

Evaluation of Strategic Dynamics of Inflation Control: A Game-Theoretic Exploration

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Abstract: The issue of why Japan had always experienced deflation since approximately 20 years ago has made the whole society depressed and, actually or potentially, it is worthwhile employing game theory as a critical analytical tool to examine the strategic interactions among key economic agents. Despite numerous interventions, such as inappropriate fiscal stimulus and aggressive monetary easing, Japan's economy is continuously under deflationary pressures. This persistent economic dilemma is probably driven by structural impediments, including demographic ageing and the lack of effective coordination between fiscal and monetary policies which are of more significance than conventional policies. Therefore, the analysis is surrounded by several theoretical models, such as the Kydland-Prescott Model of Time Inconsistency, the Barro-Gordon Model of Inflationary Bias, and the Stackelberg Leadership Model, which collectively elucidates the challenges of maintaining inflation stability and the inherent limitations of existing policies. The findings reveal that strategic coordination between the government, central bank, businesses, and households has led to suboptimal policy outcomes which may reinforce a deflationary spiral. By achieving a bright economic prospect, Japan could enhance its financial resilience break the virtuous circle from the past and aim at sustainable growth and social stability in the future.

Keywords: Structural challenges, game theory models, suboptimal economic outcomes, policy coordination.

1. Introduction

Inflation has been considered one of the most critical and persistent challenges, and it is hardly possible for economists or authorities to sort it out perfectly in the realm of macroeconomic analysis, especially in recent years. The experiences of COVID-19 and the economic crisis have led to an apparent decrease trend [1]. Inflation is commonly defined as a sustained increase in the general price level of goods and services in an economy over time. It has significant effects on decision-making, from individual consumption to the broader economy. Maintaining stable and consistent inflation is a fundamental objective for the economy, contributing to economic growth and a low unemployment rate [2]. Despite its significance, complicated mechanisms and measures taken to proposed by the government are difficult to control, involving multiple collaborations and controversial trade-offs. Consequently, strategic interactions such as monetary and fiscal policy are vital to utilize sophisticated analytical thinking [3]. A situation where rising wages lead to higher production costs, which in turn lead to higher prices, prompting further wage demands, creating an increase in inflation

called the “inflationary spiral” is one of the most disastrous consequences of inflation, as once it is out of control, inflation is possible to sore dramatically and continuously, causing the price level the identical as in Zimbabwe. Thereafter, a couple of vital models can explain those circumstances mentioned above such as the Kydland-Prescott Model of Time Inconsistency, the Barro-Gordon Model of Inflationary Bias, the Sargent-Wallace Model of Rational Expectations and Policy Ineffectiveness, Stackelberg Leadership Model in Fiscal and Monetary Policy and those concepts are highly associated with the strategic games [4].

Game theory, a mathematical calculation for analyzing situations in which the outcomes for each participant, to a certain extent, depend on the actions involved, has become an increasingly essential tool to coordinate interactions [5]. Within economics, game theory is particularly relevant for studying scenarios where the actions of economic agents-such as governments, central banks, firms, and consumers-are interdependent, meaning that the optimal strategy for any one agent depends on the anticipated strategies of others [6]. A considerable number of indispensable concepts are necessary to the dynamic analysis as well, such as the Nash Equilibrium of uncertain policymaking in repeated games and the discovery of both optimal and suboptimal games with Bayesian games and so forth [7]. In addition, the application of game theory to the study of inflation is both insightful and necessary, as it allows for a deeper exploration of how expectations, credibility, and strategic behaviour affect unintended outcomes. For instance, the concept of “time inconsistency”, a situation where the domestic authorities are motivated to deviate from previously announced policies to pursue short-term gains at the expense of long-term stability, leading to an “inflation bias”. Additionally, public de-anchoring is likely to stand out and emerge [8, 9]. Similarly, game theory serves a helpful function in the strategic interactions between central banks and other economic agents in future expectations, in which the credibility of monetary policy plays a crucial role in achieving stable and constant inflation. By analyzing the strategic interactions among economic agents through game theory, a deeper understanding of how inflationary pressures emerge and how they can be effectively managed within a complex and interconnected financial system is also a perspective to perceive [10].

This essay will explore the intricate relationship and association between game theory and inflation by examining fundamental models that have been developed to understand dynamic inflation. Specifically, Japan has evaluated and considered the implications of these models for contemporary policy, particularly under a globalized economic circumstance.

2. Methodology

2.1. Database and Models Taken

A variety of crucial elements will be taken into account in this essay, namely gross domestic product, interest rate and inflation rate in the USA and Japan. For America, the Federal Reserve Website, and Economic Data Platforms are the sources and the Bank of Japan (BOJ) Website and Central Bank Watch Websites are for Japan. These sources provide historical data and ensure the accuracy and reliability of the information used. In terms of the models, the Nash Equilibrium, the Kydland-Prescott Model of Time Inconsistency, the Barro-Gordon Model of Inflationary Bias and the Sargent-Wallace Model of Rational Expectations and Policy Ineffectiveness will also be utilized.

2.2. Selection of Data

All breakdowns of data such as interest rate, inflation rate and gross domestic product have been chosen since about 40 years ago, from 1970 to 2022. Each group of data includes the corresponding rate, year and annual rate variation and due to the amount of data, annual data are used instead of daily or monthly data (annual data is more apparent to be contained by built-in functions in Excel). Specific data points will include the GDP growth rate, inflation rate (CPI), and interest rate (including

the period of negative interest rates). The line and bar charts with different kinds of functions are under consideration. In addition to figures and statistics, those models do not provide any data, but with wordy evidence which is enough to show the huge gap between Japan and the USA in all kinds of prospects (Table 1).

Table 1: GDP, CPI, IR, ER in Japan and the USA

Year	Country	GDP (Trillion USD)	Inflation Rate	Exchange Rate (USD/JPY)	Interest Rate
1980	Japan	1.1	7.8%	240	6.0%
1980	USA	2.8	13.5%	1	11.5%
2000	Japan	4.2	2.4%	115.1	0.5%
2000	USA	10	3.4%	1	6.5%
2023	Japan	4.5	3.2%	120	0.1%
2023	USA	26	6.5%	1	5.25%

2.3. Method Introduction

As these foundational sorts of data mentioned before, they certainly correspondingly acted to each other, meaning they all have particular bonds and relationships. The interest rate is highly related to the inflation rate which means that even a slight or marginal variation occurred in interest rate, for instance, can result in a special reaction. The gross domestic product is likely to be affected negatively or positively by interest and inflation rates. This analysis is possibly to help identify patterns and correlations, highlighting differences and similarities across the three countries. Specifically, the correlation is to identify the strength and direction of relationships between interest rates, inflation, and gross domestic product growth.

Additionally, according to the models in game theory and policy-making by civil administrations, the decision of policies made by the government could influence the corresponding economic activity and for example, terrible policy may lead to a disastrous reaction as well. Consequently, it is probably the best choice if the combination of the interest rate inflation rate and the effects in the realm of politics and economics at that specific period can be shown in Excel with alpha and beta. Hence, the essay will include comparative case studies of significant monetary policy decisions, such as Japan's introduction of negative interest rates lower GDP growth, massive debt and low expectations for the future. These case studies will provide a deeper understanding of how game theory can explain the strategic interactions between central banks, governments, and market participants. Based on the analysis, policy recommendations for central banks and governments on how to effectively manage inflation in the context of strategic interactions are quite significant, considering both the successes and limitations observed in Japan.

3. Results and Discussion

3.1. Japan's "Lost Decades"

After getting an agreement in the Plaza Accord, both the Yen and Japanese economies experienced a significant increase. The CPI in the housing industry had soared for the following 2 decades and formed a market bubble. Thereafter, the bubble in housing markets caused the economic recession with low purchasing power and a downward desire for citizens. Deflation has been a serious economic issue since 1990 even until now. During this period, the game theory between monetary and fiscal policy has emerged (Figure 1).

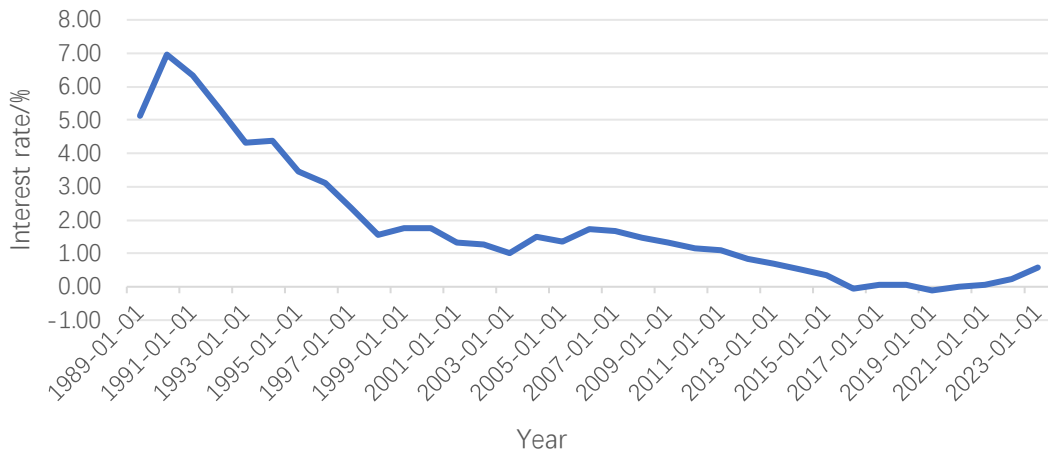


Figure 1: annual Japan interest rate

3.2. Japan's Data Analysis

If the economy will grow due to the lower interest rate and higher government spending, but the deflation still exists. Not until the year 2016, the interest certainly became negative (-0.1%), especially for companies and businesses which means if they do not spend money on improving infrastructure or investing in other areas, they will exactly lose part of their money and profit and as a consequence, as the money supply increases, inflation is likely to emerge, What is more, an unconventional monetary policy or so-called qualitative and quantitative easing has been proposed which intended to create more flowing money to invest in Japan debt (Figure 2).

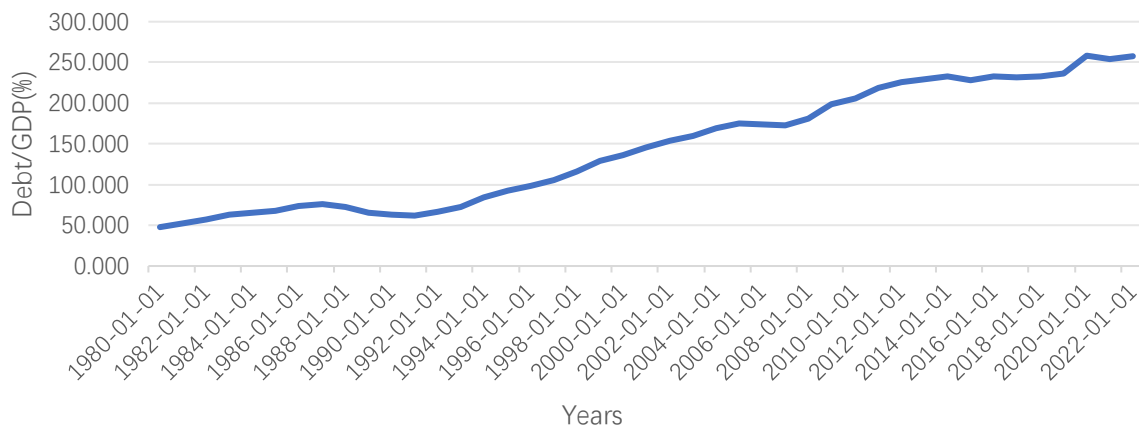


Figure 2: Debt/GDP in Japan

Theoretically, the inflation is supposed to be about 10% or even 20% if possible because both the government and the central bank contributed plenty of resources not only in increasing government spending and lowering interest rates but also stimulating citizens to have inflationary anticipation. However, according to the figure 3, the maximum inflation is only about 2.5% in 2014. Although the economy extricated from a negative inflation rate, it does not correspondingly match the resources and efforts that the whole society inputted.

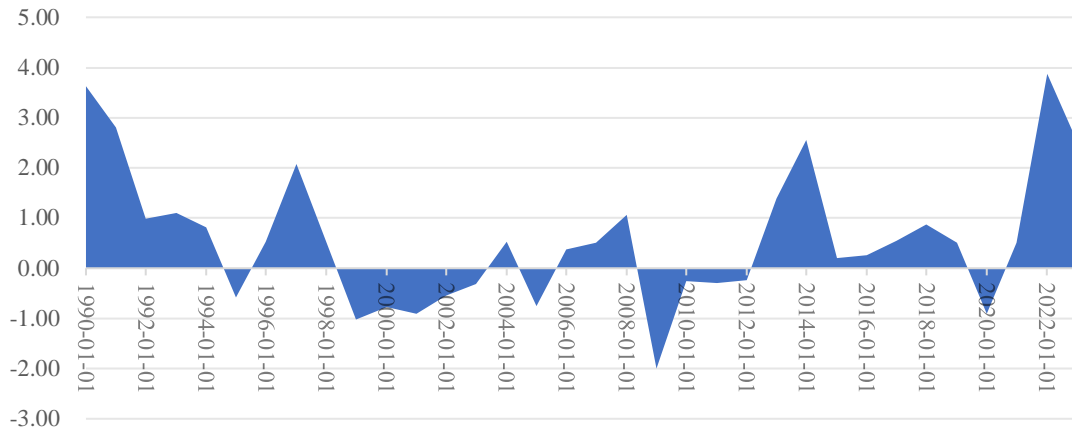


Figure 3: Japan inflation rate

Simultaneously, table 2 shows the game theory and how it took place and the Nash equilibrium is certainly if both of them choose an expansionary policy which is the best response to the other regardless of what do others choose. Undoubtedly, the combination of monetary and fiscal policy is the most likely to maximize their payoffs.

Table 2: Game theory Matrix payoff

Government \ Central Bank	Expansionary Monetary Policy	Contractionary Monetary Policy
Expansionary Fiscal Policy	(3, 2)	(1, 1)
Contractionary Fiscal Policy	(2, 1)	(0, 3)

What is noteworthy is that the effectiveness is limited. Although the GDP grew after policies taken by the nation, it is reasonable to believe that the growth is natural which means it could be seen if the policy has not been introduced as well. As a result, the improvement is not astonishing or outstanding and at least it is never worthwhile (Figure 4).

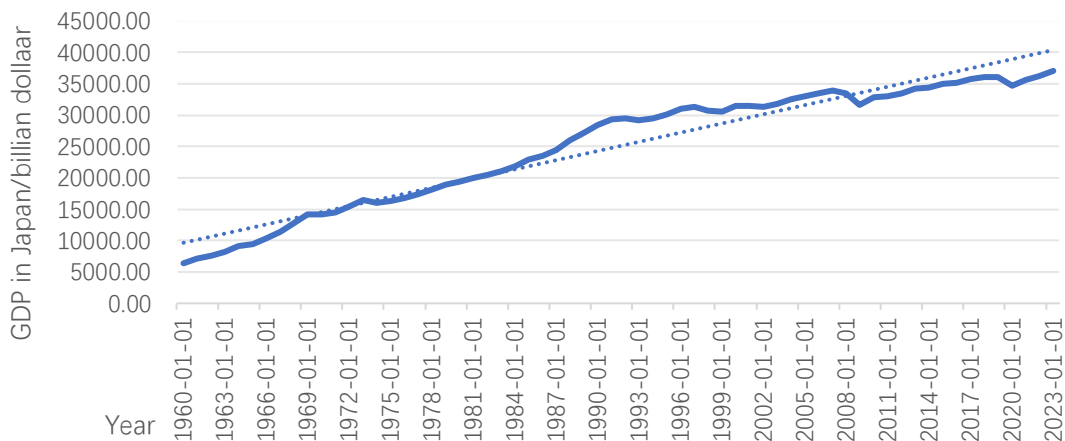


Figure 4: Japan gross domestic product

3.3. Theoretic Evaluation

When it comes to arguing why this is the case and what causes this uncommon phenomenon, a couple of reasons could explain this circumstance. Firstly, the game theory between repeated games and inflation targeting. The credibility of the policy agreement is unstable or dynamic inconsistency which means if policymakers frequently change policy or fail to meet their inflation targets, economic agents may doubt the sustainability and credibility of these policies. In the context of repeated games, economic agents or even individuals do not believe that policymakers will maintain low interest rates over the long term, and thus they do not adjust their inflation expectations or behavior. Meanwhile, since they do not believe in policies any more, with the long-term low interest rate, the anticipation and expectation of inflation rate in the future is unlikely to be changed and their decision-making is limited. Therefore, it is hardly possible for them to consume because they are likely to consume more goods in the future rather than spending currently and it is called de-anchoring or Kydland-Prescott Model of Time Inconsistency.

Indeed, market expectations are independent, meaning that current expectations are certainly influenced by past experiences. For a country like Japan which has been witnessing a low inflation and economic downturn for a long time, the market lacks confidence in future of the increase in inflation and forms an inflationary bias called the Barro-Gordon Model of Inflationary Bias, creating a vicious circle to the whole nation.

As a consequence, rational expectations lead economic agents to react to the government and central bank's monetary and fiscal policies less effectively, resulting in economic weakness and low inflation. Secondly, the issue of the coordination between the Stackelberg Leadership Model in Fiscal and Monetary Policy may take place. In the case of Japan, supposing the government is the dominant leader to set fiscal policy first. The Bank of Japan then reacts as the follower, setting monetary policy in response to the government's fiscal decisions. Thus, if the fiscal policy is expansionary, the central bank might be expected to complement this with monetary policy to support the corresponding growth. However, if the central bank considers controlling inflation or debt as the priority, it might instead choose a tighter monetary policy, mitigating the impact of expansion in the fiscal part. To a certain extent, Japan's economic situation and deflation could be partly explained by poor coordination between fiscal and monetary policies, where the leadership role is not an effective response from the follower. For instance, if the Japanese government increases spending to stimulate the economy, but the Bank of Japan, acting as a follower, tightens monetary policy to prevent inflation or control debt, the overall effect could be contractionary. This is likely to lead to ineffective policy outcomes, such as continued economic recession or deflation.

The Stackelberg model emphasizes the role of expectations. If businesses and consumers expect that the Bank of Japan will not support fiscal expansion with monetary policy, they may anticipate low future growth, leading to reduced investment and consumption. This self-fulfilling expectation could contribute to Japan's persistent deflation and weak economic growth. Thereafter, poor coordination between the government and the central bank where the leader's strategy is not effectively supported by the follower can result in suboptimal outcomes. In Japan's case, the lack of clear leadership between fiscal and monetary policies has contributed to economic difficulties, as inconsistent policy responses fail to effectively stimulate demand or raise inflation. Furthermore, all but one of the most indispensable factors is the serious aging issue in Japan. As the proportion of the elderly population rises, the labor force shrinks which may reduce social productivity and slow economic growth. Simultaneously, senior citizens are more inclined to save rather than spend. This reduction in consumption leads to insufficient demand, making deflation an urgent issue. As Figure 5 illustrated, the labour force has experienced a persistent decrease since the year 1998.

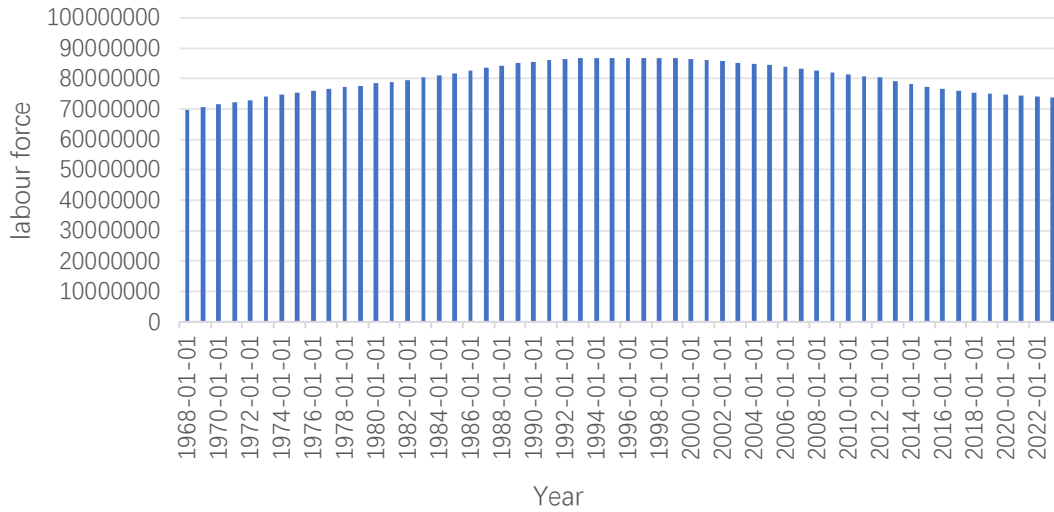


Figure 5: working age population;from15 to 64 in Japan

3.4. Game Theory Application

Also, this interaction can result in a "prisoner's dilemma" scenario. Government's Dilemma: The government aims to stimulate economic growth through fiscal stimulus and monetary easing, but due to the demand insufficiency caused by aging, these policies are sometimes ineffective. Additionally, heavy debt has already constrained the government's fiscal budget. The government's policy choices are constrained by structural problems, making it difficult to achieve the desired effects in combating deflation in the short term. Businesses' Dilemma: Businesses face the risk of contraction in the market due to an ageing society, making them more cautious in investment. With insufficient market demand, businesses are more inclined to decrease their costs rather than investment. Households' Dilemma: With a high proportion of elderly people, and young people uncertain about the future economic outlook, households tend to save more in the bank rather than consume, as households anticipate continued economic downturn, leading to more conservative consumption behaviour.

Table 3: Dilemma in the government, business and household

Policy Choices	Participants	Short-term Payoff	Long-term Payoff
Address Aging Population	Government	6	9
	Businesses	7	8
	Households	7	8
Aggressive Fiscal Stimulus	Government	8	4
	Businesses	6	5
	Households	5	3

As the table 3 shows, for the Government, by implementing policies to reform population issues such as extending the working age, postponing retirement and encouraging immigration, Japan could improve its long-term economic productive potential and social stability. While the benefits may not be immediate, addressing the root problem of ageing can fundamentally solve issues. In terms of the coordination of business and household, if businesses support the labour market and households are willing to vary their consumption behaviour, they can improve overall economic sustainability while addressing ageing and structural issues. This would enhance long-term business competitiveness and ameliorate household living standards. While aggressive fiscal policies may provide short-term

economic stimulation, they are likely to increase debt burdens and create future economic uncertainties if structural issues like ageing are not addressed completely. From the perspective of game theory, addressing the ageing population, through a long-term process, offers higher long-term payoffs compared to relying solely on aggressive fiscal policies and monetary policy. This measure can create a more sustainable growth path for Japan's economy and alleviate long-term deflationary pressures. Although the economic issues could not be solved immediately with the measures to mitigate ageing problems in the short term, if the strategies and policies about the ageing issue mentioned above proposed by the nation could have been adopted, it is reasonable to believe that the significant part of the economic circumstance on which the whole society is focused could have been prevented in the next few decades.

4. Conclusion

In a nutshell, the long-term recession of Japan's economy, often referred to as “lost decades”, is not merely the result of policy or external shocks but rather the outcome of complex interactions between various factors, including the challenges of inflation control, ageing population, and the strategic choices between fiscal and monetary policies. From the perspective of game theory, the strategic behaviour acted by the Japanese government, central bank and financial businesses in the facilitation and implementation of economic policies has significantly affected the effectiveness of economic recovery. The "prisoner's dilemma" type of game between authorities, institutions and households, which tended to target short-term interests has exactly substituted opportunities to reform structural issues at critical moments in Japan's economic history and has led to suboptimal outcomes as well. Moreover, the inconsistency and conflicting objectives of economic policies have further exacerbated economic issues. Despite multiple attempts by the government to escape the spiral of deflation through fiscal stimulus and aggressive monetary policy, an analysis of the game theory suggests that policies can only be truly effective if the interests of all parties are unanimously followed. Therefore, for Japan to achieve long-term economic recovery, it must not only adjust its economic policies but also enhance the game-theoretic analysis during the policy-making process, fostering cooperation among all parties to avoid the mistakes of the past. Future research should further explore how game theory methodologies can be employed to design more effective economic policy to ensure the sustainable development of Japan's economy with a profound prospect.

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