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Strategic Interaction Between Monetary and Fiscal Policy in Algeria: a Game Theory Approach

Cezayir'de Para ve Maliye Politikası Arasındaki Stratejik Etkileşim: Bir Oyun Teorisi Yaklaşımı

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ABSTRACT

Using a dynamic game theory framework, this study evaluates the interplay of fiscal and monetary policies under various demand and supply shock scenarios in the Algerian economy. Aligning fiscal and monetary policies is essential to mitigate potential conflicts that may arise from uncoordinated actions, such as increased inflation volatility or unsustainable public debt levels, which ultimately reduce societal welfare. In this context, the game theory-based approach utilized in this study to examine the effectiveness of different coordination methods (Nash equilibrium, Stackelberg leadership, and cooperative solution) between Algerian fiscal policy and monetary policy in a conventional macroeconomic optimization issue. Our computational analysis indicates that the cooperative Pareto equilibrium minimizes welfare loss by offering optimal responses to economic shocks, particularly in terms of output stabilization, debt sustainability, and inflation control. Although this study focuses on Algeria, the findings may provide insights for other developing economies with similar macroeconomic and institutional contexts. This study contributes to the literature by quantitatively assessing the effectiveness of policy coordination strategies through a game theory lens, filling a gap in the analysis of fiscal-monetary interplay in developing economies.

Anahtar Kelimeler:
Para Politikası,
Maliye Politikası,
Pareto Kooperatif Çözümü,
Stackelberg Dengesi,
Nash Dengesi

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ÖZET

Bu çalışma, dinamik oyun teorisi çerçevesini kullanarak Cezayir ekonomisinde çeşitli talep ve arz şoku senaryoları altında maliye ve para politikalarının etkileşimini değerlendirmektedir. Maliye ve para politikalarının uyumlu bir şekilde yürütülmesi, koordinasyonsuz eylemlerden kaynaklanabilecek potansiyel çatışmaları hafifletmek için gereklidir. Bu çatışmalar arasında artan enflasyon dalgalanmaları veya sürdürülemez kamu borcu seviyeleri yer almakta olup, bunlar nihayetinde toplumsal refahı azaltmaktadır. Bu bağlamda, bu çalışma, geleneksel bir makroekonomik optimizasyon sorunu çerçevesinde Cezayir'in maliye ve para politikaları arasındaki farklı koordinasyon yöntemlerinin (Nash dengesi, Stackelberg liderliği ve iş birliği çözümü) etkinliğini incelemek için oyun teorisi temelli bir yaklaşım kullanmaktadır. Yapılan analiz sonucunda, iş birliğine dayalı Pareto dengesinin refah kaybını minimize ederek ekonomik şoklara, özellikle de üretim istikrarı, borç sürdürülebilirliği ve enflasyon kontrolü açısından optimal tepkiler sunduğunu göstermektedir. Bu çalışma her ne kadar Cezayir'e odaklansa da, bulgular benzer makroekonomik ve kurumsal bağlamlara sahip diğer gelişmekte olan ekonomilere yönelik de içgörüler sağlayabilir. Çalışma, maliye-para politikası etkileşiminin oyun teorisi perspektifinden koordinasyon stratejilerinin etkinliğini nicel olarak değerlendirerek, gelişmekte olan ekonomilerde maliye-para ilişkisine yönelik analizlerdeki önemli bir boşluğu doldurmak suretiyle literatüre katkı sağlamaktadır.

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1. INTRODUCTION

The main instruments for controlling the economy at a large scale are fiscal and monetary policies. They aim to maintain a high level of jobs, stable prices and overall economic growth. Macroeconomists are wondering about how the relationship between fiscal and monetary policies affects the economy's performance in achieving its objectives and targets. These different objectives are the reason why the monetary and the fiscal authorities have difficulty aligning their actions, or why they do not cooperate at all. Yet, there is the capability that the decision makers are trapped in an interplay that results in high deficits and stringent money, which is a common imbalance of the fiscal-monetary mix. There are many reasons for this imbalance, but one of them is the variations in incentives of the monetary and fiscal officials. Governments are elected and do not want to initiate a policy that will worsen the economic situation before elections, even if it has some long-term benefits. Monetary decision makers frequently have a longer-term standpoint; however, they are also cautious and occasionally slow. Thus, in an economy that exhibits a large deficit equilibrium, a policy to reduce the deficit may cause a short-term but (for the elected) economically disastrous political decline, if the monetary authorities do not react quickly enough. Politicians who care about their own interests may prefer to keep the high-deficit equilibrium. This situation is called the monetary-fiscal game, because it shows that monetary and fiscal policies are largely separate and have opposite goals in several countries with large economic performance.

Policy makers and economists think that their countries have fiscal shortfalls as well as real interest rates that are too high to support enough long-term expansion of potential output and private investment, in almost all countries that have separate fiscal and monetary policies. This unfavorable fiscal-monetary mix syndrome has been present in the macroeconomic landscape for many years. Regarding Algeria, both the fiscal and external balances have worsened greatly because of the COVID-19 pandemic impact. The general government's overall balance showed a significant increase from -5.6% in 2019 to -13.6% in 2020 (see Figure A1 in the appendix), public debt also increased from 46.19% in 2019 to 60.96% in 2020 and to 65.83% in 2021(see Figure A2 in the appendix). Meanwhile, despite efforts to curb imports and sluggish domestic demand, the trade deficit widened to 18.2% of GDP due to a sharp decline in export revenues (-51%), and the current account deficit rose to 18.8% of GDP in 2020.

The government revealed a national socio-economic recovery plan to face the COVID-19 pandemic's effects on both individuals and the economy. A supplemental finance law (SFL) has measures worth 70 billion dinars to lessen the negative effects of the COVID-19 pandemic on the economy and public health. Furthermore, between March 15, 2020, and February 15, 2021, notably, the Bank of Algeria has reduced the ratio of needed reserves. 10% to 8%, then to 6%, then to 3%, and to 2%. It additionally decreases the primary policy rate to 3.25% from 3% after a difference of 25 basis points. Additionally, haircut rates for government securities utilized in refinancing operations were reduced. It stated that it was relaxing banks' reliability, liquidity, and NPLs ratios. Banks can postpone repayments on certain loans unless the need of setting aside funds for them. Within October 2017 banking law, the value of the provided loans for public treasury by the Bank of Algeria reached to 6556 billion dinars by the end of January 2019 (about 23 percent of GDP) (see Figure A3 in the appendix). This legislation permits the Bank of Algeria to directly finance activities such as the National Investment Fund, public sector debt buy-back, and budget deficit until 2022. Furthermore, given the increasing overall public funding requirements and the continued refusal of the authorities to make worldwide financial markets resources worthwhile, the financial system in Algeria may be forced to cover the bulk of Algeria's high level of public funding in the coming years. In a context where external threats continue to pose a challenge, the implementation of this new strategy could potentially worsen existing macroeconomic imbalances by fueling inflationary pressures.

Meanwhile, if we compare the interest rate on Algeria's public sector debt and economic growth (see Figure A4 in the Appendix), it becomes clear that the earlier is not particularly adequate to repay for the liability's nominal rate of interest. Since then, Algeria's fiscal space has declined because growth-adjusted interest costs are less than the pace of public sector debt increase. Algerian government bonds will experience an increase in the sovereign risk premium because of this situation and international markets will be informed about potential defaults.

In 2022, the Algerian economy experienced a boost in hydrocarbon prices, which contributed to its recovery from the pandemic-induced shock. However, the country is facing challenges such as rising inflation (which reached 9.3% in 2022) and the potential for a global economic slowdown, which could hinder its growth. The price level has increased to its highest point in a quarter of a century due to a rise in international commodity prices and a combination of global and local factors, such as the 2021 drought, loose monetary policy stance, wage hikes in 2022 and stricter import rules. The prospect of a global slowdown creates policy dilemmas in the short term, as

reducing inflation and maintaining fiscal soundness will need to be balanced against boosting growth and purchasing power. The risk of changes in hydrocarbon prices is still high.

Under these conditions, the central bank's capacity to restore stability to the economy following adverse shocks is hampered by the prevailing low rate of interest situation. Meanwhile, the historically high debt level may limit the effectiveness of fiscal measures by causing people to expect future fiscal adjustments to address solvency concerns. Coordination of these two policy areas is therefore essential, as decisions by one institution can have devastating effects on the other, leading to a loss of social welfare. The lack of coordination between fiscal and monetary policies can lead to economic imbalances and societal welfare losses. In the Algerian context, determining effective methods of policy coordination is a pressing issue for both policymakers and scholars. On the other hand, transparency in the interaction between fiscal and monetary policies is critical for fostering economic stability and public trust. Clear communication and coordination between these policy domains ensure that objectives. Transparency reduces uncertainty for investors, businesses, and households, helping them make informed decisions. Moreover, it enhances accountability, allowing policymakers to be evaluated on their effectiveness and adherence to long-term economic goals. This openness is particularly crucial during crises when confidence in economic governance can significantly influence recovery outcomes.

Against this background, many important key macroeconomic questions are addressed, and need to be investigated: How do the supremacies of Algeria's monetary and fiscal policies relate to their strategic choices? How do coordination and independence in macroeconomic policy affect the economy positively and negatively? How does the autonomy in policymaking that is deeply established in the Algerian polity impact the economy? Does a lack of political independence lead to ineffective monetary and fiscal policy coordination? When and under what conditions does choosing monetary and fiscal policy strategies independently lead to economically effective decisions, and when does coordination of decisions become necessary?

In this context, this paper aims to contribute to improving policy-making in the Algerian economy. In particular, it helps to design a more flexible fiscal policy that does not interfere with monetary policy based on different policy objectives. In order to avoid "fights" between authorities, it is important to know the leadership structure. This is because the strength of such conflicts and their impact on well-being depends on the authorities' ability to play a leading role in the policy game. To this end, the primary aim of this study is to analyze the interaction between fiscal and monetary policies in the Algerian economy and evaluate the effectiveness of various coordination mechanisms (Nash, Stackelberg, and Pareto solutions). By employing a game theory approach, the study seeks to understand the impact of policy coordination on responses to economic shocks. Effective coordination between fiscal and monetary policies is critical for economic stability and sustainable growth. This study addresses a gap in the literature on policy coordination in developing economies and provides insights that may inform policymakers in Algeria and beyond. The limitations of this study stem from the assumptions inherent in the game theory model and the focus on data specific to the Algerian economy. Moreover, the shocks analyzed are limited within the model's scope and may not fully represent real-world complexities.

The remaining portions of this study are structured as follows. Theoretical underpinnings of the interplay between fiscal and monetary policy are discussed in Section 2 using a game-theoretic approach. Section 3 includes detailed empirical evidence. Section 4 emphasizes the primary findings and the approach employed. The last section offers some conclusions and suggestions for leaders.

2. THEORETICAL BACKGROUNDS

According to the conventional macroeconomics literature, the actions of policymakers shape macroeconomic policies. The fiscal and monetary policymakers, who have different and sometimes conflicting objectives, carry out these policies with strong impacts. To affect the economy's framework and achieve their objectives, they select and put into practice the optimal policy regulation. The policy formation process is affected by the interdependence of the optimal policy rules, which stem from the diverse and conflicting goals of the policymakers. Therefore, it is essential to use game theory to model this process and capture the interaction of policymakers better. In models of game theory regarding macroeconomic strategy, those in charge are considered as individual entities with specific goals and choices, attempting to reduce their losses and enhance their advantages, similar to economic agents like households and firms. These models consider the joint strategic interaction of policymakers in their policies. Thus, in a game theoretical framework, policymakers are seen as individuals (players) with unique objectives, anticipations, and inclinations. Political and economic behavior was merged into a field of study by the new economy approach in the 1980s, which gave rise to game theoretical policy models. The new political economy approach used methods such as econometrics and game theory, which

permitted a more in-depth and thorough examination of the interconnectedness between political as well as economic initiatives of economic organizations, surpassing previous capabilities.

Presented now is a basic fiscal-monetary game designed as an introductory tool to elucidate the key issues and outcomes of this paper, drawing inspiration from the classic 'prisoner's dilemma' model. Table 1 illustrates the key suppositions and outcomes of this particular game, where we examine the possible central bank reactions and government when confronted with an adverse shock that increases inflation (interest rates) and decreases employment (output or debt).

Table 1. Monetary and Fiscal Game

		Central Bank	
		Tight Monetary	**Loose Monetary**
Fiscal Authority	Tight Fiscal	7 Low Inflation 4 Low Employment	6 Medium Inflation 6 Medium Employment
	Loose Fiscal	6 Medium Inflation 6 Medium Employment	4 High Inflation 7 High Employment

Source: Bennett & Loayza, 2002: 301.

Maximizing an asymmetric utility function is the goal of the policymaker. Both monetary and fiscal policy makers are wary of production drops and inflation increases, but they are tolerant of output increases or inflation decreases. Each fiscal and monetary authority has two alternatives: They have the option of choosing a loose or restrictive policy. In scenarios where both implement tight policies, resulting inflation remains low, yet employment levels also drop. Conversely, when both enforce loose policies, inflation and employment levels rise simultaneously. Finally, when a single authority enforces a rigid policy, it typically leads to modest levels of employment and inflation.

The payoff schedules depicted in Table 2 demonstrate the disparities in priorities between fiscal and monetary authorities when it comes to inflation and employment, which is an intriguing aspect of this fiscal/monetary interaction. Reducing inflation is more important to the monetary authority than increasing employment, while the fiscal authority places greater importance on achieving high employment than on low inflation.

Table 2. Monetary and Fiscal Game: Payoff Schedules

Inflation	Low	Medium	High
Central Bank	6	4	1
Fiscal Authority	3	2	1
Employment	Low	Medium	High
Central Bank	1	2	3
Fiscal Authority	1	4	6

Source: Bennett & Loayza, 2002: 301.

The outcome we want to emphasize is achieved by deliberately setting the differences in preferences between both authorities to be significant. The sole Nash equilibrium[1] within this game comprises a fluid fiscal policy and a stringent monetary strategy. The remaining three choices offer chances for one player to gain an advantage by separately changing from the initial phase play. Central banks' conservatism and fiscal authorities' liberalism are revealed through the game's equilibrium. The ideal reaction for both parties is highlighted because of the differences in preferences between them. If so, the monetary authority decided to implement an ambiguous policy, thereby agreeing to the government's commitment to stricter restraint, the government would likely find it advantageous to go back on its promise and engage in a loose policy. Similarly, if the government were to implement a rigid policy while the central bank is pursuing a loose policy, the monetary authority would find it advantageous to diverge from its current stance by implementing a tight policy. It should be noted that the Nash equilibrium corresponds with a strategy that combines loose monetary and tight fiscal policies when it comes to the payoffs to both players. (Bennett & Loayza, 2002, p. 301)

[1] When each authority achieves maximum utility by its self policy tool under the assumption that the other policy tool is gived, the Nash solution is achieved.

Using the *Active* and *Passive* dichotomy (according to Leeper's (1991) terminology), the strategic component of policy interactions can be evaluated through the of a 2 × 2 game. The payoff matrix in Table 3 outlines the overall game scenario with {*a, b, c, d, v, w, y, z*} representing the payoffs of policymakers across the four potential policy regimes. The payoffs are clearly dependent on the fundamental factors of the macroeconomic framework and policy choices. In the regimes categorized as non-Ricardian and Ricardian [as identified by Woodford (1994)] The F and M policies, in turn, address the F gap, leading to a consistent real debt burden. However, under the (AM, AF) regime, neither strategy addresses the issue, which results in a situation where the actual debt is increasing at a concerning rate. Ultimately, under the (PM, PF) regime, each policy tackles the issue separately, leading to a notable reduction in the actual debt.

Table 3. The Payoff Matrix

	Fiscal Authority		
		Passive Fiscal	**Active Fiscal**
Central Bank	Active Monetary	Ricardian (*a, v*)	Explosive (*b, w*)
	Passive Monetary	Mis-coordination (*c, y*)	Non-Ricardian (unpleasant arithmetic) (*d, z*)

Also, several scenarios are possible depending on the policy weights:

- The scenario of *Symbiosis*, as described by Dixit & Lambertini, where the (AM, PF) result represents the sole Nash equilibrium and is favorable for both participants. Consequently, there is an absence of *F* spillovers in this scenario.
- In scenarios of *Discipline*, what comes out of (AM, PF) remains the sole Nash equilibrium, leading to the prevention of *F* spillovers. However, the resultant outcome ceases to be *F*'s most favored choice.
- *The Tug-of-War* scenario where the (AM, AF) result emerges as the particular Nash equilibrium. Although Over time, spillovers are not anticipated, long-term sustainability of this arrangement cannot be achieved because of the government's unsatisfied budgetary constraints.
- Two clear Nash equilibrium, denoted by (AM, PF) and (PM, AF), are present in the Pure Coordination scenario, coupled with a combination of strategies Nash equilibrium that is Pareto lower to both absolute Nash equilibrium. The possibility of spillover effects from the F to M policy is low because both policymakers would favor the previous Nash equilibrium.
- *Two separate Nash equilibria are given as well in the Game of Chicken scenario.* (*AM, PF*) and (*PM, AF*) along with one equilibrium involving mixed strategies. However, there is a higher likelihood of spillover effects from F to M policy here, given that each decision-maker favors a different Nash equilibrium solution.
- In a *neglect scenario* where *(PM, AF)* represents the singular Nash equilibrium, spillovers surely occur. (Hallett et al., 2014 : 9)

We can calculate each authority's individual "happiness points" if the ideal levels of the fiscal deficit (D) and interest rate (r) were established, and if each authority had the power to set both instruments (under an independent economic maker). Figure 1 demonstrates the curves of: Fiscal Reaction Function (FRnFn) and Fiscal Cross Maximization (FCrMx), Monetary Reaction Function (MRnFn) and Monetary Cross Maximization (MCrMx). The fiscal authority's best position point is attained when the FRnFn and FCrMx intersect, yields the ideal pair (D^F; r^F). The best option point of the monetary authority, represented as (DM; rM) pair, is determined in a similar manner to that of the fiscal authority. The Nash equilibrium leads to a pair (D^N; r^N) wherein no one is able to reach a higher level of utility by independently deviating from it. The crossroad of MRnFn and FRnFn leads to the solution of Nash. Furthermore, the Nash equilibria illustrated in Figure 1 reflects the findings presented in Loewy (1988) and Nordhaus (1994): Contrasting as is said at the bliss point, in the Nash equilibrium, the real interest rate and the magnitude of the fiscal shortfall are larger. The Nash equilibrium (D^N; r^N) is Pareto inferior than a wide range of points, in particular the arc that connects both bliss points.

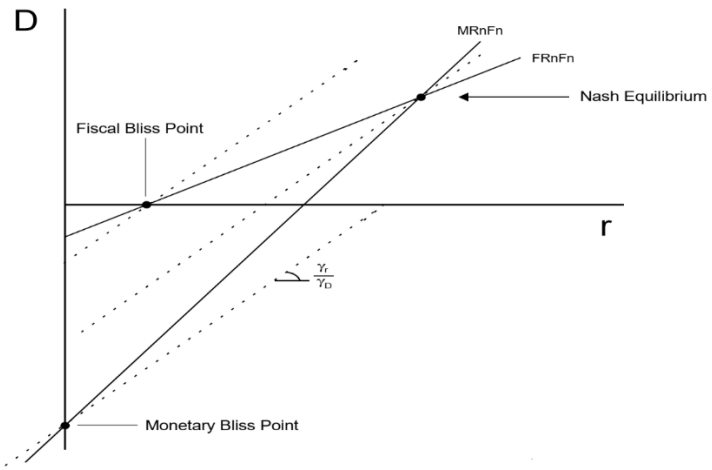

Figure 1. The Nash Equilibrium
Source: Bennett & Loayza, 2002: 312.

This game ignores the possibility of talks within monetary and fiscal authorities that might lead to coordinated efforts in policymaking (a procedure referred to be coordination is when two autonomous authorities engage in negotiations. to harmonize their approaches in an attempt to enhance outcomes for the two sides). The Stackelberg solution injects dynamic elements into the game by choosing one player as their leader, allowing the leading authority to initiate a reciprocal reaction from the follower. When the central bank takes over the leadership in the Stackelberg strategic interplay, the game is attained by optimizing *UM* with respect to *r*. Noteworthy is the fact that the central bank is now able to influence *D* in line with the fiscal authority's reaction function. Figure 2 illustrates the Stackelberg equilibrium point, where MAnFn (Stackelberg) intersects with FRnFn. In a similar manner for the Nash solution, a lack of cooperation between policies, which is portrayed as a Stackelberg strategy, leads to deeper fiscal deficits and high values of real interest rates compared to outcomes when either authority oversees the two strategy instruments. Reducing deficits and lowering interest rates is attainable by using the Stackelberg approach, just like the Nash solution. When the central bank takes the lead, in addition, it allows both authorities to attain a larger iso-utility curve than in the Nash equilibrium and denotes increased activity (and inflation). The Box in Figure 2 demonstrates a scenario in which the government takes on the leadership role. Results in this case are very similar, but the total demand level that results is less than that of the Nash solution.

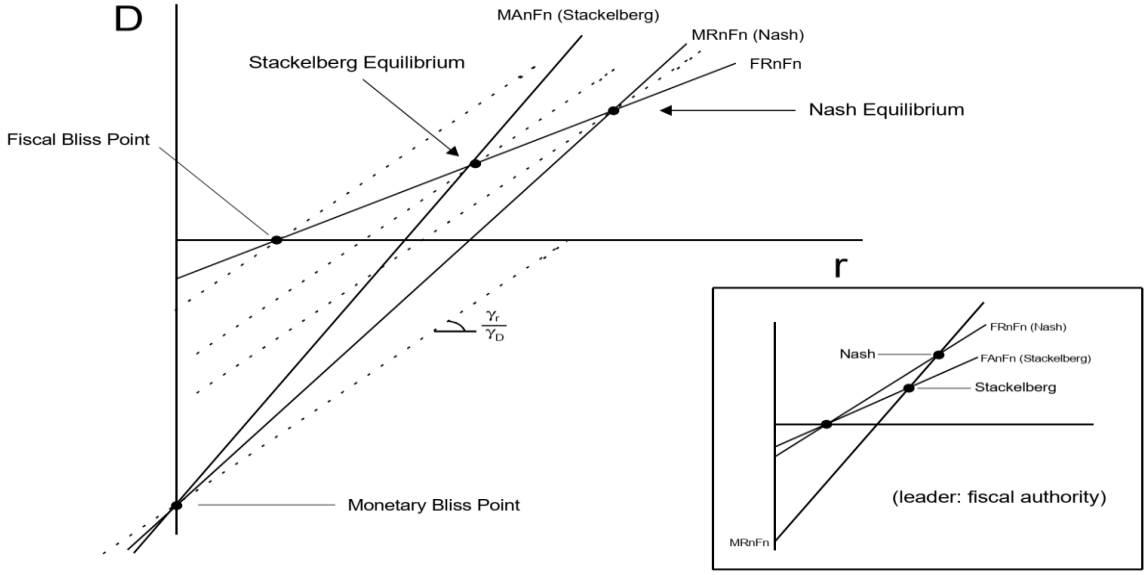

Figure 2. The Stackelberg Equilibrium (Leader: Central Bank)

Source: Bennett & Loayza, 2002: 316.

3. EMPIRICAL LITERATURE

Numerous thorough studies have explored the consequences of possible oppositions among monetary and fiscal strategies, along with the advantages of a coordinated scenario. Numerous research works rely on game theory frameworks, which assume a predetermined level of cooperation between the government and the central bank. These entities influence one another's behavior through their decisions[2]. In this regard, Blinder (1982) examined a straightforward fiscal-monetary game in which the players were the monetary and fiscal authorities, each of whom had a couple of monetary and a couple of fiscal options —the tight and loose ones. The researchers pointed out that the Nash equilibrium, that is not Pareto optimal, can arise from autonomous activities by authority. Comparable reasoning for coordinating the policies was presented, along with a comparable examination of the prisoner's dilemma situation.

Tabellini (1986) explores the problem of keeping public debt manageable as a dynamic game between monetary and fiscal authorities. The relationship among both of those authorities is modeled as a game with linear dynamics that demonstrate the debt progression in the event of external rates of interest, as well as the authorities' efforts to reduce a quadratic objective function. Among these primary results concerns the advantages of collaboration, which suggests that when two policymakers align their efforts, they are able to achieve a lower level of long-term debt. Moreover, this reduction is accomplished more quickly compared to situations where collaboration is absent. A further outcome is that when one player reduces the proportionate weight allotted to debt stabilization, the modification burden on the opposing player gets more.

In a seminal work, Nordhaus (1994) examined the intricate problem of reconciling the objectives of monetary policy and fiscal policy, which often pose a trade-off between independence and coordination moreover employing a fiscal-monetary strategic game. The game was developed using a straightforward theoretical macroeconomic model. This model incorporated utility functions representing both the government and central bank, which were influenced by their policy tools. The discussion included topics such as Nash equilibria, payoffs' Pareto optimality, potential disagreements of interest among authorities, and recommendations for coordinating policies. The Nordhaus game model served as an initial foundation for subsequent research.

Similarly, Bennett & Loayza (2002) analyze a group of 19 industrial countries from 1970-94, applying a model based on game theory to study how monetary and fiscal authorities work together to stabilize the economy. These authorities exhibit distinct preferences regarding output and inflation gaps, and they also wield varying policy instruments. Under conditions of policy coordination failure, the solution can be represented as either a Nash or a Stackelberg equilibrium, which suggests that a rise in the difference in inclinations between both fiscal and monetary authorities will occur and inevitably result in higher public deficits, ceteris paribus (the fiscal authority's policy instrument) as well as increased interest rates (the central bank's instrument).

Again, Pierre Faure (2003) analyzes the tactical confrontations between the fiscal and monetary authorities in the European Union and the broader global context, using a game-theoretic model and empirical data. The article shows that the absence of coordinated policy within and across currency areas leads to higher interest rates and public deficits, and that the European Central Bank’s angle for inflation stability may complicate international cooperation. The article suggests that institutional arrangements that allow for policy coordination can improve economic outcomes and reduce policy biases.

On the contrary, Dixit & Lambertini (2003) take into account the relationship between fiscal and monetary policies when the fiscal authority is more careful than the monetary authority. Under the two policies being discretionary, the Nash equilibrium results in lower output and increased pricing compared to the optimal points of both authorities; fiscal leadership is typically the superior option between the two leadership alternatives. When fiscal discretion is exercised; monetary commitment leads to identical outcomes as discretionary monetary leadership across all shock scenarios. However, fiscal commitment remains unaffected by monetary discretion in a similar manner. Achieving second-best results involves either both authorities committing jointly, setting identical targets leading to socially optimal outcomes and conservative price levels, or completely separating tasks.

[2] The interplay among fiscal and monetary policy is a topic of interest for many economists. To evaluate this topic empirically, there are four approaches: The first, which demonstrates that it might alter the circumstances of monetary policy's stability, is undoubtedly connected to the fiscal theory of the price level-FTPL- (central bank vs government supremacy). The second method looks at the idea of accommodating and counteractive time-varying regime changes as well as the nature of the relationships—that is, whether they are complementary or substitutes—among fiscal and monetary policies. The third approach investigates the interplay between monetary authority and fiscal authority using models of dynamic equilibrium, foundation of macroeconomic theory ever since the uprising of the real business cycle (RBC). The fourth method incorporates game-theoretic tools (advantageous interplay) and perceives fiscal authority and monetary authority as competing in a "game" opposing each other. A game-theoretic strategy necessitates coordination between both of them as actions made by one of them might have severe consequences for the other, resulting in a loss of social welfare.

Moreover, Neck (2003) explored the impact of discretionary versus rule-based policies, as well as non-cooperative versus cooperative policies in Europe. The study's goal was to evaluate their effectiveness using intertemporal objective functions. Findings indicate that the responses to these inquiries are heavily influenced by the type of shock that European and other economies experience. In addition, Neck & Behrens (2003) introduced a theory of dynamic game and the OPTGAME 2.0 algorithm to a fundamental macroeconomic model of fiscal policy and monetary policy in a monetary union. They found that optimal policies during a symmetric negative demand shock are counter-cyclical but not particularly active, with similar outcomes using different solution concepts. Considering cooperative economic policies are more effective or active than noncooperative ones, a different combination of policies is used to achieve significant stability benefits.

Moreover, Di Bartolomeo & Di Gioacchino (2008) analyze Stackelberg's concept of leadership in a debt-stabilization scenario. They contend that a Linked Equilibrium, which gives players the possibility to coordinate and correlate behavior, is a more effective solution concept for the starting point (where institutions, or the regulations for the next phase, are set up), rather than a Nash equilibrium, that limits action to be autonomous and individualistic.

Fragetta & Kirsanova (2010) delineated leadership patterns in the interplay between fiscal policy and monetary policy across three nations, precisely the US, the UK and Sweden. They construct a small-scale, open economy's structural model and simulate it using Bayesian techniques. They argue that the authorities may take a strategic part in a game of policy without cooperation, and analyze various types of leadership. They find that the fiscal leadership model is most suitable for Sweden and the UK, while the Nash or non-strategic regime is more common in the United States.

According to Merzlyakov (2012), the central bank's independence is not important in the export-driven Russian economy from 2001 to 2008. In a cooperative Stackelberg game scenario, where the government assumes a leadership role, fiscal and monetary policies can effectively complement each other through coordinated action. Under both types of interaction, minimal social loss occurs when expansionary fiscal and monetary strategies are in place for helping output reach its optimal degree. The efficient alignment of fiscal and monetary decisions is feasible whether there is coordination or political disagreements between the government and the central bank's decision-making committee. The independence of the central bank is not crucial in an economy dependent on resources with underdeveloped financial markets, as it is more of a political rather than economic concern.

In the context of Brazil, Saulo et al., (2013) assessed the most beneficial fiscal and monetary strategies under three different coordination plans: when organizations separately minimize welfare loss in a normal form game's Nash equilibrium, the Stackelberg solution where one institution acts first, and when institutions collaborating towards common objectives. Based on a numerical analysis, the smallest loss in social welfare is observed under a Stackelberg solution as the monetary authority takes the leadership while the fiscal authority plays the role of a subordinate. Evidence shows that under the best policy, Brazilian society strongly distastes inflation.

A new game-theory framework with asynchronous move timing is used by Hallett et al., (2014) to study strategic monetary-fiscal interactions. By adding a dynamic component to the commitment process, this framework expands on the classic Stackelberg leadership idea. This structure allows player movement at a predefined frequency, allowing policies to be strict or committed for different durations. They conclude that the inferior non-Ricardian regime (active fiscal, passive monetary) can arise in equilibrium and that, because of free-riding, a monetary union is a more likely place for this to occur. Unlike the situation portrayed in Sargent and Wallace's (1981) static commitment, this could still occur even if monetary policy takes the lead over fiscal policy for longer periods of time. Interestingly, in specific situations, a well-crafted institutional framework for monetary policy could assist the central bank in disciplining governments that engage in excessive spending, but also can assist it in fending off fiscal strain and avoiding the disagreeable monetarist arithmetic. By seeming like a reliable threat of an expensive tug-of-war policy, long-term monetary commitment (e.g. a legally mandated inflation target) could spur the economy to transition to a Ricardian (passive fiscal, active monetary) regime and diminish the median level of debt and the budget deficit. Generally, this paper shows how using a game-theoretic model with dynamic leadership can effectively choose a Pareto-efficient outcome in scenarios with multiple equilibria, where standard methods are not helpful.

Woroniecka-Leciejewicz (2015) discussed the outcomes of a policy-mix simulation analysis, carried out in a monetary and fiscal policies game, where the monetary and fiscal decision-makers have different objectives and instruments. She uses a modified logistic function to model the relationship between the policy instruments and the economic effects, taking into account the limited effectiveness of extreme policies and their impact on the business cycle. The findings illustrate the ways in which the function's parameters and the authorities' preferences

affect the Nash equilibrium situation, which is associated with the selection of a particular set of monetary and fiscal policies.

The Iranian economy's equilibrium model is examined by Mahmoudinia et al., (2016) applying Tabellini model (1986) in the Stackellberg case by feedback and open loop data. The main findings indicate that the open loop case exhibits a higher convergence speed than the feedback case, and the feedback case's debt equilibrium is less than the open loop state. Alternatively, the results show that the government and central bank show the capability to control debt levels in a Stackelberg game, even with significant oil revenues, by implementing policies to restrict central bank money creation.

Within the framework of a common currency union (monetary union), Chortareas & Mavrodimitrakis (2017) examine the strategic interactions that arise when a fiscal authority has a tactical edge over the adversary (monetary authority). Specifically, their approach differs from the traditional body of research on strategic interactions within monetary unions, by using an approach in which they solved a three-stage game where the two national fiscal authorities don't act at the same time. It is observed that when demand shocks occur, the leading fiscal authority is always motivated to engage in a game of three stages that makes the alternative fiscal authority more vulnerable. Compared to the usual scenario of limited coordination, choosing this option results in a more (less) unstable fiscal position across the union when faced with demand (supply) shocks. This instability is correlated with the asymmetries in demand shocks.

In a monetary union model of a two-country, Engwerda et al., (2019) examine the impact of Eurobonds introduction on debt-related factors. The analysis involves monetary and fiscal strategies in a debt stabilizing dynamic game, with government debt interest rates adjusting endogenously. Three distinct equilibria are examined: the fiscal coordination equilibrium, the fully cooperative solution and the non-cooperative Nash open-loop solution. It is demonstrated how the effects of Eurobonds are influenced by factors such as an equilibrium game theory framework, existing institutional arrangement, initial debt values, policymakers' debt stabilization goals, and financial market discipline strength.

Using a two-country monetary union dynamic game model, Blueschke et al., (2020) studied the results of sovereign debt relief for a member government or group of members following an exogenous decline in overall demand and the consequent increase in state debt. They perform numerical solution calculations for the dynamic game between the members' governments and monetary authority (ECB) depending on the use of OPT GAME 3 algorithm. The outcomes reveal that debt alleviation has no positive impact on either the "periphery" or the "core" of the monetary union, according to the study's model. They also say that after the first haircut, more debt relief will be needed, to the point where the union's continued existence is in trouble.

Tetik & Ceylan (2021) assess the strategic interaction between policymakers using the DSGE model in an economy that is small yet open to the world. The performance of an optimal strategy, derived through game theory, is evaluated through dynamic simulations within a counterfactual experiment framework. The model's parameters are measured for the Turkish economy. Based on how the impulse response works, social loss analysis. Furthermore, the dynamic simulation of the models. The main findings show that the best possible policy mix for the Turkish economy is one in which the monetary authority leads and the fiscal authority follows.

4. METHODOLOGY AND RESULTS

In this work, we stand on the MUMOD1 model and the Blueschke's et al., (2013) OPTGAME3 algorithm, developed and presented in Neck & Blueschke (2014). This model exhibits some Keynesian features in both the financial and goods markets, and it is expressed regarding deviations from a long-term growth trajectory. The short-term equilibrium between income and spending represents the goods market, known as the IS curve. Aiming to reach the effect on the ecoonomy's goods markets, monetary authority determines the prime rate.
Real output (a distinction between output in the short run and growth trajectory over the long run) is set up through the reduced form demand-side equilibrium equation:

$$y_t = \delta(\pi_{jt} - \pi_t) - \gamma(r_t - \theta) + \rho y_{jt} - \beta\pi_{it} + k y_{(t-1)} - \eta g_t + z d_t \quad (1)$$

π_t: represents inflation rate. r_t : represents the real rate of interest. g_t : real fiscal deficit or surplus, calculated as a percentage of real GDP, it is considered a control variable or tool for fiscal policy. Both the real inherent interest rate and the typical rate of growth in real output, $\theta \in [0,1]$, are taken to be equal. $\delta, \theta, \beta, k, \eta, \gamma, \rho$ are parameters assumed to be positive.

zd_t: represents external shocks in the goods market via the demand side and is an uncontrollable exogenous variable.

For t = 1,…, T, the current real interest rate is given by:

$$r_t = I_t - \pi_t^e \quad (2)$$

Where: π_t^e: is the inflation rate (expected values). I_t: is the nominal interest rate, that is given by:

$$I_t = R_{Et} - \lambda g_t + \chi D_t + zhp_t \quad (3)$$

Where: R_{Et}: represents the nominal interest rate that is determined by the monetary authority, it is assumed to be a monetary policy instrument or control variable. D_t: represents the real public debt calculated in relation to GDP.

λ: denotes the risk premium of fiscal deficit (assumed to be positive). i.e., the country i's nominal rate of interest increases by λ_i percentage points for each percentage point of the real fiscal deficit-to-GDP ratio.

χ: is a risk premium for debt level (assumed to be positive). i.e., for every percentage point increase in the real debt-to-GDP ratio, the nominal interest rate of country i rises by χ_i percentage points.

zhp_t: is an exogenous variable that simulates the "haircut penalty," or extra risk premium that financial markets impose following a haircut.

The inflation rates for t = 1,…, T are set based on an expectations-augmented Phillips curve, i.e., the current inflation rate is influenced by both anticipated inflation rates and excess demand in the goods market (a demand-pull relation):

$$\pi_t = \pi_t^e + \xi y_t + zs_t \quad (4)$$

Where: ξ: is a positive parameter. zs_t: represents uncontrollable external factors and depicts external shocks on the supply side, like rising oil prices, which could result in cost-push inflation.

π_t^e: represents the expected inflation rate, it's formed at the end of time period *t*–1.

The expected values of inflation are shaped by adaptive expectations theory:

$$\pi_t^e = \varepsilon\pi_{(t-1)} + (1-\varepsilon)\pi_{(t-1)}^e \quad (5)$$

where: is a positive parameter that determines how quickly expected inflation adjusts to actual inflation, and $\varepsilon \in [0,1]$.

Neck & Blueschke (2014) showed also that the median values of output and inflation are determined by:

$$y_{Et} = \omega y_t. \quad \omega \in [0,1] \quad (6)$$

$$\pi_{Et} = \omega\pi_t. \quad \omega \in [0,1] \quad (7)$$

The following equation denotes the government budget constraint; it is expressed as an equation linked to government debt:

$$D_t = \left(1 + BI_{(t-1)} - \pi_{(t-1)}^e\right)D_{(t-1)} - g_t + zh_t \quad (8)$$

Where: D_0 given, and it is assumed that there are no seignorage effects on the debt of governments. zh_t: indicates an external haircut impact on public debt. $BI_{(t-1)} - \pi_{(t-1)}^e$: denotes the payments of interest for the prior level of public debt.

BI_t: represents the average government bond interest rate at time t. it's as indicated by the subsequent equation:

$$BI_t = \frac{1}{6}\sum_{\tau=t-5}^{t} I_\tau \quad (9)$$

As determined by Krause & Moyen (2013, p. 4), it is assumed that government bonds have a six years maturity average.

Neck & Blueschke (2014) posit that decision makers (players) in the field of macroeconomic policy theory aim to minimize quadratic loss functions. Therefore, the central bank and the government have their own objective functions given by:

$$J = \frac{1}{2}\sum_{t=1}^{T}\left(\left(\frac{1}{1+\tau}\right)^{t-1}\left(\alpha_y(y_t-\tilde{y}_t)^2+\alpha_\pi(\pi_t-\tilde{\pi}_t)^2+\alpha_{iD}\left(D_t-\tilde{D}_t\right)^2\right)\right.$$
$$\left.+\frac{1}{2}\sum_{t=1}^{T}\left(\left(\frac{1}{1+\tau}\right)^{t-1}(\alpha_g(g_t-\tilde{g}_t)^2)\right)\right. \quad (10)$$

And

$$J_E = \frac{1}{2}\sum_{t=1}^{T}\left(\left(\frac{1}{1+\tau}\right)^{t-1}\left(\alpha_{Ey}(y_{Et}-\tilde{y}_{Et})^2+\alpha_{E\pi}(\pi_{Et}-\tilde{\pi}_{Et})^2\right)+\frac{1}{2}\sum_{t=1}^{T}\left(\left(\frac{1}{1+\tau}\right)^{t-1}(\alpha_{ER}\left(R_{Et}-\tilde{R}_{Et}\right)^2\right) \quad (11)$$

When every weight has a positive value $\alpha \in [0,1]$ and $= \theta * 1e-2$. A tilde denotes the desired (‘‘ideal’’) values of the respective variable. The combined objective function to find the collaborative Pareto-optimal solution is determined by the weighted sum of the two objective functions[3]:

$$J_{pareto} = \mu J + \mu_E J_E \text{ ,}(\ \mu, \mu_E \geq 0, \mu + \ \mu_E = 1 \quad (12)$$

Equations (1) to (12) form a dynamic game involving two players, both of them possess a single control variable.The model consists of 14 endogenous variables, as well as 7 exogenous variables. Additionally, the model assumes that it is played out within a time frame that is limited. In the trajectories of the control variable and state deviations from their respective desired values, the objective functions are quadratic. The dynamic game that is produced is nonlinear-quadratic, making it impossible to solve analytically and requiring numerical methods. For this purpose, it is necessary to define the model's parameters. In this case, an effort has been made to adjust the model parameters. Algeria's average economic indicators are the data used for calibration from 2000 to 2022, which is extracted from the Central Bank of Algeria, the International Financial Statistic (IMF), and the Algerian Ministry of Finance. For the remaining model parameters in Table 4, we use values based on econometric studies and plausibility considerations [Mahmoudinia et al., (2016); Merzlyakov (2012); Saulo et al., (2013), Tetik & Ceylan (2021)].

Table 4. Parameter values

variables	θ	η ،δ ،ε	γ،ρ ،β ،k ،λ	ξ	ω	χ	μ, μ_E
value	3	0.5	0. 25	0.1	1	0.0125	0.5

Table 5 provides the weights for the variables in the objective functions (as in Eqs (10) and (11)). The output and fiscal surplus/deficit weights x_{iy} , x_{iy} are equal to 1. It is expected that the country gives slightly less significance to inflation, which has a weight equal to 0.5. Due to the elevated levels of variable D, the country places significant emphasis (weight) on achieving fiscal stability debt targets, so α_{1D} is set to 0.01. The central bank places much greater importance on inflation than on the output goal (α_{ER}= 2 and α_{Ey}= 0. 5), which will stand for the central bank's stance, with its primary goal being price stability as mandated.

Table 5. Weights of the variables in the objective function

variables	x_{iy} , x_{iy}	$\alpha_{E\pi}$	$\alpha_{i\pi}$	α_{Ey}	α_{1D}	α_{ER}
value	1	2	0.5	0.5	0.01	3

Table 6 presents the starting values for the macroeconomic variables, which serve as the state variables in the dynamic game model. (we consider the average trend of variables in the Algerian economy).

Table 6. Initial values

variables	y	π	π^e	I	D	g	R_e
value	2.7	9.3	9.3	3.75	52.4	-0.115	3

Table 7 provides the desired values for the objective variables of players. The country's debt is currently at 52.4% of GDP and is planned to be reduced steadily to 40% at the end of the planning period. (A debt-to-GDP ratio of 60% is commonly considered a prudent threshold for developed countries, whereas developing and emerging

[3] The general loss function in the case of coordination should be the loss function for a single agent.

economies are advised to aim for a debt-to-GDP ratio of no more than 40% in the long run[4]). Regarding economic growth and inflation rates, we adopted those targeted within Algerian financial laws.

Table 7. Target value for state variables

variables	$\overline{y_t}$	$\overline{y_{Et}}$	$\overline{\pi_t}$	$\overline{\pi_{Et}}$	$\overline{D_t}$	$\overline{g_t}$	$\overline{Re_t}$
value	4.2	4.2	4	4	40	0.1	3

The model is effective in simulating the effects of various shocks depicted in the exogenous, uncontrolled variables' pathways, as well as the responses of policies to these shocks. It is assumed that the policy makers (the government and the monetary authority considered to be homogeneous) strive to minimize their loss function subject to the constraints which are given by the model, and interacting following a specific solution concept in the dynamic game. For this purpose, we consider a combined shock that affects both demand $zd_t$and supply sid zs_t: as shown in Table 8.

Table 8. Negative shock on demand and supply side

t	1	2	3	4	5	6	……..	30
zd_t	-2	-4	-2	0	0	0	…….	0
zs_t	0	0	0	2	2	2	…….	0

In the first three periods, the country experiences a negative demand shock affecting its economy in the same way. This shock will reflect a financial or economic crisis similar to the ‘‘Great Recession’’ of 2007–2010, which impacting all countries in the world. We assume a decrease in demand of 2% in the first period, 4% in the second period, and 2% in the third period. The country responds to the financial and economic crisis by boosting public expenditures, whether through discretionary measures or automatic stabilizers, and it will face the challenging issue of escalating public debt. Starting with third period country also experiences adverse supply side shocks, which lead to increase inflation rate. These shocks last three periods and the country experience an increase in inflation of 2%.

Every experiment we conduct involves calculations of four solutions for the dynamic game after executing several operations in line with MATLAB software: a baseline solution that does not include any policy intervention and describe as a simple simulation of the dynamic system, two noncooperative equilibrium solution (Nash feedback and open-loop Stackelberg[5]) and a cooperative (Pareto) solution.[6]

The following Figures 3-10 show the trajectories and the time paths for the two control variables (fiscal surplus g_{it} and the central bank’s prime rate R_{Et}) and the six most relevant endogenous variables (output y_{it}, the nominal interest rate I_{it}, the inflation rate p_{it}, the real interest rate r_{it}, public debt D_{it}, and the average interest rate for bonds BI_{it}).

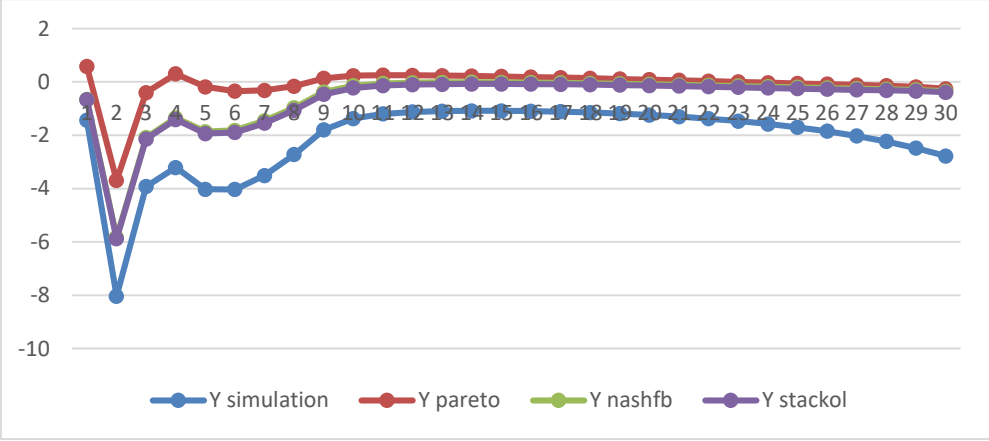

Figure 3. Country’s Output

[4] Tran (2018) finds that optimal debt thresholds ranging between 40% and 55% for a group of 14 emerging economies, Reinhart & Rogoff (2010) was proposed a range of 41% to 60% as a benchmark to ensure sustained growth.

[5] This model is compatible with Algeria's situation, which is characterized by non-Ricardian regime or fiscal dominance [Chibi et al., (2021); Ikram & Si Mohammed (2023)]. In open-loop Stackelberg equilibrium, the leader (government) commits to a predetermined plan of actions that does not depend on the current state of the game or the follower’s actions. The follower (central bank) then chooses an optimal response to the leader’s plan, taking into account the game dynamics and the leader’s information.

[6] For more details about techniques and functions you can see: Blueschke et al., (2013).

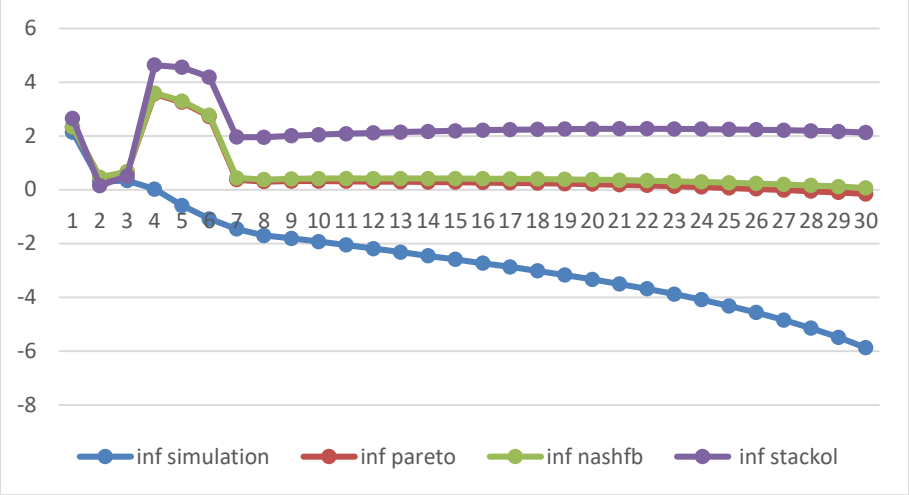

Figure 4. Country's Inflation Rate

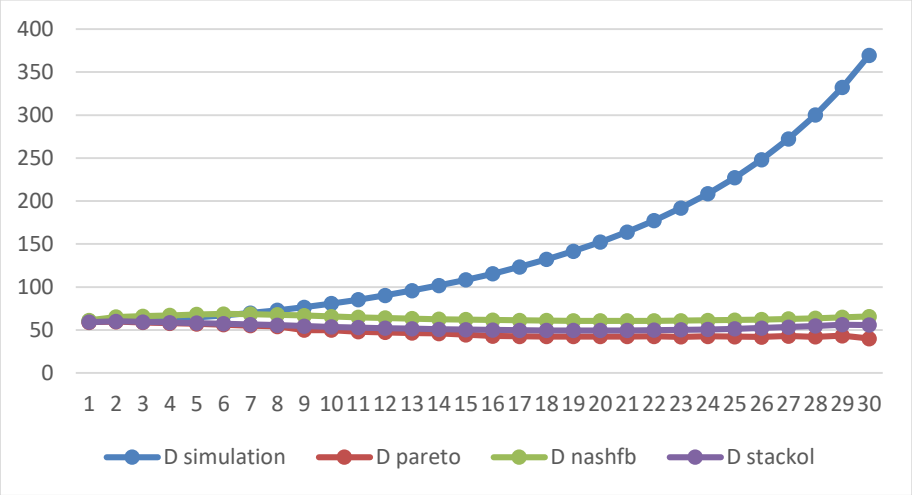

Figure 5. Country's Public Debt

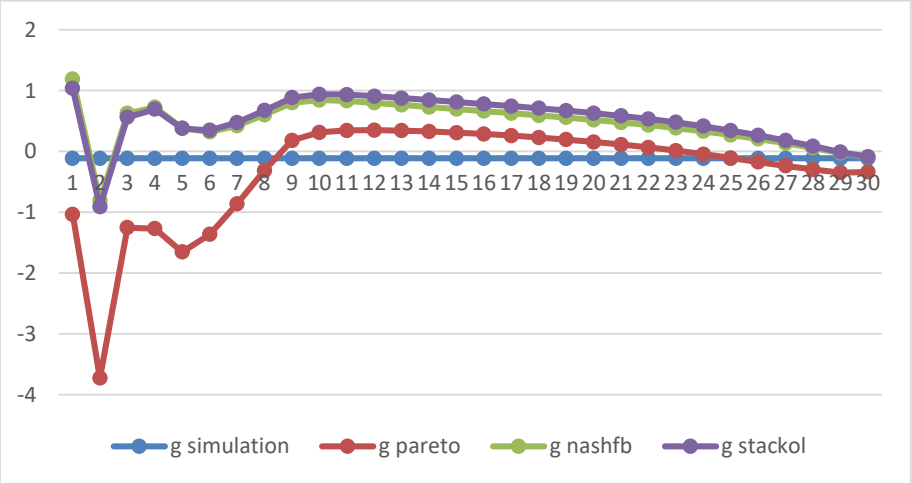

Figure 6. Country's Fiscal Surplus

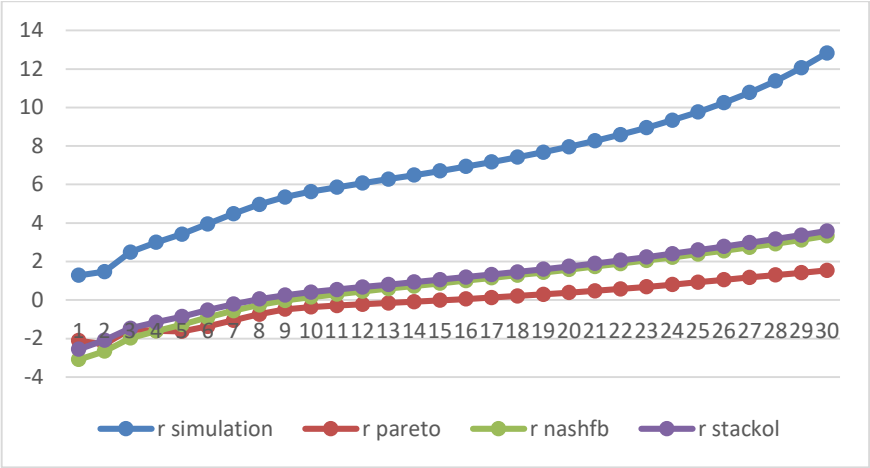

Figure 7. Country's Real Interest Rate

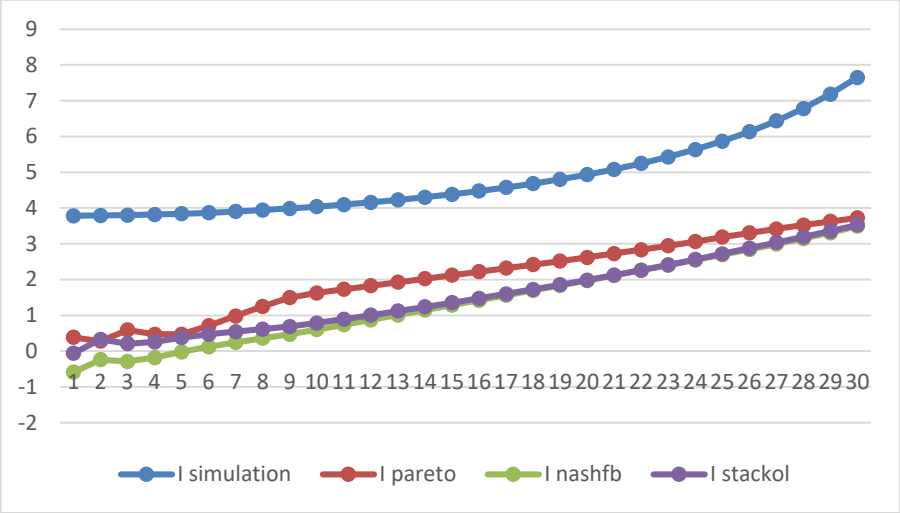

Figure 8. Country's Nominal Interest Rate

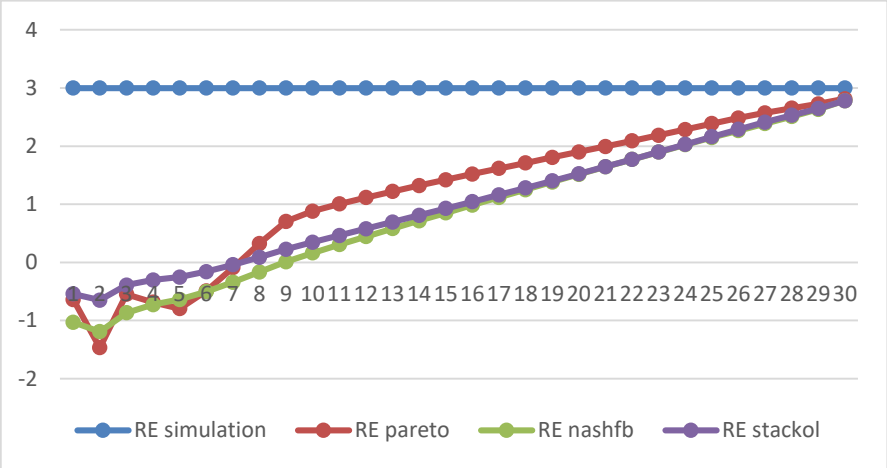

Figure 9. Country Central Bank's Prime Rate

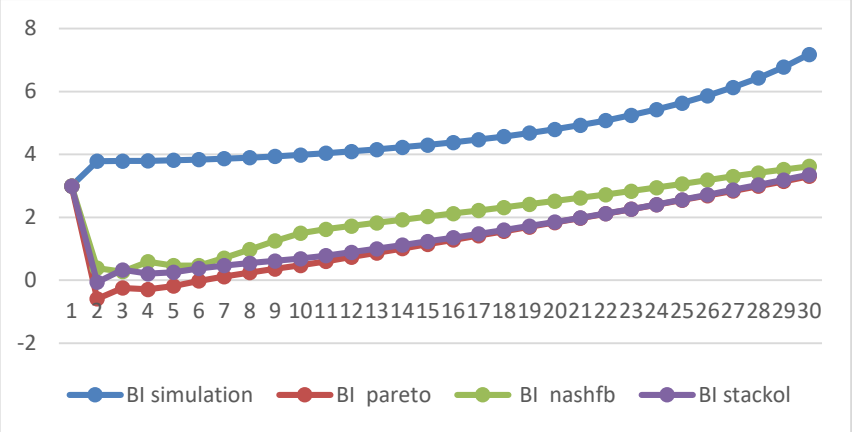

Figure 10: Country's Interest Rate for Bonds

In the absence of reactions from both fiscal and monetary authorities, (the baseline scenario denoted by simulation), the Algerian economy incurs the largest percentage of losses in terms of output decline, reaching 08%. Non-cooperative games within Nash and Stackelberg equilibrium offer solutions that are approximately 6% lower than this percentage. The optimal Pareto game equilibrium results in a decrease of only 4%, which suggests that the Algerian economy could perform better under the optimal Pareto scenario. This economic crise lowers inflation to value close to zero, but with the appearance of supply side shock inflation rate goes up especially in the Stackelberg government leader (the fiscal theory of price level), while this rate decreases in Nash and Pareto equilibrium. Even more striking is the development of public debt. Without policy intervention, it grows steadily throughout the whole planning horizon, reaching a level of 370% of GDP. That is shown a need for policy action (in all remaining scenarios) to stabilize the economy.

Overall, both monetary and fiscal policies respond to the negative demand shock in an expansionary and countercyclical way. In the Nash solution, the country incurs a fiscal deficit in the initial three periods and responds expansively in the first seven periods of the Pareto solution to mitigate the adverse effects of the demand shock. At the outset, the central bank implements an expansionary monetary policy by reducing its prime rate, gradually reverting back to the target value of 3 % by the end of the planning horizon. Such Keynesian policies assist in mitigating the impact of the adverse demand shock to a certain degree. Nevertheless, this policy has a cost in terms of its impact on the national debt and necessitates an austere fiscal policy post-crisis. Although the nation generates large budget surpluses, it also pursues a more restrained fiscal policy. Particular focus needs to be placed on the country's ability to maintain public debt at roughly a constant level of 50% of GDP under all scenarios. The solution concept has a major impact on the central bank's qualitative behavior. In the Nash equilibrium solution with non-cooperative feedback, the central bank exhibits almost no response. In the cooperative Pareto solution, after a crisis, the central bank raises the prime rate to first impose discipline on the government. Once the haircut shock has occurred, it then adopts an expansionary monetary policy to support the government. This approach can significantly reduce the negative impact of the haircut shock on output. The comparison between the Pareto solution and the feedback Nash and Stackelberg solution indicates that more active fiscal policy is needed during and immediately following a crisis with the Pareto solution, and less restrictive policies are required afterwards. Moreover, it requires a more proactive approach to monetary policy throughout the entire optimization timeframe.

The cooperative Pareto solution, overall, performs better than the feedback Nash and Stackelberg solution when it comes to its impact on output, inflation, and debt. This is evident when examining the minimum values of the loss functions calculated in Table 9 using equations (10) and (11).

Table 9. The Values Associated with the Objective Functions (loss functions, to be minimized) for Each Scenario

Strategy	JE	J	J+JE
Simulation	872,5331561	1518,251235	2390,78439
Pareto	254,83857	78,53194457	333,370515
Nash FB	474,1311267	57,03034548	531,161472
Stack OL	453,6347269	64,55909138	518,193818

5. CONCLUDING REMARKS

The fact that economic policy is not managed by a single policymaker, but rather involves more authorities making decisions on fiscal and monetary matters, raises questions about how they create a field for coordination of their actions to achieve common goals. Policymakers' work results in the outcome of the interaction between fiscal and monetary policies are determined by the rules of the game, which is the institutional regime in which they operate. In this context, we have used game theoretical methodology to examine the effectiveness of different coordination methods (Nash equilibrium, Stackelberg leadership, and cooperative solution) between Algerian fiscal and monetary policies in a traditional macroeconomic optimization issue. A numerical analysis shows that the lowest welfare loss happens under the cooperative Pareto equilibrium where the solution gives the best response to demand and supply-side shocks especially regarding output, inflation and public debt results. This result is consistent with the outcomes of Neck & Behrens (2003); Merzlyakov (2012); Woroniecka-Leciejewicz (2015); Blueschke et al., (2020)**.**

If the cooperative approach is seen as a financial arrangement that compromises all parties, it demonstrates the benefit of this institutional arrangement: it enables the country to depend on its efforts to decrease public debt. Therefore, the Algerian government could implement less strict fiscal policies due to the reduced prime rate set by the central bank of Algeria, which depends on the cooperation of the government. Specifically, coordination reduces the target-instruments problem by aligning fiscal deficits with monetary targets, ensuring smoother interest rate adjustments, and stabilizing inflation expectations.

Adequate institutional and operational arrangements are crucial for the effective coordination of monetary and fiscal policies in Algeria. Recent developments indicate a growing trend towards the division of monetary policy and public debt management at the institutional level, leading to increased independence for the agencies responsible for each. In such a context, central bank policies focus on maintaining price stability while public debt management agency aims to reduce the costs of financing fiscal deficits. Rule-based arrangements are also useful in enhancing transparency and in encouraging financial discipline, which are the key elements in providing an institutional framework that would bolster credibility and facilitate the success of stabilization policies.

Furthermore, formal channels and arrangements are needed for policy coordination, such as: independence of the central bank, limiting direct central bank credit to the government, balanced budget or deficit limitation clauses, currency board arrangements, the establishment of a separate debt management office, coordination committees, and the coordination at the day-to-day level (the management of the government cash balances, the level of central bank credit to the government, and the formulation of liquidity forecasts).

The findings from this study on Algeria provide a framework for understanding policy coordination in other developing economies with comparable institutional structures and economic conditions. Institutional and political barriers, including the central bank's independence and divergent fiscal priorities, often complicate policy coordination. The study's conclusions are contingent upon specific assumptions, such as linear policy responses and symmetric shocks. Future research could explore alternative models that incorporate nonlinear dynamics or asymmetrical shocks. It could investigate the implications of varying levels of commitment in fiscal and monetary policies, such as comparing rule-based versus discretionary frameworks.

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AUTHORS' CONTRIBUTIONS:

Conceptualization, writing-original draft, editing and data collection – **AC**, methodology and formal analysis – **YZ**, Final Approval and Accountability – **SMC**

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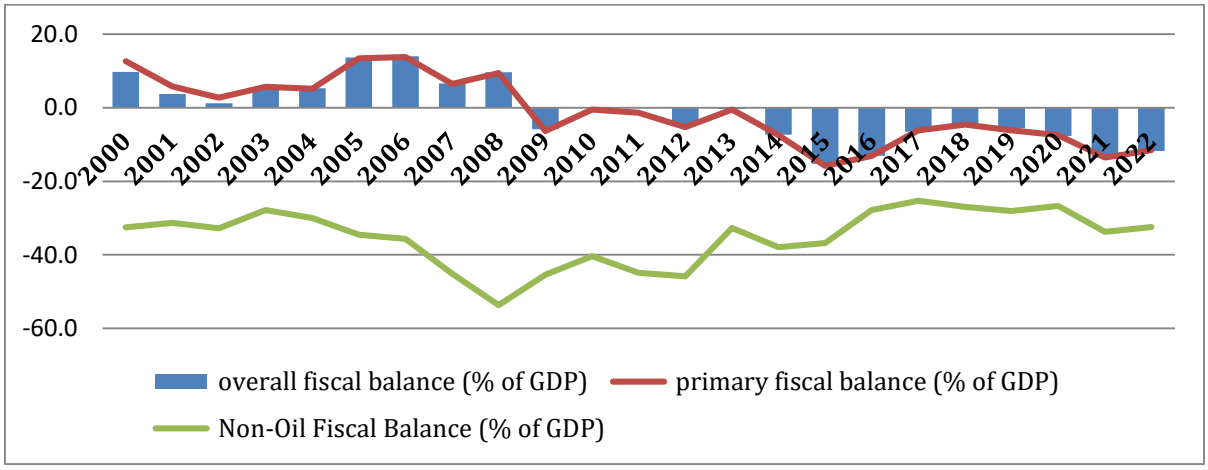
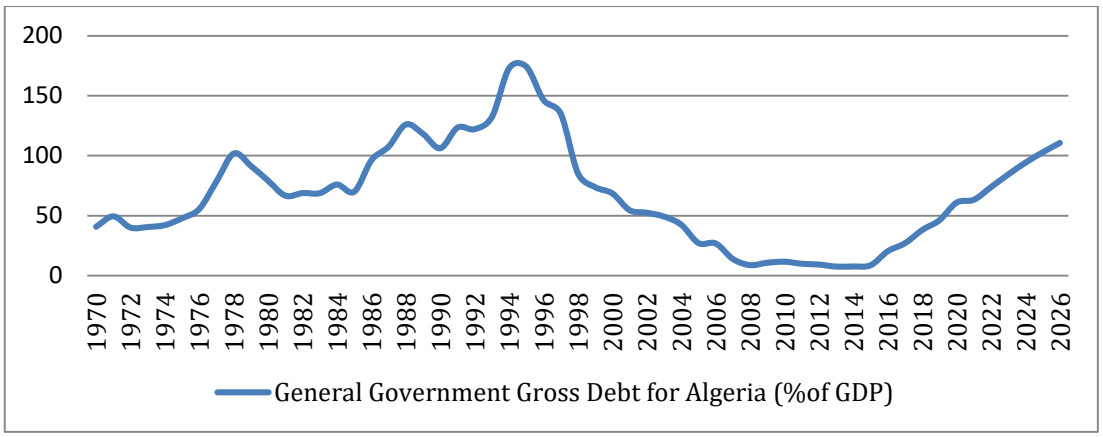
APPENDIX



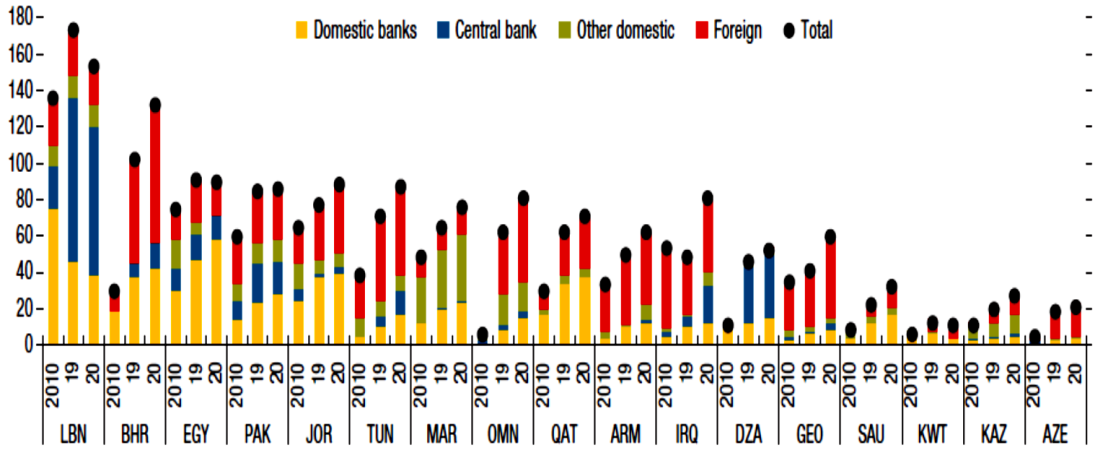
Appendix 1. Overall and primary fiscal balance for Algeria 2000-2022 (% of GDP)

Source: IMF: Regional Economic Outlook Database. April 2021 ,Fiscal Monitor Database. April 2021.



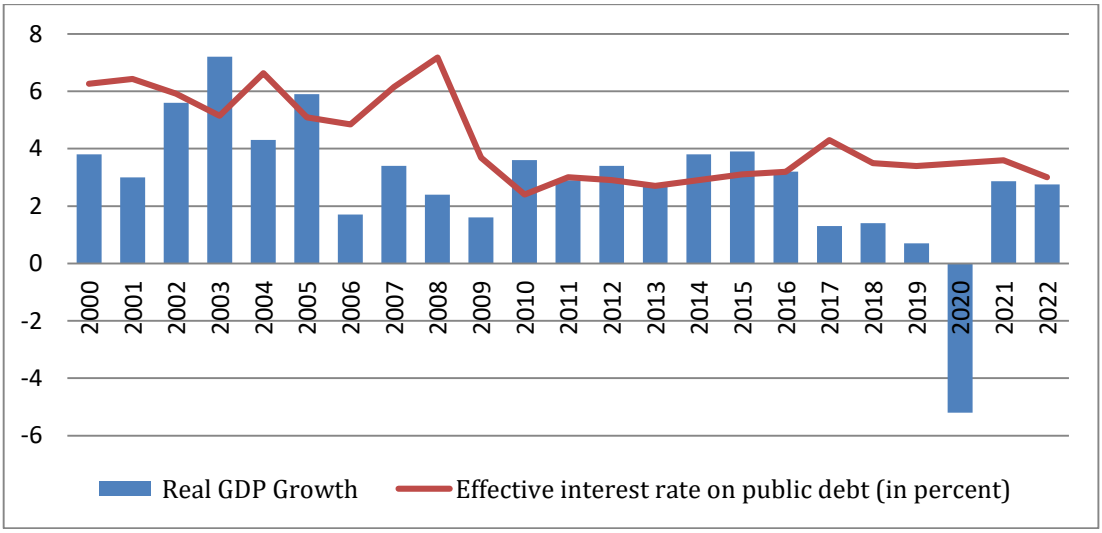
Appendix 2. General Government Gross Debt for Algeria 1970-2026 (% of GDP)

Source: IMF: Fiscal Monitor Database. April2021, World Bank: WDI.



Appendix 3. Government Debt Structure by Creditor (Percent of GDP)

Source: IMF: Regional Economic Outlook (MENA). April 2021. P: 17.



Appendix 4. Interest-rate-growth differentials for Algeria 2000-2022

Source: Authors' calculations, based on data from: Fiscal Monitor Database. April2021 and IMF Country Report No. 18/168.