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MASTER'S THESIS

Pension Sustainability and the Commuter Shift in Luxembourg

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Abstract

Population ageing poses a significant challenge to pay-as-you-go (PAYG) pension systems throughout the developed world. Luxembourg, however, represents a distinctive case: nearly half of the workforce insured under its general pension scheme consists of cross-border commuters who reside outside the country during both their working lives and retirement. This thesis examines the long-term sustainability of Luxembourg's pension system and investigates how its financial trajectory is influenced by this unique cross-border workforce structure. To do so, it develops a residence-disaggregated PAYG accounting framework that decomposes the overall balance into resident and non-resident components. This approach enables the formal identification of the commuter shift, the year in which the non-resident balance turns from surplus into deficit. Using data from the General Inspectorate of Social Security (IGSS) and STATEC, and projecting outcomes through 2070, the model indicates that, under current policy settings, the pension scheme enters deficit in 2032. The commuter shift is projected to occur in 2047, after which the deficit continues to widen, reaching approximately €40 billion by 2070. Among the five parametric reforms evaluated, every reform involving a change to the indexation of benefits fully prevents the commuter shift, whereas the duration reform merely delays its onset. The combined reform package reduces the projected 2070 deficit by roughly 84%, although it does not fully restore long-term financial balance.

Keywords: Pension sustainability; PAYG systems; cross-border workers; commuter shift; Luxembourg; parametric reform

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Introduction

Population ageing has become one of the most salient macroeconomic challenges of the developed world. As fertility rates fall and life expectancy rises, the balance between those who contribute to public pension schemes and those who receive benefits from them is shifting steadily against the contributor side. For pay-as-you-go (PAYG) systems, in which the contributions of today's workers directly finance the pensions of today's retirees, this demographic transition translates almost mechanically into a financing problem: a diminishing base of workers is asked to support a growing number of pensioners who, on average, spend an ever longer share of their lives in retirement.

Luxembourg is in this respect both an ordinary and a highly unusual case. It is ordinary in that its population is ageing and its general pension scheme faces a rising dependency ratio over the coming decades. It is unusual in the sense that close to half of the workforce employed under that scheme does not live in Luxembourg at all, but commutes daily from France, Belgium, and Germany. These cross-border workers contribute to the Luxembourgish system at the same contribution rate as residents, yet they reside abroad both during their working career and in retirement. For several decades, the sustained inflow of cross-border workers has been a stabilising force: because non-resident pensioners spend on average only part of their career in Luxembourg, they receive comparatively lower pension benefits, so that the contributions of those same workers have consistently exceeded the pensions paid to non-resident retirees. It is precisely this non-resident surplus that has kept the general scheme in aggregate surplus, even as the resident component has been in deficit since 2011.

This configuration, however, is conditional on a favourable stock dynamic. The successive waves of cross-border workers built up during the 1990s and 2000s are now approaching retirement, and the non-resident pensioner stock is projected to grow considerably faster than the non-resident workforce. The central question of this thesis follows directly from this observation: *how sustainable is Luxembourg's general pension scheme over the coming decades, and how is its long-run financial trajectory shaped by the cross-border composition of the workforce?* Answering this requires looking beyond the aggregate balance. The thesis therefore decomposes the question into two parts. First, when does the scheme as a whole slip into structural deficit, and how steep is the resulting trajectory? Second, at what point does the non-resident component stop cushioning the system and become an additional burden? To make this second part precise, the thesis defines the *commuter shift* as the year in which the non-resident pension balance turns from surplus into deficit. Analysing both the aggregate deficit and the commuter shift, and assessing how each responds to parametric reform, is the main objective of the thesis.

The motivation for this question is both analytical and practical. Pension sustainability in Luxembourg is a salient and contested matter of public policy, and a significant body of institutional and independent work already projects the aggregate balance of the general scheme to 2070. Yet, to my knowledge, none of these analyses decomposes the aggregate balance into a resident and a non-resident sub-balance, and none formally identifies the year at which the non-resident component slips into deficit. The aggregate perspective therefore conceals a structural transition that is important for reform design: the cross-border labour flows on which the Luxembourgish economy structurally depends will eventually translate into pension liabilities, and the timing of that reversal is invisible in standard sustainability reports.

To address this gap, the thesis develops a residence-disaggregated PAYG accounting framework. Building on the macro-accounting identity of [Petrides et al. \(2003\)](#), the thesis splits the five parameters of the PAYG equation (the contribution rate, the average wage, the number of workers, the average pension and the number of pensioners) into a resident and a non-resident component, which present two separate sub-balances whose sum reproduces the aggregate balance. The model is calibrated on official Luxembourgish statistics, drawn primarily from the General Inspectorate of Social Security (IGSS) for historical pension data and long-term projections, and from STATEC for short-term and demographic data, with Eurostat and the European Commission used for cross-country comparisons. Revenue and expenditure series are projected to 2070 and validated against published IGSS figures. The framework is then used to evaluate five parametric reform proposals, an indexation reform, the suppression of the end-of-year allowance, an extension of the qualifying career duration, and two combinations of these, against a dual-criterion benchmark: the trajectory of the aggregate balance, and the timing of the commuter shift.

The main results can be summarised as follows. Under unchanged policy, the aggregate balance of the general scheme slips into deficit in 2032, and the commuter shift occurs in 2047, after which a previously stabilising surplus becomes an accelerating source of deficit that reaches roughly €40 billion by 2070. The five proposed reforms differ along the two criteria. Expenditure-side reforms acting on the growth path of pensions, in particular the indexation reform, prevent the commuter shift entirely within the projection horizon, whereas the labour-supply-side duration reform only postpones it. The combined reform, combining all three measures, delivers the largest improvement, reducing the 2070 deficit by approximately 84% and preventing the commuter shift by a comfortable margin, although it does not by itself restore the long-term balance. These findings are robust across inflation and productivity scenarios, and they illustrate the central methodological point of the thesis: a reform's effect on the aggregate balance can substantially

understate, or overstate, its effect on the structural position of the cross-border component.

The thesis is organised as follows. Section 1 reviews the literature on PAYG systems, demographic pressure, parametric reform options and the role of migration in pension sustainability, and identifies the gap the thesis tries to fill. Section 2 sets out the demographic and labour market context that establishes the relevance of the topic, covering the ageing of the population, the atypical labour market and the evolution of the pensioner stock. Section 3 describes the institutional framework of the Luxembourgish general pension scheme, including the benefit formula and the indexation mechanism. Section 4 presents the empirical framework: the PAYG identity, its residence-disaggregated extension, and the formal definition of the commuter shift. Section 5 sets out the data sources, the construction of the revenue and expenditure sides, and the calibration of the baseline against IGSS figures. Section 6 presents the baseline projection and the five reform scenarios. Section 7 reports the sensitivity of the results to alternative inflation and productivity assumptions, and Section 8 concludes.

1 Literature review

1.1 PAYG

The pay-as-you-go (PAYG) framework is a non-trivial institution; without it, retirees would have no decentralised way of consuming the output of the next generation. One of the first papers to formalise this was [Samuelson \(1958\)](#). In his overlapping generations (OLG) model, in which there are only three periods (work-work-retirement), he shows that in the absence of production and durable assets, retirees cannot consume anything. Even though current workers would in principle be willing to provide for them in exchange for similar treatment when they themselves are old, there is no decentralised mechanism that makes this exchange possible. Samuelson shows that a PAYG system corrects this market failure and makes every cohort better off, that is Pareto-improving, because it allows them to consume during retirement. Nevertheless, [Samuelson \(1958\)](#) makes use of strong assumptions, such as full depreciation, meaning that no intertemporal trade through storage is possible, which makes the model unrealistic. Thus, the author's model does not provide an answer to what happens when one considers a more realistic economy with interest rates and capital.

[Aaron \(1966\)](#) develops the analysis precisely to address this question. At the time, there was an ongoing discussion on whether the fully-funded (FF) regime would generate a higher return than the PAYG. Thus, he compares which of the two pension schemes gives a higher return rate. For this, he introduces the real interest rate and the population

growth rate. He comes to the conclusion that a PAYG system is welfare-improving if and only if the sum of the population growth rate (n) and the real wage growth rate (g) exceeds the real interest rate (r). Formally, that means that if $n + g > r$, the introduction of a PAYG social insurance scheme improves the welfare of every cohort. This condition is nowadays known as the Aaron condition, and provides the standard welfare-theoretic benchmark for the sustainability of a PAYG system.

This intuition can be embedded in a neoclassical growth model with capital, as [Diamond \(1965\)](#) does. Even though his model is about national debt, one can still extend his findings to a PAYG transfer scheme, since in his framework intergenerational lump-sum transfers and internal debt operate in the same way. Both reduce private savings, because the young in his OLG model expect future transfers and thus save less. Lower savings lead to lower capital per worker, lower output, and higher interest rates. [Diamond \(1965\)](#) shows that when the economy is dynamically inefficient, that is, when the real interest rate falls below the population growth rate, a PAYG scheme can shift resources away from wasteful capital accumulation and improve welfare. Aaron's condition, $n + g > r$, is the productivity-adjusted version of Diamond's dynamic-efficiency benchmark.

As ageing populations in Western countries became salient in public discussions, the literature turned to comparing systemic reforms to parametric reforms. A systemic, or paradigmatic, reform would be a change of regime, such as moving from a PAYG basis to a FF one, or vice versa, whereas parametric reforms are changes within the PAYG framework. [Lindbeck et al. \(2002\)](#) find that the transition from a PAYG to a FF scheme does not resolve the problem of an ageing society but rather redistributes it. The transition cohort would be hit twice: once by having to finance their own pensions, and once by still paying for the pensions of the current retirees.

[Petrides et al. \(2003\)](#) provide a macro-accounting framework that operates directly on the aggregate PAYG identity rather than on the underlying OLG structure, and that holds for long-term projections. This is the model that will be used for the analysis of this thesis. The framework allows to project the long-term sustainability of the pension scheme, but it comes at a cost: individual decision-making is no longer captured, and general-equilibrium effects from policy changes and interest rates fall outside the model.

1.2 Demographic pressure

Demographic ageing is one of the most pressing macroeconomic challenges of recent decades, with the share of the population aged 65 and over rising steadily across the developed world. [Bloom et al. \(2010\)](#) show that this transformation affects economic

growth through four principal channels: labour supply, savings, human capital, and public finances. Ageing is therefore not only a pension problem but a broader macroeconomic phenomenon. Of the four channels, the fiscal one is where pension sustainability sits: rising pension and health expenditures place a growing pressure on contribution rates and public-debt sustainability, with projected ageing-related costs increasing substantially in most developed countries over the long horizon (OECD, 2025b). Two demographic forces drive the pension-specific pressure: a declining fertility rate, which shrinks the contributor base, and a rising life expectancy, which lengthens the period over which pension benefits are paid.

The classical economic explanations for fertility decline, the quantity-quality trade-off and the opportunity cost of women’s time, are now considered insufficient. Doepke et al. (2022) argue that the income-fertility relationship has flattened and turned positive in some high-income countries, and that family-policy design, social norms, and labour market flexibility have become the principal determinants of fertility outcomes in modern economies. Boldrin et al. (2015) add a further channel that is directly relevant to pension economics: generous PAYG pension systems themselves depress fertility, by reducing the old-age insurance motive that children traditionally provided. The fertility-pension relationship therefore runs in both directions, as declining fertility undermines PAYG sustainability, and PAYG generosity in turn contributes to declining fertility, compounding the structural pressure on the system.

The second demographic driver of pension pressure is rising life expectancy. Across the developed world, life expectancy at birth has risen substantially over recent decades and is projected to continue rising over the long horizon (OECD, 2025b). Combined with broadly stable statutory retirement ages, this lengthens the average period over which pension benefits are paid, mechanically raising the financial burden on the contributor base. The conventional metric used to summarise this pressure is the old-age dependency ratio (OADR), defined as the ratio of the population aged 65 and over to the working-age population. The OADR has, however, attracted growing criticism. Skirbekk et al. (2022) argue that the fixed 65-year cutoff misrepresents the real burden of ageing, since it ignores both the rising labour force participation of older workers and the heterogeneity in health trajectories across countries; they propose a health-adjusted alternative that captures dependency more accurately. Hindriks and Cetin (2025) make a related point in the context of pension policy: the OADR ignores changes in labour force participation, life expectancy, and pension-eligibility conditions, all of which are first-order for pension finance. The demographic pressures established in this section motivate the analysis of reform options that follows in the next section.

1.3 Pension Reform Options

Indexation is the mechanism that ensures pensioners do not lose their purchasing power, as their benefits are adjusted on a regular basis to at least the price index, and thus minimise the poverty risk ([Hohnerlein, 2019](#)). The indexation rule can vary across countries: pension benefits can be adjusted to prices, to wage growth, or to a mix of both. The choice has direct consequences for the evolution of pension expenditure, and over a multi-decade horizon the difference between price and wage indexation can amount to several percentage points of GDP in cumulative cost ([Whitehouse, 2009](#)). The [OECD \(2025b\)](#) shows that there is no universal indexation rule, with most countries indexing to a single parameter and only a few applying mixed or double indexation. Indexation can therefore be understood as a slope intervention of the pension expenditures: it determines how fast pension expenditure grows over time, independent of the level of benefits at retirement.

A second class of reforms acts directly on the dependency ratio by raising the number of workers or lowering the number of pensioners. The most direct way is to increase the legal retirement age or the qualifying career duration, which keeps workers in the labour force longer and shortens the period in retirement. [Gruber et al. \(1999\)](#) show that financial incentives explain a substantial share of the cross-country variation in labour force participation among workers aged 55 and above. Countries with stronger early-retirement incentives have lower older-worker participation, and the implicit tax on continued work plays a central role in the retirement decision. [Blundell et al. \(2016\)](#) refine this result by showing that the labour supply response depends on the design of the incentive, like statutory retirement ages, early-retirement penalties, and the actuarial fairness of the benefit formula, rather than on the level of benefits alone. [Pilipiec et al. \(2021\)](#) confirm that an increase in the retirement age raises labour force participation, although the consequences for health and worker well-being remain inconclusive.

A third strand of the literature has focused not on adjusting individual parameters but on redesigning the pension formula itself, a paradigmatic rather than parametric reform that preserves the PAYG financing structure while embedding automatic longevity adjustments. The notional defined-contribution (NDC) tradition, examined by [Holzmann et al. \(2006\)](#), introduces an individual-account architecture in which pension benefits are linked to lifetime contributions and to residual life expectancy at retirement, so that rising longevity reduces individual benefits automatically. Sweden was the first country to implement this design in the 1990s, dividing each cohort's notional capital by an annuity divisor that reflects expected remaining life ([Settergren, 2003](#)).

Each of the reforms reviewed above redistributes the cost of ageing across cohorts,

but aggregate sustainability metrics are not able to show how. [Auerbach et al. \(1991\)](#) provide the methodological starting point with their concept of generational accounts, which decomposes the fiscal stance of a government into the present-value of lifetime net contributions of each cohort, making the intergenerational distribution of fiscal burden explicit in a way that aggregate deficit or balance measures cannot. Applied to pension policy, this framework reveals that reforms which appear neutral at the aggregate level may impose substantial costs on younger and future cohorts. [Hindriks and Baurin \(2023\)](#) apply this logic to gradual pension reforms in Belgium and show that the indexation reform distributes the adjustment more equitably across cohorts than the accrual reform, but that the accrual reform, which concentrates the burden on younger cohorts, is preferred by older cohorts. This implies that the political feasibility and the intergenerational equity criteria may pull in opposite directions.

The reforms reviewed in this section face a common political economy constraint. As populations age and fertility rates decline, the demographic share of pensioners rises and so does their bargaining power over pension policy. [Galasso et al. \(2002\)](#) formalise this through the median-voter framework: the median voter shifts toward older cohorts as the population ages, and the naive prediction is that pension generosity should rise rather than fall. This shift is amplified by the empirical regularity that older voters have higher turnouts than younger voters, for reasons that are primarily social rather than political ([Goerres, 2007](#)), so the political weight of the retiree cohort exceeds its demographic share. [Chrisp et al. \(2019\)](#) document how this asymmetry shapes welfare-state entitlements in the UK, while [Sinn et al. \(2003\)](#) make a similar argument for Germany. [Hindriks and Cetin \(2025\)](#) test this dynamic empirically by deriving, for each EU country, the bargaining power workers would need to hold in order for the projected pension benefits to be the optimal outcome of a Nash bargaining process. They find that in most countries this implicit bargaining power increasingly exceeds workers' demographic share, suggesting that the benefit cuts may face political resistance from the elderly as a result of ageing progresses.

A recent contribution reframes this political constraint as a problem of optimal design rather than of voting equilibria. The conventional normative tradition, from [Samuelson \(1958\)](#) and [Aaron \(1966\)](#) to the reform analyses of [Lindbeck et al. \(2002\)](#), asks how intergenerational transfers should be arranged on the assumption that they are mandatory and fully enforced, while the positive approach discussed above ([Galasso et al. \(2002\)](#); [Sinn et al. \(2003\)](#)) studies voting equilibria that do not need to be Pareto-optimal. [Russo et al. \(2024\)](#) bridge the two by deriving the optimal intergenerational insurance arrangement when subsequent generations can default on the transfers promised to their predecessors. They model this limited enforcement with a participation constraint for each generation:

the arrangement must be one that every cohort would support if it were put to a vote. In practice, the young agree to support the old only if they are promised at least as much for their own old age as they would get on their own, and only if they expect the next generation to keep that promise. The design problem therefore embodies a three-way tension between maximising welfare across generations, preserving each generation's incentive to participate, and honouring the entitlements already promised to the old. Its central lesson is that full intergenerational insurance is not sustainable when it commits future generations to transfers they would refuse once born. This concern is increasingly salient: as the relative standard of living of younger cohorts has deteriorated in recent decades, future generations may prove less willing to finance the transfers underpinning PAYG systems than their predecessors were.

1.4 Migration and Labour Mobility

A first strand of the literature established that migration could help relieve the fiscal pressure created by demographic ageing in developed economies. [Storesletten \(2000\)](#) shows, in a calibrated OLG model of the US economy, that selective immigration of working-age medium- and high-skilled migrants generates net fiscal contributions large enough to close most of the projected fiscal gap from ageing. The mechanism rests on the asymmetry between immigrants' long contribution periods and shorter dependency periods in the host country. [Storesletten \(2003\)](#) then extends the analysis to Sweden and confirms that the per-immigrant net present value is positive under selective immigration scenarios, while noting that the result is sensitive to the labour market integration of the immigrant population. [Razin et al. \(1999\)](#) provide the complementary welfare-theoretic result: in a dynamic OLG framework with international capital mobility, immigration is Pareto-improving for all native cohorts, even when migrants are low-skilled net fiscal beneficiaries in the period of arrival. The optimistic framing of these foundational papers has been refined empirically and challenged theoretically over the following two decades.

As migration flows to OECD countries rose in the 2010s, the empirical question of immigrants' net fiscal contribution became increasingly salient, generating a wave of comparative studies. The [OECD \(2021\)](#) estimates, across 25 OECD countries over the 2006 – 2018 period, that immigrants on average pay more in taxes and contributions than governments spend on their social protection, health, and education. Nevertheless, the total net fiscal contribution remains modest, between -1% and +1% of GDP for most countries, and depends substantially on each country's welfare-state design and on the labour market integration of the immigrants. [Hennessey et al. \(2020\)](#) confirm that the central findings are robust across methodologies and countries, but that cross-country variation is driven primarily by immigrant characteristics (age, skill) and host-country

institutional features. Subsequent analyses have refined the picture by decomposing the net fiscal position by migrant origin. [Boffi et al. \(2026\)](#) and [Christl et al. \(2022\)](#) both find that intra-EU migrants generate systematically more positive net fiscal contributions than extra-EU migrants, with the difference largely explained by labour market integration and demographic composition. From a more critical perspective, [Aslanyan \(2014\)](#) shows that the optimistic Pareto-improvement result of [Razin et al. \(1999\)](#) does not necessarily hold under recurring unskilled immigration, and that pension benefits for native workers can be reduced rather than supported by such flows, depending on the design of the welfare state.

The literature reviewed above treats migrants as individuals whose lifecycle plays out within a single national pension system: they contribute during their working career in the host country and, in the standard case, retire there as well. The intermediate configuration, in which workers contribute to a host-country pension system during their working career but reside abroad both during work and in retirement, is institutionally distinct and has received considerably less analytical attention.

1.5 Luxembourg-specific literature

As pension sustainability in Luxembourg is a matter of active public-policy debate, a substantial body of institutional and analytical work on the topic exists. The IGSS publishes annual statistical reports on the general pension scheme ([IGSS, 2025](#)), long-run demographic and financial projections to 2070 ([IGSS, 2024b](#)), and the Luxembourg country fiche prepared for the EU Ageing Working Group ([IGSS, 2024a](#)), which together constitute the empirical baseline against which any analysis of the scheme must be calibrated. The [OECD \(2025a\)](#) provides the most recent external review of the Luxembourgish pension system and proposes a set of parametric reforms aimed at restoring long-run sustainability. The IDEA Foundation, through a series of working papers by [Bouchet \(2025a\)](#) has developed the most substantive independent analysis of the Luxembourg case, simulating combined reform packages and analysing the December 2025 reform legislation ([Bouchet, 2025b](#)).

Across this body of work, the cross-border composition of the workforce is consistently acknowledged as a defining feature of the Luxembourgish pension system, with non-residents now accounting for roughly half of all insured contributors ([IGSS, 2025](#)).

1.6 Contribution

The reviewed literature has established three foundations on which any analysis of pension sustainability builds. First, the theoretical framework of PAYG pensions, from its origins in the welfare-theoretic case for intergenerational transfer through the OLG

model with production, provides the analytical mechanism within which sustainability questions are formulated. Second, the demographic pressures created by falling fertility and rising life expectancy have made pension sustainability a first-order policy concern across the developed world, with a well-developed empirical literature documenting the magnitudes involved. Third, the parametric-reform literature offers a structured menu of policy options, like indexation rules, retirement-age extensions, formula redesigns, and intergenerational burden adjustments, whose effects on aggregate sustainability are well understood individually, and which face common political economy constraints as the demographic balance shifts toward retirees.

A fourth strand, on the macroeconomic role of migration in PAYG sustainability, has shown that working-age immigration can substantially relieve the fiscal pressure created by demographic ageing, both theoretically and in calibrated empirical models. This literature, however, treats migrants as individuals whose lifecycle plays out within a single national pension system. The configuration in which workers contribute to a host-country pension system during their working career while residing abroad both during work and in retirement is institutionally distinct. The Luxembourg-specific literature, for its part, analyses the aggregate pension balance and treats the non-resident share as a structural feature. To my knowledge, however, none of the existing analyses decomposes that aggregate balance into resident and non-resident sub-balances, and none formally identifies the year at which the non-resident component itself slips from surplus into deficit.

This thesis fills this gap with three contributions. First, it develops a residence-disaggregated PAYG accounting framework that decomposes the aggregate balance of Luxembourg's general pension scheme into resident and non-resident sub-balances. Second, it formally defines and dates the commuter shift, the year at which the non-resident sub-balance turns from surplus into deficit, identifying a structural inflexion point that is invisible in the aggregate analysis. Third, it evaluates five parametric reform proposals along a dual criterion that captures both the trajectory of the aggregate balance and the timing of the commuter shift, providing a tool for assessing reforms not only on financial sustainability grounds but also on their ability to delay or prevent the structural inversion of the current non-resident surplus.

2 Motivation

This section sets out the context that makes Luxembourg's general pension scheme a relevant case for study. Two pressures operate simultaneously. The first is an ageing population, driven by falling fertility and rising life expectancy, which steadily raises the number of retirees relative to those financing them. The second is specific to Luxembourg:

a labour market in which close to half of the insured workforce commutes daily from across the border, contributing to the scheme while residing abroad both during their careers and in retirement. The three subsections that follow document these features in turn.

2.1 Demographics

Like most developed countries, Luxembourg is facing an ageing population, with the share of elderly people rising relative to that of younger cohorts. Yet Luxembourg constitutes a particularly interesting case, since its population is growing at a markedly higher rate than in most other developed economies¹. A first useful indicator is the natural balance, which is the number of births minus the number of deaths. This balance has been steadily positive since the 1980s, meaning that each year more people are born than die (STATEC, 2025a). In 2024, for example, 6 459 births were recorded against 4 471 deaths, yielding a natural balance of 1 988. Compared with total population growth of 9 923 persons between 2023 and 2024, the natural balance accounts for only about 20% of the increase, while net immigration explains the remaining 80% (STATEC, 2025a).

Immigration is therefore the main driver of Luxembourg’s fast-growing population. Over the past decade, the population rose from 512 353 inhabitants in 2011 to 643 941 in 2021, and reached 681 973 in 2024, with roughly 80% of this growth attributable to net immigration (STATEC, 2021; 2025a). Luxembourg is well known for its unusually high share of foreign residents, far above that of any of its neighbours, with foreigners representing 47% of the population in 2024, compared with 36.9% in 2001 (STATEC, 2025a).

Population growth in Luxembourg is closely tied to economic growth: the migratory balance reflects the attractiveness of Luxembourgish wages relative to those abroad, which in turn depends on productivity gains (STATEC, 2026a). Since the 1990s, Luxembourg has consistently posted a positive net immigration balance, that is, more arrivals than departures. Departures should not, however, be neglected, since over the period 1990 – 2024 the number of emigrants has grown at a faster pace than that of immigrants, but the total number of immigrants still exceeds the emigrants (STATEC, 2025a).

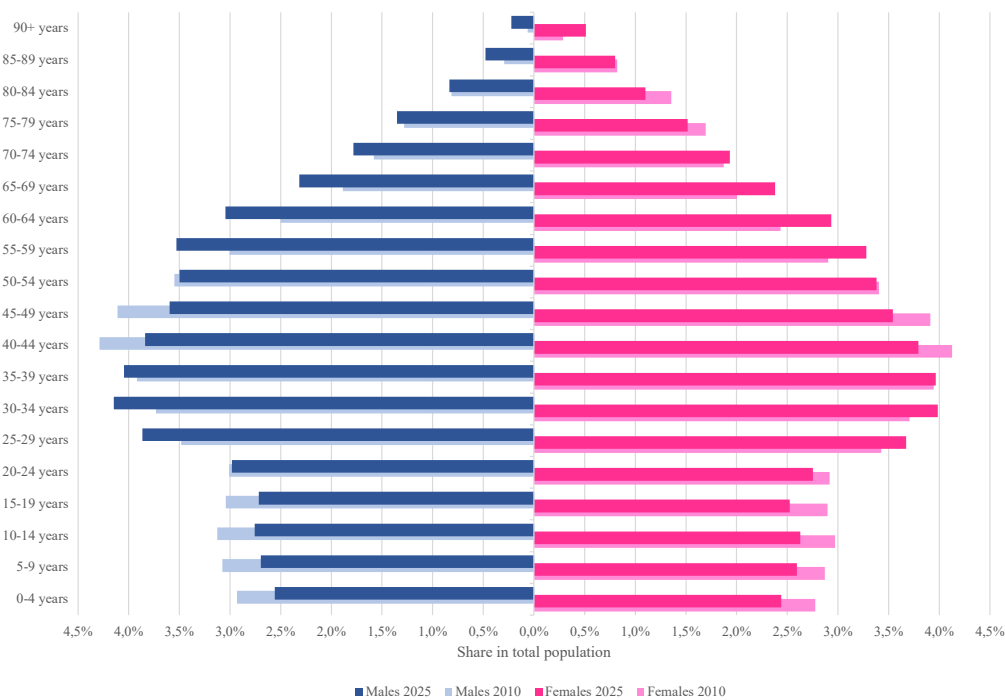
A closer look at the demographic profile reveals that immigrants are, on average, younger than the Luxembourgish-born population, both for women (38.9 vs. 42.2 years) and for men (38.6 vs. 40.0 years), and are overrepresented in the prime working-age cohort of 26 to 55 years. Together, these two effects keep the average age of Luxembourg’s population lower than that of most other EU countries. From age 55 onwards, however,

¹https://ourworldindata.org/explorers/population-and-demography?hideControls=false&indicator=Population+growth+rate&Sex=Both+sexes&Age=Total&Projection+scenario=None&country=OWID_EUR~OWID_HIC~UN_EUR~OWID_WRL~LUX~FRA~BEL~DEU

the share of Luxembourgish nationals exceeds that of foreign residents (STATEC, 2025a).

The population is nonetheless ageing, even with a steady inflow of younger workers helping to contain the rise in average age. Figure 1 illustrates this by comparing Luxembourg's age pyramid of 2010 with that of 2025. Over those fifteen years, the share of young people aged 0 to 24 declined for both men and women, while the share of those aged 55 and over increased relative to 2010. The very top cohort, aged 80 and above, is also markedly more female dominated.

Figure 1: Evolution of age pyramid for Luxembourg between 2010 and 2025



Source: own calculations based on STATEC data

Two forces drive this ageing trend. The first is the significant decline in fertility rates over recent decades. Eurostat data (Eurostat, 2026a) show that live births per woman have been falling steadily since the early 2000s: the EU average dropped from 1.46 in 2004 to 1.34 in 2024, and Luxembourg displays an even sharper trajectory. Whereas a woman in Luxembourg had on average 1.97 children in the 1970s, by 2024 the figure had fallen to 1.25.

The second force behind population ageing is the rise in life expectancy. In Luxembourg, life expectancy at birth grew from 78 years in 2000 to 83.5 years in 2024 (OECD and European Observatory on Health Systems and Policies, 2017; 2025), placing the country among the top five EU member states on this indicator in 2024 (Eurostat, 2026c). Life expectancy is projected to continue rising, with a persistent gender gap: by 2070, Eurostat expects women in Luxembourg to live to an average age of 89.9 years, against 86.0 years for men.

When combined with a legal full-career duration of 40 years and an effective retirement age of 61.4 years in 2024, barely up from 60.9 in 2010 (IGSS data), and the lowest among all OECD countries, these trends imply that Luxembourgish retirees spend a greater share of their lives in retirement than retirees in any other OECD country (OECD, 2025a).

The combined effect of falling fertility and rising life expectancy will steadily raise the share of older relative to younger individuals. This carries direct consequences for the pension regime: more pensions will need to be paid, while fewer workers will be available to finance them. A second mechanism compounds this: each new retiree cohort will, on average, spend more years in retirement than the cohorts before, meaning that under unchanged policy each pension entitlement is paid out for a longer span of time. Both effects pull the pension balance in the same negative direction.

The inflow of younger foreign workers undoubtedly helps to contain population ageing and supports the broader economy, but these same workers will eventually weigh on the pension system once they retire. In fact, since 2021, Luxembourg has already been paying out more pensions to non-residents than to residents, and the gap is set to widen further in the coming years (IGSS data; (IGSS, 2024b)).

2.2 Labour Market

The defining feature of Luxembourg's labour market is the high share of non-resident workers. The reasons for this particularity are straightforward: compared with its neighbours, Luxembourg has labour needs that its resident population alone cannot fill, offers higher wages and more generous family and social benefits, but is also characterised by higher housing costs, which push many workers to live abroad while working within Luxembourgish borders (Pigeron-Piroth et al., 2011). The result has been successive waves of foreign worker inflows. Taking the longer view first, the foreign workforce in Luxembourg as a whole tripled between 1960 and 2010. This expansion accelerated from 2000 onwards, with the number of non-resident workers doubling between 2000 and 2024. Whereas in 1961, foreign workers represented just 3% of total employment, by 2010 the share had risen to 44%, and by 2024 it stood at 48.7% (IGSS, 2025; STATEC, 2012). The most pronounced acceleration occurred from the mid-1980s onwards: between 1986 and the onset of the financial crisis in 2008, total employment grew at an annual rate of 3.8%, while resident employment grew at only 1.6% per year (STATEC, 2012). Over the past decade, the number of non-resident workers grew faster than the residents', as the gap between the two trajectories decreased over time (Appendix 16).

Since this thesis focuses on the general pension scheme, which covers the private-sector employment, the discussion now restricts itself to the workers insured under that

scheme. In 2024, the general pension regime accounted for roughly 90% of all workers in Luxembourg, making it by far the largest pension scheme in the country (IGSS, 2025). The number of insured workers has grown steadily over the past decade, rising from 384 047 in 2014 to 504 742 in 2024, with an average annual growth rate of 2.2% between 2020 and 2024 (IGSS, 2015; 2025). One striking feature is that on 1 January 2025, Luxembourg's total resident population stood at 681 973 (STATEC, 2025a). Dividing the labour force covered by the general scheme by total population yields a ratio of 74%, which would imply that three quarters of the population are in employment. This figure is clearly inconsistent with the age structure shown in the population pyramid (Figure 1). This apparent paradox in fact illustrates just how atypical Luxembourg's labour market is: the workforce captured by the general pension scheme is far larger than the country's resident working-age population, because a substantial share of it lives across the border.

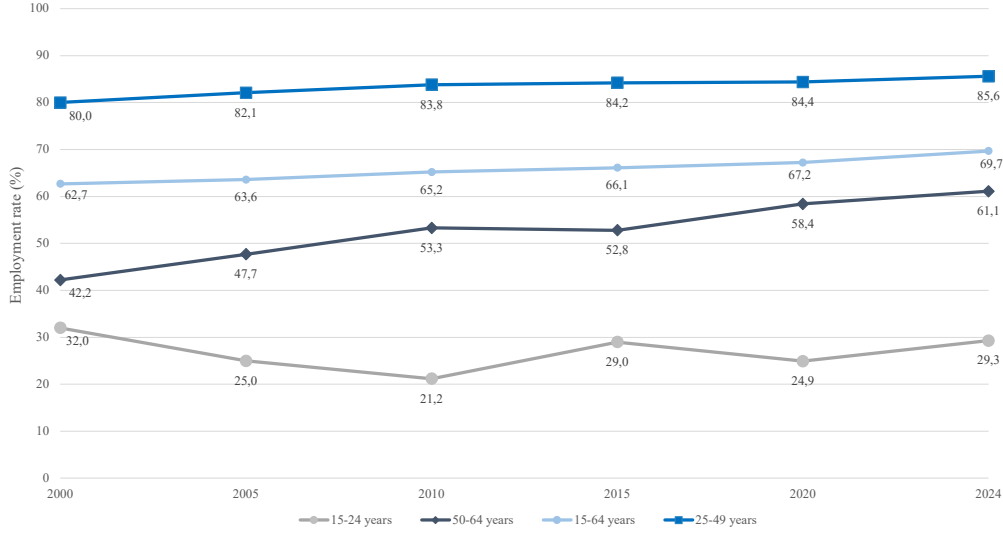
One important qualification is that cross-border workers do not spend their entire career in Luxembourg, but only a fraction of it. This fraction has nonetheless been increasing steadily, rising from 16 years in 2010 to 21.3 years in 2024 (IGSS data). Given the legal full-career duration of 40 years in Luxembourg, this implies that cross-border workers now spend on average more than half of their career in the country. The implication for pension expenditure is direct: as the duration of careers spent in Luxembourg lengthens, future cross-border retirees will be entitled to higher pension benefits than their predecessors, but at the same time will have a higher total amount of contributions paid. To date, the high growth rate and strong presence of cross-border workers have allowed the pension scheme to collect more in contributions than it pays out in benefits. As that growth rate converges and successive waves of cross-border workers reach retirement, this favourable balance could erode.

A closer look at the composition of the cross-border workforce reveals a striking pattern: the share of French cross-border workers is high and growing at a faster pace than that of their Belgian or German counterparts (Appendix 17). This trend is far from new. In 1980, French and Belgian workers each accounted for 44% of all non-residents employed in Luxembourg. From the 1990s onwards, the French share rose sharply, while the Belgian and German shares grew at a slower pace. By 2010, French cross-border workers accounted for 50% of all non-resident employment, while Belgians and Germans had each settled at around 25% (STATEC, 2012). The French share continued to climb, reaching 54% in 2024, with Belgians and Germans now stable at 23% each (IGSS, 2025).

Turning to employment rates, Figure 2 plots the rates by age group. The employment rate of the working-age population rose by 7 percentage points between 2000 and 2024, a gain driven primarily by stronger participation among older workers. The employment rate of those aged 50 to 64 increased by 19 percentage points over the same period, although it still lags behind the rate for the broader working-age population. The rise in older-worker

participation is nonetheless a crucial observation in the context of the pension system: as these cohorts are the closest to retirement, keeping them in employment for longer directly relieves pressure on pension payments.

Figure 2: Employment rate per age group, 2000 – 2024



Source: STATEC data

2.3 Pensioners

The number of pensioners under the general scheme has risen sharply over the past decade. In December 2014, the State paid out a total of 161 331 pensions; ten years later, in December 2024, that figure had reached 229 906 (IGSS, 2015; 2025). The corresponding 43% growth rate is striking when set against the 21% growth in the resident population and the 31% growth in total employment over the same period (IGSS and STATEC data). Disaggregating again by residence, the number of pensions paid to non-residents overtook the total number of resident pensioners in 2021 (Appendix 18).

As a consequence, the share of pensions paid to residents has been declining steadily: it stood at 56% in 2014 and fell to 49.7% in 2021. This divergence is highly atypical and country-specific and provides further empirical grounding for the commuter shift.

A closer look at the country of residence of non-resident pensioners reveals a pattern that broadly mirrors the composition of the cross-border workforce. French pensioners again form the largest group, accounting for 35.6% of all non-resident pensioners, followed by Germans at 22.6% and Belgians at 18.9%. The remaining 23% live elsewhere, with Portugal and Italy alone accounting for 37% and 29% of this residual category respectively (IGSS data).

The fact that more pensions are now paid abroad than domestically constitutes a fiscal liability, even if non-resident pensions are, on average, lower than resident pensions,

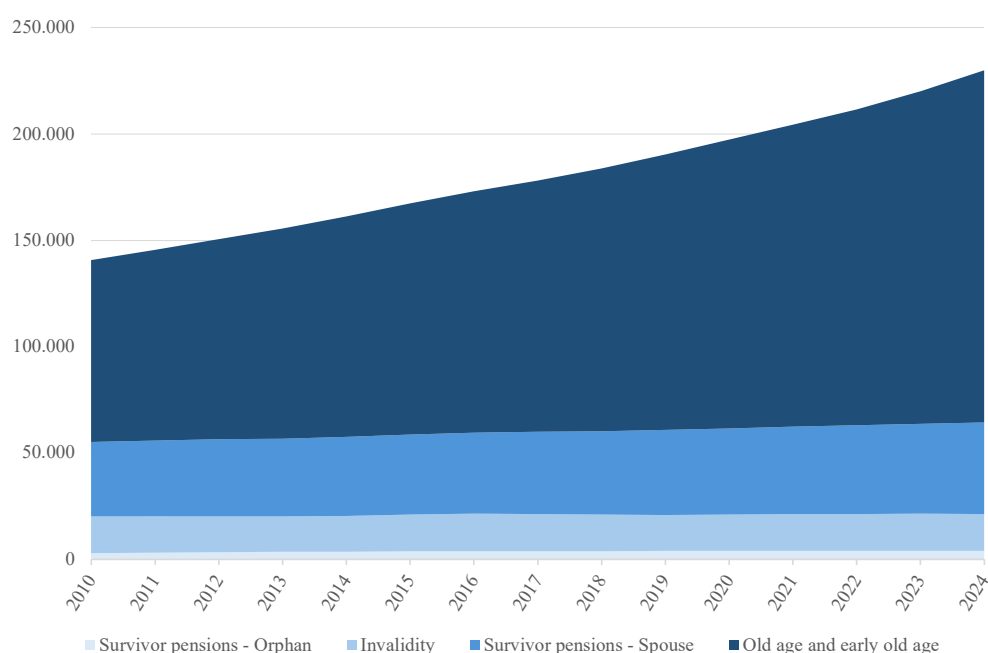
since non-residents typically spent only part of their working career in Luxembourg and therefore qualify for benefits proportional to that share. The remainder of their pension is, by law, paid out by the social security systems of the other countries in which they worked ([European Union, 2015](#)).

The fiscal asymmetry, however, is more subtle than the level of the pension paid. As of 2024, non-resident pensioners worked on average only 21.3 years in Luxembourg (IGSS data), during which they paid VAT on their consumption, and helped finance the pensions of the retirees of the time by paying their contribution. Once they retire, however, Luxembourg ceases to collect contributions from them and, crucially, ceases to recover any indirect tax revenue from their consumption, since this consumption now takes place abroad. Resident pensioners, by contrast, continue to consume domestically, generating VAT and other tax revenues that flow back into public finances. The State budget operates through separate sub-budgets, nonetheless, to the extent that fiscal capacity expands with domestic consumption, a higher share of pensioners living abroad mechanically narrows the fiscal base that could otherwise help finance pension expenditure.

For the commuter shift, this implies that the high volume of past cross-border employment will translate into a sharp increase in pension payments to non-residents, not because the average pension amount itself rises sharply, but because the number of non-resident pensioners grows so rapidly. Combined with the high growth rate of this cohort, this constitutes an additional and accelerating burden for the Luxembourgish public finances.

Turning to the composition, the general pension scheme distinguishes three types of benefit: early old-age and old-age pensions, invalidity pensions, and survivor pensions, the latter further subdivided into survivor-spouse and survivor-child pensions. In 2024, 72% of all pensions paid out were early old-age or old-age pensions, 7% were invalidity pensions, and the remaining 21% were survivor pensions ([IGSS, 2025](#)). The composition does not differ significantly between residents and non-residents. Figure 3 traces the evolution of the number of pensioners in each category over the past decade. The dominant pattern is the sharp rise in the share of old-age pensions, while the shares of invalidity and survivor pensions have remained broadly stable, which is a logical outcome of the fact that the bulk of the new pensioner inflow is composed of standard retirees, retiring by definition either before the legal retirement age of 65 (early old-age pensions) or at 65 (old-age pensions), with invalidity and survivor cases constituting a structural minority. Over the period 2010 to 2024, the shares of invalidity and survivor pensions both declined in relative terms, in favour of a rising share of old-age pensions, which climbed from 60% in 2010 to 72% in 2024 (IGSS data). It is worth noting that the absolute numbers of invalidity and survivor pensions did increase slightly over the same period; their declining shares simply reflect the much faster growth of old-age pensions.

Figure 3: Evolution of the number of pensioners in each category, 2010 – 2024



Source: IGSS data

Turning to the gender pension gap, Luxembourg has narrowed the gap considerably, although significant differences persist (Appendix 19). The downward trend is clearly visible, yet the gap remains substantial: in 2024, the average old-age pension for men is still 37% higher than that of women, down from 50% a decade earlier. A striking exception concerns survivor-spouse pensions, for which the situation is reversed: women receive on average pensions 130% higher than men. This counter-intuitive pattern follows mechanically from the design of the benefit. Survivor pensions are paid to the surviving spouse, and since women live on average longer than men and men also tend to have higher own pensions, surviving widows are entitled to substantially more than surviving husbands. By contrast, the survivor-child pension is at parity, and has been stable over time.

The OECD (2025b) explains the persistence of the gender pension gap primarily through three channels: the gender pay gap, the lower female participation rate in the labour market, and shorter average careers among women. Across the OECD, men earn on average more than women for equivalent work, which feeds directly into the pension level upon retirement. Men also accumulate longer careers, which compounds the gap. IGSS data confirms this for Luxembourg: in 2024, the average total insurance career amounts to 41.4 years for men, against only 38.3 years for women.

A notable point of contrast is that, in 2025, Luxembourg was the only EU member state to record a negative gender pay gap (-0.9%): on average, women have a slightly

higher hourly gross wage compared to men (STATEC, 2025c). The progressive narrowing of the pay gap is mirrored in the falling gender pension gap. That said, Luxembourg still posts the largest gap in median pension income across the EU (Eurostat, 2026b), reflecting the lag with which past inequalities feed through the pension formula. Convergence towards parity is therefore likely to continue in the years ahead, although the full effect will unfold only as today’s working-age cohorts retire.

3 Institutional Framework

This section describes the institutional rules of Luxembourg’s general pension scheme. It sets out the scope of the scheme and its financing, the formula used to compute benefits, and the indexation mechanism that governs how pensions evolve over time. These rules apply identically to residents and non-residents, a feature that proves central to the residence-disaggregated analysis developed later.

Luxembourg’s pension system comprises several schemes. Alongside the general pension insurance scheme, a number of special regimes exist, but these will not be covered in this thesis. The focus here is on the general pension scheme, which covers the private sector and accounts for roughly 90% of Luxembourg’s total workforce in 2024 (IGSS, 2025). Public servants fall under a separate special regime that lies outside the scope of this analysis. The general pension scheme provides three types of benefits: early and old-age pensions, survivor pensions, and invalidity pensions. Its administration is entrusted to the Caisse Nationale d’Assurance Pension (CNAP), under the supervision of the General Inspectorate of Social Security (Inspection Générale de la Sécurité Sociale - IGSS) (IGSS, 2025). The scheme is financed primarily through contributions, currently set at 25.5% of gross wages and split into three equal shares of 8.5% each, borne respectively by the employee, the employer, and the central government (*Code de la sécurité sociale* 2025). Prior to 1 January 2026, each share stood at 8%, resulting in a total contribution rate of 24%. After that date, the government increased the contribution rate for each party by 0.5 percentage points, leading to the current global contribution rate of 25.5% (*Loi Du 19 Décembre 2025* 2025). The second pillar, voluntary occupational pension arrangements set up by employers, and the third pillar, private individual pension schemes, are not considered in this thesis.

The calculation of pension benefits under the general scheme is governed by the *Code de la sécurité sociale*, as reformed by the law of 21 December 2012 (*Code de la sécurité sociale* 2025). The formula is derived from the IGSS (2024a) and computes the annual pension as the sum of four distinct components, each capturing a different dimension of

the insured person's career and of the scheme's redistributive architecture:

$$P = P_1 + P_2 + P_3 + P_4, \text{ where}$$

$$P_1 = q_1 \cdot \text{TCI}$$

$$P_2 = (\text{AGE} + \text{CP} - q_{2,\text{base}}) \cdot q_2 \cdot \text{TCI}, \quad \text{if } \text{AGE} + \text{CP} > q_{2,\text{base}}$$

$$P_3 = \frac{\min(40, \text{CP} + \text{NP})}{40} \cdot q_3 \cdot \text{REF}$$

$$P_4 = \frac{\min(40, \text{CP} + \text{NP})}{40} \cdot 0.025 \cdot \text{REF}$$

The value of the average pension P depends on five individual inputs and four annual parameters. The individual inputs are the applicant's age at retirement (AGE), the number of contributory years (CP), the number of non-contributory but credited years (NP), the total contributory income accumulated over the career (TCI), and the reference amount REF, which roughly corresponds to the social minimum wage. The four parameters q_1 , $q_{2,\text{base}}$, q_2 , and q_3 are set by law and follow a predefined evolution over time, with the intention of progressively rebalancing the formula across its components (see Table 22 for their trajectory between 2013 and 2052).

The pro-rata component P_1 represents a given percentage q_1 of the total contributory income TCI. It is the part of the pension that directly reflects the insured person's lifetime earnings: the higher the accumulated TCI, the higher P_1 . This component is also the channel through which the distinction between full-time and part-time careers enters the formula, both types of careers can reach a 'full career' in the legal sense, as discussed below, but part-time workers accumulate a lower TCI and therefore receive a lower P_1 for an otherwise identical career length.

The incremental component P_2 adds a supplement for each complete year in which the sum of the applicant's age and contributory periods exceeds the annual threshold $q_{2,\text{base}}$. For every such year, the pro-rata base is incremented by a fixed percentage q_2 , up to a maximum of 2.05%. The economic logic of this component is to reward later retirement and longer careers: an insured person who continues to work past the threshold accumulates a progressively higher pension entitlement, which constitutes an implicit incentive to delay retirement.

The flat component P_3 is tied to the reference amount REF rather than to individual earnings. For a full career of 40 or more combined years (CP + NP), this component equals $q_3 \cdot \text{REF}$. For shorter careers, it is prorated by the ratio $\min(40, \frac{\text{CP} + \text{NP}}{40})$, meaning that each missing year reduces P_3 by one-fortieth. The purpose of this component is redistributive: it ensures that contributors with low lifetime earnings, but complete careers, still receive a meaningful flat contribution, partially decoupling the pension from the

pro-rata earnings logic embodied in P_1 .

The end-of-year allowance (EOYA) P_4 functions as a thirteenth-month payment. It represents 2.5% of REF for a full career, prorated in the same way as P_3 for shorter careers. An important legal condition attaches to P_4 : the 2012 law explicitly ties its payment to the global contribution rate remaining at or below 24%. Should the rate be increased, the allowance is legally conditional. This condition will be revisited in Section 6.3 in the context of the 2025 reform.

A career is considered complete, for the purposes of P_3 and P_4 , when CP + NP reaches 480 months, equivalent to 40 years of combined contributory and credited periods. This 40-year threshold should not be confused with the legal retirement age of 65: because it applies to career length rather than to age, an insured person who began contributing before the age of 25 can in principle reach a full career well before 65. This goes a long way towards explaining why the effective retirement age in Luxembourg, 61.4 years in 2024, is the lowest in the OECD (OECD, 2025a).

In Luxembourg, once a person retires, their pension is automatically adjusted to evolving price levels. In fact, the scheme operates a double indexation mechanism: pensions are linked both to consumer prices and to the growth of real wages. Whenever the consumer price index rises by more than 2.5%, pension benefits are revalued accordingly (IGSS, 2024a). This double indexation places a substantial burden on public finances, as it drives pension amounts upward at a sustained pace. On the other hand, it preserves the purchasing power of retirees and acts as an effective safeguard against old-age poverty.

Real wage indexation in turn relies on two distinct mechanisms: a revalorisation factor and an adjustment factor. The revalorisation factor links the initial pension benefit to past wage growth, by updating the earnings recorded over the insured person's working career to current price levels. The adjustment factor, by contrast, links ongoing pensions to real wage growth after retirement. In this respect, the Luxembourgish pension system can fairly be described as generous: it not only pays the highest pension amounts in the OECD, but also offers retirees a double indexation mechanism, whereas in most other countries pensions are typically indexed to a single parameter (OECD, 2025b).

The system also includes a legal reserve fund, which functions as a safety net for pension expenditures. The law (art. 238) requires this reserve to amount to at least 1.5 times annual pension expenditure (*Code de la sécurité sociale* 2025). The reserve is held in the form of invested assets and therefore generates returns on investment. As of today, it stands at roughly four times annual pension expenditure. While this may appear reassuring, projections show that under unchanged policy the reserve will continue to grow until 2030, but decrease afterwards and fall under the legal threshold around 2040,

as a consequence of the steep growth in pension expenditure (IGSS, 2024a). The returns on investment and the legal reserve are not considered in this thesis.

Finally, the first pillar pays out both a minimum and a maximum pension. The minimum pension is set at the level of the social minimum wage, while the maximum is set at $\frac{5}{6}$ of five times that amount. Contributions are similarly capped at five times the social minimum wage (OECD, 2025a).

All of these rules, the formula used to compute pension benefits, the indexation of pensions to current prices, and the eligibility conditions, apply identically to residents and non-residents.

4 Empirical framework

This section presents the accounting framework used to assess the sustainability of the scheme. It first introduces the standard PAYG identity, then extends it by disaggregating each parameter into a resident and a non-resident component, which yields two separate sub-balances whose sum reproduces the aggregate balance. This decomposition allows the formal definition of the commuter shift, the year in which the non-resident balance turns from surplus into deficit.

4.1 PAYG Framework

As in most of the developed world, Luxembourg’s pension system relies on a defined-benefit PAYG framework, in which active workers finance current pension benefits through contributions collected from their wages (OECD, 2025b). Active workers therefore do not pay for their own future pensions, but their contributions fund the benefits paid to today’s retirees. Petrides et al. (2003) translate this into the following simple equation:

$$c \cdot w \cdot L = p \cdot B \tag{1}$$

where c is the contribution rate set by the state, w the average wage of workers, L the number of workers in a given year, p the average pension benefit, and B the number of pensioners in a given year. The detail of how these parameters are computed, and the values they take, is given in Section 5. The system is in equilibrium when total revenue, the left-hand side, equals total expenditure, the right-hand side. This is a macro-model: it captures the general equilibrium of the pension system and does not model individual retirement decisions.

With a few simple manipulations, equation (1) can be rewritten as follows:

$$c = \frac{B}{L} \cdot \frac{p}{w} \quad (2)$$

Equation (2) gives the equilibrium contribution rate that keeps the system balanced, meaning that total expenditure equals total revenue. If the actual contribution rate lies below the equilibrium rate, the system runs a deficit; if it lies above, the system runs a surplus. The ratio $\frac{B}{L}$ is the dependency ratio, which expresses the number of retirees per worker. It is important not to confuse this dependency ratio with the old-age dependency ratio (OADR), a well-known metric used to track the evolution of population ageing and to show how rapidly the number of retirees grows relative to the working-age population. However, as Skirbekk et al. (2022) discuss, it does not capture the real dependency of older citizens, some of whom remain in employment, since the cutoff for being considered "old" is typically fixed at 65 years.

Here, the model, as in Petrides et al. (2003), works directly with the number of retirees and the number of workers, and therefore with the dependency ratio. The interpretation is straightforward: the ratio captures the burden carried by workers in financing pension benefits. An increase in the ratio means that fewer workers must pay for more retirees. The replacement rate $\frac{p}{w}$, in turn, indicates how much a retiree receives as a percentage of their last earned income; in the framework used in this thesis, it is the average replacement rate of the economy. For example, a replacement rate of 75% means that the average pension benefit represents 75% of the average wage of workers.

Equation (1) is the standard simplified model used for most countries, whose populations are largely homogeneous in this respect. For Luxembourg, however, it is natural and arguably the single most important modelling choice to disaggregate the parameters into residents and non-residents, given the strong presence of non-resident workers and retirees in the economy. This distinction leads to rewrite equation (1) as:

$$c \cdot ((w_{\text{res}} \cdot L_{\text{res}}) + (w_{\text{NR}} \cdot L_{\text{NR}})) = (p_{\text{res}} \cdot B_{\text{res}}) + (p_{\text{NR}} \cdot B_{\text{NR}}) \quad (3)$$

where the subscript *res* stands for residents and NR for non-residents. The contribution rate is, of course, identical for resident and non-resident workers, since it is a uniform statutory rate. This formulation allows to distinguish clearly between the resident and non-resident balances, and to refine the estimations by accounting for differences in average pension benefits and wages across the two groups. The corresponding balances for residents and non-residents are written as follows:

$$BAL_{\text{res},t} = (c_t \cdot w_{\text{res}} \cdot L_{\text{res},t}) - (p_{\text{res},t} \cdot B_{\text{res},t}) \quad (4)$$

$$BAL_{\text{NR},t} = (c_t \cdot w_{\text{NR}} \cdot L_{\text{NR},t}) - (p_{\text{NR},t} \cdot B_{\text{NR},t}) \quad (5)$$

Both equations show that, at time t , the balance (BAL) equals the difference between total revenues and total expenditures. If revenues exceed expenditures, the balance is in surplus; if expenditures exceed revenues, the balance is in deficit. Combining the two sub-balances yields the total balance of the pension regime:

$$BAL_{\text{total},t} = BAL_{\text{res},t} + BAL_{\text{NR},t} \quad (6)$$

This total balance is the variable that determines whether the scheme is in surplus or deficit, and by how much.

4.2 Commuter Shift

The disaggregation of the variables, and of the total balance, allows to introduce the central analytical point of this thesis, a country-specific phenomenon labelled the *commuter shift*. To understand it, one must first note that the non-resident balance is currently in surplus, while the resident balance is in deficit; the explicit figures and the methodology behind this decomposition are presented in Section 5. Building on this, the commuter shift is defined as the point in time at which the non-resident balance itself turns into deficit, thereby adding a further burden to the already strained sustainability of the pension scheme. Formally:

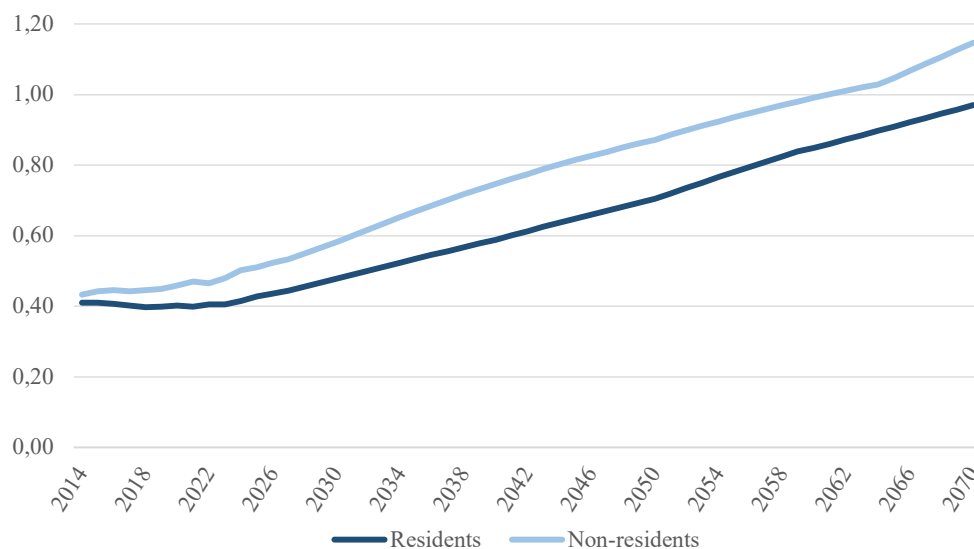
$$t^* = \min t : BAL_{\text{NR},t} < 0 \quad (7)$$

where t^* denotes the first year in which the non-resident balance becomes negative. Before t^* , the non-resident component of the equation cushions the total balance, as contributions from non-resident workers exceed the benefits paid to non-resident retirees; once this component itself slips into deficit, the total balance deteriorates further and more sharply. This year therefore marks a structural shift, in which a previously stabilising force becomes a liability in its own right. The distinction matters for policy design. Luxembourg relies heavily on cross-border labour flows, yet these same flows will eventually translate into pension liabilities; separating the resident from the non-resident balance allows policymakers to assess reforms cohort by cohort rather than in aggregate. One important comment must be made: non-residents cannot be blamed for the rise in pension expenditures, as they are important to keep the economy running and represent close to 50% of Luxembourg's workforce (STATEC, 2026b).

As described in the preceding Section, the dependency ratio is computed as the total number of pensioners divided by the total number of workers. It is the standard metric for assessing the demographic pressure on a pension system. For Luxembourg's general scheme, this ratio rises sharply over the projection horizon, as illustrated in Figure 4. In consistency with the analytical strategy of this thesis, it is useful to compute this

ratio separately for residents and non-residents. In 2014, both ratios stood at around 0.4, meaning that 100 workers were financing the pensions of 40 retirees. By 2070, the IGSS projections (IGSS, 2024b) imply a ratio of 1.15 for non-residents and 0.97 for residents. A non-resident ratio of 1.15 means that 100 non-resident workers will be expected to fund the pensions of 115 non-resident retirees, a configuration that is difficult to sustain on conventional assumptions. The non-resident series, in particular, captures one of the central drivers of the commuter shift: while the stock of non-resident workers comfortably exceeds the stock of non-resident retirees in 2025 (ratio of 0.51), this cushion is projected to invert before 2070, with the non-resident pensioner stock surpassing the corresponding worker stock (IGSS, 2024b). The resident dependency ratio rises more moderately and remains just below one over the same horizon. While the dependency ratio establishes the

Figure 4: Evolution and projection of the dependency ratio, 2014 – 2070



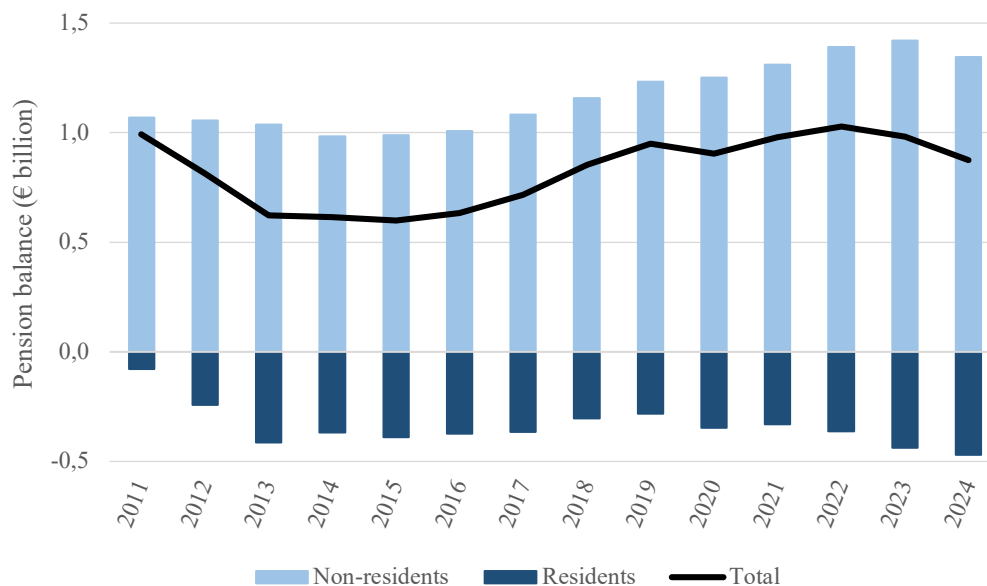
Source: own calculations based on IGSS data

demographic pressure on the system, it does not by itself quantify the financial burden it implies. In particular, they cannot capture the specific fiscal weight that residents and non-residents place on Luxembourgish public finances, which depends not only on stock counts but also on the relative levels of average wages and average pensions across the two groups. Section 6.1 therefore moves from headcount ratios to monetary balances, decomposing the projected revenues and expenditures of the scheme by residence. This monetary decomposition is what enables a precise empirical formulation and dating of the commuter shift.

Looking at the historical total balance for residents and non-residents over 2011 – 2024, one observation stands out: it is the non-residents who keep the general pension regime in surplus. Figure 5 illustrates this clearly. The resident balance has been in deficit throughout the period, meaning that residents on average cost the scheme more

in pension payments than they contribute. The non-resident balance shows the opposite pattern: contributions exceed benefits, and the surplus generated is large enough to keep the aggregate balance positive over the full 2011 – 2024 window. The mechanics behind

Figure 5: Evolution of the historical pension balance by residence, 2011 – 2024



Source: own calculations based on IGSS data

the non-resident surplus are straightforward. As discussed earlier, non-resident pensioners receive on average lower pension benefits, but as non-resident workers contribute at the same statutory rate as residents, the surplus is the arithmetic consequence of this asymmetry. The crucial point, however, is that this configuration is conditional on a favourable stock dynamic. With non-resident pensioners growing rapidly and non-resident workers expanding more slowly, the dynamic is set to invert. The successive cohorts of cross-border workers built up during the 1990s and 2000s are about to enter retirement, raising the non-resident dependency ratio sharply (Figure 4).

Once the non-resident balance turns negative, the commuter shift occurs, and what was previously a stabilising surplus becomes an additional source of deficit, compounding rather than offsetting the deterioration on the resident side. The exact year at which this transition takes place at unchanged policy is identified in Section 6.1.

The purpose of this section is therefore to establish that Luxembourg’s general pension scheme is atypical in a specific and analytically tractable way: its aggregate balance can be cleanly decomposed into a resident and a non-resident component, each driven by distinct dynamics. Public institutions and standard sustainability reports almost always analyse the total balance only and only briefly discuss the impact of non-residents. The two-dimensional perspective adopted here adds a second analytical lens: it allows reform proposals to be assessed not only on their effect on the aggregate balance, but also on their ability to delay or prevent the inversion of the non-resident balance.

Throughout the analysis that follows, every proposal will be evaluated against two criteria. The first is the traditional and arguably most important indicator, the trajectory of the total balance. The second is the disaggregated balance by residence, which makes it possible to assess each reform’s effect on cross-border cohorts specifically. Together, these two criteria form the dual evaluation framework applied throughout Section 6.

The distinction between the aggregate balance and the cohort-specific balances is more than a methodological refinement: it has direct implications for policy design. An overall positive or negative balance can mask diverging dynamics across the two cohorts, and disaggregation makes it possible to identify precisely where the imbalance originates. A reform that affects residents and non-residents differently is, however, politically more delicate to implement than a uniform measure, since it raises questions of equity and EU non-discrimination law ([European Union, 2015](#)). At the same time, one cannot ignore the political-economy dimension: policymakers respond to electoral incentives, and the electorate is composed of residents only, which may bias reform design towards measures whose costs fall disproportionately on cross-border workers. Such a strategy, however, would carry significant negative spillovers: less generous treatment of non-residents could, over time, reduce the inflow of cross-border workers on which the Luxembourgish economy structurally depends, and ultimately weigh on growth and on the contribution base itself.

This section has presented the descriptive statistics underlying the analysis and laid out the structural features of Luxembourg’s pension system: an ageing society, an atypical labour market with a sustained inflow of cross-border workers, and a pension benefit formula that combines flat-rate, proportional, and indexation components. It has also formalised the central analytical contribution of this thesis, the commuter shift, and introduced the dual-criterion framework (aggregate balance & non-resident balance trajectory) against which each reform proposal will be evaluated.

5 Data

This section describes the data used to calibrate and project the model. It sets out the sources drawn on for the historical series and long-term projections, and explains how the revenue and expenditure sides of the PAYG identity are constructed. It then compares the baseline computations against the official IGSS figures before the results are presented in Section 6.

5.1 Data Sources

The computations rely primarily on official Luxembourgish public statistics, drawn from two main institutional sources: the General Inspectorate of Social Security (IGSS) and the National Institute of Statistics and Economic Studies (STATEC). Two additional sources are used in a more limited way: Eurostat, for cross-country demographic comparisons, and the European Commission, for life expectancy data. All data used in this thesis are publicly available; no proprietary or microdata access has been required.

The principal source for the historical pension data is the annual *Rapport Général sur la Sécurité Sociale*, published by the IGSS. This report provides yearly data on contribution revenues, pension expenditures, the number of insured contributors and the number of pensioners, all disaggregated by residence and, on the expenditure side, by pension category (old-age, invalidity, survivor). Because the IGSS source covers exclusively the general pension insurance scheme, which is the scope of this thesis, it provides the most directly applicable historical data. Annual reports from 2014 through 2025 are used, providing twelve years of historical observations. Furthermore, the raw data on pensions was obtained from the IGSS website.

The principal source for long-term projections is the IGSS (2024b) *Cahier statistique no. 18*, which provides demographic and financial projections of the general pension scheme through 2070. The document shows projected worker and pensioner counts at ten-year intervals (2030, 2040, 2050, 2060, 2070), along with assumed macroeconomic developments. Because the projections are reported at ten-year intervals, linear interpolation is applied to obtain annual values for the projection horizon. The document also reports the projected categorical mix of pensions in 2070, which is used to interpolate the category shares between the 2024 observed distribution and the 2070 target.

Short-term worker projections (2025 – 2027) are taken from the STATEC (2025b) *Note de conjoncture 2-25*, which provides more current macroeconomic forecasts than the IGSS publication. The choice to blend STATEC short-term data with IGSS long-term projections is discussed in Section 5.2.

Demographic data on the resident population, fertility rates, and population structure are taken from STATEC (STATEC, 2025a). Cross-country comparisons of life expectancy and fertility rely on Eurostat (Eurostat, 2026a; c). Life expectancy data for Luxembourg are taken from the European Commission’s *Country Health Profile 2025* (OECD and European Observatory on Health Systems and Policies, 2025).

Several wage-related cross-checks rely on STATEC microdata at the NACE-sector level, used in Section 5.2 to validate the assumption of equal average wages between residents

and non-residents in the private sector. These data are publicly available through STATEC.

No transformation of the underlying data is required beyond standard interpolation of projected series to annual frequency and the disaggregation procedures described in Sections 5.2 and 5.3. All computations are performed in Excel, with the implicit method (equations (8) and (9)) used to recover the average wage and average pension figures consistent with IGSS aggregates.

5.2 Revenue Side

This section describes the left-hand side of equation (1), which captures the total revenues generated by workers' contributions. Each parameter is presented and explained, as well as the source of the data and the way the values are computed.

The first variable of the left-hand side of equation (1) is c , the general contribution rate. This rate is split equally between three parties: the central State, the employer, and the employee, each of whom pays 8.5% as of 1 January 2026. Before that date, the total contribution rate was 1.5 percentage points lower, with each party contributing 8%. No distinction between resident and non-resident workers can be made here, as both are subject to the same statutory rate. The self-employed pay both the employer and the employee shares, so that their total contribution rate amounts to 17%, but to which then the State adds the rest, so that for the estimations there is no difference between self-employed individuals and hired workers. Here, the contribution rate is treated as exogenous, with a single break between the pre- and post- 1 January 2026 regimes.

The second parameter on the left-hand side is the average insurable wage w , defined as the gross annual wage. Two approaches are in principle available to compute it: taking the arithmetic mean across all contributors, or inverting the total-revenue identity. Here, the second approach is followed, recovering the average wage as:

$$w_t = \frac{\text{Total contribution income}_t}{c_t \cdot L_t} \quad (8)$$

The total contribution income is reported in the annual *Rapport Général sur la Sécurité Sociale* published by the IGSS, which decomposes contributions into the shares paid by employees, employers, and the central State. For instance, in 2024 employee and employer contributions amounted to €5 120 million, while the State share stood at €2 560 million, for a combined total of €7 680 million (IGSS, 2025). Computing the average wage in this way implies a methodological assumption: residents and non-residents are taken to have the same average wage in the private sector, that is, $w_{\text{res}} = w_{\text{NR}}$.

This assumption turns out to be far less restrictive than it might appear. STATEC data show that the average wage of residents and non-residents in the private sector are remarkably close. As an illustration, in 2022 the full-time-equivalent arithmetic average wage across all NACE categories, excluding public administration, since civil servants are not covered by the general pension regime, was €58 102 for residents and €58 485 for non-residents (own computations). These figures are obtained by multiplying the average wage in each NACE category by the corresponding number of workers, summing across categories, and dividing by the total number of workers, separately for residents and non-residents. While individual NACE categories do display significant differences², generally in favour of residents, these differences largely wash out at the aggregate level. The reason lies in the sectoral composition of the two populations: non-residents are heavily concentrated in the private sector, while residents are over-represented in public administration, which inflates the resident average wage in administrative-only comparisons but is excluded from the relevant figure here. As a benchmark, resident workers outnumber non-residents in public administration by a factor of nearly thirteen to one (49 650 against 3 930) (STATEC data).

Note that the NACE-level comparison is used here only as an external check on whether the wage differs by residence; the projection still relies on the implicit method for the actual computation of the average wage. A practical advantage of recovering the wage from the total-revenue identity is that the resulting figures match the official IGSS contribution totals exactly, which matters because all subsequent projections build on these numbers. Constructing average wages job-by-job from NACE-level data, while in principle interesting, would mechanically introduce deviations from the official IGSS revenue figures and lies outside the scope of this thesis.

The consequence of the assumption of a uniform wage for the model is that the asymmetry in the pension balance between residents and non-residents is driven by only three channels: the number of workers, the number of pensioners, and the average pension level. The commuter shift identified by the model is therefore primarily a demographic phenomenon, not a wage phenomenon. Should residents in fact earn slightly more than non-residents on average, the model would overstate non-resident contributions and therefore delay the inversion of the non-resident balance. In the absence of disaggregated wage data by residence for the private sector, the present approach offers the best available compromise between methodological transparency and consistency with the IGSS revenue figures, which is further discussed in Section 6.1.

A clear limitation of this method is that it does not allow for a disaggregated anal-

²[https://lustrat.statec.lu/vis?lc=en&tm=DF_C1224&pg=0&snb=1&df\[ds\]=ds-release&df\[id\]=DSD_ESS_EARN_A%40DF_C1224&df\[ag\]=LU1&df\[vs\]=1.0&dq=..A4._T%2BB-E%2BF%2BG%2BH%2BI%2BJ%2BK%2BM%2BL_N%2B0%2BP%2BQ%2BR_S.....&pd=2010%2C&to\[TIME_PERIOD\]=false](https://lustrat.statec.lu/vis?lc=en&tm=DF_C1224&pg=0&snb=1&df[ds]=ds-release&df[id]=DSD_ESS_EARN_A%40DF_C1224&df[ag]=LU1&df[vs]=1.0&dq=..A4._T%2BB-E%2BF%2BG%2BH%2BI%2BJ%2BK%2BM%2BL_N%2B0%2BP%2BQ%2BR_S.....&pd=2010%2C&to[TIME_PERIOD]=false)

ysis of differences across job types, of the determinants of wage levels, or of how wages evolve at the sectoral level. Since the present projection is a macro-simulation, however, the use of an economy-wide average wage is justifiable: the aim is not to capture individual retirement or labour-supply decisions, but to assess the pension system as a whole.

The projection of the gross annual wage follows the same assumption as [IGSS \(2024b\)](#): a real wage growth rate of 0.9% per year. Combined with the European Central Bank’s inflation target of 2% per year, this yields a nominal wage growth rate of 2.9%.

The final variable on the left-hand side is the number of workers L , which is disaggregated into resident workers L_{res} and non-resident workers L_{NR} . The historical data on workers by residence are taken from the annual *Rapport Général sur la Sécurité Sociale* published by the IGSS. The justification is straightforward: the IGSS source covers only workers insured under the general pension scheme, whereas STATEC data refer to the labour force as a whole. For the short-term projection horizon, the growth rates recently published by [STATEC \(2025b\)](#) are used, whereas for the long-term horizon, the growth rates provided by the [IGSS \(2024b\)](#) are considered. As the IGSS projects the total number of workers for every 10 years, simple linear interpolation is used between the years, to have continuity in the data.

The reason for this blended approach is that the IGSS short-term projections in 2024 were somewhat optimistic relative to the actual evolution of the labour market. This is in large part the result of global political and economic developments and their consequences on the labour demand in Luxembourg. Therefore, the estimations apply distinct growth rates for the period 2025 – 2027, separately for residents and non-residents ([Appendix 11](#)). From 2028 onwards, the IGSS long-term growth rates are used again, namely 1.1% per year for non-resident workers and 0.5% per year for resident workers.

In 2024, the projections start from a total of 504 742 insured contributors, of which 268 523 are residents (53.2%) and this number rises to 540 798 in 2030 whereas the projection of the [IGSS \(2024b\)](#) comes to a number of 590 000 of the active population in 2030. A consequence of starting from a lower 2024 base than the IGSS is that the projected trajectories lag the IGSS ones by a few years. Where the IGSS projects that the number of resident workers will remain stable from 2050 onwards at 330 000, the projections of this thesis reach the same level ten years later, in 2060. The same shift applies to non-residents: the IGSS expects the cross-border workforce to peak at 375 000 in 2060, whereas in the projections here this peak happens around 2065. The end-value in 2070 is nonetheless identical to the IGSS one: a total workforce of 705 000, decomposed into 375 000 non-residents and 330 000 residents. The details and differences between the figures obtained here and the IGSS ones can be found in [Appendix 10](#).

Under the current projections, non-resident workers will outnumber residents from around

2046 onwards (Appendix 21), consistent with the findings in section 2.2.

5.3 Expenditure Side

This section describes the right-hand side of equation (1), which represents total pension expenditure. The intuition is simple: total pension expenditure equals the average pension multiplied by the number of pensioners receiving it. The expenditure side, however, is disaggregated more finely than the revenue side: not only by residence, but also by type of pension, in order to identify clearly the main drivers of the rising pension cost.

To compute the average pension amount, the distinction is made jointly along two dimensions: residence (residents vs. non-residents), and pension category (old-age, invalidity, and survivor pensions, the latter further split between spouse and orphan benefits). This dual disaggregation gives the clearest possible view of the dynamics at work within the scheme. Following the same logic as for the implicit wage computation on the revenue side, the average pension is obtained by dividing total expenditure by the number of pensioners, separately for each combination of residence and pension type. Formally:

$$p_{cat,resid,t} = \frac{\text{Total expenditure}_{cat,resid,t}}{B_{cat,resid,t}} \quad (9)$$

where the subscript *cat* denotes the category of the pension, *resid* denotes the residence of the retiree, and *t* is the time variable. This fine disaggregation is feasible because the IGSS reports the total amount paid out by pension type and by country of residence of the recipient, along with the corresponding number of pensioners. From these two series, the average pension for each cell can be recovered directly. Any pension paid to a recipient residing outside Luxembourg is treated as a non-resident pension, which therefore includes recipients in the rest of the world, not only those in the three neighbouring countries.

Unlike the wage variable, the average pension differs sharply between residents and non-residents, a consequence of the shorter working careers spent in Luxembourg by cross-border workers, as discussed in Section 2.2. Disaggregating by pension type is equally important, since the average amount paid varies markedly across categories: old-age pensions are substantially higher than invalidity and survivor pensions (IGSS data). In 2024, the gross average old-age pension stood at €44 941 per year for residents, against only €20 585 for non-residents, which is less than half of the resident level (own computations).

A natural question is why one does not simply use the average pension amounts published directly by the IGSS. The IGSS in fact provides two such series for migratory

and non-migratory pensions, one for the average first pension and one for the average across all pensions in payment, and additionally in the annual *Rapport Général sur la Sécurité Sociale*, the average pension amount by pension type, again distinguishing between migratory pensions and all pensions. Two considerations pointed towards recovering the average pension by computation instead. First, computing it as the ratio of total expenditure to the number of pensioners avoids any ambiguity in definition and ensures that the model reproduces the IGSS total expenditure figures per country exactly. Second, and more importantly, migratory pensions are not equivalent to non-resident pensions: a migratory pension is one paid to an individual who has worked abroad for part of their career, regardless of where they currently reside. A Luxembourgish resident with prior work experience abroad, for instance, is classified as a migratory pensioner. The migratory against non-migratory split therefore does not map onto the resident against non-resident distinction central to my analytical framework, which made an own computation necessary.

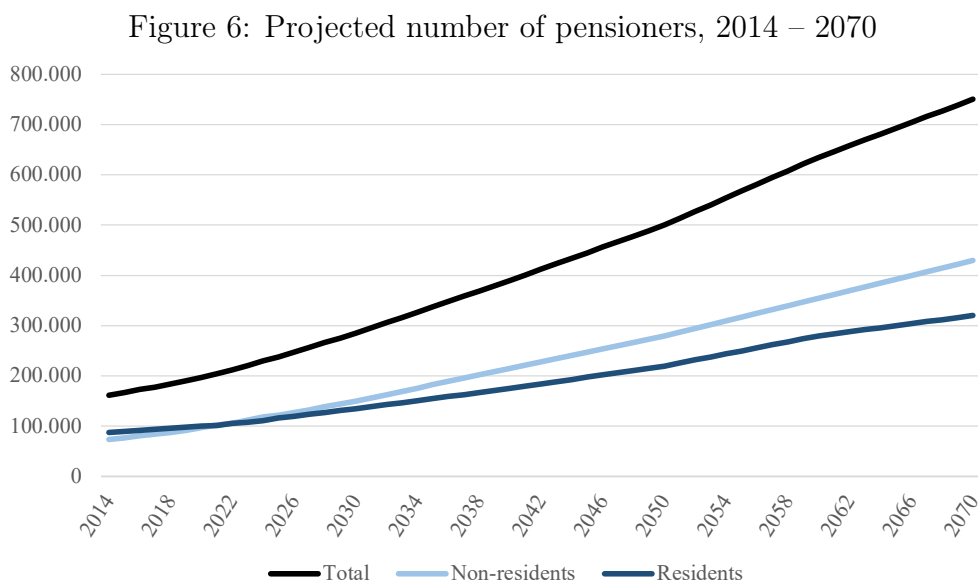
For each pension type and for both residents and non-residents, the same projected nominal growth rate of 2.9% is applied, as for the projections of wages on the revenue side. This is justified by the double indexation of pensions: pensions evolve in parallel with both real wages (+0.9% per year) and inflation (+2% per year), so that their projected nominal growth must coincide with that of wages. Applying the same growth rate to residents and non-residents until 2070 implies that the structural gap between their average pension levels remains constant over the projection horizon. This follows directly from a key modelling assumption: the average number of years worked in Luxembourg by non-residents does not increase further, but remains fixed at its 2024 level of 21.3 years (IGSS data). Relative to a full Luxembourgish career of 40 years, this means that non-residents spend 53% of their career in Luxembourg. The assumption is admittedly strong, given that the average duration has risen markedly over the past decade, raising from 16.0 years in 2010 to 21.3 years in 2024 (IGSS data), but career duration is not endogenously modelled in the present macro-simulation, and the constancy assumption is the cleanest tractable choice. If the average duration would exceed the current average of years worked in Luxembourg, then this would mean that non-residents would contribute more, but at the same time also get higher average pensions, which makes the total effect on the pension balance ambiguous.

As discussed in Section 3, the end-of-year allowance (EOYA), which is the parameter P_4 , functions as a thirteenth month and is therefore already embedded in the average pension calculation. The IGSS nonetheless reports the EOYA as a separate item in the social security accounts. Over the period 2010 – 2024, the EOYA consistently represented between 1.85% and 1.88% of total pension expenditure (Appendix 8). Therefore, 1.87% is retained as the share of the EOYA in total pension payments throughout the projection. This figure will become central in Section 6.3, where the suppression of the EOYA is exam-

ined as a reform option. It should also be noted that the EOYA is distributed uniformly across all pensioners, and that the simulation here does not allow for an individual-level identification of recipients.

The second parameter on the right-hand side is the number of pensioners B , again disaggregated by pension type and by residence. The historical evolution has already been described in Section 2.3, where the strong recent increase in the pensioner stock was documented and shown to continue, and to accelerate, over the 2070 horizon. As for the number of workers, the projections follow the IGSS (2024b) and use linear interpolation to ensure continuity (as the IGSS projection is done for every 10 years). The same source projects that the composition of pensions across categories will shift over time, thus the IGSS shares are adopted, again interpolated linearly. The share of old-age pensions is projected to rise from 72% in 2024 to 85% in 2070, while invalidity and survivor pensions decline from 7% to 4% and from 21% to 11% respectively. The rising share of old-age pensions, which on average pay more than invalidity and survivor pensions, mechanically pushes the average pension upward through composition over the projection horizon. The implied annual growth rates of the total number of pensioners are 2.4% for residents and 3.0% for non-residents (IGSS, 2024b). In aggregate, the total number of pensioners is expected to rise from 229 906 in 2024 to 750 000 in 2070, illustrated in Figure 6 which is a more than three-fold increase.

The expenditure side is therefore fully disaggregated by residence, by pension type, and



Source: own calculations based on IGSS data

by average pension level for each. This gives a clean view of pension expenditure by residence. The revenue side, by contrast, is disaggregated only at the worker level, since the average wage is assumed to be uniform across residence. Thus, the disaggregated

structure of the expenditure side, combined with the disaggregated worker counts on the revenue side, is what enables the resident to non-resident balance decomposition that defines the commuter shift discussed in Section 4.2.

5.4 Baseline Calibration

Before turning to the projection results, this section assesses the consistency of the model’s historical fit against the official IGSS figures published annually in the *Rapport Général sur la Sécurité Sociale*. The aim is twofold: to verify that the model reproduces the observed evolution of the pension scheme over the 2014 – 2024 period, and to make explicit any residual differences in scope between my computations and the published aggregates. Three quantities are compared: total revenue, total expenditure, and the stocks of workers and pensioners.

By construction, the total revenue series matches the IGSS figure exactly for every year of the historical sample, as shown in Table 1. This is a direct consequence of the methodology adopted in Section 5.2: since the average wage w is recovered by inverting the total-revenue identity: $w_t = \frac{\text{Total contribution income}_t}{c_t \cdot L_t}$ the implied product $c_t \cdot w_t \cdot L_t$ reproduces the contribution income reported by the IGSS by definition. The validation here is therefore not a non-trivial empirical test, but a confirmation that the computation has been performed correctly. The disaggregation of total revenue into a resident and a non-resident component is, however, an output of the model that cannot be directly validated, since to my knowledge no official data source reports contributions split by the residence of the worker.

The expenditure-side comparison is more informative, since here the computations and the IGSS published series are not identical by construction. The IGSS reports an aggregate *cash benefits* item in its annual social security accounts. A closer inspection of this item reveals that it includes, in addition to gross pension payments, several smaller components: *intérêts moratoires* (default interest), *remboursement de cotisations* (contribution reimbursement), and *indemnités d’attente* (waiting allowance)³. These items are not included in the average pension that are computed here, since they are not part of the pension benefit as such. A second discrepancy concerns the source figure for total pension payments itself: the headline figure used in this thesis, drawn from the disaggregation by residence and pension type, differs slightly from the *pensions brutes* (gross pensions) item reported in the detailed expenditure tables of another IGSS publication. To illustrate this, in 2024 the disaggregated source records a total of €6 805

³The details can be found on the IGSS website under the following link: https://igss.gouvernement.lu/dam-assets/publications/statistiques/assurance-pension/ap-2/AP_2-205.xlsx

million, against €6 865 million for the *pensions brutes* (gross pensions) figure, which represents a difference of roughly 0.9%. To this figure of €6 865 million the IGSS adds the other small components, so that they get a total pension expenditure of €6 988 million.

I have not been able to reconcile this internal IGSS difference, but I have retained the disaggregated-source figure because it is the only one available with the dual residence and category breakdown required by the model. The combined effect of these two scope differences is that my estimated total expenditure deviates from the IGSS’ *cash benefits* figure by between 1.0% and 2.6% over the 2014 – 2024 period (own computations), with my model consistently understating the IGSS aggregate. The deviation is small and broadly stable across years, which suggests that the gap reflects a constant difference in scope rather than a systematic error in the model. Table 1 reports the year-by-year comparison.

Table 1: Comparison of IGSS published data and own computations

	IGSS data	My computations	Difference (%)
Total revenue (in millions)			
2020	5 883	5 883	0%
2022	6 695	6 695	0%
2024	7 680	7 680	0%
Total expenditures (in millions)			
2020	4 996	4 929	−1.3%
2022	5 726	5 668	−1.0%
2024	6 988	6 805	−2.6%

Note: The IGSS data are here the one published in the annual *Rapport Général sur la Sécurité Sociale*, meaning that there are the other small components included, besides the gross pension.

The validation of the projected stocks of workers and pensioners is straightforward, since the IGSS (2024b) projection paths are adopted directly, with linear interpolation between reported years to ensure continuity. As discussed in Section 5.2, the difference in the 2024 starting point produces a multi-year lag between the estimated trajectory and the IGSS one for the worker stock, but the 2070 values coincide exactly: 705 000 workers in total, of which 375 000 non-residents and 330 000 residents (Appendix 10).

For the pensioner stock, the values match the IGSS values throughout the projection horizon.

The validated revenue and expenditure series presented here constitute the *baseline scenario* of the projection (Section 6.1), the unchanged policy trajectory of the pension scheme up to 2070, against which the five parametric reforms simulated in Section 6 are subsequently evaluated.

6 Results

This section presents the baseline projections of the general pension scheme, derived from the revenue and expenditure series constructed in Section 5, and then assesses the impact of five parametric reforms designed to correct the projected deterioration of the pension balance. The baseline is to be interpreted as the trajectory of the scheme at unchanged policy: the path that revenues, expenditures, and the resulting balance would follow if the current institutional parameters were left unchanged through 2070. It serves as the reference point against which each reform is evaluated. Every reform is presented in turn, motivated, and then compared with the baseline along the dual-criterion framework introduced in Section 4.2: the trajectory of the aggregate balance, and the timing of the commuter shift. All projections run from 2025 to 2070, with 2024 as the last year of observational data.

The timing of the proposed reforms follows directly from Bouchet (2024), who shows that the longer a structural intervention is delayed, the more difficult it becomes to stabilise the pension balance. Waiting until the legal reserve falls below the 1.5 times annual expenditure threshold set by law (*Code de la sécurité sociale* 2025) risks acting too late: by that point, the trajectory of the deficit may already be too steep to be meaningfully corrected by parametric reforms alone. By contrast, Bouchet (2024) shows that a pre-financing effort equivalent to 10% of pension expenditure, through reduced expenditure, increased revenue, or both, preserves a substantially less deteriorating trajectory.

Each of the five reform scenarios examined in this thesis is therefore implemented from 2027, the earliest practicable date.

The five reforms that follow can be grouped by the channel through which they operate. Reforms 1 (indexation) and 2 (indexation combined with EOYA suppression) act on the expenditure side: by lowering the projected growth path of average pensions, they slow the deterioration of both the resident and the non-resident balances symmetrically. Reform 3 (career duration extension) acts on the labour supply side: by raising the qualifying career from 40 to 42 years, it simultaneously increases the worker count and reduces the pensioner count, thereby improving the dependency ratio on both sides. Reforms 4 and 5 combine the two channels: Reform 4 pairs indexation with the duration extension, while Reform 5, which is called the combined reform, applies all three measures jointly. This typology matters analytically, because the expenditure-side and labour-supply-side channels affect the resident and non-resident sub-systems in different ways, with direct implications for the timing and magnitude of the commuter shift under each scenario. In this macro-simulation, reforms cannot be socially targeted, so all of the following reforms are implemented uniformly across pensioners; the welfare losses reported should be read

with this in mind.

6.1 Baseline Projections

The baseline projection requires precise definition before its results are presented. The term *Baseline* refers to the joint projected trajectory of the resident pension balance, the non-resident pension balance, and the resulting aggregate balance, obtained by extrapolating each of the five variables of the PAYG identity (c , w , L , p , B). Concretely, the baseline projection rests on the following set of assumptions, which are summarised in Table 2. The contribution rate c is held constant at 25.5% and set by the State. Nominal

Table 2: Baseline assumptions

Assumption	Value
Contribution rate	fixed at 25.5%
Nominal wage growth	2.9% per year
Nominal pension growth	2.9% per year
Worker / pensioner projections	short-term STATEC, long-term IGSS
Full pension career	40 years
Non-resident career length	constant at 21.3 years
EOYA share	fixed at 1.87% of total pension expenditure

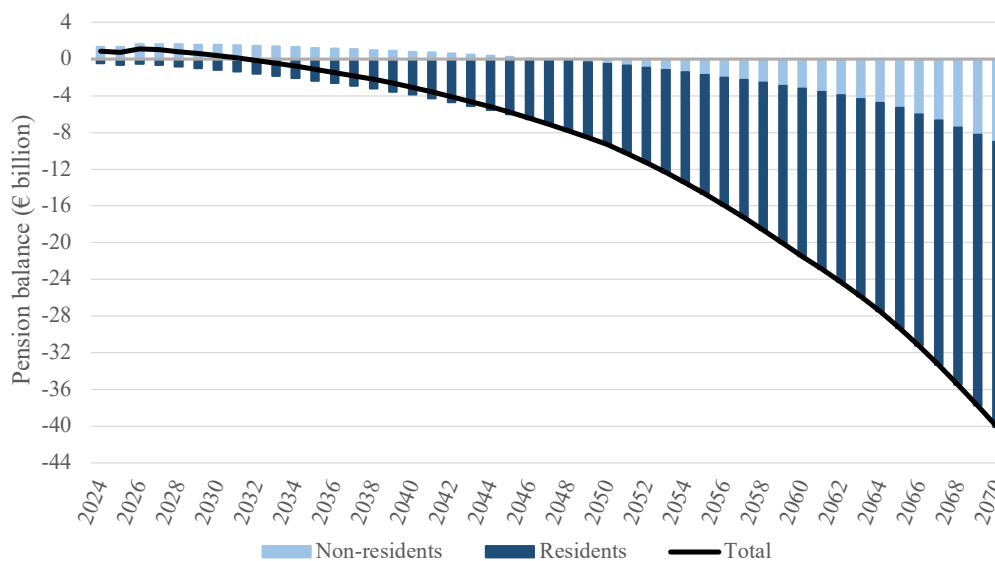
wages grow at 2.9% per year, decomposing into 0.9% real wage growth and the ECB’s 2% inflation target. The number of workers L and the number of pensioners B follow the projected trajectories from STATEC (2025b) for the short term and IGSS (2024b) for the long term, with linear interpolation between reported years. The average gross pension p grows at the same nominal rate of 2.9%, in line with the double indexation mechanism. The required career duration for a full pension remains unchanged at 40 years, and the average career length spent in Luxembourg by non-residents is held constant at its 2024 value of 21.3 years. Demographic projections, the resident population, and the implied retirement flows, follow IGSS (2024b). Finally, the end-of-year allowance is held at a constant share of 1.87% of total pension expenditure throughout the projection horizon.

The line that goes through the bars in Figure 7 shows that the aggregate balance of the general pension regime starts in surplus in 2024 and registers a small upward jump in 2026, reflecting the recent reform that raised the total contribution rate by 1.5 percentage points. This adjustment allows the balance to remain in surplus until 2032, when the first deficit appears. The trajectory of the aggregate balance turns after the brief 2026 surplus jump and follows a steepening downward path, reaching a deficit of approximately €40 billion by 2070. This deterioration reflects the joint effect of rising average pensions and a rising stock of pensioners, against a stock of workers that grows at a slower pace, as illustrated by the projected dependency ratio (Figure 4). The widening gap between pensioner and

worker growth rates is precisely what generates the increasingly steep slope of the deficit. The results lag by one year relative to the finding of [Bouchet \(2025b\)](#), who projects the first deficit for 2031. The discrepancy is small and traceable: Bouchet builds on the [IGSS \(2024b\)](#) projections updated to 2025 with the higher pension expenditure base, whereas the projection here uses the disaggregated source figures discussed in Section 5.3, which produce a slightly lower starting expenditure level.

Disaggregating the total balance by residence reveals a more complex underlying structure.

Figure 7: Decomposition of the pension baseline balance, 2024 – 2070.



Source: own calculations based on IGSS data

As discussed in Section 4.2, the resident balance has been in deficit since 2011, and it is the non-resident balance that has kept the system in surplus and will keep it that way until 2032 (Figure 7). After this date, the non-resident balance remains in surplus for some years, but the rapidly deepening resident deficit progressively dominates, driving the aggregate balance into deficit. The year 2047 then marks the commuter shift: the non-resident balance itself slips into deficit, transforming what had been a stabilising component into an additional source of financial pressure. The magnitude of this transition is substantial. The initial non-resident deficit in 2047 amounts to only €30 million, but it widens rapidly thereafter, reaching close to €9 billion by 2070. This is a deterioration that overshadows the modest size of the initial shift and represents a sizeable additional burden on the sustainability of the scheme.

The fifteen-year window separating the aggregate deficit (2032) from the commuter shift (2047) is analytically important. During this period, the system is in aggregate deficit, but the non-resident component is still partially absorbing the financial pressure. Reforms enacted before 2047 can therefore exploit this remaining cushion, while reforms enacted after 2047 face a structurally worse starting point on both balances simultaneously. This temporal structure is invisible at the aggregate level and emerges only through the

residence disaggregation; it constitutes one of the analytical contributions of the framework adopted in this thesis. It also carries direct implications for reform design: the urgency of intervention is measured not only by the aggregate deficit year, but also by the years remaining before the commuter shift, which define the window in which non-residents continue to relieve fiscal pressure on the system.

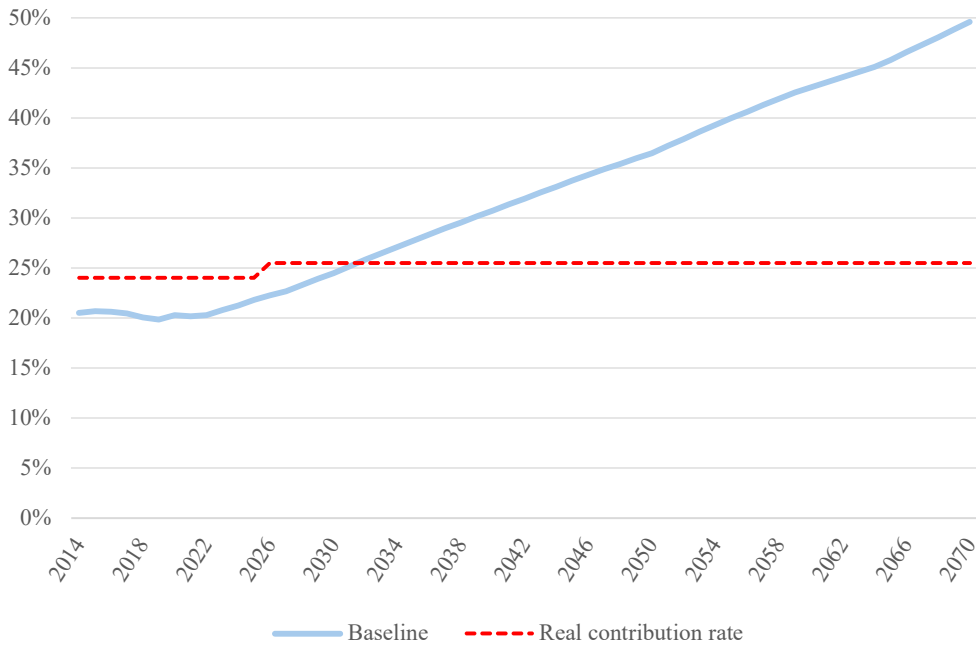
Computing the share of non-residents in both total revenue and total expenditure provides further insight into the dynamics underlying the commuter shift. In 2024, non-residents account for 46.80% of total contribution revenue, meaning that nearly half of all revenue collected by the scheme is generated by cross-border workers. This is consistent with the labour-market description in Section 2.2, which showed that resident workers still slightly outnumber non-residents in absolute terms, and therefore contribute somewhat more in aggregate. By 2070, the non-resident share in revenue is projected to rise to 53.19%, mirroring the inversion of the workforce composition over the projection horizon. The evolution of the non-residents share in both expenditures and revenues can be found in Appendix 9.

On the expenditure side, the picture is qualitatively similar but quantitatively weaker: the non-resident share rises from 33.06% in 2024 to 38.28% in 2070. The non-resident expenditure share grows more slowly than the revenue share because of the modelling assumption that the average career length spent in Luxembourg by non-residents remains constant at 21.3 years. Under this assumption, average non-resident pensions rise only through indexation to wages and prices, not through a mechanical lengthening of insured careers. The slower expansion of the expenditure share, relative to the revenue share, is precisely what allows the non-resident balance to remain in surplus for so long.

As shown in equation 2, the equilibrium contribution rate, which is the rate at which the system's balance is exactly zero, can be derived directly from the PAYG identity. Figure 8 plots its trajectory alongside the actual contribution rate set by the State, and offers an alternative way of visualising the timing of the first deficit: the system is in surplus as long as the equilibrium rate lies below the actual rate, and slips into deficit as soon as the equilibrium rate exceeds it. The two curves cross in 2032, consistent with the first deficit year identified above. From that point onwards, the equilibrium rate rises sharply, reaching 49.59% by 2070. To keep the baseline trajectory balanced through 2070, the contribution rate would therefore have to be raised by 24.09 percentage points, nearly doubling its current level. The economic implications of such an adjustment would be severe: each of the three contributing parties, the employee, the employer, and the central State, would see its individual share rise from 8.5% to roughly 16.5% of gross wages, with predictable consequences for labour costs, disposable income, and the public budget.

The baseline projection establishes three central findings: an aggregate deficit from 2032,

Figure 8: Equilibrium contribution rate for the Baseline scenario, 2024 – 2070.



Source: own calculations based on IGSS data

a commuter shift in 2047, and an equilibrium contribution rate approaching 50% by 2070. Together, these results show a structural and progressive deterioration of the scheme that contribution rate increases alone could not realistically address.

It is important to stress that the baseline is a counterfactual prediction rather than a projection. It describes the trajectory of the system if no further reform were implemented after 2026. In practice, it is not realistic that a sustained deterioration of this magnitude would unfold without policy intervention, as it is already a high salient public issue. Thus, the value of the baseline lies precisely in its function as the reference scenario against which alternative policy paths can be evaluated.

Each of the five reform scenarios that follows is evaluated against the baseline along the dual-criterion framework. The first criterion concerns the aggregate balance: by how many years does the reform delay the aggregate deficit, and by how much does it reduce the projected 2070 deficit relative to the €40 billion baseline? The second criterion concerns the commuter shift: does the reform delay or eliminate the inversion of the non-resident balance, and how does it reshape the trajectory of the non-residents' balance over the projection horizon?

6.2 Indexation Reform

The first reform examined is the indexation reform, which modifies a single parameter of the expenditure projection, the annual growth rate of pensions in payment, and constitutes the most powerful intervention against which more complex reform packages can be benchmarked.

This reform consists in suppressing the indexation of pensions to real wage growth, estimated at 0.9% per year (IGSS, 2024b). Pensions remain linked to inflation, set at 2% per year in line with the ECB target, but are no longer adjusted to productivity gains (which increase the real wage). The projected nominal growth rate of pensions therefore declines from 2.9% to 2% per year, phasing in gradually from 2027 onwards.

The reform is in line with the recommendations of OECD (2025a) and with the proposal of the IDEA Foundation in their working paper no. 31 (Bouchet, 2025a). Bouchet proposes a socially targeted de-indexation, preserving the wage-growth component for low-pension households while suppressing it for higher-pension ones. As noted, this thesis implements the suppression uniformly, rather than targeted.

In Luxembourg's pension formula, pensions are linked to real wages through two distinct mechanisms. The first is the readjustment of pensions in payment, which periodically adapts ongoing pensions to the evolution of average real wages and whose magnitude can be limited by the adjustment factor. The second is the revalorisation factor, which is used to update past wages earned over the career when computing the initial pension; this factor, generally greater than 1, is set annually by Grand-Ducal regulation on the basis of the work of the IGSS (*Loi Du 21 Décembre 2012 Portant Réforme de l'assurance Pension 2012*). The reform suppresses both channels: the adjustment factor is cancelled, so that pensions in payment are no longer readjusted to real wage growth, and the revalorisation factor is set to 1, so that initial pensions are no longer revalued in line with real wages either.

It should be noted that this measure does not reduce the purchasing power of pensioners, but merely slows its growth, since pensions remain indexed to prices. Given that pensions in Luxembourg are already substantially generous, with the average relative income of persons aged 65 and over relative to the total population being the highest in the OECD and the replacement rate being among the top four (OECD, 2025a), this adjustment appears defensible on comparative grounds. Most OECD countries index pensions either to wages or to prices, or to a mix of the two (Estonia, for instance, indexes 80% to wages and 20% to prices), whereas Luxembourg's double indexation is exceptional (OECD, 2025b).

The reform also ensures that pensioners contribute to the effort, rather than placing the burden exclusively on active contributors. It nonetheless raises distributional concerns:

by spreading the adjustment over time, it affects both current and future retirees, with differences in exposure across cohorts generating disparities in lifetime pension losses (Hindriks and Baurin, 2023).

In the projections, the indexation reform is implemented by changing the projected nominal growth rate of average pensions gradually from 2.9% per year to 2.0% per year, starting from 2027 and having full effect in 2030, while all other parameters remain identical to the baseline. Thus, the reform affects only the trajectory of the average pension over the projection horizon. Because both the non-resident and resident average pensions grow at the same lower rate after the reform, the structural ratio $\frac{p_{\text{res}}}{p_{\text{NR}}}$ remains unchanged from the baseline. The reform reduces both pensions proportionally rather than asymmetrically.

Under the indexation reform, the aggregate deficit is delayed, and the projected 2070 deficit is substantially smaller than under baseline (Appendix 23). The first year of aggregate deficit shifts from 2032 to 2034, which does not seem like a big delay, but by 2070, the aggregate deficit is reduced from €40 billion to approximately €14 billion, a reduction of 65% of the baseline deficit which is a significant improvement.

The mechanics are straightforward. The reform reduces the projected growth path of average pensions, and through it the projected growth of total expenditure ($p \cdot B$). Since the total revenue ($c \cdot w \cdot L$) is unchanged, the gap between revenue and expenditure widens more slowly than under baseline. The first deficit is delayed because the year in which expenditure overtakes revenue is pushed forward; the cumulative gap that builds up to 2070 is smaller because the indexation reform changes the slope of the expenditure trajectory, which grows less aggressively over time.

The reform does not, however, eliminate the deficit by 2070. The system remains structurally in deficit at the end of the projection horizon. Indexation reform alone substantially improves the trajectory but does not by itself restore long-term balance.

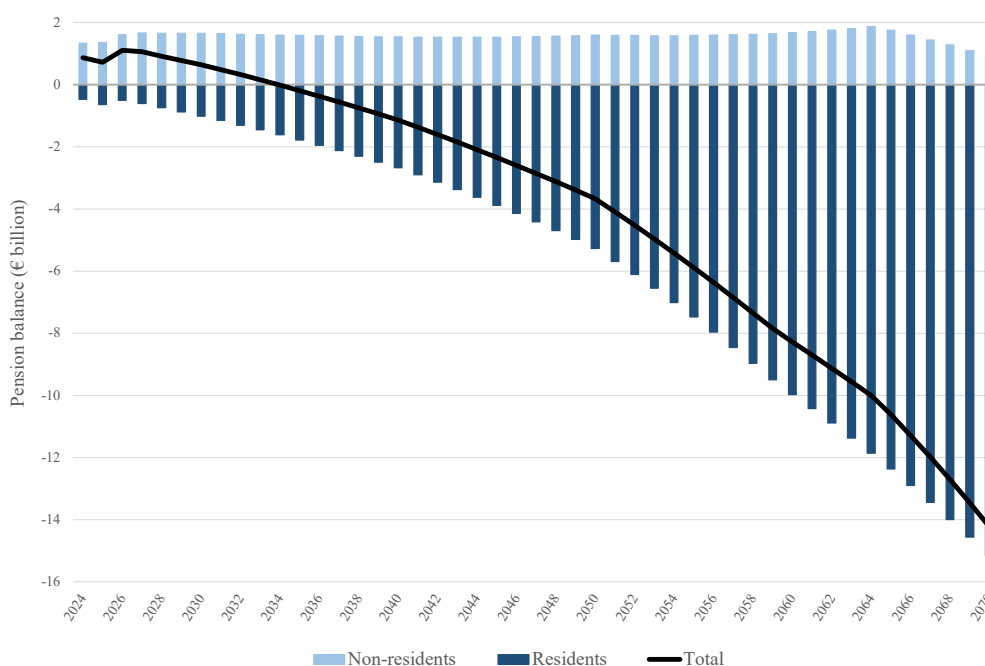
The reform's effect on the disaggregated balances (Figure 9), reveals an analytically important asymmetry. In the baseline scenario, the resident balance was already in deficit and deteriorating; the non-resident balance was in surplus until 2047, when the commuter shift occurred. Under the indexation reform, both components benefit from the slower growth of pensions, but the structural effect on the non-resident balance is particularly significant. In fact, the indexation reform prevents the commuter shift within the projection horizon, as the non-resident balance remains in surplus over the projection period.

The reason for this asymmetry lies in the structural composition of the system. Slowing the growth of expenditure extends the period during which contributions outpace

expenditure for non-residents, because the non-resident expenditure trajectory was the smaller one in absolute terms and grows more slowly under the reform. The reform therefore preserves the structural cushion that the non-resident component had been providing, rather than merely delaying its disappearance.

This asymmetry is exactly what the dual-criterion framework introduced in Section 4.2 was designed to expose. An aggregate analysis would understate the structural value of the indexation reform, because the cumulative benefit on the non-resident component accumulates over a longer horizon than the aggregate deficit delay alone suggests. The indexation reform is, in this sense, a structurally well-targeted intervention: it acts on the channel that is most directly responsible for the eventual non-resident balance inversion. Nevertheless,

Figure 9: Decomposition of the indexation reform balance, 2024 – 2070.



Source: own calculations based on IGSS data

the reform is not without trade-offs. By 2070, the average pension is approximately 31% lower in real terms than under baseline (Appendix 30). This is a substantial reduction in the real generosity of the scheme, even if the absolute purchasing power of pensions is preserved through the inflation indexation. The intergenerational equity question raised by Hindriks and Baurin (2023) is therefore real: due to the gradual phase-in of reforms, different cohorts experience unequal pension losses over their remaining lifetimes, with younger and future retirees typically bearing a larger share of the adjustment.

The reform's analytical interest extends beyond its immediate sustainability effect. It demonstrates that a single, structurally well-targeted parameter change can have outsized effects on the disaggregated balance trajectory, even when its effect on the aggregate

balance is more moderate. The next reform builds on this by adding the suppression of the EOYA, examining whether removing one further structurally smaller component of expenditure adds materially to the indexation reform alone.

6.3 Indexation and suppression of EOYA

The legal framework governing the EOYA is worth recalling, because it bears directly on the analytical interest of this reform. The 2012 law stipulates that “an end-of-year allowance is granted to persons entitled to a pension on December 1, provided that the overall contribution rate referred to in Article 238 does not exceed 24 percent” (*Code de la sécurité sociale* 2025). The 2025 reform, however, raised the overall contribution rate from 24% to 25.5% starting in January 2026. In practice, the EOYA was nonetheless retained when the contribution rate was increased. The reform examined here therefore does not introduce a fundamentally new policy: it enforces a condition that the original 2012 law had already established, but that has been de facto suspended since the 2025 contribution rate increase.

As with the indexation reform, the IDEA Foundation proposes a socially targeted suppression of the EOYA, preserving it for low-pension households (Bouchet, 2025a). Whereas in this thesis, a uniform suppression is implemented from 2027.

Whereas the indexation reform operates on the growth of pensions over the projection horizon, the EOYA suppression operates on the level of total pension expenditure from the moment of implementation. Thus, the two interventions therefore address different aspects of the expenditure trajectory: indexation reform changes the slope, the EOYA suppression changes the intercept.

In the projections, the reform is implemented in two steps. First, the indexation reform of Section 6.2 is applied: the projected nominal growth rate of average pensions decreases from 2.9% to 2.0% per year from 2027 onwards. Second, the total pension expenditure is reduced by 1.87% from 2027 onwards to reflect the EOYA suppression, which is applied uniformly across all pensioners, regardless of category or residence.

As with the indexation reform, the EOYA suppression does not directly affect the number of workers, the number of pensioners, the contribution rate, or the categorical mix.

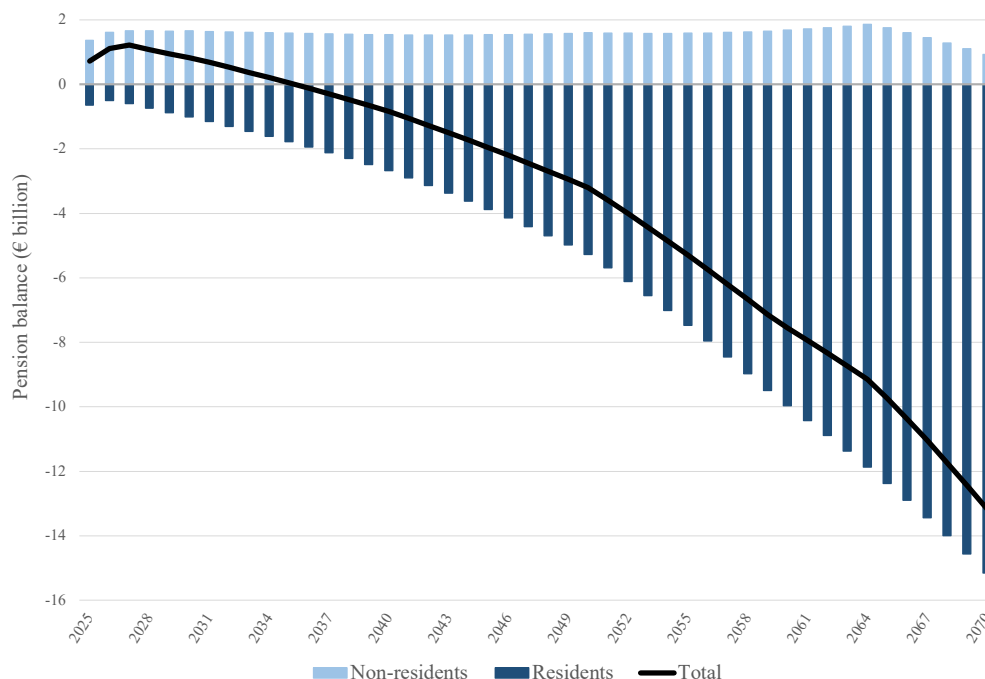
The reform delays the aggregate deficit by four years relative to the baseline, from 2032 to 2036 (Appendix 24). By 2070, the projected aggregate deficit is reduced from €40 billion to approximately €13 billion, which is a reduction of 67.5% relative to baseline.

The marginal contribution of the EOYA suppression on top of the indexation reform alone is positive but limited. The 1.87% reduction in expenditure is small relative to the

magnitude of the deficit accumulating to 2070, and it does not compound over time in the way that a slower growth rate does. The EOYA suppression therefore adds a modest two-year delay in the aggregate deficit (from 2034 under indexation alone to 2036 with EOYA suppression added) and a moderate further reduction in the 2070 deficit.

Again, the reform does not eliminate the deficit by 2070. The qualitative conclusion is unchanged: a markedly better trajectory, but still a deficit at the horizon.

Figure 10: Decomposition of the indexation and EOYA reform balance, 2024 – 2070.



Source: own calculations based on IGSS data

Under the reform, the non-resident balance remains in surplus throughout the 2025 – 2070 period, as shown in Figure 10. The commuter shift is therefore prevented within the projection horizon. The resident balance, by contrast, remains in deficit throughout the horizon, although the deficit grows more slowly than under the baseline. The structural pattern is the same as under the indexation reform alone, with the EOYA suppression amplifying the effect at the margin. The indexation reform was already substantial enough to preserve the non-resident surplus; adding the EOYA suppression simply widens the cushion further. From the perspective of the dual-criterion framework, both criteria are satisfied: the aggregate deficit is delayed and the commuter shift is prevented.

The two reforms examined so far have operated exclusively on the expenditure side of the PAYG identity, reducing the projected growth path of average pensions either through suppressed indexation or through the additional removal of the EOYA. The next reform operates on a different channel: the labour-supply side.

6.4 Duration Reform

This reform extends the qualifying career length for a full pension from 40 to 42 years, phased in gradually over fifteen years (from 2027 to 2041). This reform operates on the labour-supply side of the PAYG identity, rather than on the expenditure side: by raising the threshold required for a full career, it simultaneously increases the contributor count and reduces the pensioner count, thereby improving the dependency ratio without directly reducing the average pension level.

The reform examined here is not entirely new: the 2025 pension reform introduced precisely the same mechanism ([Loi Du 19 Décembre 2025 2025](#)), although in a more limited form. That reform extended the qualifying career duration by a total of eight months, phased in between 2025 and 2030, which is an increase of 1.6 months per year. The reform proposed here builds directly on this approach but applies it more ambitiously, extending the qualifying period by 24 months over fifteen years rather than eight months over five years.

The literature supports this kind of reform, as [Pilipiec et al. \(2021\)](#) show that raising the retirement age has positive effects on labour market participation. Although the reform examined here concerns the qualifying period rather than the legal retirement age, the effect is comparable in the Luxembourg context, since the qualifying period rather than the legal retirement age constitutes the effective constraint on retirement for the majority of insured persons.

The IDEA Foundation also proposes a closely related reform: indexing retirement ages to life expectancy, with a gradual increase of two years by 2050 followed by an additional two years by 2070 if life expectancy continues to rise ([Bouchet, 2025a](#)). The [CEPR \(2024\)](#) further indicates that reforms targeting the retirement age are more effective than purely monetary incentives.

Several observations justify the reform in the Luxembourg context. First, life expectancy in Luxembourg has risen from 78 years in 2000 to 83.5 years in 2024 ([OECD and European Observatory on Health Systems and Policies, 2017; 2025](#)). Combined with an effective retirement age of 61.4 years in 2024 ([IGSS, 2025](#)), the average time spent in retirement has increased from 17 to 22.1 years over the span of 24 years, without any adjustment to the required career duration. Second, the effective retirement age in Luxembourg is the lowest among all OECD countries in 2022, which suggests room for an increase ([OECD, 2025a](#)). Third, IGSS data show that workers already have a nearly complete career in 2024: 39.5 years on average for residents and 40.9 years for non-residents. The problem therefore does not lie in careers being too short, but in the fact that the system allows retirement well before the legal age of 65. An increase in the

qualifying period would bring the effective retirement age closer to the legal age. Fourth, the employment rate, as shown in Figure 2, of those aged 50 – 64 rose from 42.2% in 2000 to 61.1% in 2024, reflecting a growing capacity of older workers to remain active. Although still below the overall employment rate of 69.7%, the trend points to untapped potential for extending working life among older cohorts.

In principle, this reform could primarily target workers close to retirement, where the employment rate gap is largest. However, the aggregate model does not allow for the simulation of measures targeted at a specific age group, so the reform is implemented uniformly across all workers and pensioners.

The reform is done through two symmetric adjustments to the model, both phased linearly over the implementation window of 2027 to 2041.

First, on the pensioner side, the average time spent in retirement is given by life expectancy minus the effective retirement age, in 2024 it was of: $83.5 - 61.4 = 22.1$ years. Extending the qualifying career by two years reduces this average retirement period by the same amount, bringing it to 20.1 years, which is a reduction of approximately 9%. This 9% is spread linearly over the fifteen-year implementation window: in year 1 (2027), the pensioner count is reduced by $\frac{1}{15} \cdot 9\%$ relative to the baseline projection; in year 2, by $\frac{2}{15} \cdot 9\%$; and so on, until the full 9% reduction is reached in 2041 and maintained through 2070. The reform applies only to old-age pensions, since one does not choose to become disabled or to lose a spouse. The invalidity and survivor pension counts therefore remain unaffected.

Second, on the worker side, by symmetry extending the career from 40 to 42 years represents a 5% increase in the number of required contribution years, leading to a 5% increase in the number of workers, also phased linearly over the same fifteen-year window. The intuition is straightforward: workers who would have retired after 40 years instead remain in the workforce for 42 years, increasing the average length of working life by two years and thereby raising the projected contributor count. Table 3 shows how the duration reforms changes the number of pensioners and workers by comparing it to the baseline projections.

A third effect of the reform requires explicit methodological discussion. Extending working life by two years leads, in reality, to a higher end-of-career salary, since wages tend to be higher at later career stages. Furthermore, the total contributory income (*TCI*) of the pension formula would also increase, as workers gain more over their whole working period. This higher salary and total life-income would impact the pension formula and would produce a higher initial pension. A naive implementation of the duration reform would therefore generate an indirect upward pressure on average pensions, which would partially offset the savings achieved through the reduction in the pensioner count.

In the model, however, the projected nominal growth rate of average pensions is held

Table 3: Comparison of the total number of workers and pensioners between the duration reform and the baseline, 2020 – 2070

Number of workers			Number of pensioners		
Year	Baseline	Reform	Year	Baseline	Reform
2020	461 345	461 345	2020	197 414	197 414
2030	540 798	548 008	2030	285 000	280 075
2040	585 088	612 392	2040	390 000	366 412
2050	633 566	665 245	2050	500 000	467 600
2060	688 248	722 661	2060	635 000	593 852
2070	705 000	740 250	2070	750 000	701 402

constant at 2.9% per year under the duration reform, thus the same rate as under the baseline. This choice implicitly assumes that the upward pressure on pensions from longer careers is neutralised by a corresponding downward adjustment. The economic content of this assumption is similar to that of a longevity coefficient: a mechanism that reduces the individual pension benefit when the cohort retires with a longer expected period in retirement.

In Sweden, a similar mechanism was introduced in 1993, dividing the accumulated notional capital by a conversion coefficient reflecting the residual life expectancy of the cohort at the time of retirement. The coefficient is recalculated annually based on a five-year moving average of mortality tables: if life expectancy increases between two cohorts, the divisor increases and the annual pension mechanically decreases (Settergren, 2003). The IDEA Foundation has proposed a comparable mechanism for Luxembourg (Bouchet, 2025a).

The model cannot include the longevity coefficient explicitly in the aggregate framework, since it operates on individual cohort accounts. By holding the average pension growth rate constant under the reform, however, the model captures its aggregate effect: the indirect pension increase is netted out, and the duration reform delivers the savings of the count adjustment without the offsetting expenditure increase. The duration reform as modelled here should therefore be understood as a combined intervention: a two-year extension of the qualifying career, accompanied by an implicit longevity coefficient that prevents the indirect upward pressure on average pensions. Without the implicit coefficient, that is allowing the average pension to grow faster under the reform than under the baseline, the reform’s aggregate effect would be weaker, and the commuter shift would likely arrive earlier than the figures reported below.

The reform delays the aggregate deficit and the projected 2070 deficit is smaller than under baseline (Appendix 25). The first year of aggregate deficit shifts from 2032 to 2035. By 2070, the projected aggregate deficit is reduced from approximately €40 billion to

approximately €31 billion, a reduction of approximately 22.5% relative to baseline.

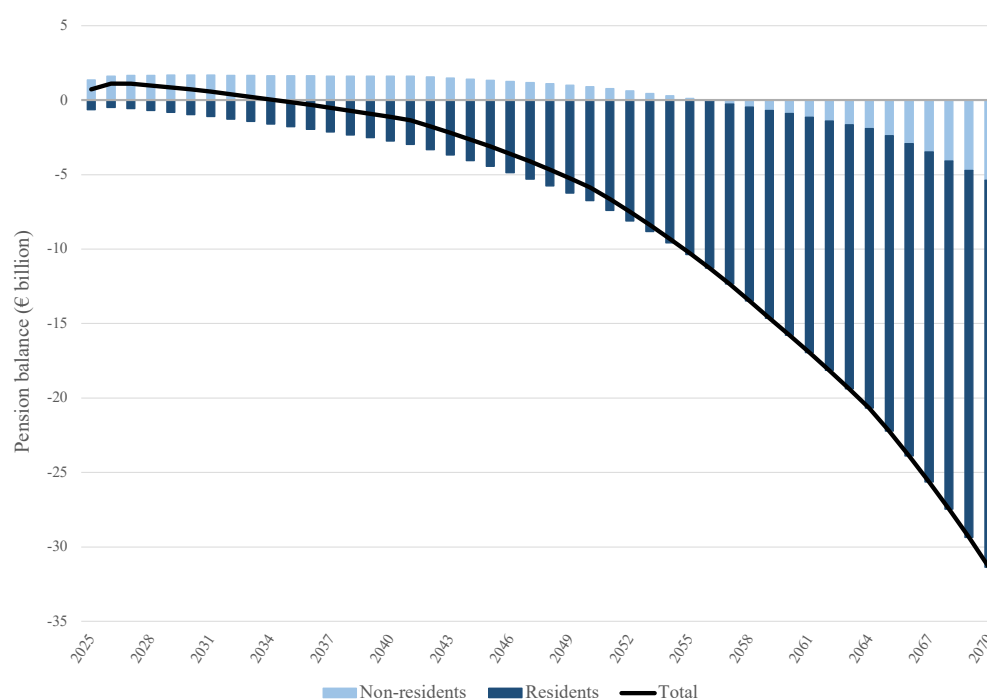
The 22.5% reduction in the 2070 deficit is meaningful but a lot smaller than what the indexation reform alone achieves (reduction of deficit by 65%). This is the first analytically important result of the section: a labour-supply intervention as ambitious as a two-year extension of the qualifying career, even when combined with an implicit longevity coefficient that neutralises the indirect upward pressure on pensions, delivers a smaller aggregate-balance improvement than a single-parameter modification of the indexation rule. The reason is structural: the indexation reform reduces the growth rate of expenditure across the entire projection horizon, with cumulative savings that compound over time. The duration reform reduces the level of the pensioner count and increases the level of the contributor count, but does not alter the growth path of average pensions, which under double indexation continues at 2.9% per year. The duration reform is therefore fundamentally a level intervention, whereas the indexation reform is a slope intervention, which accumulates larger cumulative savings over a 45-year projection horizon.

The disaggregated balance under the duration reform, depicted in Figure 11, reveals a fundamentally different structural pattern from the expenditure-side reforms examined in the previous sections. Under the indexation reform, the non-resident balance was preserved in surplus through the projection horizon, preventing the commuter shift. Under the duration reform, by contrast, the non-resident balance still turns negative, though at a later year than under baseline. The commuter shift occurs in 2056, nine years later than the baseline year of 2047. The reform therefore delays the commuter shift by nine years but does not prevent it within the projection horizon. This is a substantively different outcome from the indexation reform.

The aggregate-balance criterion, taken alone, would suggest that the duration reform is a meaningful intervention. However, the dual-criterion analysis reveals, that the reform leaves the structural commuter shift largely intact, only postponed. Whereas expenditure-side reforms preserve the non-resident surplus throughout the horizon, the labour-supply side reform merely delays its disappearance.

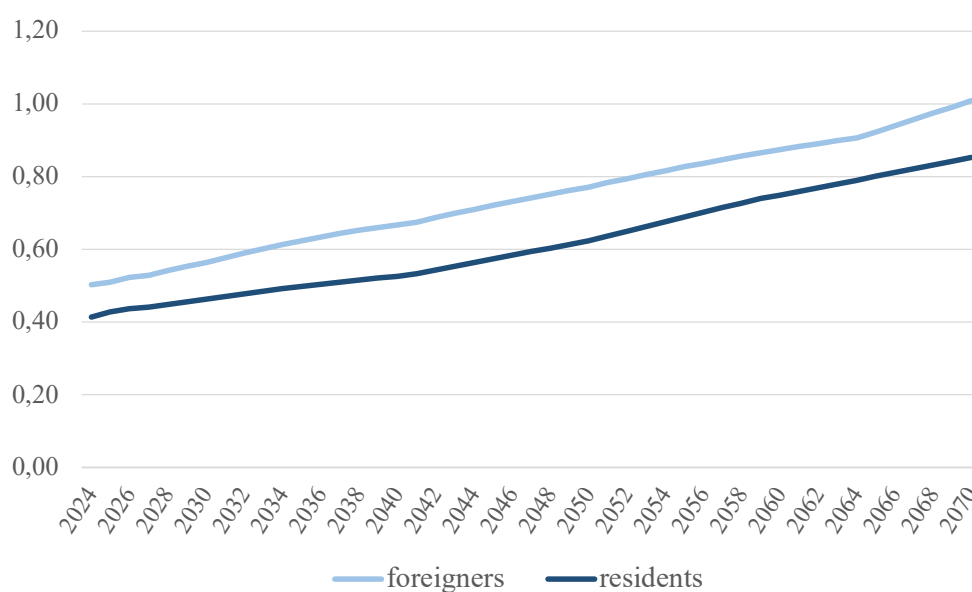
The duration reform is therefore both less effective on the aggregate criterion and structurally less protective on the commuter shift criterion. The duration reform's impact on the dependency ratio is illustrated in Figure 12: by changing worker and pensioner counts proportionally on both sides, the reform reduces both ratios relative to the baseline, but the non-resident ratio still reaches 1.01 by 2070, marginally above unity. This is the logical consequence of acting on the labour-supply side: although the non-resident dependency ratio is brought down from 1.15 (baseline) to 1.01, the level remains above the threshold at which the number of pensioners exceeds the number of workers. The resident ratio is reduced as well, from 0.97 to 0.85. The reform therefore has a measurable effect on

Figure 11: Decomposition of the duration reform balance, 2024 – 2070.



Source: own calculations based on IGSS data

Figure 12: Dependency ratio after the duration reform, 2024 – 2070.



Source: own calculations based on IGSS data

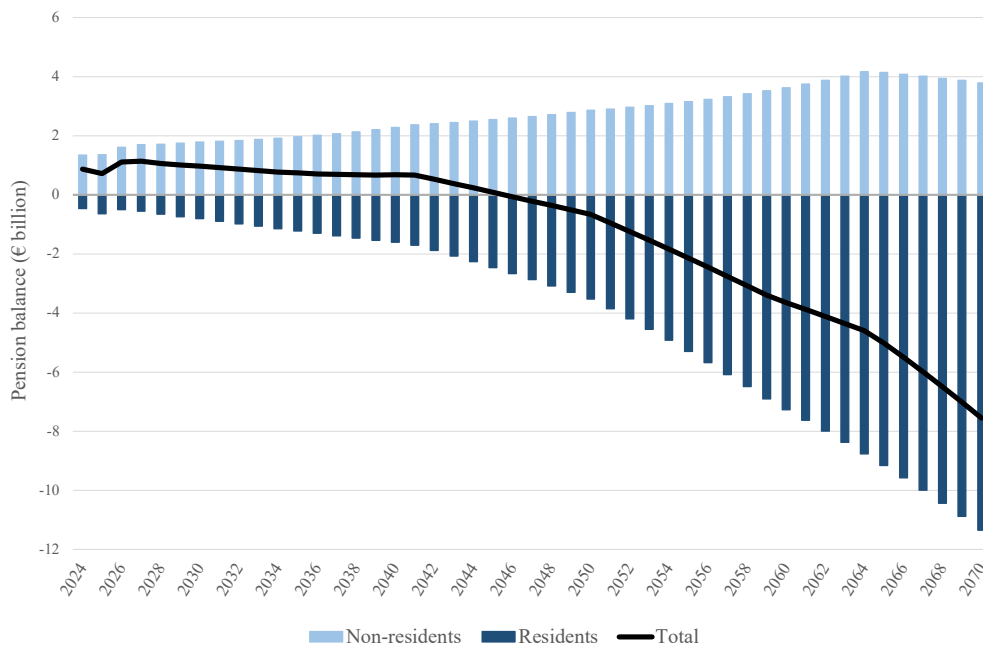
both ratios, but not one strong enough to bring the non-resident ratio comfortably below unity, which again displays the stronger pensioners growth rate, even with an uptick in the number of workers.

6.5 Indexation and Duration

This reform is done by applying both the indexation reform and the duration reform simultaneously, starting from 2027. The indexation reform component reduces uniformly the projected nominal growth rate of average pensions from 2.9% to 2.0% per year from 2027 onwards. The duration reform component is implemented as in the preceding section: the qualifying career length is extended from 40 to 42 years, phased linearly over fifteen years (2027 to 2041) and the longevity coefficient is introduced. The two components apply jointly and from the same starting year, so that no further ordering of effects is required. The combined reform leaves the contribution rate, the EOYA, and the categorical mix unchanged from baseline.

Under the combination of both the indexation and duration reform, the aggregate deficit

Figure 13: Decomposition of the indexation + duration reform balance, 2024 – 2070.



Source: own calculations based on IGSS data

is delayed substantially and the projected 2070 deficit is reduced markedly relative to baseline (Appendix 26). The first year of aggregate deficit shifts from 2032 to 2046. By 2070, the projected aggregate deficit is reduced from €40 billion (baseline) to approximately €7.5 billion, a reduction of 81.3% relative to baseline, which represents a remarkable correction.

The two reforms taken together guarantee the commuter-shift protection of the indexation reform, as can be seen in Figure 13. The non-resident balance remains in surplus throughout the projection horizon, and the commuter shift is therefore prevented within the 2025 – 2070 window. The non-residents' balance reaches a surplus of €3.7

billion in 2070. This cushion allows limiting the total deficit and keep it under €8 billion. Nevertheless, the reform is not sufficient to balance out the resident's global balance, which remains largely in deficit at a value of €11.3 billion in 2070.

6.6 Combined Reform

The 'combined reform' combines all three measures examined separately in the preceding sections: the indexation reform, the suppression of the EOYA, and the duration reform. All three components are implemented jointly from 2027, on the same terms as in their individual sections. The implicit longevity coefficient remains also in force.

Under the combined reform, the aggregate deficit is delayed substantially, and the projected 2070 deficit is reduced markedly relative to baseline (Appendix 27). The first year of aggregate deficit shifts from 2032 to 2049. By 2070, the projected aggregate deficit is reduced from €40 billion to €6.5 billion, which corresponds to a reduction of 83.8% relative to baseline.

Although the system remains in deficit by 2070, the magnitude of the residual gap is significantly smaller than under any single reform examined in the previous sections. The combined reform therefore delivers the largest aggregate-balance improvement of all five reform scenarios but does not by itself restore long-term equilibrium within the projection horizon.

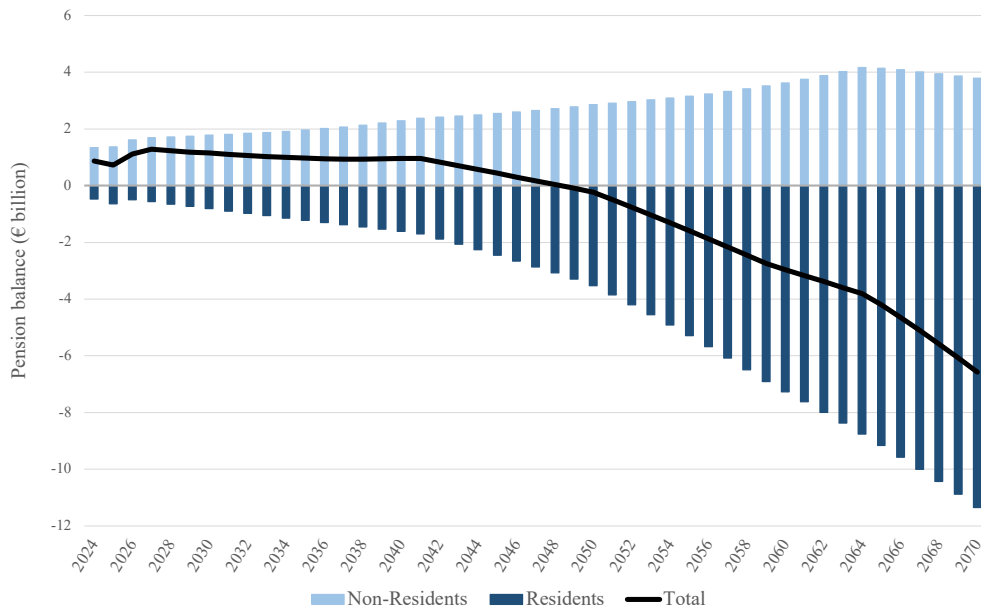
The disaggregated balance in Figure 14 under the combined reform mirrors the structural pattern observed under the combined indexation and duration reform, with all components further reinforced. The non-resident balance remains in surplus throughout the projection horizon, standing at €3.7 billion in 2070. The commuter shift is therefore prevented within the 2025 – 2070 window, and by a comfortable margin.

The structural mechanism is unchanged from the previous combined reforms. The indexation reform reduces the slope of the expenditure trajectory across both residences. The EOYA suppression and the duration reform reduce the level of expenditure further while raising the level of revenue. Together, these effects compress the projected expenditure trajectory of the non-resident component substantially below the trajectory of non-resident contributions, preserving the non-resident surplus throughout the horizon at a larger margin than under any individual reform.

The system remains in deficit at the end of the projection horizon, but at a substantially reduced magnitude. Whether this is a "manageable" residual deficit is a normative question outside the scope of this thesis; what the model demonstrates is that the combined reform delivers a meaningful sustainability improvement without restoring full balance.

As shown in the baseline scenario, the equilibrium contribution rate provides an

Figure 14: Decomposition of the ‘combined reform’ balance, 2024 – 2070.

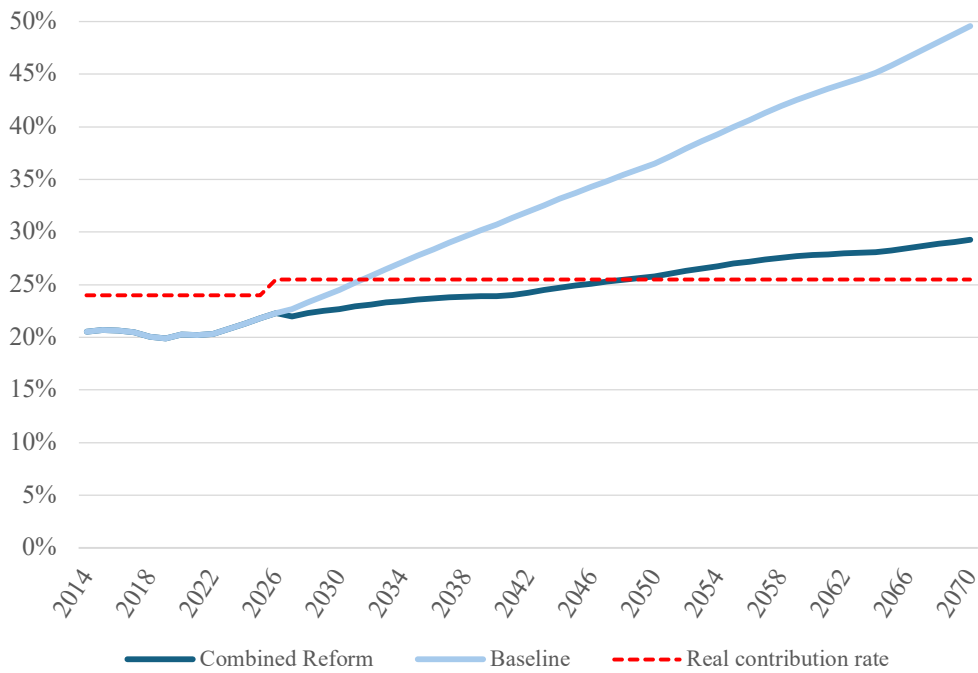


Source: own calculations based on IGSS data

alternative way of locating the moment at which the aggregate balance enters deficit, namely the year in which the equilibrium and statutory contribution rates cross. Figure 15 illustrates this comparison, plotting the equilibrium contribution rate under the combined reform alongside the baseline trajectory. The contrast highlights the substantial structural improvement delivered by the combined reform: by 2070, the equilibrium rate reaches approximately 30%, against nearly 50% under the baseline. To restore the equilibrium, the statutory contribution rate would therefore need to rise by approximately 4 percentage points by 2070, well below the 24.09 percentage point increase that would be required in the baseline scenario.

A final comparison concerns two ratios expressed relative to GDP: total pension expenditure and the total pension balance. On the expenditure side, the baseline trajectory rises steeply from 7.90% of GDP in 2024 to 17.25% by 2070, a path broadly in line with IGSS (2024a), who report 17.5% in 2070. The figures here rely on nominal GDP, projected at an average growth rate of 3.8% per year, the same used by the IGSS (2024b). When comparing the baseline trajectory with that obtained under the combined reform, the contrast is striking: whereas the baseline ratio more than doubles over the projection horizon, gaining nearly 10 percentage points, the combined reform keeps the expenditure-to-GDP ratio firmly under control (Appendix 28). The ratio peaks at 10.81% in 2060 and then edges down to 10.68% by 2070, corresponding to a total increase of 2.8 percentage points relative to 2024. The reform therefore not only delays the deterioration of the pension balance, but also stabilises the macroeconomic weight of pension expenditure

Figure 15: Equilibrium and real contribution rate, 2024 – 2070.



Source: own calculations based on IGSS data

over the long run.

The same contrast emerges for the total balance as a share of GDP. Under the baseline, it deteriorates from a surplus of 1% in 2024 to a deficit of 8.4% in 2070, once more close to [IGSS \(2024b\)](#), who project a deficit of 8.0% in 2070. Under the combined reform, by contrast, the ratio is contained at a deficit of only 1.4%, reaffirming the substantial contribution of the reform to the sustainability of the scheme.

Table 4: Summary of reform outcomes

Scenario	First deficit year	Year of commuter shift	Projected 2070 balance (million €)
Baseline	2032	2047	-40 106
Indexation	2034	prevented	-14 224
Index + EOYA	2036	prevented	-13 164
Duration	2035	2056	-31 363
Index + Duration	2046	prevented	-7 550
Combined reform	2049	prevented	-6 576

Everything taken together, Table 4 shows the summary of all the reforms, the corresponding deficits as well as the first year of deficit and the year of when the commuter shift occurs.

7 Sensitivity Analysis

Since the estimations rely on a number of macroeconomic assumptions, this section presents alternative scenarios for cases in which these assumptions do not hold. Specifically, a change in the inflation rate and a change in the productivity growth rate are simulated, for both the baseline scenario and the combined reform. The purpose is to show how pension sustainability would be affected if the factors treated as exogenous to the PAYG identity were to differ from their assumed values. This matters all the more given that the projection extends to 2070: over such a long horizon, there can be no certainty that the macroeconomic assumptions will be realised.

7.1 Inflation

This section examines a change in the inflation rate. The previous projections used the ECB's target inflation rate of $\pi = 2\%$; this section considers two further scenarios, a lower rate of $\pi = 1.5\%$ and a higher rate of $\pi = 2.5\%$. Since the projection runs from 2024 to 2070, it is reasonable to expect the average inflation rate over that period to correspond to the ECB's target. Nevertheless, the macroeconomic uncertainty of recent years makes it relevant to project the pension balance under alternative inflation rates. At the same time, it is implausible that the average rate over 2024 – 2070 would deviate substantially from the 2% target, which justifies limiting the variation to an increase and a decrease of 0.5 percentage points.

Here, inflation is varied while the productivity and demographic projections are held constant at their baseline values. This sensitivity analysis therefore captures the marginal effect of inflation alone, and not the other features that might change alongside it. In reality, the inflation rate would affect other macroeconomic variables as well, but these interactions are not considered here.

In the pension balance projections of this thesis, a change in the inflation rate should have similar effects on total pension expenditure and total revenues, since wages and pension benefits are both indexed to price changes simultaneously. The impact on the PAYG identity should therefore be approximately neutral, as inflation scales wages and pensions up by the same amount. Changes in the level of the deficit may nonetheless be expected.

The results in Table 5 confirm the analytical expectation: inflation enters approximately symmetrically on both sides of the PAYG identity, leaving the structural balance largely invariant. The PAYG identity is approximately homogeneous of degree one in inflation: contributions and pension expenditure both scale with the price level through

Table 5: Inflation sensitivity: baseline and combined reform balances in 2070

	$\pi = 1.5\%$	$\pi = 2.0\%$	$\pi = 2.5\%$
Baseline (no reform)			
Aggregate balance 2070 (€bn)	−32.1	−40.1	−50.1
Expenditures 2070 (% of GDP)	17.21%	17.25%	17.28%
Year of first deficit	2032	2032	2032
Year of commuter shift	2047	2047	2047
Combined reform			
Aggregate balance 2070 (€bn)	−5.2	−6.6	−8.3
Expenditures 2070 (% of GDP)	10.64%	10.68%	10.72%
Year of first deficit	2049	2049	2049
Year of commuter shift	prevented	prevented	prevented

Notes: Inflation $\pi = 2.0\%$ corresponds to the central baseline scenario. Productivity ($g = 0.9\%$), employment growth, and the contribution rate are held at their central values. *Source:* Own calculations based on IGSS data.

the indexation of wages and pensions, while the real quantities, the labour force, the pensioner stock, and the contribution rate, are unaffected by inflation. A change in the long-term inflation rate therefore scales both sides of the identity proportionally, and with them the gap between them. The deepening of the nominal deficit from €32.1 billion under 1.5% inflation to €50.1 billion under 2.5% inflation does not reflect a deterioration of the system, but it reflects the same structural deficit at a higher price level. This is confirmed by the expenditure-to-GDP ratio, which moves by only 0.07 percentage points across all the inflation scenarios, and by the year of first deficit, which is identical at 2032 in all three baseline scenarios.

The marginal upward drift in the ratio of expenditures over GDP under higher inflation arises from a second-order composition effect. Pensions in payment in 2024 are calibrated to historical wage levels and catch up to the new wage trajectory only gradually through the readjustment mechanism, while pensions newly liquidated after 2024 reflect the higher wage trajectory in full. Under higher inflation, the share of "new-regime" pensions in total expenditure rises slightly faster, producing the small drift observed. The same logic carries over to the combined reform: although the indexation rule is different, pensions now track inflation only, both wages and pensions still scale with the price level, so the structural balance and the year of first deficit (2049 in all three scenarios) remain effectively the same. Under the combined reform, the commuter shift is prevented for all three inflation scenarios, confirming that this signature feature of the reform is driven by the de-indexation from real wage growth, not by the absolute level of inflation. The structural sustainability of the system is therefore approximately independent of the inflation regime, by construction of the double indexation mechanism on the revenue side and the price indexation mechanism on the expenditure side.

7.2 Productivity

In this section, a change in productivity is projected in order to assess how the pension balance responds. This exercise is important, as it tests how effective the proposed reforms remain under a different macroeconomic environment. The baseline and the reform projections both assume an annual productivity growth of 0.9%, so that wages and pensions increase by this amount plus the inflation rate. Here, a pessimistic and an optimistic scenario are projected instead, each of which affects both the number of workers and the number of pensioners. IGSS (2024b) carries out the same exercise, and the data used in this section is drawn from it. The IGSS conducts its sensitivity analysis using scenarios developed by STATEC. The decision to rely on an existing sensitivity scenario, rather than constructing one from scratch, was motivated by the relevance of its estimated changes in the total number of workers and pensioners. A new scenario would require strong external assumptions about how the labour force responds to a given change in productivity. Such assumptions could easily produce unrealistic trajectories and weaken the relevance of the sensitivity analysis.

IGSS (2024b) publishes both the baseline scenario used in this thesis and a set of robustness checks based on alternative scenarios developed by STATEC. The baseline scenario relies on the demographic projections of EUROPOP2023, published by Eurostat and also used by the Ageing Working Group (AWG) of the European Commission. STATEC, by contrast, produces its own internally consistent demographic projections. These differ from EUROPOP2023 in that they are more precise about the productivity assumptions and explicitly account for Luxembourg's attractiveness arising from its higher salaries. As an illustration, whereas the baseline scenario foresees the labour force peaking at 705 000 workers from 2060 onwards, the STATEC scenarios still project a continued increase.

STATEC proposes four scenarios, each combining a different level of total factor productivity (TFP) with a different investment rate. Scenario S1 is the most pessimistic and scenario S4 the most optimistic, while scenarios S2 and S3 represent intermediate cases between these two extremes and are not considered here.

Scenario S1 assumes a TFP growth rate of 0.0% and an investment rate of 15%, which together yield an average productivity growth of 0.4% per year. This translates into employment growth of 0.9% per year and real GDP growth of 1.0% per year. At the other end of the spectrum, scenario S4 assumes a TFP growth rate of 0.8% per year combined with an investment rate of 20%. Productivity growth is therefore set at 1.2% per year and employment growth at 1.1% per year, resulting in average real GDP growth of 2.1% over 2024 – 2070.

Both scenarios affect the number of workers and pensioners, as shown in Table 6,

where they are compared with the baseline used in this thesis.

Table 6: Labour force and number of pensioners: baseline and STATEC scenarios S1 and S4, 2030 – 2070 (in thousands)

	2030	2040	2050	2060	2070
Number of workers					
Baseline (own projection)	541	585	634	688	705
Scenario S1	570	645	695	725	745
Scenario S4	570	650	715	775	830
Number of pensioners					
Baseline (own projection)	285	390	500	635	750
Scenario S1	280	385	495	620	730
Scenario S4	280	385	495	625	735

Notes: The baseline rows report the projection used in this thesis (see Section 4). The S1 and S4 rows reproduce the STATEC scenarios published by [IGSS \(2024b\)](#) (Tableaux 13 and 14), rounded by the source to the nearest thousand. *Source:* Own calculations and IGSS data.

To make the two STATEC scenarios comparable to the baseline, three variables were modified. First, productivity growth influences the level of wages and, through the indexation mechanism, the level of pensions. For the low-productivity scenario of 0.4% per year, for instance, the growth rate of both wages and pensions becomes $2\%(\text{inflation}) + 0.4\%(\text{productivity}) = 2.4\%$. For these scenarios, the ECB target of 2% inflation is retained. The same computation is used for the high-productivity scenario.

Second, the number of workers was adjusted to the figures proposed by each scenario. Since [IGSS \(2024b\)](#) publishes only the total number of workers, the resident and non-resident shares of each year are taken from the baseline scenario, and the annual figures are again obtained by linear interpolation. As in the baseline projection and the reform projections, the total number of workers was overstated relative to the observed figures; the number of workers and pensioners was therefore adjusted to follow the STATEC short-term projections, published recently, until 2027 ([STATEC, 2025b](#)). The difference is significant: for both S1 and S4, the year 2030 counts 570 000 workers in total, whereas the projections here give 540 000 for S1 and 546 000 for S4 due to the adjustments based on the recent [STATEC \(2025b\)](#). Nevertheless, the numbers of the projections converge to the same total in 2070 as the published figure of S1 and S4.

The same procedure is applied to the number of pensioners. Here too, only the total number is published, so the share of each pension category and of each residence group is taken from the baseline.

Before turning to the results, the expected pattern can be set out analytically. Under the baseline, a change in productivity should not have a significant impact, since both wages and pensions are adjusted by the same amount of real wage growth through the

indexation mechanisms. Any differences that emerge are therefore attributable to the demographic changes noted earlier. Under the combined reform, by contrast, higher productivity should contribute substantially to correcting the pension deficit. Because wages continue to grow at the higher rate while pensions are adjusted to inflation alone, the wedge between the two widens considerably. This raises total revenues and lowers expenditure relative to revenue, which progressively corrects the deficit.

Table 7: Growth sensitivity: baseline and combined reform balances in 2070

	S1 ($g = 0.4\%$)	Baseline ($g = 0.9\%$)	S4 ($g = 1.2\%$)
Baseline (no reform)			
Aggregate balance 2070 (€bn)	−28.3	−40.1	−36.2
Expenditure 2070 (% of GDP)	19.13%	17.25%	17.07%
Year of first deficit	2033	2032	2033
Year of commuter shift	2048	2047	2055
Combined Reform			
Aggregate balance 2070 (€bn)	−11.3	−6.6	+8.4
Expenditure 2070 (% of GDP)	14.60%	10.68%	9.44%
Year of first deficit	2042	2049	no deficit
Year of commuter shift	prevented	prevented	prevented

Notes: The Baseline column corresponds to the IGSS baseline used in Section 4. The S1 and S4 columns use the STATEC alternative scenarios (IGSS, 2024b). Productivity (g) is combined with 2% inflation.

Source: Own calculations based on IGSS data.

Table 7 presents the results of the assumed productivity change for both the no-reform scenario and the combined reform, compared with the baseline, which uses a productivity growth rate of 0.9% per year. Under the baseline, where the projection assumes unchanged policy, the 2070 deficit ranges from €28.3 billion under S1 to €40.1 billion under the central scenario, with S4 standing between the two at €36.2 billion. The expenditure-to-GDP ratio is highest in the low-productivity scenario and lowest under S4. In both productivity scenarios, the first deficit is delayed by one year relative to the central case, from 2032 to 2033, and the commuter shift is likewise postponed.

Under the combined reform, the spread is wider: the low-productivity scenario S1 records a 2070 deficit of €11.3 billion, while S4 produces a surplus of €8.4 billion. The expenditure-to-GDP ratio is again highest under S1, at just under 15%, whereas under the central scenario and S4 it lies around 10%. The timing of the first deficit, however, is not ordered by productivity: it appears in 2042 under S1, in 2049 under the central scenario, and not at all under S4. In all three scenarios, the commuter shift is prevented.

Two findings in Table 7 appear counterintuitive at first sight. First, the baseline scenario, with a productivity growth rate of 0.9%, shows the largest deficit of the three, despite occupying the middle of the productivity range. Second, under the no-reform

projection, the first deficit appears one year later in both S1 and S4 than under the central case. Both findings have the same cause: the demographic assumptions differ between the two sensitivity scenarios and the central baseline. Both STATEC scenarios end in 2070 with a higher number of workers and a lower number of pensioners than the baseline scenario. In the beginning of the projection period the divergence is small, but it widens over time. This twofold effect reduces pension expenditure and raises contributions, all else equal. As noted earlier, the short-term growth rate of the labour force is adjusted using the recently published STATEC figures (STATEC, 2025b), while the long-term growth rates are taken from the respective scenarios; the 2070 end-value serves as an anchoring point, ensuring that the trajectories converge exactly (Appendix 12). Both STATEC scenarios are therefore more favourable for the dependency ratio than the IGSS baseline, which explains their lower end-of-horizon deficit. The expenditure-to-GDP ratio offers a complementary perspective: it is highest under low productivity and lowest under high productivity, consistent with intuition.

The variations in Table 7 can be explained through three mechanisms. The first is a denominator effect, which lowers pension expenditure expressed as a percentage of GDP. Under higher productivity, GDP grows at a faster rate, enlarging the denominator and thereby reducing the ratio, so that the outcome appears more favourable than under low productivity (17.07% under S4 against 19.13% under S1). The second mechanism is the demographic channel discussed above: a more favourable dependency ratio lowers pension expenditure and delays the first deficit, although only by a small margin of one year. The third mechanism, and the most important, is a wedge effect under the combined reform. By de-indexing pensions from real wage growth and linking them to inflation only, the reform allows wages to continue growing at a higher pace than pensions, so that the gap between the two widens over time. Under S1 this wedge is only 0.4 percentage points, whereas under S4 it is three times larger, at 1.2 percentage points. Compounded over the projection period, the wedge transforms the trajectory of the pension balance entirely, moving the 2070 outcome from a deficit of €11.3 billion under S1 to a surplus of over €8 billion under S4. This is a substantial difference, and it illustrates the strong impact of the indexation reform: under the no-reform scenario, by contrast, pensions continue to grow at the same rate as wages, and a significant deficit remains.

The main result of this sensitivity analysis is more qualitative than quantitative. Under the most dynamic STATEC scenario (S4), the combined reform fully restores long-term pension sustainability, producing a surplus of over €8 billion in 2070. The commuter shift is successfully prevented, and it is again the non-resident component that keeps the aggregate balance in surplus, while the resident balance remains in deficit in 2070, at €4.7 billion (Appendix 29). Thus, under an optimistic but not implausible macroeconomic

environment, the combined reform would be sufficient to keep the system in surplus.

Under the more pessimistic S1 scenario, characterised by low productivity, the reform remains impactful: it reduces the 2070 deficit by more than half (from €28.3 billion to €11.3 billion) and prevents the commuter shift. The qualitative result holds across all productivity scenarios, since the commuter shift is prevented in every case. The magnitude of the effect, however, depends strongly on productivity gains, which in turn shape the dependency ratio in a favourable direction.

Taken together, the inflation and productivity sensitivity analyses show that the combined reform is robust across all scenarios and substantially reduces the 2070 end-of-horizon deficit. The balance is approximately invariant to changes in inflation, since the indexation mechanism enters identically on both sides of the PAYG equation. Under the combined reform, the pension balance depends positively on productivity growth: higher productivity provides a better balance and, in the most dynamic scenario, even a surplus. In every scenario, higher productivity at least reduces the deficit, because contributions then grow at a faster rate than pension benefits. Importantly, the combined reform prevents the commuter shift in all scenarios, keeping the non-resident balance as a cushion rather than turning it into an additional burden. The central conclusion of this work is therefore that the combined reform consistently improves the pension balance across all scenarios examined, even though the magnitude of the improvement, and whether it is sufficient to fully restore balance, depends on the productivity environment.

8 Conclusion

This thesis set out to assess the long-run sustainability of Luxembourg's general pension scheme and to determine how its financial trajectory is shaped by the cross-border composition of the workforce. To do so, it developed a residence-disaggregated PAYG accounting framework that splits the aggregate balance of the scheme into a resident and a non-resident sub-balance, and it used this framework both to date the structural deterioration of the system and to evaluate five parametric reform proposals against a dual criterion: the trajectory of the aggregate balance and the timing of the commuter shift.

Two baseline findings emerge. First, under unchanged policy the general scheme slips into structural deficit in 2032, with the aggregate gap widening to roughly €40 billion by 2070 and the equilibrium contribution rate approaching 50%, an adjustment that contribution increases alone could not plausibly absorb. Second, the resident balance has been in deficit since 2011, so it is the non-resident surplus that has kept the system afloat. This thesis formally identifies and dates the *commuter shift*, the year that surplus turns

into deficit. In the baseline this happens in 2047, when a previously stabilising component becomes an accelerating source of pressure. This temporal structure, a fifteen-year window between the aggregate deficit and the commuter shift, is invisible in the aggregate analysis adopted by the existing literature and constitutes the central analytical contribution of the framework.

The reform analysis adds a third set of findings. Expenditure-side reforms acting on the growth path of pensions, the indexation reform in particular, are structurally well targeted: by slowing the slope of the expenditure trajectory they preserve the non-resident surplus over the whole horizon and prevent the commuter shift entirely. The duration reform, acting on the labour-supply side, only postpones it. The combined reform, mixing all three measures, reduces the 2070 deficit by approximately 84% and prevents the commuter shift by a comfortable margin, though without restoring the balance within the horizon. These results are robust across alternative inflation and productivity scenarios, and they confirm the methodological point that motivated the disaggregation: a reform's effect on the aggregate balance can substantially understate its effect on the structural position of the cross-border component.

These results also point beyond the reforms evaluated here. Every measure considered in this thesis is parametric: it recalibrates the indexation rule, the EOYA, or the qualifying career length, but leaves the architecture of the scheme intact. The analysis shows that such reforms can slow the deterioration significantly, but even the combined package does not restore balance, and both forces driving the deficit, demographic ageing and the commuter shift, are structural and, on current trends, effectively irreversible. When the shocks a system faces are permanent rather than transitory, repeatedly tightening parameters is an incomplete response: each adjustment must be re-legislated as conditions worsen, and, as the political-economy literature reviewed above suggests, faces growing resistance as the electorate ages. This raises the question of a paradigmatic reform, a change in the architecture itself rather than in its parameters. A notional-account design, in which an explicit accrual rate and a revaluation rate govern how rights are earned and evolve over time, can embed an automatic demographic and economic stabiliser: when longevity rises, growth slows, or the ratio of workers to pensioners falls, the accumulation of new rights decelerates by rule, rather than producing a debt-financed deficit that must be corrected after the fact. Such a design would absorb both the demographic and the commuter shift endogenously, although it does so by transferring more risk to pensioners, whose final pension is less fully guaranteed, and it raises transition questions that lie beyond the accounting framework developed here. It is therefore a direction for reform that the present results motivate rather than one this thesis can itself evaluate.

Several limitations should be kept in mind. The projections rest on a macro-simulation, that does not capture individual retirement or labour-supply decisions, nor general-equilibrium feedback from reforms to wages, employment or migration flows. The assumption of a uniform average wage across residence, and of a constant non-resident career length of 21.3 years, are tractable but strong, and the reform scenarios are necessarily uniform where a socially targeted design would be preferable. These limitations point to natural extensions: endogenising the cross-border career length, incorporating the behavioural response of migration to less generous non-resident treatment, and embedding the framework in a generational accounting structure to assess the intergenerational distribution of the reform burden.

Finally, the commuter shift identified here is a sharp instance of a more general phenomenon. Its underlying mechanism is not specific to cross-border work: any PAYG system that relies on a strong inflow of contributors whose pension benefits are only paid later, whether cross-border workers or working-age immigrants, enjoys a temporary surplus that mechanically reverses once the first large cohorts reach retirement. Luxembourg is simply the clearest case: with nearly half of its contributors residing abroad, the non-resident component can be isolated in the accounts, exposing a transition that many ageing economies with large foreign-origin workforces undergo less visibly. Two lessons follow. First, financing a deficit through continued inflows is, in effect, a bet on the permanent acceleration of those inflows; as the worker projections in this thesis show, once that growth converges, the favourable balance erodes. Second, and consistent with the migration literature, the standard analysis of migration and pensions assumes that contributors retire in the same system to which they contribute. The Luxembourg case shows what happens where this assumption fails: workers pay contributions during their careers but draw their pensions only much later, so that the surplus is larger while it lasts and its eventual reversal sharper. The residence-disaggregated framework developed here offers a tool for dating that reversal before it arrives.

References

- Aaron, Henry (1966). “The Social Insurance Paradox”. In: *The Canadian Journal of Economics and Political Science / Revue canadienne d’Economie et de Science politique* 32.3, pp. 371–374. ISSN: 0315-4890. DOI: [10.2307/139995](https://doi.org/10.2307/139995). JSTOR: [139995](https://www.jstor.org/stable/139995). URL: <https://www.jstor.org/stable/139995>.
- Aslanyan, Gurgen (2014). “The Migration Challenge for PAYG”. In: *Journal of Population Economics* 27.4, pp. 1023–1038. ISSN: 1432-1475. DOI: [10.1007/s00148-014-0516-x](https://doi.org/10.1007/s00148-014-0516-x). URL: <https://doi.org/10.1007/s00148-014-0516-x>.
- Auerbach, Alan J., Jagadeesh Gokhale, and Laurence J. Kotlikoff (1991). “Generational Accounts: A Meaningful Alternative to Deficit Accounting”. In: *Tax Policy and the Economy, Volume 5*. The MIT Press, pp. 55–110. DOI: [10.1086/tpe.5.20061801](https://doi.org/10.1086/tpe.5.20061801). URL: <https://www.nber.org/books-and-chapters/tax-policy-and-economy-volume-5/generational-accounts-meaningful-alternative-deficit-accounting>.
- Bloom, D. E., D. Canning, and G. Fink (2010). “Implications of Population Ageing for Economic Growth”. In: *Oxford Review of Economic Policy* 26.4, pp. 583–612. ISSN: 0266-903X, 1460-2121. DOI: [10.1093/oxrep/grq038](https://doi.org/10.1093/oxrep/grq038). URL: <https://academic.oup.com/oxrep/article-lookup/doi/10.1093/oxrep/grq038>.
- Blundell, Richard, Eric French, and Gemma Tetlow (2016). “Retirement Incentives and Labor Supply”. In: *Handbook of the Economics of Population Aging*. Vol. 1. Elsevier, pp. 457–566. ISBN: 978-0-444-63405-4. DOI: [10.1016/bs.hespa.2016.10.001](https://doi.org/10.1016/bs.hespa.2016.10.001). URL: <https://linkinghub.elsevier.com/retrieve/pii/S2212007616300190>.
- Boffi, Giacomo, Eduard Suari-Andreu, and Olaf Van Vliet (2026). “Decomposing the Net Fiscal Position of Migrants in Europe”. In: *International Tax and Public Finance*. ISSN: 0927-5940, 1573-6970. DOI: [10.1007/s10797-025-09942-4](https://doi.org/10.1007/s10797-025-09942-4). URL: <https://link.springer.com/10.1007/s10797-025-09942-4>.
- Boldrin, Michele, Mariacristina De Nardi, and Larry E. Jones (2015). “Fertility and Social Security”. In: *Journal of Demographic Economics* 81.3, pp. 261–299. ISSN: 2054-0892. JSTOR: [26422376](https://www.jstor.org/stable/26422376). URL: <https://www.jstor.org/stable/26422376>.
- Bouchet, Muriel (2024). *Document de travail N°29 : Pensions : une si coûteuse procrastination*. IDEA. URL: <https://www.fondation-idea.lu/2024/12/11/document-de-travail-n29-pensions-une-si-couteuse-procrastination/>.
- Bouchet, Muriel (2025a). *Document de travail N°31 : Pensions, un quatuor de réformes*. IDEA. URL: <https://www.fondation-idea.lu/2025/04/03/dt-31-pensions-un-quatuor-de-reformes/>.
- Bouchet, Muriel (2025b). *Document de travail N°32 : Paquet de réforme des pensions 2025 : analyse et amendements*. IDEA. URL: <https://www.fondation-idea.lu/2025/11/11/document-de-travail-n32-paquet-de-reforme-des-pensions-2025-analyse-et-amendements/>.

- CEPR (2024). *Rethinking Pension Reform*. CEPR. URL: <https://cepr.org/publications/books-and-reports/rethinking-pension-reform>.
- Chrisp, Joe and Nick Pearce (2019). “Grey Power: Towards a Political Economy of Older Voters in the UK”. In: *The Political Quarterly* 90.4, pp. 743–756. ISSN: 0032-3179, 1467-923X. DOI: [10.1111/1467-923X.12737](https://doi.org/10.1111/1467-923X.12737). URL: <https://onlinelibrary.wiley.com/doi/10.1111/1467-923X.12737>.
- Christl, Michael et al. (2022). “Projecting the Fiscal Impact of Immigration in the European Union”. In: *Fiscal Studies* 43.4, pp. 365–385. ISSN: 1475-5890. DOI: [10.1111/1475-5890.12314](https://doi.org/10.1111/1475-5890.12314). URL: <https://onlinelibrary.wiley.com/doi/abs/10.1111/1475-5890.12314>.
- Code de la sécurité sociale* (2025). URL: <https://cmss.gouvernement.lu/dam-assets/files/code-securite-sociale-2025.pdf>.
- Diamond, Peter A. (1965). “National Debt in a Neoclassical Growth Model”. In: *The American Economic Review* 55.5, pp. 1126–1150. ISSN: 0002-8282. JSTOR: [1809231](https://www.jstor.org/stable/1809231). URL: <https://www.jstor.org/stable/1809231>.
- Doepke, Matthias et al. (2022). *The Economics of Fertility: A New Era*. 29948. NATIONAL BUREAU OF ECONOMIC RESEARCH. DOI: [10.3386/w29948](https://doi.org/10.3386/w29948). URL: https://www.nber.org/system/files/working_papers/w29948/w29948.pdf.
- European Union, Official Journal of the (2015). “Regulation (EC) No 883/2004 of the European Parliament and of the Council of 29 April 2004”. In: *Core EU Legislation*. London: Macmillan Education UK, pp. 288–318. ISBN: 978-1-137-54501-5 978-1-137-54482-7. DOI: [10.1007/978-1-137-54482-7_27](https://doi.org/10.1007/978-1-137-54482-7_27). URL: http://link.springer.com/10.1007/978-1-137-54482-7_27.
- Eurostat (2026a). *Fertility Statistics*. Eurostat. URL: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Fertility_statistics.
- Eurostat (2026b). *Women’s Pension 25% Lower than Men’s in 2024*. URL: <https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20260225-1>.
- Eurostat (2026c). *Life Expectancy*. Eurostat. URL: https://ec.europa.eu/eurostat/databrowser/view/proj_19nalexp/default/table?lang=en.
- Galasso, Vincenzo and Paola Profeta (2002). “The Political Economy of Social Security: A Survey”. In: *European Journal of Political Economy* 18.1, pp. 1–29. ISSN: 01762680. DOI: [10.1016/S0176-2680\(01\)00066-0](https://doi.org/10.1016/S0176-2680(01)00066-0). URL: <https://linkinghub.elsevier.com/retrieve/pii/S0176268001000660>.
- Goerres, Achim (2007). “Why Are Older People More Likely to Vote? The Impact of Ageing on Electoral Turnout in Europe”. In: *The British Journal of Politics and International Relations* 9.1, pp. 90–121. ISSN: 1369-1481, 1467-856X. DOI: [10.1111/j.1467-856x.2006.00243.x](https://doi.org/10.1111/j.1467-856x.2006.00243.x). URL: <https://journals.sagepub.com/doi/10.1111/j.1467-856x.2006.00243.x>.

- Gruber, Jonathan and David A. Wise (1999). “Introduction to “Social Security and Retirement around the World””. In: *Social Security and Retirement around the World*. University of Chicago Press, pp. 1–35. URL: <https://www.nber.org/books-and-chapters/social-security-and-retirement-around-world/introduction-social-security-and-retirement-around-world>.
- Hennessey, Gemma and Jessica Hagen-Zanker (2020). *The Fiscal Impact of Immigration*. Working paper 573. ODI (Overseas Development Institute). URL: <https://apo.org.au/node/303629>.
- Hindriks, Jean and Arno Baurin (2023). “Intergenerational Consequences of Gradual Pension Reforms”. In: *European Journal of Political Economy* 78, p. 102336. ISSN: 01762680. DOI: [10.1016/j.ejpoleco.2022.102336](https://doi.org/10.1016/j.ejpoleco.2022.102336). URL: <https://linkinghub.elsevier.com/retrieve/pii/S0176268022001392>.
- Hindriks, Jean and Sefane Cetin (2025). “Sustainability of Pension Reforms: An EU-wide Political Stress Test”. In: *Journal of Pension Economics and Finance*, pp. 1–27. ISSN: 1474-7472, 1475-3022. DOI: [10.1017/S1474747225100103](https://doi.org/10.1017/S1474747225100103). URL: https://www.cambridge.org/core/product/identifier/S1474747225100103/type/journal_article.
- Hohnerlein, Eva Maria (2019). “Pension Indexation for Retirees Revisited – Normative Patterns and Legal Standards”. In: *Global Social Policy* 19.3, pp. 246–265. ISSN: 1468-0181, 1741-2803. DOI: [10.1177/1468018119842028](https://doi.org/10.1177/1468018119842028). URL: <https://journals.sagepub.com/doi/10.1177/1468018119842028>.
- Holzmann, Robert and Edward E. Palmer (2006). *Pension Reform: Issues and Prospects for Non-Financial Defined Contribution (NDC) Schemes*. Washington, DC: World Bank. 686 pp. ISBN: 978-0-8213-6038-5. DOI: [10.1596/978-0-8213-6038-5](https://doi.org/10.1596/978-0-8213-6038-5). URL: <https://openknowledge.worldbank.org/entities/publication/ea2f1644-1ab6-5fe3-881d-564cf7cc5a22>.
- IGSS (2015). *Rapport général sur la sécurité sociale 2015*. Inspection Générale de la Sécurité Sociale. URL: <https://igss.gouvernement.lu/dam-assets/publications/rapport-g%C3%A9n%C3%A9ral-sur-la-s%C3%A9curit%C3%A9-sociale/rg-2015.pdf>.
- IGSS (2024a). *2024 Ageing Report – Pension Projections COUNTRY FICHE FOR LUXEMBOURG*. European Commission. URL: https://economy-finance.ec.europa.eu/document/download/fb78e27d-6c9d-45ff-9bea-9832b9bf5c49_en?filename=2024-ageing-report-country-fiche-Luxembourg.pdf.
- IGSS (2024b). *Cahier statistique no 18 - Projections démographiques et financières du régime général d’assurance pension*. URL: <http://igss.gouvernement.lu/fr/publications/apercus-et-cahiers/cahiers-statistiques/202407no18.html>.
- IGSS (2025). *Rapport général sur la sécurité sociale 2025*. Inspection Générale de la Sécurité Sociale. URL: <http://gouvernement.lu/fr/publications.html>.

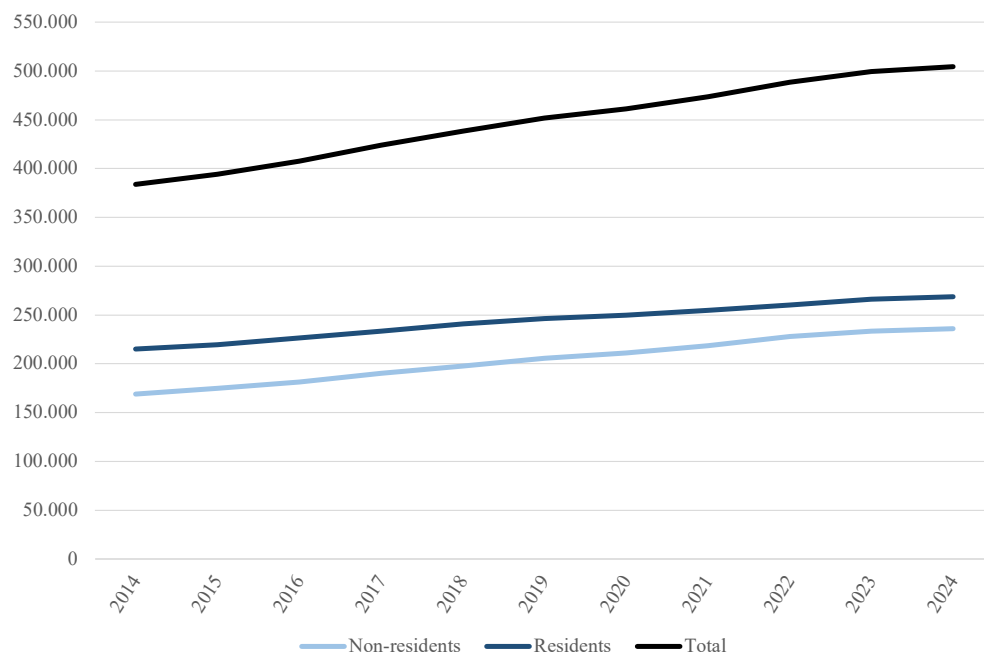
- Lindbeck, Assar and Mats Persson (2002). *THE GAINS FROM PENSION REFORM*. 712. Stockholm, Sweden: INSTITUTE FOR INTERNATIONAL ECONOMIC STUDIES Stockholm University. URL: <https://www.econstor.eu/bitstream/10419/81275/1/wp580.pdf>.
- Loi Du 19 Décembre 2025* (2025). URL: <https://legilux.public.lu/filestore/eli/etat/leg/loi/2025/12/19/a606/jo/fr/pdfa/eli-etat-leg-loi-2025-12-19-a606-jo-fr-pdf.pdf>.
- Loi Du 21 Décembre 2012 Portant Réforme de l'assurance Pension* (2012). URL: <https://legilux.public.lu/filestore/eli/etat/leg/memorial/2012/a279/fr/pdf/eli-etat-leg-memorial-2012-a279-fr-pdf.pdf>.
- OECD (2021). *International Migration Outlook 2021*. International Migration Outlook. OECD Publishing. ISBN: 978-92-64-99766-0 978-92-64-52958-8 978-92-64-67790-6. DOI: 10.1787/29f23e9d-en. URL: https://www.oecd.org/en/publications/international-migration-outlook-2021_29f23e9d-en.html.
- OECD (2025a). “OECD Economic Surveys: Luxembourg 2025”. In: *OECD Economic Surveys: Luxembourg 2025*. DOI: 10.1787/803b3ea1-en. URL: https://www.oecd.org/en/publications/oecd-economic-surveys-luxembourg-2025_803b3ea1-en.html.
- OECD (2025b). *Pensions at a Glance 2025: OECD and G20 Indicators*. OECD Pensions at a Glance. OECD Publishing. ISBN: 978-92-64-32487-9 978-92-64-80894-2 978-92-64-90357-9. DOI: 10.1787/e40274c1-en. URL: https://www.oecd.org/en/publications/pensions-at-a-glance-2025_e40274c1-en.html.
- OECD and European Observatory on Health Systems and Policies (2017). *Luxembourg: Country Health Profile 2017 | European Observatory on Health Systems and Policies*. OECD Publishing / European Observatory on Health Systems and Policies. URL: <https://eurohealthobservatory.who.int/publications/m/luxembourg-country-health-profile-2017>.
- OECD and European Observatory on Health Systems and Policies (2025). *Luxembourg: Country Health Profile 2025 | European Observatory on Health Systems and Policies*. OECD Publishing / European Observatory on Health Systems and Policies. URL: <https://eurohealthobservatory.who.int/publications/m/luxembourg-country-health-profile-2025>.
- Petrides, L V and B C Dangerfield (2003). “Financing Retirement: A Basic Economic Analysis of the Pay-As-You-Go (PAYG) System and the Expected Consequences from a Transition to a Fully-Funded (FF) Scheme.” In: *System Dynamics Review*. URL: <https://proceedings.systemdynamics.org/2003/proceed/PAPERS/393.pdf>.
- Pigeron-Piroth, Isabelle and Rachid Belkacem (2011). “Travail Frontalier et Développement Transfrontalier Au Sein de La Grande Région Saar-Lor-Lux”. In: pp. 13–28. DOI:

- https://orbilu.uni.lu/bitstream/10993/9486/1/BD%20GeoRegards4_3-12_13-28.pdf.
- Pilipiec, Patrick, Wim Groot, and Milena Pavlova (2021). “The Effect of an Increase of the Retirement Age on the Health, Well-Being, and Labor Force Participation of Older Workers: A Systematic Literature Review”. In: *Journal of Population Ageing* 14.2, pp. 271–315. ISSN: 1874-7876. DOI: [10.1007/s12062-020-09280-9](https://doi.org/10.1007/s12062-020-09280-9). URL: <https://doi.org/10.1007/s12062-020-09280-9>.
- Razin, Assaf and Efraim Sadka (1999). “Migration and Pension with International Capital Mobility”. In: *Journal of Public Economics* 74.1, pp. 141–150. ISSN: 00472727. DOI: [10.1016/S0047-2727\(99\)00038-9](https://linkinghub.elsevier.com/retrieve/pii/S0047272799000389). URL: <https://linkinghub.elsevier.com/retrieve/pii/S0047272799000389>.
- Russo, Alessia, Francesco Lancia, and Tim Worrall (2024). “Intergenerational Insurance”. In: *Journal of Political Economy* 132.10, pp. 3500–3544. ISSN: 0022-3808, 1537-534X. DOI: [10.1086/730206](https://www.journals.uchicago.edu/doi/10.1086/730206). URL: <https://www.journals.uchicago.edu/doi/10.1086/730206>.
- Samuelson, Paul A. (1958). “An Exact Consumption-Loan Model of Interest with or without the Social Contrivance of Money”. In: *Journal of Political Economy* 66.6, pp. 467–482. ISSN: 0022-3808, 1537-534X. DOI: [10.1086/258100](https://www.journals.uchicago.edu/doi/10.1086/258100). URL: <https://www.journals.uchicago.edu/doi/10.1086/258100>.
- Settergren, Ole (2003). “La réforme du système de retraite suédois. Premiers résultats”. In: *Revue française des affaires sociales* 4, pp. 337–368. ISSN: 0035-2985. DOI: [10.3917/rfas.034.0337](https://shs.cairn.info/revue-francaise-des-affaires-sociales-2003-4-page-337). URL: <https://shs.cairn.info/revue-francaise-des-affaires-sociales-2003-4-page-337>.
- Sinn, Hans-Werner and Silke Uebelmesser (2003). “Pensions and the Path to Gerontocracy in Germany”. In: *European Journal of Political Economy* 19.1, pp. 153–158. ISSN: 01762680. DOI: [10.1016/S0176-2680\(02\)00134-9](https://linkinghub.elsevier.com/retrieve/pii/S0176268002001349). URL: <https://linkinghub.elsevier.com/retrieve/pii/S0176268002001349>.
- Skirbekk, Vegard et al. (2022). “The Health-Adjusted Dependency Ratio as a New Global Measure of the Burden of Ageing: A Population-Based Study”. In: *The Lancet Healthy Longevity* 3.5, e332–e338. ISSN: 26667568. DOI: [10.1016/S2666-7568\(22\)00075-7](https://linkinghub.elsevier.com/retrieve/pii/S2666756822000757). URL: <https://linkinghub.elsevier.com/retrieve/pii/S2666756822000757>.
- STATEC (2012). *Les mutations de l’emploi de 1960 à 2010*. STATEC. URL: <https://statistiques.public.lu/fr/publications/series/luxembourg/2012/luxembourg-04-12.html>.
- STATEC (2021). *La démographie luxembourgeoise en chiffres 2021*. URL: <https://statistiques.public.lu/dam-assets/catalogue-publications/en-chiffres/2021/demographie-en-chiffres-21.pdf>.

- STATEC (2025a). *La démographie luxembourgeoise en chiffres 2025*. URL: <https://statistiques.public.lu/fr/publications/series/en-chiffres/2025/demographie-lux-en-chiffres-2025.html>.
- STATEC (2025b). *Note de conjoncture 2-25*. URL: <http://statistiques.public.lu/fr/publications/series/note-conjoncture/2025/note-conjoncture-02-2025.html>.
- STATEC (2025c). *Regards 01/25 - Panorama sur le monde du travail luxembourgeois à l'occasion du 1er Mai*. STATEC. URL: <https://statistiques.public.lu/fr/publications/series/regards/2025/regards-01-25.html>.
- STATEC (2026a). *Projections Démographiques Du Luxembourg : Vers Un Million d'habitants d'ici 2070*. URL: <https://statistiques.public.lu/fr/actualites/2026/stn11-26-projections-long-terme.html>.
- STATEC (2026b). *Regards 02/26 - Panorama sur le monde du travail luxembourgeois à l'occasion du 1er Mai*. URL: <https://statistiques.public.lu/fr/actualites/2026/regards-02-26.html>.
- Storesletten, Kjetil (2000). "Sustaining Fiscal Policy through Immigration". In: *Journal of Political Economy* 108.2, pp. 300–323. ISSN: 0022-3808, 1537-534X. DOI: [10.1086/262120](https://www.journals.uchicago.edu/doi/10.1086/262120). URL: <https://www.journals.uchicago.edu/doi/10.1086/262120>.
- Storesletten, Kjetil (2003). "Fiscal Implications of Immigration: A Net Present Value Calculation". In: *The Scandinavian Journal of Economics* 105.3, pp. 487–506. ISSN: 0347-0520. JSTOR: [3440952](https://www.jstor.org/stable/3440952). URL: <https://www.jstor.org/stable/3440952>.
- Whitehouse, Edward (2009). *Pensions, Purchasing-Power Risk, Inflation and Indexation*. OECD Social, Employment and Migration Working Papers 77. DOI: [10.1787/227182142567](https://www.oecd.org/en/publications/pensions-purchasing-power-risk-inflation-and-indexation_227182142567). URL: [https://www.oecd.org/en/publications/pensions-purchasing-power-risk-inflation-and-indexation_227182142567.html](https://www.oecd.org/en/publications/pensions-purchasing-power-risk-inflation-and-indexation_227182142567).

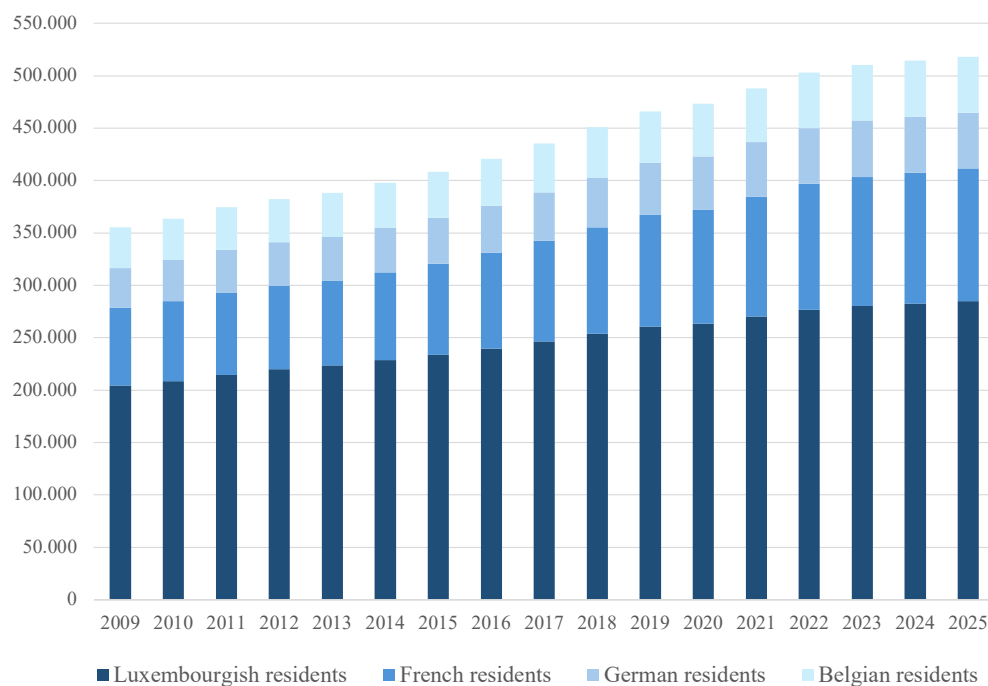
9 Appendix

Figure 16: Evolution of the number of workers between 2014 and 2024



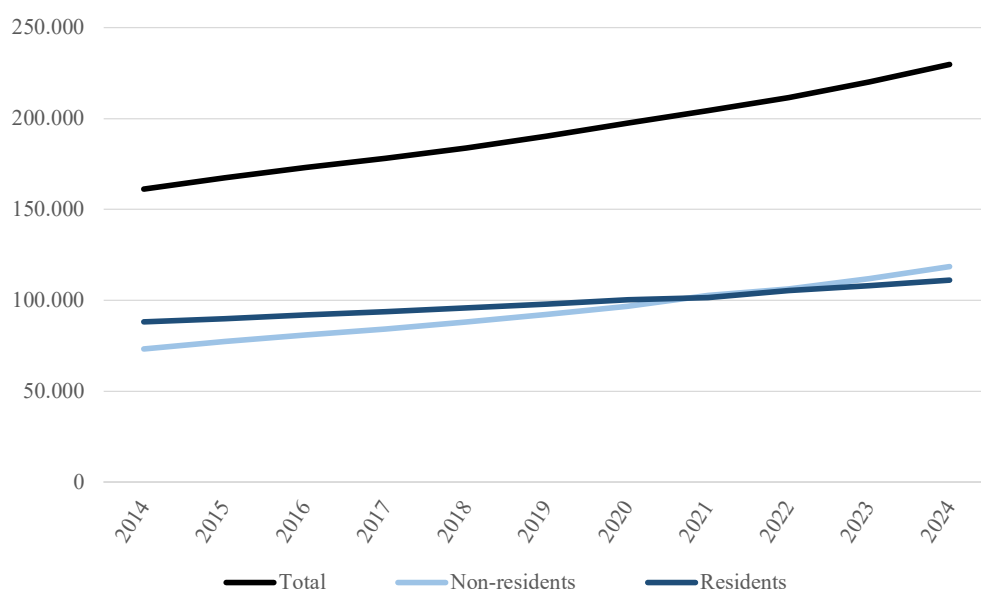
Source: IGSS data

Figure 17: Evolution of the number of workers per residence, 2010 – 2024



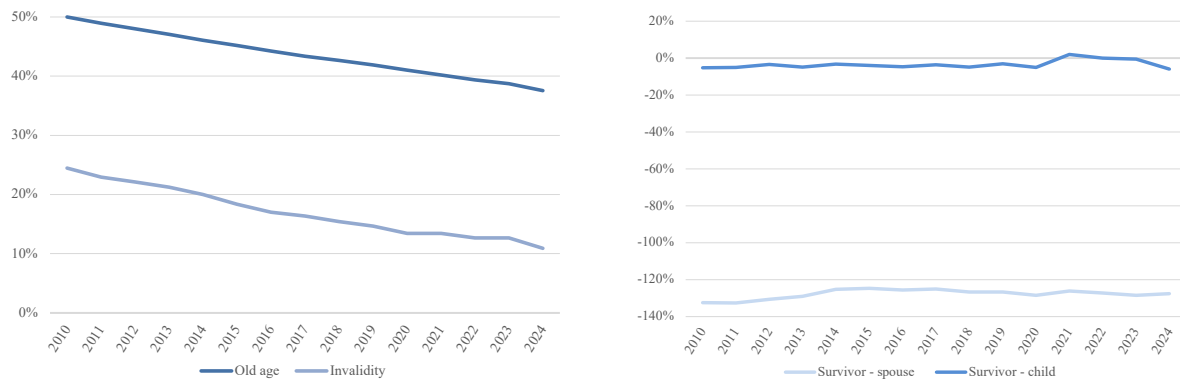
Source: IGSS Data

Figure 18: Evolution of the number of retirees, 2014 – 2024



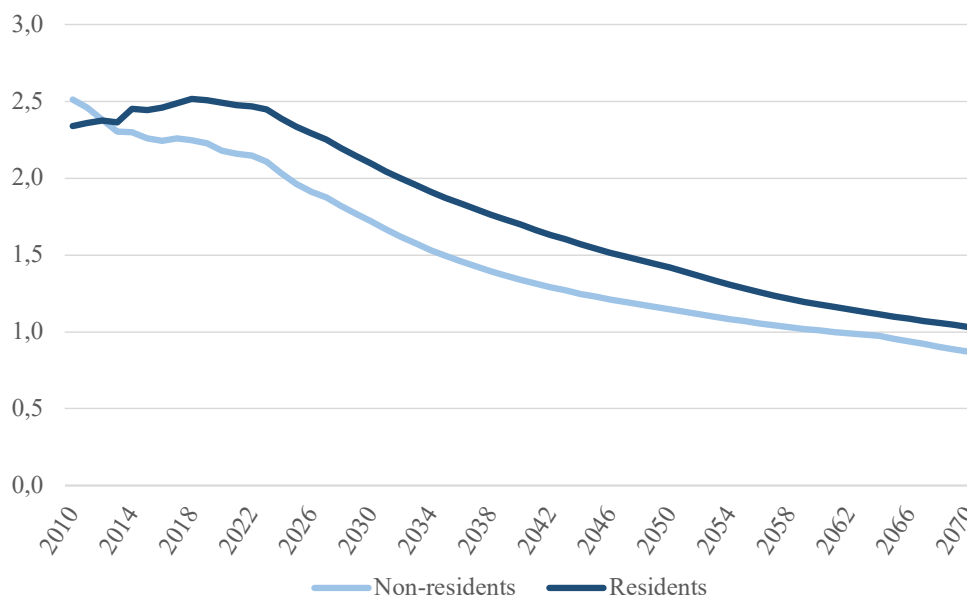
Source: IGSS data

Figure 19: Difference between the average pension of men and women relative to the average pension of men (in %)



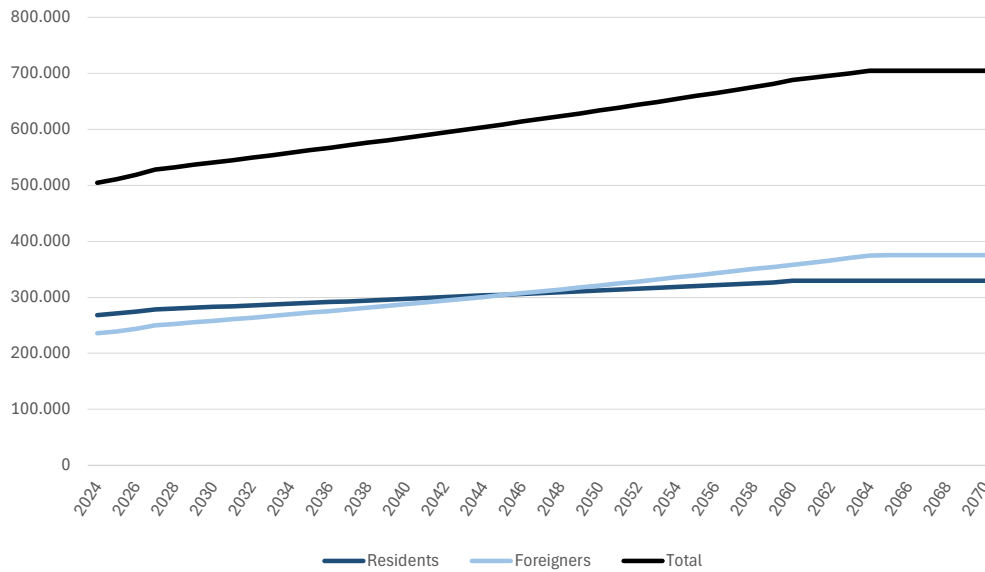
Source: own calculations based on IGSS data.

Figure 20: Evolution of the support ratio, 2010 – 2070



Source: Own calculations based on IGSS Data

Figure 21: Projection of the total number of workers per residence



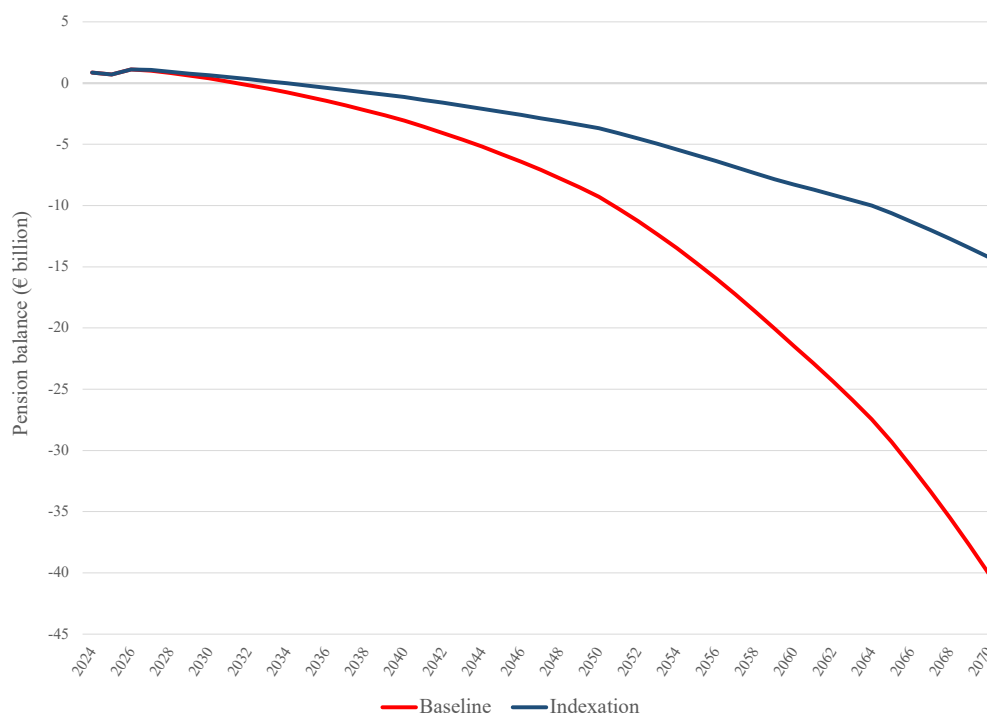
Source: Own calculations based on STATEC and IGSS Data

Figure 22: Evolution of the annual pension parameters, 2013 – 2052

Year	q1 (%)	q2 _{base}	q2 (%)	q3 (%)	Year	q1 (%)	q2 _{base}	q2_2 (%)	q3 (%)
before 2013	1.850	93	0.010	23.500	2033	1.719	96	0.018	25.863
2013	1.844	93	0.011	23.613	2034	1.713	96	0.019	25.975
2014	1.838	93	0.011	23.725	2035	1.707	97	0.019	26.088
2015	1.832	93	0.012	23.838	2036	1.700	97	0.019	26.200
2016	1.825	93	0.012	23.950	2037	1.694	97	0.020	26.313
2017	1.819	93	0.012	24.063	2038	1.688	97	0.020	26.425
2018	1.813	94	0.013	24.175	2039	1.682	97	0.021	26.538
2019	1.807	94	0.013	24.288	2040	1.675	97	0.021	26.650
2020	1.800	94	0.013	24.400	2041	1.669	98	0.021	26.763
2021	1.794	94	0.014	24.513	2042	1.663	98	0.022	26.875
2022	1.788	94	0.014	24.625	2043	1.657	98	0.022	26.988
2023	1.782	94	0.015	24.738	2044	1.650	98	0.022	27.100
2024	1.775	95	0.015	24.850	2045	1.644	98	0.023	27.213
2025	1.769	95	0.015	24.963	2046	1.638	98	0.023	27.325
2026	1.763	95	0.016	25.075	2047	1.632	99	0.024	27.438
2027	1.757	95	0.016	25.188	2048	1.625	99	0.024	27.550
2028	1.750	95	0.016	25.300	2049	1.619	99	0.024	27.663
2029	1.744	95	0.017	25.413	2050	1.613	99	0.025	27.775
2030	1.738	96	0.017	25.525	2051	1.607	99	0.025	27.888
2031	1.732	96	0.018	25.638	2052	1.600	100	0.025	28.000
2032	1.725	96	0.018	25.750	after 2052	1.600	100	0.025	28.000

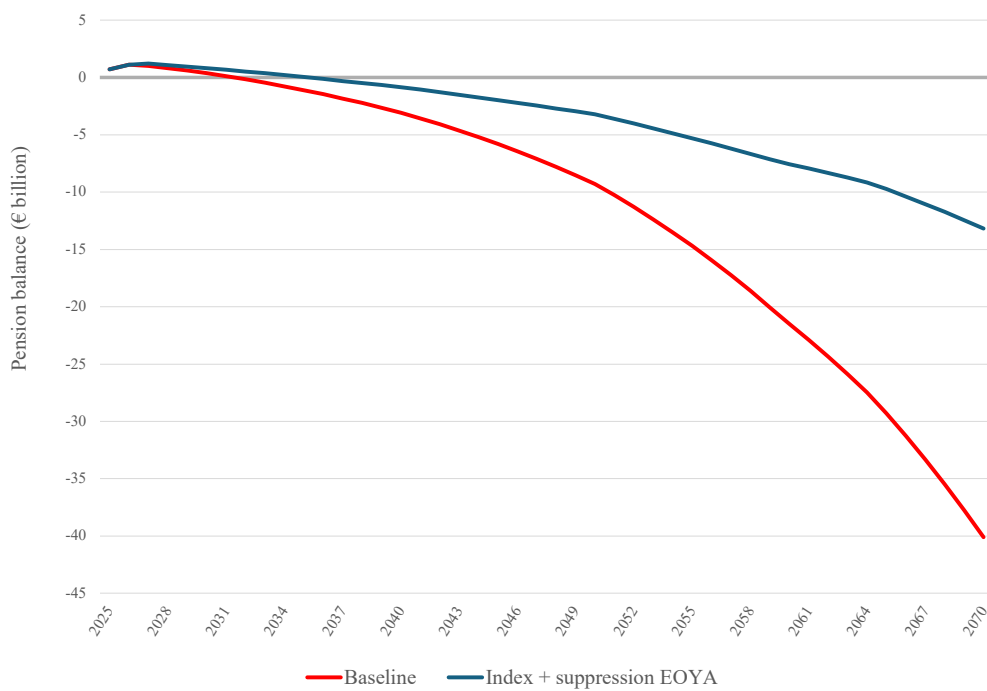
Source: IGSS (2024a)

Figure 23: Comparison of the indexation reform and baseline balances, 2024 – 2070.



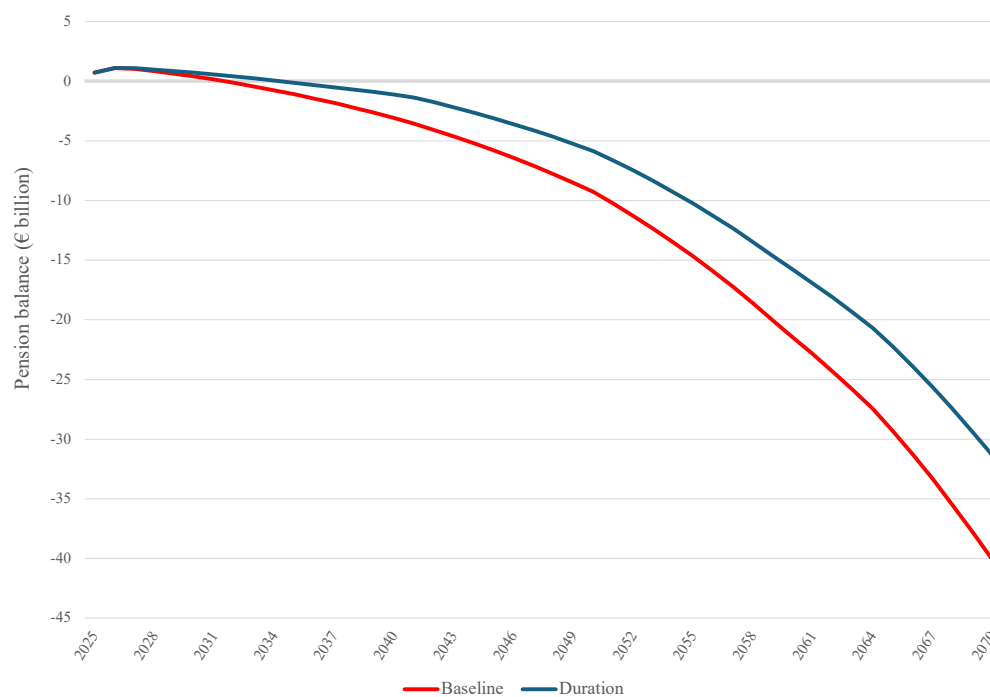
Source: own calculations based on IGSS data

Figure 24: Comparison of the indexation and EOYA reform to baseline balance, 2024 – 2070.



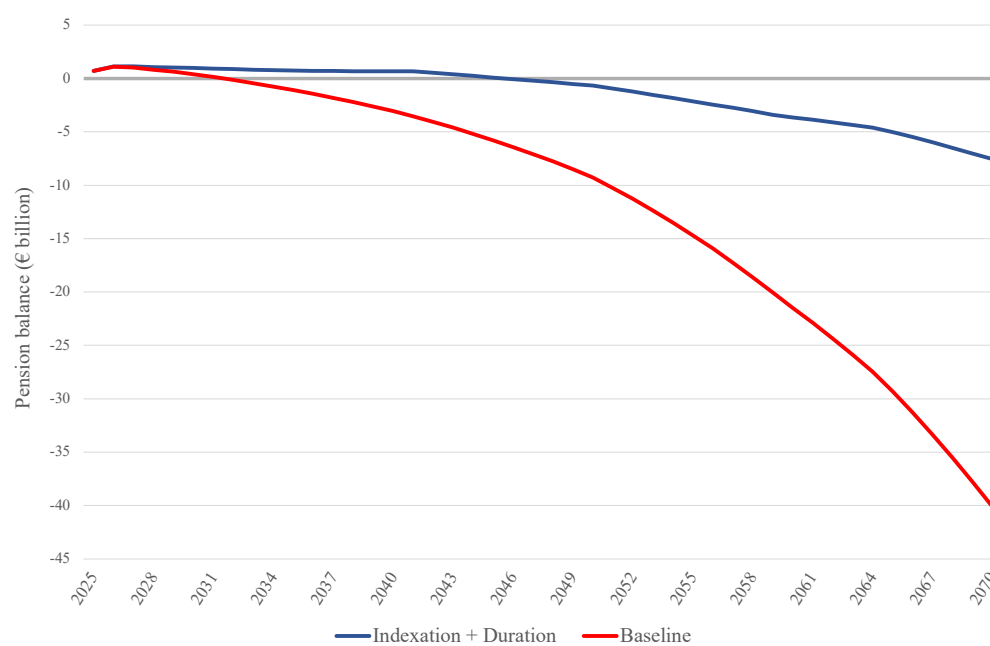
Source: own calculations based on IGSS data

Figure 25: Comparison of the duration reform to baseline balance, 2024 – 2070.



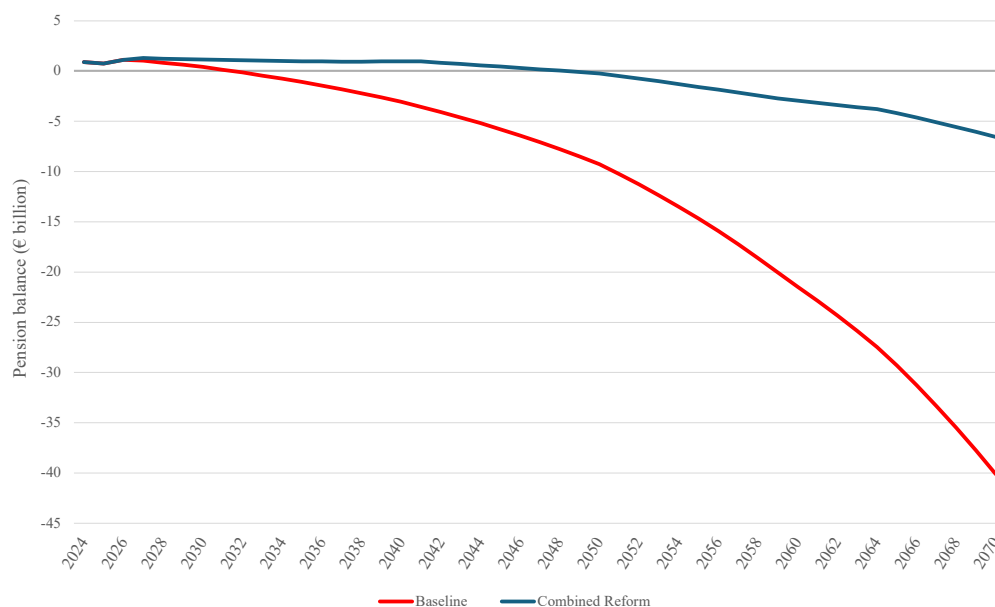
Source: own calculations based on IGSS data

Figure 26: Comparison of the indexation + duration reform to baseline balance, 2024 – 2070.



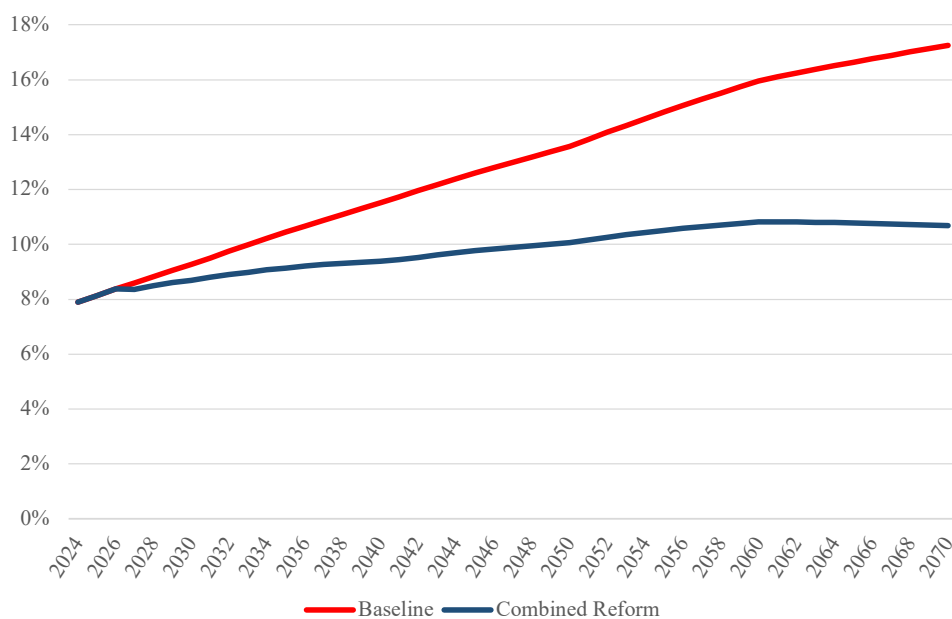
Source: own calculations based on IGSS data

Figure 27: Comparison of the ‘Combined Reform’ to baseline balance, 2024 – 2070.



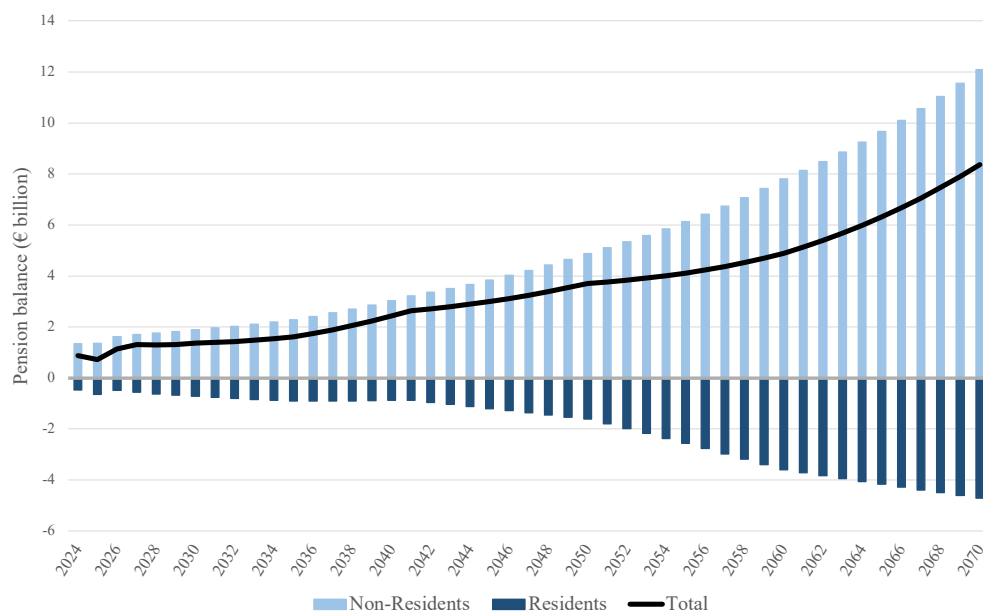
Source: own calculations based on IGSS data

Figure 28: Evolution of total pension expenditures in % of GDP for the baseline and combined reform, 2024 – 2070.



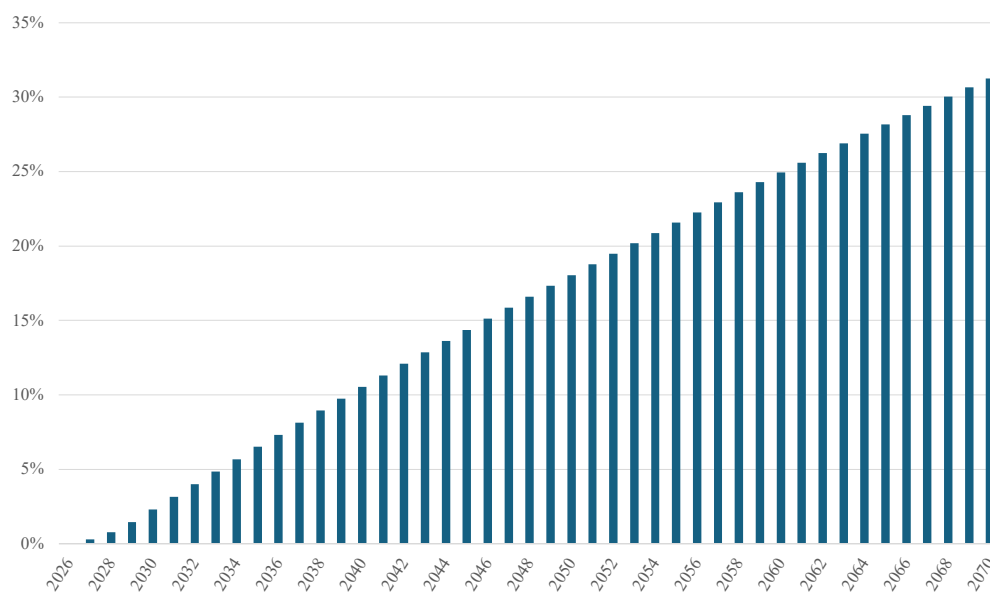
Source: own calculations based on IGSS data

Figure 29: Decomposition of the ‘Combined Reform’ balance under S4, 2024 – 2070



Source: own calculations based on IGSS data

Figure 30: Loss in the average old-age pension relative to the baseline scenario



Source: Own calculations based on IGSS Data

Table 8: Share of the end-of-year allowance in total expenditures, 2011 – 2024

Year	Total expenditures (€)	EOYA (€)	share EOYA (%)
2011	2.958.565.217	55.623.117	1,88%
2012	3.164.689.155	59.364.525	1,88%
2013	3.356.792.857	62.857.308	1,88%
2014	3.505.168.250	65.055.232	1,86%
2015	3.639.476.015	67.422.063	1,85%
2016	3.787.840.546	70.200.670	1,85%
2017	4.033.554.674	74.962.683	1,86%
2018	4.258.275.633	79.448.885	1,87%
2019	4.464.213.718	83.019.870	1,87%
2020	4.808.068.353	89.343.373	1,86%
2021	5.148.626.744	96.160.296	1,86%
2022	5.561.794.440	103.546.565	1,86%
2023	6.341.456.532	118.606.844	1,87%
2024	6.744.433.711	125.457.605	1,86%

Table 9: Share of non-residents in the total expenditures and total revenue

Total expenditures		Total revenue	
Year	Share	Year	Share
2024	33,06%	2024	46,80%
2030	34,01%	2030	47,71%
2040	36,27%	2040	49,08%
2050	37,06%	2050	50,69%
2060	36,95%	2060	52,05%
2070	38,28%	2070	53,19%

Table 10: Comparison of worker projections, 2024 – 2070

My projections				IGSS projections			
Year	Residents	Non-residents	Total	Year	Residents	Non-residents	Total
2024	268.523	236.219	504.742	2024	268.000	230.000	498.000
2030	282.780	258.018	540.798	2030	295.000	300.000	590.000
2040	297.242	267.847	585.088	2040	320.000	330.000	645.000
2050	312.443	321.124	633.566	2050	330.000	360.000	690.000
2060	330.000	358.248	688.248	2060	330.000	375.000	705.000
2070	330.000	375.000	705.000	2070	330.000	375.000	705.000

Table 11: Projected growth rates of workers by residence:

Year	Residents	Non-residents
2025	1,10%	1,20%
2026	1,20%	2,00%
2027	1,20%	2,00%
2028 onwards	0,50%	1,10%

Table 12: Active population: own projections versus IGSS scenarios S1 and S4, 2020 – 2070 (in thousands)

Year	Scenario S1		Scenario S4	
	Own projection	IGSS	Own projection	IGSS
2022	488	490	488	490
2030	541	570	546	570
2040	585	645	616	645
2050	634	695	696	715
2060	687	725	775	775
2070	745	745	830	830

Notes: “Own projection” reports the active-population trajectory used in this thesis under each scenario; “IGSS” reproduces the corresponding STATEC figures from [IGSS \(2024b\)](#) (Tableau 13), rounded by the source to the nearest thousand. The two trajectories are constructed to converge by 2070, which serves as the anchoring point. *Source:* Own calculations and IGSS data.

Declaration on the Use of Generative AI

During the preparation of this thesis, the author used the following generative AI tools:

- **Claude (Opus 4.8 and 4.7)** was used for language editing: improving the English, checking for grammatical mistakes, and refining the overall clarity and readability of the text.
- **Claude Code and Codex, within Visual Studio Code**, were used as coding assistants for $\text{\LaTeX}$: resolving $\text{\LaTeX}$ errors and problems as they arose, and assisting with document layout and formatting.

These tools were used solely to support the writing and typesetting process. No generative AI was used to produce the research itself. All results, analyses, and interpretations presented in this thesis are the author's own. The author reviewed and verified all AI-assisted output, edited it as needed, and takes full responsibility for the entire content of the thesis.