

Pension Fund Crisis in Tunisia: Econometric Asymmetries Between the CNSS and CNRPS and Differentiated Parametric Reforms

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ABSTRACT	ARTICLE DETAILS
This article examines the multidimensional crisis facing Tunisia's pension schemes, namely the CNSS and CNRPS, within a pay-as-you-go system strained by accelerated demographic ageing, widespread informality, high unemployment, and institutional fragmentation. Drawing on a multidisciplinary framework combining historical analysis, VECM econometric modelling for 1990–2024, and micro-macro simulations, the study identifies pronounced structural asymmetries: the CNSS is highly vulnerable to cyclical shocks, especially unemployment and informality, whereas the CNRPS is relatively more resilient to parametric reforms, particularly an increase in the effective retirement age, and to economic growth. The findings support a hybrid and differentiated reform strategy combining a gradual increase in the effective retirement age, asymmetric contribution adjustments, pilot capitalisation, institutional consolidation through digitalisation, and stronger governance. Optimised through micro-macro simulations, these measures reconcile financial sustainability with social equity and help to build a resilient intergenerational compact in a context of stagnant growth and rising demographic pressure. KEYWORDS: Pension System, Demography, Informality, Parametric Reform, VECM Modelling.	Published On: 07 July 2026 Available on: https://ijiissh.com/
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1. INTRODUCTION

Social protection, and pension systems in particular, constitute a central pillar of contemporary social policy because they organise intergenerational redistribution and secure income in old age. In Tunisia, the pension system has historically been based on a pay-as-you-go arrangement in which workers' contributions finance retirees' benefits. This model, long considered socially inclusive, is now facing structural tensions linked to demographic transition, labour-market fragility, and institutional imbalances (Banque mondiale, 2024).

Demographic pressure has intensified under the effect of rapid population ageing. Life expectancy has risen sharply over recent decades, while fertility has declined significantly, progressively narrowing the contributory base and increasing the average duration of pension payments (INS, 2024). These demographic developments are compounded by an important economic constraint: low employment formalisation, high unemployment, and moderate growth limit the expansion of the contribution base and weaken the financing of the funds. This situation is aggravated by the fragmentation of the system between the CNSS, the CNRPS, and several special schemes, whose different rules complicate any comprehensive reform.

In this context, this article proposes a comparative econometric analysis of the determinants of the financial balances of the CNSS and the CNRPS using annual time series covering the period 1990–2024. The study mobilises a vector error-correction framework in order to distinguish long-run relations and short-run adjustments between the financial balance of the funds, the contribution rate, the effective retirement age, unemployment, and GDP growth. The results show that raising the retirement age improves financial sustainability over the long run, with a stronger effect for the CNRPS, while unemployment mainly deteriorates the CNSS balance. An increase in the contribution rate has a favourable long-run effect, whereas economic growth supports the sustainability of the CNRPS more than that of the CNSS (INS, 2025; Banque mondiale, 2024).

Impulse response functions confirm this reading by highlighting the greater resilience of the schemes to positive shocks in retirement age, contributions, and growth, but also the particular vulnerability of the CNSS to shocks in unemployment and informality (BIT,

2025; CNSS, 2024). These findings support a differentiated reform strategy combining parametric adjustments, institutional rationalisation, and stronger coordination between the schemes. The article also examines, as a complementary avenue, the potential of voluntary capitalisation as an instrument for diversifying funding sources and strengthening medium-term sustainability.

The article is organised in six sections. The first presents the conceptual foundations and international experiences in pension reform. The second describes the institutional and financial configuration of the Tunisian schemes. The third, fourth, and fifth sections present the methodology, econometric estimates, and comparative results. The final section discusses the implications for economic policy and concludes.

2. LITERATURE REVIEW AND INTERNATIONAL EXPERIENCE

Pension systems are a central instrument of the contemporary welfare state, but they are increasingly subject to structural pressures linked to demographic ageing, changing labour markets, and persistent macroeconomic fragility. Recent literature converges on the view that no institutional design can remain permanently insulated from actuarial balance constraints, which is why structural and parametric reforms are needed to restore long-term financial sustainability. For emerging economies such as Tunisia, this issue is especially acute because low employment formalisation, structural unemployment, and institutional fragmentation reduce the contributory base while widening the gap between contributors and beneficiaries.

Demographic ageing operates through a dual mechanism: it unfolds “from above” through rising life expectancy and “from below” through sustained fertility decline below replacement level. This transformation mechanically alters the dependency ratio, lengthens the average duration of pension payment, and weakens public and para-fiscal finances. Added to this are weak productivity growth, sluggish economic expansion, and informality, which are especially pronounced in developing countries, where traditional contributory systems face limits in coverage and redistributive effectiveness.

Within this framework, recent literature emphasises the urgency of parametric reforms, notably raising the statutory retirement age, extending contribution periods, and adjusting benefit formulas. Yet such reforms are not sufficient on their own: their effectiveness often depends on favourable assumptions about growth and productivity. Overlapping-generation models also show that demographic shocks propagate over several decades, which justifies the introduction of automatic balancing mechanisms to smooth adjustments and reduce the risk of persistent public deficits. Without such mechanisms, several studies project severe fiscal pressures by 2050, especially in ageing economies.

Institutionally, three broad architectures dominate the debate: pay-as-you-go, funded pension systems, and hybrid models. Pay-as-you-go schemes rest on immediate intergenerational solidarity, as workers’ contributions directly finance retirees’ pensions. They are transparent in redistributive terms, but highly exposed to dependency-ratio dynamics and contractions in the wage bill. By contrast, funded systems individualise retirement saving and may strengthen capital accumulation, but they shift a substantial share of risk to individuals, especially in the presence of financial volatility, incomplete careers, or longevity risk. Hybrid systems have therefore emerged as a compromise, combining pooling, actuarial clarity, and corrective mechanisms.

The Swedish case is emblematic of this evolution. The reform was designed during the 1990s, with principles agreed in 1991, a first parliamentary vote in 1994, and final legislation in 1998. It combines a public pay-as-you-go pillar based on notional accounts indexed to the wage bill, a longevity coefficient, and an automatic balancing mechanism, alongside mandatory funded components. This architecture seeks to preserve financial equilibrium while maintaining relatively high replacement rates within a long-term sustainability framework. Its strength lies less in generosity than in its capacity for self-adjustment in response to demographic and macroeconomic shocks.

Latin American experiences also confirm the value of hybrid architectures, while highlighting their limits when informality restricts effective coverage. In Colombia, Law 100 of 1993, which came into force in 1994, introduced coexistence between a public pay-as-you-go scheme and a private funded scheme; more recent reforms have aimed to increase system clarity by moving toward a more explicit pillar-based structure, including a solidarity component and voluntary savings mechanisms. However, effective coverage remains limited by informality, which restricts access to pensions for a large share of older persons. In Chile, the reform adopted in 2025 marked a significant shift away from the earlier pure funded model by increasing employer contributions and adding a stronger redistributive component, in order to improve low pensions and correct the system’s weak return performance.

These trajectories point to the same conclusion: hybrid systems are better equipped than pure models to distribute financial, demographic, and social risks. They make it possible to combine actuarial discipline, diversified funding sources, and correction of career inequalities. For emerging economies, and particularly Tunisia, the literature therefore supports a reform agenda that combines parametric adjustments, stronger actuarial governance, automatic balancing mechanisms, and explicit consideration of informality and labour-market segmentation. In the Tunisian case, this implies moving beyond a simple budgetary compensation logic toward a more robust architecture based on multidimensional indicators of sustainability, coverage, and generosity, together with closer institutional coordination between the CNSS and the CNRPS.

3. THE TUNISIAN PENSION SYSTEM AND STRUCTURAL CHALLENGES

Tunisia provides a particularly revealing case for analysing the economic and institutional tensions facing pay-as-you-go pension systems in emerging economies. Built gradually since independence on the basis of a Bismarckian model with universalist ambitions, the Tunisian social protection system rests on compulsory contributory schemes managed by the National Social Security Fund (CNSS) for the private sector and the National Retirement and Social Welfare Fund (CNRPS) for the public sector, alongside targeted assistance programmes, notably the National Aid Programme for Needy Families (PNAFN) and Free Medical Assistance (AMG). While this architecture long made it possible to combine broad coverage, relatively generous rights, and high replacement rates, it is now confronted with a structural exhaustion of its financing model. Rapid financial deterioration, driven by accelerated demographic ageing, persistent labour-market informality, and fragmented governance, has turned this pillar of social cohesion into a major source of fiscal and macroeconomic vulnerability.

The following sections provide a systemic reading of this crisis. Section 2.1 examines the institutional architecture and financial trajectory of the CNSS and CNRPS, highlighting the cumulative dynamics of deficits and collection failures. Section 2.2 then deepens the analysis by focusing on the demographic and economic determinants of this drift, particularly the contraction of the active-to-retiree ratio and the corresponding erosion of retirees' purchasing power. Together, these sections establish an integrated diagnosis of the pressures undermining the sustainability of the Tunisian pension system.

3.1. Institutional structure and financial crisis of the CNSS-CNRPS schemes

The historical evolution of social security in Tunisia reflects a gradual and cumulative expansion of rights, inherited from the first structures introduced during the protectorate—namely the mutual aid society established in 1898 and the 1921 legislation on occupational accidents—and subsequently modernised after independence. The legislator successively extended coverage to the private sector in 1960, introduced old-age pensions in 1974, and integrated self-employed workers in 1982. This long sedimentation of rights produced a highly fragmented institutional landscape, with the system now divided into 11 mandatory schemes.

At the parametric level, the system is characterised by differentiated but structurally generous rules governing entitlement and benefit calculation:

- The legal retirement age has been set at 62 following recent reforms, reduced to 57 for arduous occupations, with an optional extension up to 65.
- The overall contribution rate stands at 17.7% in the public sector, of which 10.3% is borne by the employer, and 12.5% in the private sector, of which 7.76% is paid by the employer; the scheme for non-salaried workers is set at 7%.
- In the public sector, the pension is based on the last salary earned, with a replacement rate ranging from 35% to 90%; in the private sector, it is calculated on the average of the last 10 years of wages, capped at six times the minimum wage, with a replacement rate between 40% and 80%. Benefits are automatically indexed to the minimum wage or to salary increases in the civil service.

This generous parametric design, initially viable in a context of a young demographic structure, came into conflict from the 1990s onwards with population ageing, rising life expectancy, and slowing formal employment growth. Financial stress therefore evolved from a cyclical shock into a chronic and cumulative drift. Over the decade, the CNSS deficit multiplied approximately sevenfold, rising from 68 million Tunisian dinars in 2006 to nearly 470 million in 2016. The CNRPS followed an even more explosive trajectory, with its net deficit increasing fourteenfold over the same period, from 38 million to 529 million, due to the combined effects of the maturation of public pensions and hiring freezes in the civil service.

Table 1. Economic and financial situation of the pension funds (million TND)

Indicator	2016	2017	2018	2019	2020	2021	2022
CNSS / Contributors (000)	2280	2345	2364	2402	2353	2358	2376
Pensioners (000)	708	763	822	871	886	956	953
Operating result	-477	-527	-553	-1131	-1251	-1208	-1106
Net result	-475	-525	-550	-667	-1092	-1274	-962
Debt	499	1247	1712	2420	6953	8665	9973
CNRPS /Contributors (000)	780	782	779	764	776	774	768

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Indicator	2016	2017	2018	2019	2020	2021	2022
Pensioners (000)	343	359	382	393	399	407	422
Operating result	-976	-811	-974	-1106	-642	-1014	-802
Net result	38	-183	-770	-652	-171	-158	-579
State subsidy	300	500	200	0	460	835	195
Debt	1948	2190	2879	3421	4109	4453	5518
(CNSS + CNRPS) /Contributors (000)	3060	3127	3163	3166	3130	3132	3144
Pensioners (000)	1051	1122	1204	1264	1285	1363	1376
Net result	-438	-708	-1320	-1319	-1263	-1432	-1540
Debt	2447	3437	4591	5841	11062	13118	15460

Source: Public enterprise reports, Ministry of Finance, compiled by the author.

The figures in Table 1 show that, between 2019 and 2022, the consolidated net deficit persistently exceeded the critical threshold of 1.2 billion TND per year, reaching a financing need of 1.54 billion TND in 2022. This deterioration generated an explosive debt trajectory: the total debt of the funds rose from 2.44 billion TND in 2016 to 15.46 billion in 2022. This accumulation of liabilities reflects the complete exhaustion, already by 2013, of technical reserve buffers that should normally cover several years of benefits. Without a financial buffer, the CNRPS has become structurally dependent on the central budget, requiring massive liquidity injections through direct treasury advances over the period 2020–2025. These transfers no longer function as temporary smoothing devices; they now constitute a permanent refinancing mode that masks the scheme's technical insolvency.

In addition to these macro-demographic forces, the system is constrained by major operational rigidities and incentive distortions. First, the expansion of the informal economy, which now absorbs 38% of total employment, dramatically reduces the potential contribution base. Second, the persistence of a structural unemployment rate of 15.4% in the third quarter of 2025 mechanically compresses the inflow of contributors. Third, the system suffers from acute base erosion through fraud and optimisation strategies: wage underreporting is estimated at 15.6% of the declared wage bill in the CNRPS, while control anomalies and discrepancies affecting up to 23.8% of staff records have been identified.

Finally, outstanding unpaid contributions owed by public enterprises, together with non-maximised asset management and weak portfolio profitability, have turned the funds' assets into latent liabilities. Although the parametric reforms introduced by Law 35/2019, especially the increase in retirement age and the rise in contribution rates, temporarily slowed the deficit trajectory, they remain structurally insufficient. Without a reform of governance—through full digitalisation of contribution collection, unification of fragmented schemes, and independent audit safeguards—long-term viability remains out of reach.

3.2. Demographic dynamics and pressures on sustainability

The financial insolvency of Tunisia's pension schemes directly reflects an advanced and exceptionally rapid demographic transition by MENA standards. The shift in system balance can be measured through the continuous deterioration of the dependency ratio. The macroeconomic ratio of active workers to retirees fell sharply over the past decades, moving far below the theoretical sustainability threshold for a pure pay-as-you-go system.

This decline, from 5.75 to 2.28 over two decades, confirms that the growth of the contributor base has been fully outpaced by the pace of pension liquidation. The process is driven by two long-term variables. On the one hand, infant mortality has fallen sharply, while life expectancy has continued to rise, thereby extending pension payment durations, including survivor benefits. On the other hand, the total fertility rate has stabilised at around replacement level. Official demographic projections indicate stagnation in total population, together with ageing from the top of the age pyramid.

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Table 2. Evolution of the active insured/pensioner ratio (2001–2022)

Year	Active insured (1)	Pensioners (2)	Total	Ratio (1/2)
2001	1639	285	1924	5.75
2016	3060	1051	4111	2.91
2022	3144	1376	4520	2.28

Source: Author's calculations based on INS and social security fund data.

Table 3 points to a doubling of the share of individuals aged 60 and over, with the historical crossover point between the 0–14 and 60+ cohorts expected around 2036. The pure demographic dependency ratio is thus projected to double, effectively doubling the financial burden borne by each formal worker.

Table 3. Projected population structure by age group (2019–2044, %)

Age group	2019	2024	2029	2034	2039	2044
0–14 years	25.2	25.6	24.3	21.4	19.1	18.3
15–59 years	61.5	59.0	58.3	59.2	59.4	57.5
60+ years	13.3	15.4	17.4	19.4	21.5	24.2
60+/20–59 years	21.6	26.0	29.8	32.7	36.3	42.0

Source: INS projections; author's calculations.

To assess the direct impact of ageing on the working-age population, Table 4 formalises the evolution of the absolute number of working-age individuals available per 100 persons aged 60 and over.

Table 4. Active population (15–59) per 100 persons aged 60+

Year	2019	2024	2029	2034	2039	2044
15–59 (thousand)	7209	7282	7461	7760	7914	7798
60+ (thousand)	1556	1895	2222	2537	2870	3278
Ratio	463	384	336	306	276	238

Source: INS projections.

This decline in macro-demographic coverage, from 463 workers per 100 older persons in 2019 to just 238 in 2044, is compounded by a cyclical shock in the labour market. Between 2013 and 2019, formal employment increased only modestly before contracting sharply after COVID-19. This erosion of the contribution base explains why the CNSS contribution-to-benefit ratio has exceeded critical levels, leaving the self-financing ratio below 40%.

This insolvency has, in turn, generated a social crisis of pension precarisation. Although the nominal average pension stands at 1,300 TND per month, this average masks substantial disparities: 40% of pensioners receive less than 500 TND, 30% receive between 500 and 1,000 TND, and only 12.8% fall in the 1,000–1,500 TND bracket. Nearly 70% of retirees thus remain below the 1,000 TND threshold, in a context of high cumulative inflation. Successive increases in the minimum wage have not offset the erosion of purchasing power. In the absence of complementary pension schemes, family solidarity remains essential, often through intergenerational cohabitation.

These alarming demographic dynamics, together with mass informality and institutional fragmentation, call for a profound and hybrid overhaul of the Tunisian pension system, moving beyond isolated parametric adjustments that have provided only temporary relief. A multi-pillar architecture appears indispensable, structured around a solidaristic fiscal floor financing minimum pensions for

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precarious and informal workers, complemented by compulsory contributory pillars that are professionalised, and by individual or sectoral funded accounts, along the lines of Swedish or Chilean models adapted to the Tunisian context. Such diversification would reduce the demographic risks concentrated in pure pay-as-you-go financing while promoting long-term saving.

At the same time, a radical strengthening of governance is imperative: progressive merger of the funds to eliminate administrative duplication, full digitalisation of contribution collection, annual independent audits, and tripartite mechanisms bringing together the State, trade unions, employers, and pensioners to restore transparency and trust. These reforms, consistent with international recommendations, should form part of an inclusive social pact incorporating micro-macro simulations to preserve both generational and gender equity, while protecting the most vulnerable retirees through a reinforced fiscal safety net. A holistic approach combining budgetary discipline with social justice therefore appears to be the only viable lever in the face of a projected ratio of 238 workers per 100 retirees by 2044.

4. ECONOMETRIC ANALYSIS OF THE DETERMINANTS OF FINANCIAL SUSTAINABILITY

This section examines the economic, demographic, and institutional determinants of the financial sustainability of Tunisia's two main pension funds, the CNSS and the CNRPS. The analysis is based on annual time series covering the period 1990–2024 and relies on an econometric design suitable for long-run relationships and short-run adjustment dynamics. In particular, it combines unit root tests, Johansen cointegration analysis, and vector error correction models (VECM) to distinguish between persistent equilibrium relations and temporary deviations.

The objective is to identify the factors that shape the long-run financial balance of each fund and to determine whether these balances adjust efficiently in the short run following economic or institutional shocks. This framework is especially appropriate in the Tunisian case, where pension sustainability is affected by demographic ageing, labour-market segmentation, informality, and institutional asymmetry across schemes.

4.1. Variables and stationarity tests

The econometric analysis uses annual series that are consistent over the period 1990–2024 for both funds. The data are drawn from annual reports of the CNSS and CNRPS and complemented by macroeconomic series from the National Institute of Statistics, the Central Bank of Tunisia, and international organisations. This combination ensures coherence, comparability, and sufficient temporal depth for time-series modelling.

Table 5. Study variables

Variable	Type / unit	Description	Role in the model
Financial balance	Billion TND	Difference between contribution revenues and pension expenditures	Dependent variable
Contribution rate	% of gross wage	Employee and employer social contribution rate	Key explanatory variable
Effective retirement age	Years	Actual average age at pension take-up	Demographic / reform variable
Parametric reform dummy	Binary (0/1)	Indicator of reform implementation	Institutional variable
Real GDP	Billion TND	Real output level at constant prices	Macroeconomic control
Unemployment rate	%	Share of the labour force without employment	Macroeconomic control
Informality rate	%	Share of informal employment in total labour force	CNSS-specific explanatory variable

Source: Author's compilation.

The informality variable is included only for the CNSS, because it captures a structural vulnerability specific to the private sector. It would not be conceptually appropriate to impose the same variable on the CNRPS, whose membership is overwhelmingly linked to formal public employment.

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Stationarity is tested using both Augmented Dickey-Fuller and KPSS procedures. The results show that all series are non-stationary in levels but become stationary in first differences. This indicates that the variables are integrated of order one, $I(1)$, and therefore suitable for cointegration analysis.

Table 6. Stationarity tests in levels

Variable	ADF/ p-value CNSS/CNRPS	ADF conclusion	KPSS/ CNSS/CNRPS stat.	KPSS conclusion	Decision
Financial balance	0.85 / 0.82	Non-stationary	0.70 / 0.68	Non-stationary	Likely $I(1)$
Contribution rate	0.95 / 0.95	Non-stationary	0.69 / 0.70	Non-stationary	Likely $I(1)$
Effective retirement age	0.92 / 0.82	Non-stationary	0.70 / 0.96	Non-stationary	Likely $I(1)$
Real GDP	0.57 / 0.57	Non-stationary	0.70 / 0.70	Non-stationary	Likely $I(1)$
Unemployment rate	0.66 / 0.66	Non-stationary	0.40 / 0.40	Non-stationary	Likely $I(1)$
Informality rate	0.30 / —	Non-stationary	0.67 / —	Non-stationary	Likely $I(1)$

Table 7. Stationarity tests in first differences

Variable	ADF/ pvalue CNSS/ CNRPS	ADF conclusion	KPSS/ CNSS/ CNRPS stat.	KPSS conclusion	Decision
Δ Financial balance	0.0002 / 0.0000	Stationary	0.008 / 0.03	Stationary	Confirmed $I(1)$
Δ Contribution rate	0.076 / 0.0000	Stationary	0.010 / 0.07	Stationary	Confirmed $I(1)$
Δ Effective retirement age	0.0000 / 0.0000	Stationary	0.012 / 0.04	Stationary	Confirmed $I(1)$
Δ Real GDP	0.002 / 0.002	Stationary	0.017 / 0.06	Stationary	Confirmed $I(1)$
Δ Unemployment rate	0.0003 / 0.0000	Stationary	0.055 / 0.032	Stationary	Confirmed $I(1)$
Δ Informality rate	0.000 / —	Stationary	0.000 / —	Stationary	Confirmed $I(1)$

Source: Author's calculations.

These results justify the use of cointegration methods. They indicate that the series are governed by common stochastic trends, while their short-run deviations are corrected over time. This is precisely the analytical setting in which a VECM is most informative.

4.2. Cointegration and VECM specification

The Johansen test is used to identify the number of cointegrating vectors among the variables, that is, the number of stable long-run relations linking the financial balance to its determinants. Before estimating the cointegration system, the optimal lag length is selected using the Akaike and Schwarz criteria. For the CNSS, one lag is retained, reflecting a more compact and responsive dynamic structure. For the CNRPS, four lags are selected, which is consistent with a slower and more institutionalised adjustment process. The Johansen results indicate a single cointegrating vector for each fund. This means that, despite the non-stationarity of the individual series, the financial, demographic, and macroeconomic variables move together in a stable long-run equilibrium. This finding supports the estimation of separate VECM specifications for the CNSS and the CNRPS.

Table 8. Johansen cointegration test

Rank	Trace	Prob.	Maximum eigenvalue	Prob.
0	149.97	0.0000	80.06	0.0000
1*	69.90	0.0492	27.47	0.2389
2	42.43	0.1470	22.67	0.1882

Source: Author's calculations. One cointegrating vector retained for each regime.

The error-correction term is significant in both cases, but the adjustment speeds differ substantially. The CNSS shows faster correction, suggesting greater sensitivity to short-run disequilibria and a more rapid response to shocks. The CNRPS adjusts more gradually, reflecting stronger institutional rigidity and greater reliance on public budgetary support.

The econometric diagnostics are satisfactory overall: the coefficients of determination are high, the Durbin-Watson statistics are close to 2, and the normality and serial-correlation tests do not reveal major specification problems. These properties confirm the robustness of the chosen model.

5. ECONOMETRIC RESULTS AND COMPARATIVE ANALYSIS

The estimation results reveal a clear asymmetry between the CNSS and the CNRPS. Although both schemes are affected by demographic and macroeconomic forces, their adjustment mechanisms differ in both intensity and direction. The CNSS is more exposed to labour-market volatility, especially unemployment and informality, whereas the CNRPS reacts more strongly to demographic and parametric variables, particularly the effective retirement age and GDP growth.

5.1. Long-run coefficients

The long-run coefficients confirm that the effective retirement age is the most powerful common determinant of financial sustainability in both regimes. A higher retirement age improves the balance of the two funds, but the effect is stronger for the CNRPS, which reflects the more rigid and more public nature of that scheme. Contribution rates also have a positive long-run effect, although the magnitude and interpretation differ between the two funds. By contrast, GDP growth and unemployment exert more complex effects, and informality remains a structural drag on the CNSS only.

These results suggest that the financial balance of the CNSS depends heavily on labour-market quality, while the CNRPS is more insulated from informality but more sensitive to state support and macroeconomic growth. In other words, the CNSS is exposed to the structure of private employment, whereas the CNRPS is shaped more by public-sector demography and budgetary transfers.

Table 9. Long-run cointegrating coefficients

Determinant	CNSS coefficient	CNRPS coefficient	Interpretation
Effective retirement age	+1.84	+2.20	Strong positive effect, stronger in CNRPS
Contribution rate	+7.50	+10.01	Positive fiscal effect, more marked in CNRPS
Real GDP	-1.25	-0.67	Weak direct long-run association
Unemployment rate	-2.31	+0.35	CNSS vulnerable; CNRPS largely insulated
Informality rate	-1.67	—	Structural vulnerability specific to CNSS

Source: Author's calculations.

5.2. Short-run dynamics and error correction

The short-run estimates reinforce this asymmetry. The error-correction term is significant in both systems, confirming that deviations from long-run equilibrium are corrected over time. However, the speed of adjustment differs: the CNSS reacts more quickly to

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disequilibria, while the CNRPS adjusts more slowly and with greater inertia. This reflects the weaker institutional flexibility of the public scheme and its dependence on administrative and fiscal smoothing mechanisms.

The short-run coefficients show that shocks to unemployment and informality deteriorate the CNSS balance almost immediately, whereas positive shocks to retirement age and contribution rates improve the trajectory of both funds. For the CNRPS, GDP growth has a more visible stabilising role over the short run, while unemployment remains almost neutral.

5.3. Impulse response functions

The impulse response functions provide a dynamic view of these relationships over ten periods. They confirm that the CNSS responds strongly and negatively to shocks in unemployment and informality, while positive shocks in retirement age, contribution rates, and GDP gradually improve its balance. The CNRPS shows a smoother and more protected profile: its balance benefits markedly from GDP growth and later retirement, but the response to contribution rate increases is weaker and sometimes even counterintuitive, suggesting a possible substitution effect through public transfers.

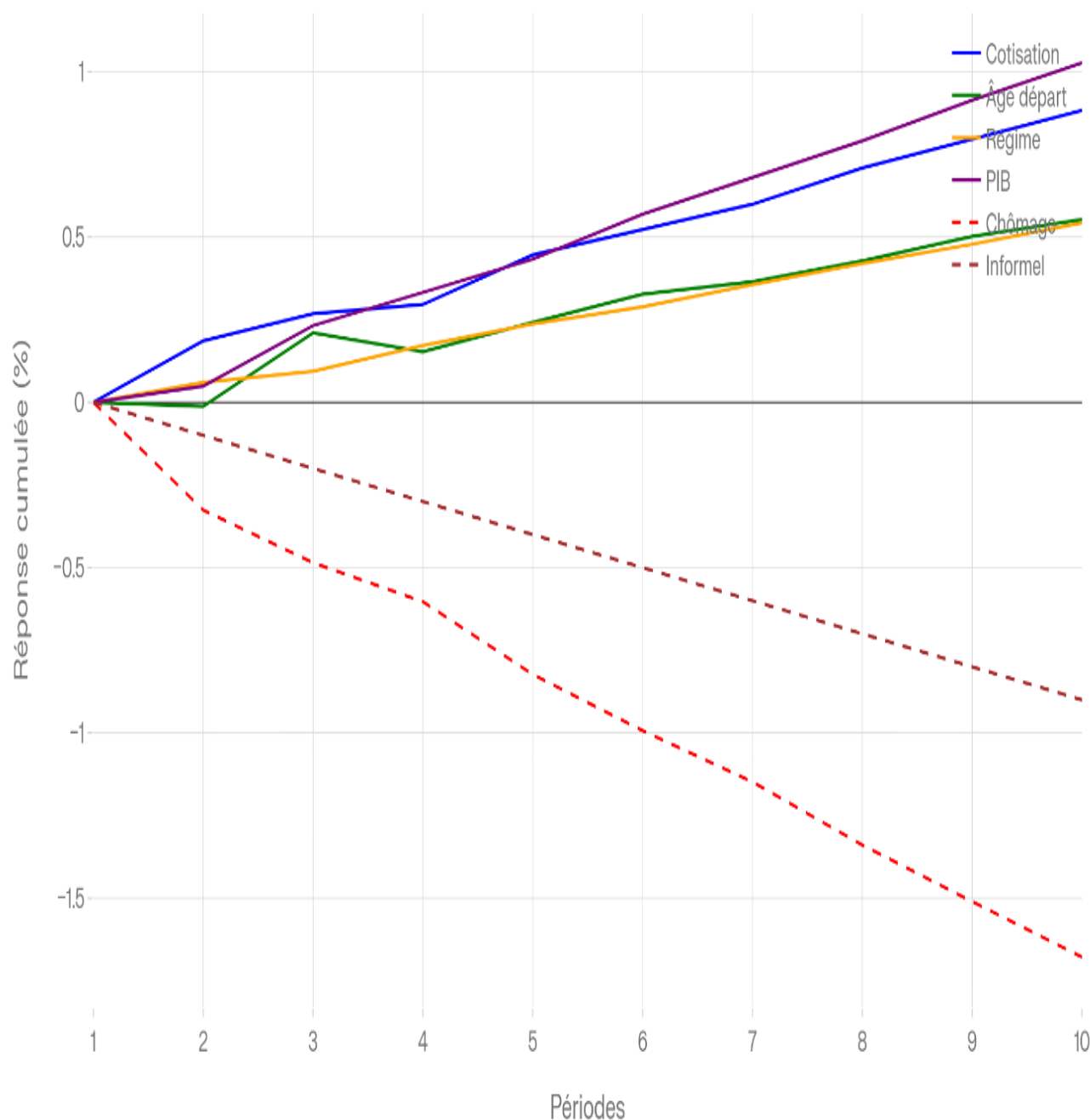


Figure 1. Consolidated impulse responses for the CNSS over ten periods
Source: Author's Calculations

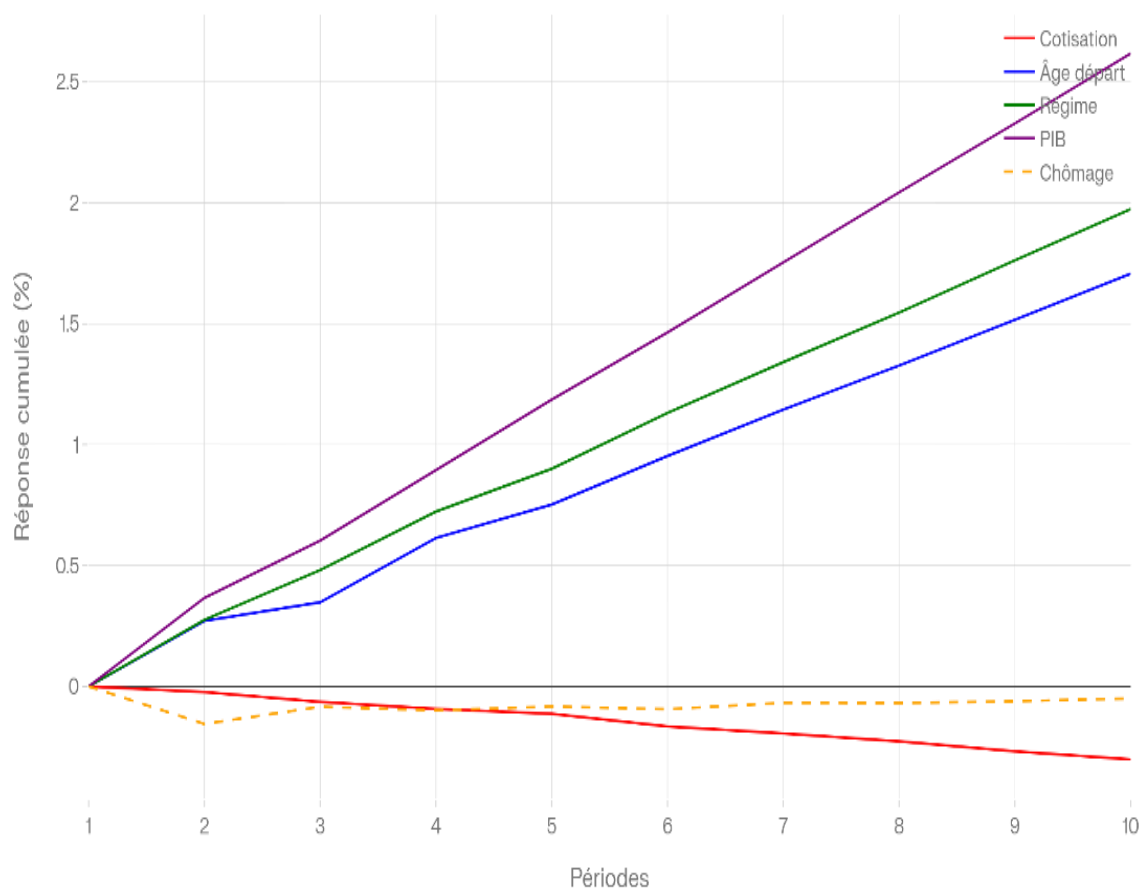


Figure 2. Consolidated impulse responses for the CNRPS over ten periods

Note: Cotisation, Age depart, Régime, PIB, chômage refer to the contribution rate, retirement age, pension scheme, GDP, unemployment, and informality.

Source: Author's Calculations

Table 10. Cumulative impulse responses over ten periods

Shock	CNSS (%)	CNRPS (%)	Diagnostic
Effective retirement age	+0.55	+1.71	Stronger amplification in CNRPS
Contribution rate	+0.88	-0.30	Paradoxical substitution effect in CNRPS
GDP	+1.03	+2.62	CNRPS more growth-dependent
Unemployment	-1.68	-0.05	CNSS highly labour-sensitive
Informality	-0.90	—	Structural vulnerability of CNSS

Source: Author's calculations.

The impulse responses therefore confirm a fundamental asymmetry: the CNSS is highly sensitive to short-run labour-market shocks, whereas the CNRPS depends more on demographic parameters and macroeconomic growth. The effective retirement age remains the strongest common lever, but its impact is amplified in the public scheme because institutional rigidities slow adjustment and increase reliance on the State.

6. MICRO-SIMULATION, VIABILITY, AND DISTRIBUTIONAL EFFECTS

The transition from econometric estimation to micro-simulation makes it possible to evaluate reform scenarios prospectively. The objective is not only to project fiscal sustainability, but also to assess distributional consequences, especially pension inequality and the position of lower-income retirees.

6.1. Prospective viability of the CNRPS

The simulations indicate that, in the absence of reform, the CNRPS would remain in significant deficit by 2035. The status quo preserves high expenditure and high public subsidies, without a meaningful improvement in distributive equity. By contrast, scenarios involving a higher retirement age, increased contribution rates, or stronger GDP growth significantly improve the financial trajectory.

The most robust scenario is the hybrid reform, which combines parametric adjustment, solidarity mechanisms, and diversified financing. It reduces the net deficit while also improving the distribution of pensions and expanding coverage.

Table 11. Prospective viability of the CNRPS under reform scenarios

Scenario	Contributions	Expenditure	Subsidies	Net deficit	Pension Gini	Bottom decile (TND/month)
Status quo	4.5	6.8	1.2	+2.5	0.42	1,200
Effective age +2 years	5.2	5.9	0.8	+0.5	0.38	1,416
Contributions +2 pts	6.1	6.5	0.9	+0.3	0.39	1,344
GDP growth +1 pt	5.8	5.2	0.7	-0.1	0.37	1,500
Hybrid reform	6.3	5.4	0.6	-0.3	0.35	1,584

Notes: deficit = expenditure – contributions – subsidies. Coverage target: 85%, including 20% of informal workers through minimum contributions.

The hybrid scenario clearly dominates in terms of both sustainability and equity. It improves revenues, restrains expenditures, and offers better protection for lower-income pensioners. It is therefore not merely a budgetary correction, but a broader institutional reconfiguration.

6.2. Distributional effects and pension inequality

The distributional analysis complements the sustainability diagnosis. The Gini coefficient applied to pensions captures the degree of inequality in the distribution of retirement income. Under the status quo, pension distribution remains relatively unequal, reflecting career gaps, early exits, and institutional fragmentation. The reforms alter this distribution to different degrees depending on their ability to act simultaneously on contribution length, the contributory base, and solidarity mechanisms.

Table 12. Pension distribution and Gini coefficient

Scenario	Pension Gini	Δ Gini	P90/P10	Share of bottom 40% income groups	Interpretation
Status quo	0.42	Reference	4.8	18%	Baseline inequality
Effective age +2 years	0.38	-9.5%	4.2	22%	Equity through longer careers
Contributions +2 pts	0.39	-7.1%	4.5	20%	Moderate effect
GDP growth +1 pt	0.37	-11.9%	3.9	24%	Redistribution via employment

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Scenario	Pension Gini	Δ Gini	P90/P10	Share of bottom 40% income groups	Interpretation
Hybrid reform	0.35	-16.7%	3.6	27%	Best combination

Raising the effective retirement age reduces inequality by making contribution histories more homogeneous. Stronger GDP growth improves the pensions of the lowest deciles more substantially by supporting formal employment and contribution revenues. The hybrid reform delivers the best results because it combines actuarial fairness with redistribution that corrects pre-existing inequalities.

The hybrid reform reduces the Gini coefficient to 0.35, which indicates a notably more balanced distribution. It also raises the share of low-income retirees in total pensions, signalling a stronger redistributive effect. This matters because financial sustainability cannot be reduced to accounting balance alone: it also depends on the system's social legitimacy.

7. COMPARATIVE SYNTHESIS AND STRATEGIC RECOMMENDATIONS

The comparative econometric analysis of the CNSS and CNRPS reveals a fundamentally asymmetrical architecture of sectoral vulnerabilities. The effective retirement age emerges as the most powerful universal determinant, with positive effects on both long-run financial balance and short-run adjustment. This effect is more pronounced in the CNRPS, reflecting the structure of the public scheme and its greater capacity to absorb parametric reforms.

By contrast, the CNSS remains sharply exposed to unemployment and informality. These two variables exert a lasting negative effect on financial balance, confirming the private scheme's dependence on labour-market quality and employment formalisation. The CNRPS is less sensitive to these shocks, but more dependent on growth and budgetary support. The impulse responses corroborate this asymmetry: GDP and retirement-age shocks improve both regimes, while unemployment and informality mainly damage the CNSS.

These results justify a differentiated reform portfolio. For the CNSS, the priority is to formalise employment, reduce contribution losses, and improve collection efficiency. For the CNRPS, sustainability should be strengthened through gradual parametric reform, stronger linkage to growth, and diversified funding sources. In both schemes, notional accounts and hybrid mechanisms appear to be the most promising tools for combining actuarial fairness, solidarity, and sustainability.

Table 13. Comparative econometric effects for the CNSS and CNRPS

Determinant	CNSS	CNRPS	Structural difference
Effective age	+1.84 / +1.45	+2.20 / +1.92	Universal lever, stronger in CNRPS
Contributions	+7.50 / +2.21	+10.01 / +14.83	Positive, but more complex in CNRPS
GDP	-1.25 / -17.11	-0.67 / -8.65	CNRPS more growth-dependent
Unemployment	-2.31 / -2.73	+0.35 / +4.15	Exclusive vulnerability of CNSS
Informality	-1.67 / -0.77	Not applicable	Structural risk specific to CNSS

Source: Author's calculations.

Under a baseline scenario, the CNSS remains fragile while the CNRPS continues to face a high deficit. By contrast, a scenario combining a later retirement age, labour-market formalisation, and stronger growth yields a much more favourable trajectory, including a combined surplus and a marked reduction in pension inequality. The sustainability of Tunisia's pension system therefore depends less on any single measure than on a coherent combination of institutional, demographic, and macroeconomic levers.

8. CONCLUSION

This article has shown that Tunisia's pension crisis is not a temporary imbalance but a structural and multidimensional breakdown of a pay-as-you-go system under demographic, labour-market, and institutional pressure. The comparative analysis of the CNSS and CNRPS reveals a pronounced asymmetry: the CNSS is highly exposed to unemployment and informality, whereas the CNRPS is more sensitive to retirement-age reforms and macroeconomic growth. This difference implies that a single uniform reform is unlikely to deliver durable results.

The econometric results confirm that raising the effective retirement age is the most powerful common lever for improving sustainability in both schemes. Contribution-rate increases can also help, but their effect is more limited and institution-specific. By contrast, unemployment and informality continue to erode the CNSS contribution base, which means that improving labour-market formalisation is not merely a complementary policy but a core condition for restoring balance.

The simulation exercises further show that sustainability cannot be assessed only in accounting terms. Reform scenarios that reduce deficits while worsening inequality would remain politically fragile. For this reason, the hybrid reform scenario is the most convincing: it combines a gradual increase in the effective retirement age, a broader contributory base, stronger solidarity mechanisms, and diversified financing. It improves both financial viability and the distribution of pensions, especially for lower-income retirees.

More broadly, the Tunisian case suggests that pension reform must be thought of as institutional redesign rather than a technical correction. A viable strategy requires coordination between parametric reform, governance reform, and labour-market formalisation. It also requires a social pact capable of balancing budgetary discipline with intergenerational equity and protection of vulnerable retirees. In this sense, the future of the Tunisian pension system depends less on isolated measures than on a coherent and politically credible reform sequence.

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