective on Portuguese pension model and open the door for other better alternatives to the serious problem facing the actual pension model. The problem of the current DB model is a question of adequacy and sustainability, and there are already a few studies showed a better path for a pension model in Portugal. The successive governments have been postponing the redesign of the pension model Portugal because the problem is not immediate. However, the reform is inevitable, and the change from a DB to multiple models including a Bismarck plan will be necessary not only because the actual DB plan is unsustainability but also because of new standards forms of work.

Finally, it is important to stress that this paper focused only on the old-age risk coverage, but there is also an urgent need to redesign and rethink the other protection coverages provide by the Portuguese social security as such as unemployment, sickness and disability coverage for the non-standard workers.

6. LIMITATIONS AND RECOMMENDATIONS FOR FUTURE WORKS

The simulation performed on the cases studies were under a limit range of assumptions and based on an active male member, but the changing the assumptions on return on assets for the DC plan, the mortality table as well other assumptions could affect the results of the pension models, and this is a limitation of this study.

In this study, we also not mentioned the impact of the Gender, longevity, and the homogeneity factors on the models, and therefore, how should be a design of a model to incorporate all these factors and to be fair for all citizens – standard workers, nonstandard workers, females workers, males workers, Blue collars workers and white-collar workers.

In respect of recommendation of future works, the study shows some evidence that by changing the actual DB pension plan in Portugal to multiple models with DB plus DC type would improve the adequacy and sustainability levels for all workers inclusive nonstandard workers. However, this transition will not be possible without a detailed plan design for this transition. Part of the tax contributions for the sub-DC plan is distributed individually, therefore, reducing the level of redistribution between generations. The shortness of taxpayers to pay the current pensioners would provoke a disruption on the sustainability of the already fragile Portuguese DB model. Therefore, this should be a future study to consider how to transition from a DB plan to other plan design without disrepute all the pension system in Portugal.

Another study would be performing a mathematical study to find out a model that could calculate the optimal parameters of the different possible models to minimise the actuarial fairness measures as well as the portion of allocations of the contributions to each sub-model in case of a multiple pension model.

Finally, this paper showed evidence that multiple models with two sub-model provides better adequacy, sustainability and distributiveness measures but would be wise to analyse the behave of the multiple models with more than two models.

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8. ANNEXES

Annexe 1 – Pension Models and Unemployment Insurance in Portugal

The Portuguese DB model

The calculation of the pension benefit (P) in the Portuguese earnings-related public pension scheme based in the following accrued benefit formula at retirement age:

$$P = RE\ x\ A\ X\ SF$$

Where RE is the Reference Earnings, A the accrual Rate and SF the Sustainability Factor. The reference earnings are calculated by averaging monthly earnings for all years of coverage up to 40 years, adjusted according to the consumer price index (CPI). The Accrual rates vary from 2% to 2.3% depending on the individual earnings relative to the value of the IAS (Indexante dos Apoios Sociais) as follows:

Reference Earnings/IAS	**≤ 1.1**	**$> 1.1; \leq 2.0$**	**$> 2.0; \leq 4.0$**	**$> 4.0; \leq 8.0$**	**>8.0**
Accrual Rate	2.3%	2.25%	2.2%	2.1%	2.0%

For a given value of RE, the corresponding pension formula is as follows:

RE/IAS	**Pension Formula at Normal Retirement Age**
≤ 1.1	$P = RE\ x\ 2.3\%\ X\ N\ x\ SF$
$> 1.1; \leq 2.0$	$P = (1.1\ IAS\ x\ 2.3\% + (RE - 1.1IAS)\ x\ 2.25\%)\ x\ Nx\ SF$
$> 2.0; \leq 4.0$	$P = (1.1\ IAS\ x\ 2.3\% + 0.9IAS\ x2.25\% + (RE - 2IAS)\ x2.2\%)\ x\ Nx\ SF$
$> 4.0; \leq 8.0$	$P = (1.1\ IAS\ x\ 2.3\% + 0.9IAS\ x2.25\% + 2.2\%\ x\ 2IAS + (RE - 4IAS)\ x2.1\%)\ x\ Nx\ SF$
>8.0	$P = (1.1\ IAS\ x\ 2.3\% + 0.9IAS\ x2.25\% + 2.2\%\ x\ 2IAS + 2.1\%\ x\ 4IAS + (RE - 8IAS)\ x2.0\%)\ x\ Nx\ SF$

Note: N = Number of contributions years

The sustainability factor is a demographic factor designed to adjust pension benefit to longevity changes. This factor calculated on an annual basis by dividing overall population life expectancy at age 65 in 2000 and the one recorded in the year before the pension claim:

$$SF_t = \frac{e_{65:2000}}{e_{65:t-1}}$$

The contributions to finance the old-age benefit based on the current contributions schedule in Portugal, i.e., for a standard worker is a total combined contribution (employer plus employee) of 34.75% which 20.21% finances old-age benefit (ssa.gov). For a non-standard worker (assumed to be self-employed) is 29.6%, and we estimated to be 17.21% to sponsor old-age benefit based on the proportion of the contribution for a standard worker.

The NDC model (inspired by the Sweden Model)

The NDC model analysed on this study is based on the current Sweden Model, where the primary pension entitlement came from a Notional Defined Contribution supplemented by a small portion of a Funded Defined Contribution (FDC). The old-age pension entitlement from the NDC model based on the following formula:

$$P_{NDC} = \frac{Acumulated\ Notional\ Balance}{AN}$$

The Notional Accumulated Balance is accrued based on the following formula:

$$Acumulated\ Notional\ Balance\ = \sum_{i=1}^{N} cw_i(1+r_i)^{N-i}$$

Where, w_i, individual reference earnings in year i, and c is the contribution rate. The notional capital is increased each year by the notional interest rate, r assumed to be 2% p.a..

The notional actuarial annuity factor AN at age retirement age estimated based o the mortality table as defined in section 3, and a hypothetical discount rate of 3.00% p.a.

The old-age benefit is supplemented by a defined contribution plan, with lower contribution rates, and where the pension entitlement is calculated by dividing the accumulated contribution at retirement age by the expected future lifetime at retirement age, a_{ret}, to estimate a pension benefit at retirement age:

$$P_{DC} = \frac{AC_{Ret}}{a_{ret}}$$

The accumulated contributions at retirement age is as follows:

$$AC_{Ret} = \sum_{i=1}^{N} cw_i(1+Cap_i)^{N-i}$$

Where, Cap_i, the capitalization of the contributions based on a return rate of 3.00 p.a. The total pension entitlement for the NDC model is as the sum of the two pensions descrived above, i.e.

$$P = P_{NDC} + P_{DC}$$

The contributions to finance the old-age benefit for the NDC model:

Contributions Rate (c)	Standard worker	Non-Standard Worker
NDC Plan	17.71%	14.71%
DC Plan	2.50%	2.50%
Total contributions under NDC model	**20.21%**	**17.21%**

The DC model (inspired by the Venezuelan Model)

The DC model considered in this study inspired by the Venezuelan model (Floor-offset plan) where the old-age pension entitlement based on a pure DC plan, where the pension entitlement is as follows:

$$P_{DC} = \frac{AC_{Ret}}{a_{ret}}$$

Where, a_{ret}, the expected future lifetime based on the mortality table defined in section 3, and AC_{Ret}, defined as:

$$AC_{Ret} = \sum_{i=1}^{N} cw_i(1 + Cap_i)^{N-i}$$

Where, Cap_i, the capitalization of the contributions based on the assumed return rate defined in section 3, and w_i, individual reference earnings in year i, and c, the contribution rate.

However, the old-age pension entitlement cannot be lower the Reference Salary at retirement (RE_{ret}) times the number of contributions years (N), I,e,

$$P = \max(P_{DC}, RE_{ret}\ N)$$

The contribution rate (c) is assumed to be equal to the current contribution made to finance the old-age benefit in Portugal, i.e., for a standard worker is 20.21%, and for a non-standard worker is 17.21%.

The Systems Point model (inspired by the German Model)

The systems points system considered in this study is based on the German model. The old-age pension entitlement at retirement age is as follows:

$$P = v_N \times Accumulated\ Points$$

Where, v_N, is the point value at retirement age, and the accumulated points are the sum of the points through total contributions years. N.

$$Accumulated\ Points = \sum_{i=1}^{N} \frac{c\ w_i}{K_i}$$

Where, w_i is individual reference earnings in year i, K_i is the value of the point in year i, and c is the contribution rate. For simplicity purpose, we assumed one unit point per year of contribution. There is a ceiling amount on the reference earnings.

The contribution rate (c) is assumed to be equal to the current contribution made to finance the old-age benefit in Portugal, i.e., for a standard worker is 20.21%, and for a non-standard worker is 17.21%.

The Cash Balance model (inspired by the Swiss Model)

The cash balance model considered in this study is based on the Swiss model. The Swiss model is a multi-model based on a Cash Balance plan (CB) plus a Target Plan with the defined benefit feature.

The old-age pension entitlement is as follows:

$$P = P_{Target\ Plan} + P_{Cash\ Balance}$$

The target plan based on the scale table depending on the years of service. The scale table provides a flat benefit which is a multiple of the minimum old-age pension, depending on the of Reference Salary. Therefore, the Target benefit depends on contributions years and Reference salary.

$$P_{Target\ Plan} = FixAmount(Contributionsyears, ReferenceSalary) = N \times Minimum\ Pension$$

The N is the multiple of the Minimum Pension defined by the Scale table and based on the Reference Salary. The higher is the contributions year and the reference salary, the higher is the N multiple factor.

The Cash Balance model is identical to the DC model, but the return on the contributions is pre-established by the plan:

$$AC_{Ret} = \sum_{i=1}^{N} cw_i(1 + CBap_i)^{N-i}$$

Where, $CBap_i$, the capitalization of the contributions based on the guarantee return rate defined in section 3, and w_i, individual reference earnings in year i, and c, the contribution rate. Then, the pension entitlement for the Cash Balance calculated by dividing the expected future lifetime at retirement age.

$$P_{Cash\ Balance} = \frac{AC_{Ret}}{a_{ret}}$$

The contributions to finance the old-age benefit for the NDC model:

Contributions Rate (c)	Standard worker	Non-Standard Worker
Basic Plan	10.21%	7.21%
Cash Balance Plan	10.00%	10.00%
Total contributions under NDC model	**20.21%**	**17.21%**

The contributions for the Basic Plan based on the IAS (Indexante dos Apoios Sociais).

Unemployment program in Portugal

The unemployment insurance benefits are only granted for those involuntary unemployed that are not working, registered as a job seeker with the jobcentre, fully capable of working, available and actively looking for work, are not in receipt of an invalidity or old-age pension and reside in Portug (Herce & Bravo, 2017).

The unemployment benefit corresponds to 65% of the reference wage, reduced by 10% after 180 days. The benefit cannot be higher than 75% of the net value of the reference wage (used to calculate the old-age benefit under the Portuguese social security) or the equivalent of 2.5 times the indexing reference of social support IAS and lower than the IAS unless the net value of the reference wage is below that level. The duration of the unemployment benefit is proportional to the number of contributive years for social security as follows:

Age in years	Contribution period	Duration of the unemployment benefit
Lower than age 30	< 15 months	150 days
	≥ 15 mints and < 24 months	210 days
	≥24 months	330 days; 30 extra days every five years of registered income during the last 20 years preceding unemployment.
Between age 30 and age 40	< 15 months	180 days
	≥ 15 mints and < 24 months	330 days
	≥24 months	420 days; 30 extra days every five years of registered income during the last 20 years preceding unemployment.
Between age 40 and age 50	< 15 months	210 days
	≥ 15 mints and < 24 months	360 days
	≥24 months	540 days; 45 extra days every five years of registered income during the last 20 years preceding unemployment.
Higher than age 50	< 15 months	270 days
	≥ 15 mints and < 24 months	480 days
	×24 months	540 days; 60 extra days every five years of registered income during the last 20 years preceding unemployment.

Annexe 2 - The World Bank's Conceptual Framework

Initial Conditions	***I. Inherited System*** ▪ Elderly vulnerability and poverty prevalence in absolute terms and relative to other age groups ▪ Existing mandatory and voluntary pension systems ▪ Existing social security schemes ▪ Existing levels of family and community support ***II. Reform needs*** – such as modifying existing schemes in the face of fiscal unsustainability, coverage gaps, aging and socio-economic changes assessed against the primary and secondary evaluation criteria below ***III. Enabling environment*** ▪ Demographic profile ▪ Macroeconomic environment ▪ Institutional Capacity ▪ Financial market status
Core ***Objectives*** of Pension Systems	▪ Protection against the risk of poverty in old age ▪ Consumption smoothing from work to retirement
Modalities for achieving objectives	▪ *Zero Pillar* – non-contributory social assistance financed by the state, fiscal conditions permitting ▪ *First Pillar* – mandatory with contributions linked to earnings and objective of replacing some portion of lifetime pre-retirement income. ▪ *Second Pillar* - mandatory defined contribution plan with independent investment management ▪ *Third Pillar* - voluntary taking many forms (e.g. individual savings; employer sponsored; defined benefit or defined contribution) ▪ *Fourth Pillar* - informal support (such as family), other formal social programs (such as health care or housing), and other individual assets (such as home ownership and reverse mortgages).
Primary Evaluation Criteria	▪ Adequacy ▪ Affordability ▪ Sustainability ▪ Predictability ▪ Equity ▪ Robustness
Secondary Evaluation Criteria	Contribution to output and growth through: ▪ Lowering labor market distortions ▪ Contributing to savings ▪ Contribution to financial market development

Annexe 3 – Portuguese Social Security Framework