SJIF Impact Factor (2024): 8.282 Journal DOI: 10.36713/epra0003 ISSN: 2250 – 2017
International Journal of Global Economic Light (JGEL)
Volume: 10 | Issue: 3 |March 2024

# THE RELATIONSHIP BETWEEN MONETARY AND FISCAL POLICY AUTHORITIES ON INFLATION STABILITY
## (STATISTIC GAME WITH INCOMPLETE INFORMATION)

**Dr. Phebe Padolo Moye Ph.D., MBA, B.Sc**
*Associate Professor, Cuttington University, Suakoko, Bong County, Republic of Liberia*

**Article DOI: https://doi.org/10.36713/epra16026**
**DOI No: 10.36713/epra16026**

**ABSTRACT**
*This paper attempts to study the collaboration between fiscal and monetary policy in a game-theoretic approach. The significant nature of coordination between these two policymakers is essential to the growth of any economic, holding to the facts that certain decisions taken by one institution may have devastating effects on the other institution, by resulting in loss of social welfare of the citizens of that nation. In this logic, this paper derived optimal monetary and fiscal policies in one context of coordination or form of interaction using the Two-stage game with complete and perfect information in normal-form representation of the prisoner's dilemma: when the two institutions minimize their losses by only taking into account their objectives or responsibilities they owed to the society, formulation of solution known as the Nash equilibrium solution; when an institution moves first in pursuance of the objectives in improving the social welfare and the other follows, in a mechanism known as the optimal solution; when institutions behave cooperatively, seeking common goals. Like in the case Brazilian economy, the two institutions simultaneously demonstrated coordination at the level were both the monetary and fiscal authorities choose the (4, 4) as the optimal point in stabilizing inflation and output remains at its maximum level, that a minimal loss is found when there is a Nash equilibrium, particularly when monetary policy is the leader of the economy and fiscal policy follows.*

**KEYWORDS:** *Fiscal and Monetary Policy, Game Theory, Nash Equilibrium, Stackelberg Equilibrium, Cooperation.*

## INTRODUCTION
It has been difficult it comprehends the interactions and penalties to determine what kind of policies both the monetary and fiscal authorities should take in proving the social welfare of the citizens of a particular economy. The mean reason for this is to outhouse some of these policies by analyzing the effect of the interaction between monetary and fiscal authorities on a different aspect of policy formulation and implementation in the art of stabilizing the inflation rate in the economy using the game approach. Introducing the analysis, a brief overview of the tools which are used by the two authorities throughout their works in providing a smooth environment where inflation will be attained at its optimal level and to enhance output maximization. Hence, the next topics introduce the reader to monetary policy, fiscal policy, and game theory. Posteriorly, specific objectives are presented.

### Monetary Policy
The interest rate which is used as a proxy variable of the monetary policy represents the element of economic policy focused mainly on the determination of the control of the lending rate of the economy and focused on the growth and stability of the economy.

The central bank is the institution which is incumbent to execute these objectives and setting up its basic instruments for implementation, the key tools are:
• Compulsory deposit requirements;
• Discount window;
• Open market operations.
The monetary authority used two policies in terms of regulating the money supply within an economy, namely, contractionary or expansionary policies; an economy with a high rate of money multiplier rate could introduce the contractionary policy to reduce the money supply thus leading to the reduction in the inflation rate. On the

other hand, an economy with a low rate of money multiplier rate could introduce the expansionary policy to increase the money supply (Walsh, C. E. 2003).

The monetary authority which havens to be central bank may, for example, lend (long-term) money charging high discount rates, to discourage commercial banks to narrow the mindset of borrowing money which further may reduce the money supply and consequently the inflation rate. Otherwise, the central bank may lend (short-term) money charging a low-interest rate, resulting in a reduction in the inflation rate.

In pursuing stability in the price level in line with economic growth the monetary authority has many available tools of the monetary regime; the key among these tools that has gained much more attention is the inflation-targeting monetary regime.

Inflation targeting is a monetary policy that has been adopted by many countries that yielded positive outcome, notable among these nations is Brazil; major goal is to keep inflation at measurable band, where the interest rate responds to an inflation target and stabilizing the real economy, represented by the output gap and changes in both inflation and output. Providing an analysis of how to overcome the confidence crisis faced by Brazil, the inflation targeting policy implemented in Brazil's economy Bogdanski et al. (2000) Minella et al. (2002) and Minella et al. (2004).

They formulated a framework to estimate a response function for the Central Bank, concluding a forward-looking stance in the period analyzed, and confidence in responses for variation in inflation and output, corroborating the importance of the estimations. Although there has been highlighted that the central banks are not good predictors of the output gap in real-time.

**Fiscal Policy**

The fiscal policy is a process through which the fiscal authority of the government directs her spending and revenue collection to influence the economy positively. The fiscal policy involves the full definition and application burden upon the actors of the economy, along with government expenditure, which driven by the collection of taxes and issuing of bonds.

Considerable due to importance and impact on other financial variables such as the monetary policy and fiscal policy tries to keep the economy in a straight line with the monetary structures i.e. control over the interest rate and the supply of money, the three foremost tools of the fiscal policy are government spending, taxation, and debt issuance. A fiscal deficit is often funded by issuing treasury bills, which are bonds issued by a government [Lopreato (2006), Toye (2006), Tanzi & Schuknecht (2003), Perotti (1999), Kneller et al (1999)].

Furthermore, the expansionary stance of fiscal policy comprises an unbalanced budget where net government expenditure is higher than the tax revenue (G > T).

This situation could be due to increases in government expenditure, on the other hand, a fall in tax revenue (e.g. a cut in income tax), or both. A contractionary fiscal policy (G < T) occurs when government net expenditure is reduced through either higher taxation revenue or reduced government spending, or both. Fiscal policy can assume three postures, videlicet neutral, contractionary and expansionary. A neutral stance of fiscal policy suggests a balanced budget which means the spending of government expenditure is equal to the tax revenue (G = T).

The government usually used the fiscal policy to influence the level of aggregate demand in the economy, in the art of controlling or maintaining price stability to achieve economic objectives of full employment and growth in the macroeconomic performance like for instance duty free of rice importation will certainly help in reducing the price of most stable food in the county.

Monetary and fiscal objectives converge but frequently there are incongruences, for example, the implementation of fiscal incentives can have inflationary effects driven by increased demand. Thus, coordination between these two policies is essential to keep price stability and economic growth (Tanzi, V. & Schuknecht, V. 2003).

**Review of The Concept of Game theory on the Inflation rate**

The game theory is a mathematical instrument generated to further improve the understanding or to the interpretation of how strategic interactions among rational players produce outcomes concerning the utilities (or preferences) of those players, none of each of them rationale might have been intended by any of them.

The history of game theory is related to the first known discussion which occurred in a letter wrote by James Waldegrave to Nicolas Bernoulli. Waldegrave analyzes the card game 'le Her' and provides a minimax mixed

strategy solution. According to Cournot's work (see Cournot (1938)) it deliberated that a duopoly market and presents a solution that is a restricted version of the Nash equilibrium. The benchmark came through with the mathematician John von Neumann who published a series of papers in 1928.

However, only in 1944 John von Neumann and Oskar Morgenstern wrote a book called "The Theory of Games and Economic Behavior" (see von Neumann & Morgenstern (1944)), game theory attacked the economics and the applied mathematics, since others experts also decided to donate for the theory development, which mathematics give the bases for an economic theory as a first objective to determine. The idea of creating reliable mutually based solutions for the two-person zero-sum game was formulated by mathematician John Forbes Nash Junior In 1950, which was published in four major articles in the game theory field. In "Equilibrium Points in n-Person Games" (Nash Jr. (1950b)) and "Non-cooperative Games" (Nash Jr. (1951)), Nash proposed equilibrium in mixed strategies for non-cooperative games and further recommended an approach for cooperative games based on non-cooperative players.

**Stability in the Inflation Rate**

Economists as well as advised policy-makers have long considered that aggregate demand discipline as a necessary condition for sustained price stability. Of most recent countries like Argentina, Israel and Brazil decided to reacted to inflation by focusing on the supply side of inflation, in an art to stabilize prices by both policies income and monetary reforms, if the mixture of these policies with yield positive outcome or not with depends on the management of a number of factors, such as adequate aggregate demand in the economy. Yet it may not be sufficient to successfully stop big inflation, as demonstrated by the failure of several IM.

It should be well understood that the central role of incomes policies is not to pressure decision making individual but to clear externalities in a agree with imperfect information, telling each actor how the others will play. Incidentally, this dismisses a traditional argument against income policies which states that the private markets are more equipped than governments to identify individual Nash strategies.

The mean idea behind the central problem is not to discover such strategies but to coordinate their simultaneous playing. This also implies that wage-price controls should be removed gradually in a second stage of the stabilization program, at successive sectorial steps, and this cannot be done in a one-shot manner. No matter, how successful enough income policies are to bring the economy to Nash equilibrium, there is no reason to convey such information to the participating players of the game. Each player finds himself in or at equilibrium but does not have the available information if the same applies to other players of the game. Players will get to realize that no participant in the game will increase prices even when even they are allowed to do so, in the case were controls are lifted sector by sector. In order words, the one-shot approach would simply bring back the uncertainty of assurance of individual players as to what other players will do, perhaps triggering large defensive wage-price increases.

**Static Game with Incomplete Information**

The games which will be described in this paper treat with two players, namely monetary represented by the central bank and the fiscal authority implies to the treasury ministry of finance were each player has its instrument with their separate functions fiscal authority has absolute control over the government expenditure and the monetary authority provides regulator over the banking sector as it relates to interest rate.

The interaction between those two authorities in the economy, as previously highlighted, happens in three different manners:

(1) The first approach is that when monetary and fiscal policymakers set their policy tools simultaneously in a Non-cooperatively manner using a Nash game; this regime suits the case of a game in standard form;
(2) The second set on a condition when the fiscal or monetary authority moves first, as a Stackelberg leader, anticipating the response from the fiscal/monetary authority; this means a category of game is in the extensive form and it is the appropriate manner to represent that coordination;
(3) The third and final stage is noted when monetary and fiscal policymakers set their policy instruments instantaneously but in a more cooperative manner with each other in pursuit of a common objective, one can interpret this set of policy intervention as a situation where players coordinate their actions to maximize social welfare in the stabilization of inflation in the economy.

According to Osborne & Rubinstein (1994) will do a descriptive presentation of the three models such as normal or standard, extensive and bargain problem.

Moreover, we will incorporate the tools in regards to the equilibria considering each of the coordination namely: Nash, Stackelberg leadership, cooperation.

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**Normal form**

Under the normal or standard form is the easier manner for the representation of the game. To represent the game in normal form, we need to identify three key things; the first one is to know the set of players, secondly the strategies set by each player, and finally, player's preferences over the set of outcomes (or consequences) that are induced by the game strategy profiles.

Formally, we define a game in normal form to be a triple $\Psi = (N, (C_i)_{i\epsilon\, N}, (\upsilon_i)_{i\epsilon\, N})$

Given that:

- N is define as the set of players;
- $C_i$is represent the available strategies to each player $i$
- $\upsilon_i$ denotes the function of assigns to each strategy profile assigned to the game $c \epsilon\, X_{i\epsilon\, N} C_i$ indicating the real number $\upsilon_i(c)$ representing the payoff of player $i$, if and only if c was consider as the combination of strategies implemented by the participating players in the game.

A normal form game shown by $\Psi$ is thought to be in a finite if the set of players $N$ and their sets of strategies $C_i$ are in a finite position. It is significant to identified that differently from extensive games, where the time factor is present, in analyzing the games in normal form time is there is an exclusion of the time factor, since the condition set is that players choose their strategies simultaneously and once and for all, this means, each player chooses a strategy without knowing the strategies chosen by other players.

**Strategies**

- Definition 2.5.1. In a pure strategy is any $c_i \in C_i$ of player $i$, in a normal game $\Psi = (N, (C_i)_{i\epsilon\, N}, (\upsilon_i)_{i\epsilon\, N})$.

Given that the strategy profile of the game is an element of $X_{i\epsilon\, N} C_i$.

**Nash Equilibrium**

A strategy profile is Nash equilibrium if even knowing other players' strategies; an individual player does not have motivation to change his strategy because it is the best choice compare to other players' strategies.

Definition: A profile of pure strategies $C^*$ is a Nash equilibrium of $\Psi = (N, (C_i)_{i\epsilon\, N}, (\upsilon_i)_{i\epsilon\, N})$ only when $\upsilon_i(C^*_{-i}, C^*_i) \geq \upsilon_i(C^*_{-i}, C^*_i), \forall_i \in N$

Application: A Nash game between fiscal and monetary policy-makers

Consider the following equalities:

$$\upsilon_M(\vec{\imath}^*, \vec{g}^*) \geq \upsilon_M(\vec{\imath}, \vec{g}^*),$$

And

$$\upsilon_F(\vec{\imath}^*, \vec{g}^*) \geq \upsilon_F(\vec{\imath}^*, \vec{g}),$$
$$\forall_i \in C_M \; and \; \forall_{\vec{g}} \in C_F$$

**Nash Extensive form**

The extensive form of a game is appropriate when we want to consider the order a game runs. The structure of the game suits well to certain situations where there is a sequential decision is made. Just imagine two players: player 1 moves first and chooses an action A, then player 2 sees player 1's move and then chooses an action B.

In this section we provide a formal description of an extensive game with perfect information (hereafter extensive game).

Firstly, focus on games in which all important moves are made by the players, i.e. randomness does not intervene.

Given that vector of extensive game: $\tau = (N, H, P, \{\upsilon_i, i \in N\})$,

Where:

- $N$ is a set of players;
- $H$ H is a set made by sequences (finite or infinite) of actions.
- H is a set made by sequences (finite or infinite) of actions. The set H is closed with respect to prefixes21, namely $h \in H$ and $h'$ is given as a prefix of $h$, formerly $h \in H$. Each member of $H$ is a past record and each node is considered by a particular history (sequence of necessary actions to achieve the node). A history is called terminal if it is not a strict prefix to any other history at $H$.

**Nash Equilibrium**

We say that a strategy profile is a Nash equilibrium if and no player has incentive to change his strategy, in doing so the player will not increase his payoff. Formally, it is possible to define the Nash equilibrium under strategies preserved as choices that are made once and for all before play begins. $\tau = (N, H, P, \{\upsilon_i, i \in N\})$, consider as Nash equilibrium conditional on every player $i$ we have this outcome:

$$\upsilon(S^*_{-i}\, C^*_i) \geq \upsilon(S^*_{-i}, S_i)$$

Which means for every pure strategy $S_i$

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**Application: Stackelberg leadership: The case of fiscal leadership**

Assume that the first moves were made by fiscal authority as a Stackelberg leader, expecting the response from the monetary authority. The fiscal authority taking in account if the follower's optimal policy, the fiscal authority policy best response depends on the best response of the monetary authority, that is, $\vec{g}^* = \vec{g}^*(\vec{\imath}^*)$, although the follower's optimal policy is the Nash solution.

The utilities function of each authority participating can once more is interpreted by the following equations:

$$v_M(\vec{\imath}, \vec{g}) \geq -L^M$$

$$v_F(\vec{\imath}, \vec{g}) \geq -L^F$$

Nevertheless, note that for each $k \in \{1, 2 \dots n\}$, $\vec{\imath}^*$ that is:

$$v^M(\vec{\imath}^*_k, \vec{g}_k) \geq v^M(\vec{\imath}_j, \vec{g}_j)$$

$\forall_j \in \{1,2 \dots . L\}$ Instead $\vec{g}^*$ is equal to $\vec{g}_k$, which implies that:

$$v^F(\vec{\imath}^*_k, \vec{g}_k) \geq v^F(\vec{\imath}_j, \vec{g}_j)$$

$\forall_j \in \{1,2 \dots . L\}$.

**Cooperative games Social welfare criterion**

The social welfare criterion expresses a role of the social welfare which depends upon the loss both of the monetary and fiscal authorities. As stated earlier, this paper makes use of that criterion to analyze the cooperative solution of those economic actors. The cooperation occurs indirectly when both authorities consider a positive weight on their instrument variables in the direction of stabilizing the economy. The mechanism gives the authorizations of a direct adjustment to ongoing actions taken by the other authority. Fundamentally, the problem is to maximize a social welfare (utility) or, otherwise, to minimize the social loss function $L^s$, which is defined by this equation $L^s = L^M + L^F$ which is, the sum of the authorities' losses

Application: Cooperation between policy-makers

Consider now the following definitions:

$$v_M = -L^M$$
$$v_F = -L^M$$

Where $u_j$ is the utility of authority $j$. $L_j$represents the loss function related of authority $j$.

This means that a solution of cooperative between monetary and fiscal authorities takes place if there exists only single solution $\varphi(\cdot, \cdot)$ which satisfies the axioms PAR, SYM, and IIA, that is, that solutions satisfies the two-authorities bargaining problem $(F, v)$,

$$\varphi(F, v) \in argmax_{x \in F, x \geq v}(x_1 - v_1)(x_2 - v_2)$$

Where, $x_1 = v_M$, $x_2 = v_F$ and $v_1$and $v_2$ are consider monetary utility and fiscal utility, respectively using the Nash equilibrium.

Despite the bargain solution, we can interpret the cooperation in terms of social welfare.

Thus, the objective is to minimize the social loss function, i.e. $L^s = L^M + L^F$

Therefore, it makes no sense to have only two player's monetary and fiscal authorities of the economy to be medium in solving the problems of an entire economy. The purpose of this paper is not meant to solve already existing formulated problems but it is to formulate a strategy in providing a solution to an already that existing in a developing economy. The players play a game by taking actions which are called strategy which is considered as a rule that determines the player's actions at any stage of the game. The players play a game by taking *actions* that consider as a rational decision in being the economy to zero-based inflation and increase in output, whereas, injection of strategy can be referred to as a rule which determines player's actions at any stage of the game.

Games are represented graphically by using several typical ways, namely the normal-form game which implies the game that is represented in a matrix form. Of course, there are many kinds of games in terms of information provided to the players during the game as mention above; this term paper is concentrated on the normal-form game with complete information.

A game with complete information is defined as every player knows the sets of strategy and payoff functions in the game. Because of the nature of game theory players are usually assumed to act rationally where their actions will be driven in the direction of finding a solution to the already set goals of playing a game. The main goal set is to find some equilibrium solutions to reducing the inflation rate to a zero-based inflation rate in the economy with a high rate of output, having two rational and independent players (monetary and the fiscal authorities) of the economy, these equilibria should be the results of the game.

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Considering the most mutual equilibrium of both players is called the Nash equilibrium and it is named after a famous game theorist John Nash Jr (). The Nash equilibrium is formed when players are not willing to deviate from their equilibrium playing strategies. A game is called a static game if and only if all actions are taken simultaneously by the players in the game and on the other hand a game is called a dynamic, if and if there are stages in which one or more players take their actions.

The concept used in this study is a *two-stage game*; this means that there are opportunities provided for chose in two stages in which players choose their actions/strategies simultaneously. In some games, players might have the opportunity to observe among the stages what other players have chosen in earlier stages or strategy applied by earlier players. Considering the earlier stages outcomes are allowed or not have a huge impact on the solution of the game if this approach is allowed it is said the game has perfect information.

Definition: perfect information. The game has perfect information if at each time player makes a decision between actions in the game he knows the full past information of the game accordingly.

The investigation is based only on the perfect information; therefore I make essential use of a two-stage game in predicting measures by both where the case of sub-game simply implies that the game left to play given actions in the first stage.

The Game: We have a two-stage complete and perfect information game with two players (monetary and fiscal authorities) using their policy tools individually and cooperatively to target a zero-based inflation of the Liberian economy. On the first stage players simultaneously choose between high inflation (H) and Low inflation (L). In the second stage, they are informed about the outcome of the first stage and they again choose actions simultaneously. Player (monetary authority) chooses between High inflation (H) and Low inflation (L) and the player chooses between High inflation (H) and Low inflation (L). The outcome of the first stage determines the payoffs of each outcome in the second stage. In the figure, the Nash equilibria of subgames are circulated. Thus, if the first stage is played such that a particular subgame is reached, the payoff will be the one circulated in the subgame. The game is represented in Figure (1) below:

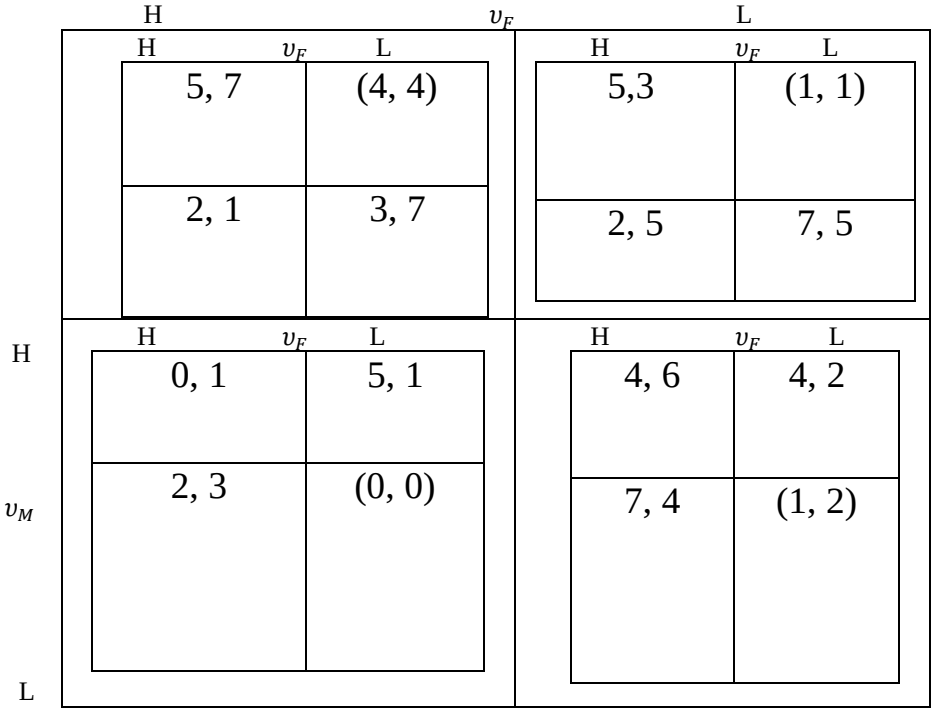


**Figure 1: Two-stage game with complete and perfect information in normal-form representation.**

In Figure (1) above we can now replace each sub-game by its outcome. Now we have a one stage game which we can solve as such. So we conclude that this is Nash equilibrium outcome of the two-stage game. The previous figure was solved using the two-stage game method called *backwards induction*. This means that in *N*-stage game with every possible profile of actions in the 10 stages we solve the equilibrium in the last stage as a subgame. When we have equilibria solved for each of these subgames we can simply replace the subgames by their outcomes in (*N*-1)th stage. By repeating the procedure by working backwards the game finally reduces to a one-stage game.

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The unique Nash equilibrium is again circulated in the below figure 2.

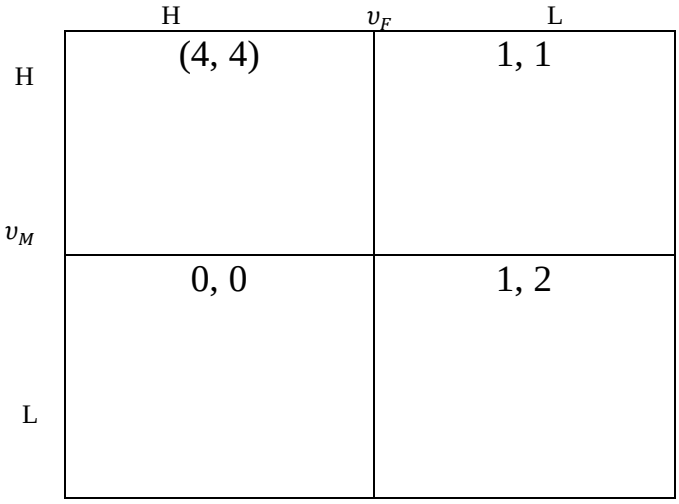


**Figure 2: Normal-form representation of prisoner's dilemma.**

In this game the two players (both the monetary and fiscal authorities) of the economy have optimal interest in a parameter $C$ which denotes the growth rate of the economy, the $b$ parameter represents the inflation rate a proxy variable of the monetary authority and parameter $d$ simplifies fiscal authority. Therefore, we need to identify the conditions set of the three parameters of the economy, beginning with parameter $b < 1$ (monetary authority) means that, there is the presence of monopolistic power in the economy which indicate that the monetary authority wants to unilaterally use it policy instruments in order to stabilize the inflation rate, on the other hand, parameter $d > 0$ shows the measure of the effect on surprise inflation on output through the fiscal authority instruments. The fiscal policy involves the full definition and application burden upon the actors of the economy, along with government expenditure, which is driven by the collection of taxes and issuing of bonds. The final parameter $C > 0$ states that it reflects both the monetary authority and fiscal authority trade-off between its two goals. Meaning at the point where both fiscal and monetary authorities cooperate in the measures for inflation to be reduced at zero and output (y) to be at its efficient level, implies that employment, the smooth implementations of expenditure, collection revenue and the control of interest rate are at its efficient level. Finally, given the conditions set by parameters $C$ and this paper can reliably say that the coordination of the two players is found in the third parameter, therefore the Nash equilibrium can be found (1, 1) in order to have a stable economy and the full cooperation of both authorities in the economy.

## CONCLUSIONS

This work has embedded game-theoretical approach coordination schemes (Nash solution, cooperative solution) into an optimization problem to deliver some numerical assessment of the losses of each authority of coordination. The analysis focused on the loss associated with each regime. In particular, according to the results, the monetary leadership led to the lowest economic losses. The weighted analysis showed that Nash and cooperative solutions respond more uniformly to the weights placed on their target variables (inflation).

These two policymakers are essential to the growth of any economy, holding to the facts that certain decisions taken by one institution may have devastating effects on the other institution, by resulting in loss of social welfare of the citizens of that nation. In this logic, this paper derived optimal monetary and fiscal policies in one context of coordination or form of interaction using the Two-stage game with complete and perfect information in normal-form representation of the prisoner's dilemma: when the two institutions minimize their losses by only taking into account their objectives or responsibilities they owed to the society, formulation of solution known as the Nash equilibrium solution; when an institution moves first in pursuance of the objectives in improving the social welfare and the other follows, in a mechanism known as the optimal solution; when institutions behave cooperatively in seeking common goals.

The results presented are of paramount importance, considering the relative difficulty to apply fit in models of game theory in macro-econometrics models. The concept developed in this work will help to improve the analysis done by experts in both macroeconomics and game theory to do optimal choices mainly concerning social welfare of an economy like Liberia that is, in global terms; the results will help the economist in setting up an empirical model in addressing the problem of inflation stability in seeking the increase of society's social welfare.

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## ABOUT THE AUTHOR

**Dr. Phebe Padolo Moye (Ph.D., MBA, BSc.)**

*Associate Professor, Cuttington University, Suakoko, Bong County, Republic of Liberia*