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# Unraveling the Enigma of Japan's Lost Decades: An Econometrics Study using VAR Model

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To my loving family.

The love across oceans and borders from home illuminates this special journey.

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**Abstract**

This paper investigates the driving factors of Japan's stagnation for over 20 years. Through reading various studies and reports, the main factors considered in this econometric study are the government policies, including fiscal and monetary policies, demographic change, and the international competition. These are represented by government spending, interest rates, age dependency ratio, and net export, respectively. The Vector Autoregression (VAR) Model is used in two separate periods. The findings show that for the first period (1991-2000), the age dependency ratio, net exports and interest rate slowed down the economy; however, for the second period, the net exports became the only statistically significant factor using the same method. The balance of trade appears to be a consistent variable that influences the real GDP growth rate, indicating that Japan's loss of competitiveness in the global market plays a role in Japan's long stagnation from 1988 to 2012. This paper contributes to the existing literature on Japan's Lost Decade by offering another way to analyze the determinants of Japan's economic stagnation during this critical period. By identifying the key factors driving low growth in each phase, this study sheds light on the complex interactions of demographic, policy, and international dynamics that shaped Japan's economic situation.

## Introduction

The idea of delving deeper into Japan's economy and its unique periods was inspired by two classes I took with Professor L. Randall Wray, which focused on an alternative perspective of government spending: Modern Monetary Theory. He mentioned several times that Japan is a unique economy in the world, and how it appears to follow the MMT sparked my initial curiosity. By taking a closer look at Japan's economy, we can see that both the government and the people are struggling and indecisive, despite the country's respectable economic standing globally. This realization prompted me to explore the factors and dynamics that led to Japan's Lost Decade, a period of prolonged economic stagnation that has been the subject of much debate and analysis.

Japan's Lost Decade refers to the prolonged economic stagnation that began in the early 1990s and extended into the 2000s and has been the center of discussion for a very long time. This phenomenon has been attributed to complex interactions of factors, including demographic changes, the scale of government spending, interest rates over time, and the rise of international competition. Understanding the driving forces behind this period of economic malaise is crucial for gaining insights into the challenges faced by advanced economies and preventing similar episodes in the future. In this paper, we seek to investigate the primary factors that contributed to Japan's Lost Decade by employing a Vector Autoregression (VAR) model to analyze quarterly data from 1988 to 2000 and 2001 to 2012 separately.

This paper divides Japan's long stagnation into two phases, each characterized by its own set of economic challenges. The first phase, from 1988 to 2000, faced the collapse of the asset price bubble, followed by a banking crisis, deflation, and a general decline in economic growth. During this time, the Japanese government and the Bank of Japan implemented a series of

monetary and fiscal policies aimed at recovering the economy. However, due to a lack of experience, the monetary and fiscal policies were later questioned by scholars. The second phase, from 2001 to 2012, was marked by a slow recovery, accompanied by ongoing demographic shifts and increasing international competition, which continued to exert downward pressure on Japan's economic growth.

Chapter 1, the literature review, introduces the background context and examines how other scholars view Japan's stagnation since 1991. Although the reasons vary from different perspectives, it is evident that Japan faced challenges during the two specified periods. The facts and some historical events mentioned in the literature review are then confirmed by the data presented in Chapter 3. In addition to the data, Chapter 3 also provides the results from the VAR model. The explanation of the VAR model and the adapted model for Japan's case is presented in Chapter 2. Chapter 4 concludes the test results and provides insights on how to improve government actions when facing situations similar to Japan's.

This paper uses the VAR model to assess the relationships between demographic change, government monetary and fiscal policies, and international competition as potential drivers of Japan's economic stagnation during these two periods. By analyzing the Granger causal relationships among these factors and the GDP growth rate, we aim to identify the most significant determinant of Japan's economic performance during these two Lost Decades. The results of this study indicate that throughout the initial period (1988-2000), demographic shifts, net trade, and interest rates Granger-caused the low growth rate. However, the influencing variables underwent a transformation in the subsequent period (2001-2012). These test outcomes highlight the dynamic nature of Japan's economy within a globalization context.

This paper contributes to the existing literature on Japan's Lost Decade by offering another way to analyze the determinants of Japan's economic stagnation during this critical period. By identifying the key factors driving low growth in each phase, this study sheds light on the complex interactions of demographic, policy, and international dynamics that shaped Japan's economic situation, providing valuable insights for both academics and policymakers seeking to understand the challenges faced by advanced economies in the modern era.

## Chapter 1: Literature Review

Japan's post-war economic trajectory can be separated into two distinct phases: an extraordinary post-war boom and a lasting stagnation following this boom. The initial phase of reconstruction, commencing in December 1945, witnessed rapid economic growth, fueled by substantial financial aid and strategic guidance from the U.S. This support aimed to establish Japan as a bulwark against the Soviet Union's expanding influence in Asia. Meanwhile, the boost of consumer confidence directly caused the first baby boom and a continuous increase of GDP. The outbreak of the Korean War in 1950 further enhance Japan's economy, as a huge amount of U.S. military orders led to a remarkable accumulation of foreign reserves. Consequently, in 1954, Japan's Ministry of International Trade and Industry pivoted its focus from agriculture to heavy industries. The completion of the Tokyo Tower in October 1958 symbolized Japan's restored post-war confidence and sustained economic growth.

In 1985, Japan signed the Plaza Accord to assist the U.S. in depreciating the dollar to reduce its trade deficit. The Japanese yen remained strong until the Louvre Accord in 1987. To prevent an *endaka* recession and compensate the export sector, the Bank of Japan initiated a quantitative easing policy by lowering its interest rates. The quantitative easing directly resulted in an excess of liquidity and encouraged the speculation in the real estate and stock markets due to decreased borrowing costs.

The belief that the estate prices would never decrease led banks to continue expanding the credit. In addition to investing in domestic properties, Japan also holds a large number of overseas properties. In 1989, Mitsubishi Company spent $846 million on 51% of the Rockefeller Group, becoming the owner of Rockefeller Center and other 19 buildings. There were some studies at that time argued that the speculation sector was overheated, especially the housing

sector—the price of land has far exceeded its real demand and the Japanese economy would fall into recession in the near future. It is almost the same story as 2008 U.S— the bubble in real estate and the stock market finally burst in 1990. Since then, Japan has fallen into the lost decade (1990-2000), which was a period characterized by low growth rate and low expectations for the future. From 2000 to 2008, Japan's economy appeared to have recovered from the bubble burst by looking at its GDP growth. However, after the 2008 Great Recession, Japan's economy seems to have stagnated again.

Scholars have frequently cited Japan as a cautionary example of mismanaging an advanced economy. The main criticism from the worldwide economic institutions of Japan's poor economic performance after 1990 is that the government's ineffective fiscal policies failed to incentivize aggregate demand. In addition to the policy shortcomings, numerous studies have proposed alternative explanations for Japan's stagnation during the 1990s and 2000s, such as an aging population and the intensifying international competition. This section will present various interpretations of Japan's "Lost Decades" and the underlying factors contributing to the nation's economic stagnation.

1. Monetary and Fiscal Policies

   In *Japan's Lost Decade*[1], Yoshikawa (2001) specifies that the recession stems from the demand side. Yoshikawa uses the Growth Accounting by Demand approach to identify which type of demand affects GDP (Gross Domestic Product) fluctuations the most. This approach breaks down GDP by different types of demands (consumption, investment, government spending, and net export) and weights them by their relative shares in GDP. The results show that the main driver of GDP growth rate changes was

[1] Yoshikawa, H. (2001). *Japan's Lost Decade*. First Edition, International House of Japan.

private investment throughout the 1990s. In addition to the unpromising private investment, consumption also decreased, dragging down the GDP growth rate.

When facing a situation characterized by underinvestment and lack of consumption, fiscal policy should be targeted at increasing private investment and encouraging consumption. Yoshikawa (2001) credits the expansionary fiscal policy for supporting the economy to some extent at the beginning of the recession. However, the expansionary fiscal policy was not strong enough. In other words, the increase in government spending was too small. The rise in government spending caused a massive government deficit, so when the economy seemed to recover in 1997, the expansionary fiscal policy suddenly turned contractionary to increase government revenue. Yoshikawa points out that, in 1997, the rise in the tax burden and a significant cut in government spending undermined consumer confidence again (Yoshikawa, 2001). Many other studies made similar points about Japan's fiscal policies in the 1990s. Fisher & Makin (2001) believe that the sudden contractionary fiscal policy shocked market confidence and expectations, making the recession worse. In 1996, the growth rate was 3.6%, and the recession seemed to be over by then. However, due to the enormous government deficit resulting from the bubble burst, the Japanese government decided to increase the value-added tax starting in July 1997. The economy then "fell off the edge of the cliff". The outcome of the contractionary fiscal policy was unexpected for the Japanese government because they thought the "growth momentum of 1996 was sufficiently strong to withstand a negative fiscal impulse". The fiscal policy turned expansionary soon after the drastic reaction to the attempted contractionary fiscal policy (Fisher & Makin, 2001).

Why are economists expecting the fiscal policy to play the main role in the Japanese stagnation instead of the monetary policy? Akram (2016) explains why monetary policy only helped a little during the Lost Decade: the interest rate was low when Japan was experiencing an economic boom in the 1980s, due to the quantitative easing policy and a strong future expectation. To cool down the overheated housing and stock markets, in 1989 BOJ started to tighten monetary policy, raising the discount rate from 2.5% to 4.5%. In 1990, BOJ continued the tightening monetary policy and the discount rate increased to 6%. After the bubble burst, BOJ gradually lowered the interest rate and the discount rate to encourage investment and consumption. In 1995, the discount rate reached 0.5%, and it could not be any lower. When the interest rate is close to zero, it is impossible to go down further, making the expansionary monetary policy hard to operate at that point. During the Lost Decade, even borrowing money costs almost nothing, the private sector still refused to invest or consume because of deflation. The whole economy entered a liquidity trap. Private sector expects the price will be lower in the future, so it will not spend unless it is necessary. The liquidity trap explains the private sector's lack of investment and consumption in the previous paragraph—nothing can incentivize the private sector to spend (Akram, 2016).

Paul Krugman (1998) argues that the simplest way to pull an economy out of the liquidity trap is to give the inflation expectation needed, that is, promising the private sector that the expansionary monetary policy will not reverse when the economy starts to grow. Unfortunately, as mentioned before, the fiscal policy is too eager to solve government debt, which is totally unnecessary in a country with monetary sovereignty. It is hard to reestablish the future expectation when the policy varies a lot during a short

time period. The reason why the government debt should not be the primary concern and Japan's tightening fiscal policy was ridiculous at that time is explained in Stephanie Kelton's *The Deficit Myth (2021)*. Kelton believes a sovereign government does not need "money" to spend for the public project. Any government, with its debt in its own currency, is a currency issuer instead of a currency user.

Though from the policy perspective, the Bank of Japan and the Japanese government did not do a great job, many studies on Japan's lost decade suggest other factors as the main cause of Japan's stagnation from 1990 to 2000. In 2004, Paul Krugman wrote "Apologizing to Japan" to complement his earlier argument about the causes of Japan's economic stagnation that policies were not the only factor that causes such long-term shutdown in the growth. By comparing the fiscal and monetary policies in other countries or regions when facing the liquidity trap, Krugman found out that the Japanese government, in fact, did a relatively better job than other governments did. But Japan's stagnation seems more severe. Thus, Krugman implies there is more than one main factor-driver for Japan's decade-long stagnation.

2. Demographic Changes

There are studies suggesting that the stagnation comes from the structural problem embedded in the society instead of the questioned policies. Aoki (2013) points out the structural problem refers to the drastic demographic changes: "notably the population aging caused by low fertility and increased longevity" in Japan since World War II. Meanwhile, as the manufacturing and technology industries developed rapidly after World War II, the expanding market needed a larger labor supply. The conflict then existed between the declining labor supply and the increasing labor demand caused by

expanding markets (Aoki, 2013). Otsu & Shibayama (2022) uses a neoclassical growth model to examine the Japanese economy post-World War II and indicates that demographic changes were a key contributor to the decline in output and employment—the increase in the proportion of the elderly population[2] has been the major factor causing the decline in employment, which led to an 8% reduction in output. Otsu & Shibayama also points out that the bad economic performance causes changes in labor policies and taxation, which further reduced output levels. The Workweek Shortening Policy resulted in a reduction in working hours over the period of 1988-1994, causing output to fall by 20% from its potential level. The rise in labor tax has discouraged working hours and led to an 11% reduction in output from its potential level. The change in the pattern of government spending has potentially slowed down productivity growth and thus led to a reduction in the potential output level itself.

One problem the aging population brings is that the non-working population poses a heavy burden on the private sector. Horioka et al (2007) examine the relationship between Japan's aging population and household saving rates, and conclude that Japan's population age composition can help to understand the current level of household savings rate in Japan and its historical and future trends. The household savings rate of Japan is declining due to the fast-aging population, and this trend is predicted to persist. The decline of personal savings further disincentivizes spending and investment, making it more difficult for Japan to recover from the recession.

[2] The proportion of population aged 65 years and above among those aged 15 years or older has risen from 8% in 1955 to 30% in 2015 (Otsu & Shibayama, 2022).

Miyazato (2015) uses generational accounting and time series data analysis to study intergenerational redistribution policies in Japan during the 1990s and 2000s and finds that the policies in the 1990s transfer the financial burden from the current generation (in 1990s) to the future generation. Results indicate that policies in the 1990s reduced the financial burden of the present generation by passing it on to future generations, which continued until the early 2000s. However, the latter half of the 2000s saw a change, where the burden of the future generation was reduced by increasing the burden on the young generation instead of reducing the benefit for the retired generation. Nonetheless, the decline in the burden of the future generation was not enough to address the generational imbalance that existed in 1990.

The opposing argument proposed by Ono & O'Connor (2021) states that social welfare and well-being increased during the lost decades, which helped with the labor shortage. The government provided more support than ever to help alleviate the family burden and encourage people to engage in the labor market (Ono & O'Connor, 2021). In addition, Miyazawa (2017) argues that although the labor supply fell, the overall quality of human capital improved compared to the earlier period, thanks to the investment in the education system during the bubble economy period. Simple tasks can be replaced by machines, which compensate for the decrease in labor supply.

3. International Competition

Other than the aging population and the decrease in the labor supply, economists also think the increasing international competitions Japan faced after 1990, mainly in the manufacturing and semiconductor sector, contributes to Japan's long stagnation. Welfens et al., (1999) argues the effects of China's economic opening-up in the 1980s which

coincided with fast structural change and rapid growth rates for output and exports, should be taken into account as one of the main reasons for the slow-down of Japanese manufacturing exports. As to the semiconductor industry, Uno (2022) points out, by the late 1990s, the prevailing model for the semiconductor industry was shifting from vertically integrated, which both designed and manufactured semiconductors, towards highly-specialized firms which either designed or manufactured chips. At that time, Japan just encountered stagnation. The Japanese semiconductor industry failed to adopt the new business model, making themselves less competitive. In addition to the failure of industrial transformation, Japan's trade with the United States was not going well either. Japan's continued increasing share in the U.S. 64K RAM (one kind of chips) merchant market alarmed the Americans. With the fear that Japanese chips were taking over U.S. chips, The United States began pressing the Japanese government to make trade concessions (Sugano et al., 1984). Fearing the risk of being completely shut out of the US market, Japan made concessions under the US-Japan Semiconductor Agreement in 1986. Under the agreement, the U.S. government has the right to set a minimum fair market price for chips in the United States and to increase the foreign share of the Japanese semiconductor market from 10% to 20%. Uno (2022) points out that these two regulations simultaneously weakened Japan's competitiveness in both foreign and domestic semiconductor markets, allowing semiconductor companies from the United States, South Korea and other countries to gain a large share of the world semiconductor market.

After the collapse of the bubble economy, the Japanese government implemented various reforms to stimulate the economy, aiming at expanding domestic demand,

streamlining administration, and implementing structural reform. In the middle 1990s, the Japanese government accelerated the speed of reform, but Japan's economy remained sluggish, with an average annual growth rate of 0.89% from 1992 to 2002. After nearly a decade of exploration, the Japanese government learned a lesson from the previous stagflation, not only focusing on increasing government spending, but also paying attention to rebuilding consumer confidence. According to Callen and Ostry (2003), The Prime Minister Koizumi administration, which took office in April 2001, has made some progress in solving the core weaknesses in the economy. The banking strategy focused on reducing risks, including strengthening the loan classification, accelerating the NPLs (nonperforming loans) disposals and reducing the exposure to equity price risks. 2002 April, the special inspection on major banks demonstrates the Japanese government's commitment to risk avoidance to encourage investment and consumption in the private sector (Callen and Ostry, 2003). The shift of the focus makes the economy gradually recover from the effects from the 1991 bubble collapse. The average GDP growth rate increased from 0.89% (from 1992 to 2002) to 1.67% (2003 to 2007). However, the 2008 Great Depression sent Japan back to sluggish growth. The average growth rate from 2008 to 2019 fallen to 0.43%[3].

Media portrayed the slow economic growth after 2000 as another Lost Decade. Different from the previous stagnation, the pressure of the unpromising growth trend afterwards mainly comes from the net export sector. In the first half of the 1990s, Japan's trade balance kept positive and the trade surplus continued increasing despite the

[3] Author calculation. Original Data: World Bank. Access: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=JP

country's economic depression. After the mid-1990s, the frequent fluctuations of the yen exchange rate,1997 Asian financial crisis, bursting of the U.S. IT bubble in 2001, and the international financial crisis in 2008 made Japan's foreign trade unstable (Xinhua Net, 2015). In addition, as discussed above, the lack of investment in the semiconductor sector during the upgrading period reduced Japan's competitiveness worldwide (Uno, 2022). In addition to the decrease in exports, the increase of imports also expanded the trade deficit. According to Sasaki and Yoshida (2018), Japan's end of its trade surplus in 2012 is because of the depreciation of Japanese Yen and the increase of the oil price. In addition to the effects from weak currency, Sasaki and Yoshida also found a structural change in Japan's export and import sector that both the import and export are more responsive to the real income change. The trade deficit adds concerns to Japan's recovery that the higher price of imported energy and food limits the demand.

4. Initial Assumptions

Based on the existing literature, my hypothesis posits that during the first period, ineffective monetary and fiscal policies contributed to the decline of Japan's economy, while in the second period, the loss of international competitiveness further slowed the economy down.

## Chapter 2: Model Description: Vector Autoregression and Granger Causality Test

This chapter will introduce the model used to examine the effects of the dominant factors that contribute to the prolonged recession in Japan. The previous section provided an overview of the primary drivers that have been identified in the literature, including ineffective monetary and fiscal policies, demographic shifts, and intensifying global competition. In short, this paper uses the Vector Autoregression (VAR) Model because the VAR model is well-suited to capturing complex interrelationships between multiple time series variables.

1. Advantages of VAR model

   Time series analysis is a statistical method used to analyze and make predictions based on historical data (the lagged values). According to Hyndman & Athanasopoulos (2021), there are several common methods used to test time series data, including Autoregressive Integrated Moving Average (ARIMA), exponential smoothing, and seasonal decomposition. However, one limitation is that these models impose a unidirectional relationship. That is, the dependent variable is affected by the independent variables, but the independent variables are not affected by the dependent variable. In the case of Japan, it is obvious that economic growth has a significant impact on the rest of the variables. The Vector Autoregression (VAR) model allows for the analysis of multiple time series variables simultaneously, capturing the interrelationships and feedback mechanisms between them. Additionally, VAR models can be used for impulse response analysis, which examines the impact of shocks to one variable on the other variables in the system.

2. Vector Autoregression Model

   a. Univariate Autoregressive Model

To understand the multivariable vector autoregression model, I would like to start with a univariate autoregression model focusing on a single variable at a time. According to Hyndman & Athanasopoulos (2021)[4], a Univariate Autoregressive (AR) Model is a statistical technique used to model time series data. In an AR model, the value of a variable at a given time point is predicted based on its past values and more recent values having a stronger influence than earlier ones. The method of least squares is commonly used to estimate the parameters of the univariate autoregression model. This involves minimizing the sum of squared errors between the predicted values of the variable and the actual observed values. The result univariate autoregression provides can be interpreted as whether the future value of this variable can be predicted by the past values. The order of autoregression, denoted by the value of $p$, indicates the number of past values of the dependent variable that are included in the model. Autoregression is often used in combination with other time series models, such as moving average and seasonal models, to form more complex and accurate forecasts.

The formula provided by Hyndman & Athanasopoulos (2021) for an AR model is:

$$y_t = c + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots + \beta_p y_{t-p} + \varepsilon_t$$

In this formula, $y_t$ represents the dependent variable at time $t$, $c$ is the intercept, or, the constant. $\beta_1$ through $\beta_p$ are the coefficients of the autoregressive terms. $\varepsilon_t$ is the error term at time $t$, refers to the difference between the observed value of a

[4] Chapter 8, Section 3.

dependent variable and its predicted value based on a statistical model. $\varepsilon_t$ represents the part of the dependent variable that is not explained by the independent variables in the model. The autoregressive terms, $y_{t-1}$through $y_{t-p}$, are lagged values of the dependent variable, indicating that the current value of the variable is a function of its past values.

If the p-value of the AR test is small, then we can say this variable can be explained by its lagged values.

b. Stationary test and correction[5]

Most of the time we need to do stationary tests for each variable before doing the VAR model.

i. Dickey-Fuller Test[6]

The Dickey-Fuller (DF) test is a statistical test used to determine whether a time series data is stationary or non-stationary. Stationarity refers to the statistical properties (means, variances, and etc.) of a time series that remain constant over time. The DF test is based on the assumption that a non-stationary time series can be transformed into a stationary one by differencing. The test involves fitting an autoregressive (AR) model to the time series and calculating a test statistic. The test statistic is compared to critical values from a table to determine whether the time series is stationary.

[5] Chetty, Priya, & Divya Narang (2017, Dec 02). The problem of non-stationarity in time series analysis in STATA. Knowledge Tank; Project Guru. https://www.projectguru.in/problem-non-stationarity-time-series-stata/

[6] https://en.wikipedia.org/wiki/Dickey%E2%80%93Fuller_test

If the test statistic is less than the critical value, the null hypothesis that the time series is non-stationary can be rejected, and the conclusion is that the time series is stationary. On the other hand, if the test statistic is greater than the critical value, the null hypothesis cannot be rejected, and the conclusion is that the time series is non-stationary.

ii. Correction: taking derivative

According to Hyndman & Athanasopoulos (2021), taking the first difference of a non-stationary time series can often transform it into a stationary one. The intuition behind this approach is that a non-stationary time series often exhibits trends and other forms of systematic variation that can be removed by taking differences. By removing the trend, the resulting series can become stationary with a constant mean, variance, and autocorrelation structure.

c. Vector Autoregression

According to Stock & Watson (2021), VAR is an extension of the univariate autoregression and is used to analyze the interdependencies and feedback loops between multiple time-series variables. Unlike other models, VAR models do not require the specification of a dependent variable, as all variables in the model are treated as endogenous. As mentioned in the beginning, the VAR model analyzes the bi-directional effects between the dependent and independent variables. The VAR model uses a system of linear equations where each endogenous variable is regressed on its own lagged values and the lagged values of all other endogenous variables. The model assumes that the errors in the

equations are normally distributed with a constant variance over time. The VAR model is typically estimated using maximum likelihood estimation for Bayesian methods.

The formula for the VAR model of order one with three time series variables and is[7]:

$$y_{1,t} = c_1 + \beta_{11,1} y_{1,t-1} + \beta_{12,1} y_{2,t-1} + \varepsilon_{1,t}$$

$$y_{2,t} = c_2 + \beta_{21,1} y_{1,t-1} + \beta_{22,1} y_{2,t-2} + \varepsilon_{2,t}$$

Where $y_1$ and $y_2$ are the two time series variables and the *t* represents the $t^{th}$ observant in each variable. $\beta$ is the component of the coefficient matrix. $\beta_{11,1}$ is the coefficient in the first column and first row, and it represents the first-order lag in a VAR model. $c$ is the constant; and $\varepsilon$ is the error term at time *t*. As the name, VAR model is best expressed in a matrix form because all of the variables can be seen as a vector.

$$\text{Set } Y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix}, C = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix}, A_1 = \begin{bmatrix} \beta_{11,1} & \beta_{12,1} \\ \beta_{21,1} & \beta_{22,1} \end{bmatrix}, E = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}$$

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} + \begin{bmatrix} \beta_{11,1} & \beta_{12,1} \\ \beta_{21,1} & \beta_{22,1} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}$$

$$Y_t = C + A_1 Y_{t-1} + E$$

The general formula for the $K^{th}$ order of lag VAR model with N time series variables is:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_t Y_{t-k} + E$$

*Where*

[7] 11.2 vector autoregressive models VAR(P) models: Stat 510. PennState: Statistics Online Courses. (n.d.). Retrieved April 2, 2023, from https://online.stat.psu.edu/stat510/lesson/11/11.2

$$Y_t = \begin{bmatrix} y_{1,t} \\ y_{2,t} \\ \cdots \\ y_{N,t} \end{bmatrix}$$

$$A = \begin{pmatrix} \beta_{11,j} & \cdots & \beta_{1N,j} \\ \vdots & \ddots & \vdots \\ \beta_{N1,j} & \cdots & \beta_{NN,j} \end{pmatrix}, j = 1,2, \ldots, k.$$

There are three types of the VAR model: reduced, recursive, and structural. Reduced form VAR models use ordinary least squares regression to estimate linear equations for each variable based on its past values and the past values of all other variables, with the error terms representing unexpected movements in the variables. Recursive VAR models use current values of some variables as regressors in each equation to ensure uncorrelated error terms across equations. Structural VAR models use economic theory to identify causal links between variables and require identifying assumptions, producing instrumental variables for estimating contemporaneous links. The number of possible structural VAR models is limited only by the creativity of the researcher. Each type of VAR model has its own strengths and limitations and can be used to analyze different aspects of time-series data.

d. Granger Causality Test

According to Stock & Watson (2021), Granger causality is part of the VAR model that measures the causal relationship between two time series variables. The idea behind Granger causality is that if variable X causes variable Y, then the past values of X should contain information that can help predict the future values of Y beyond what can be predicted by past values of Y alone. Granger causality examines whether the past values of one variable can help

predict the future values of another variable, after controlling for the effects of the past values of the dependent variable.

Granger causality is a statistical method used to see if one variable X has an influence on another variable Y. First, we estimate the VAR model using lagged values of both variables. This means we use past values of both variables to try and predict their future values. Then, the model tests the null hypothesis that variable X does not have any influence on variable Y by comparing the fit of two different models: a reduced VAR model that only includes variable Y, and a full VAR model that includes both variables X and Y. If the full VAR model provides a significantly better fit than the reduced VAR model, then we can conclude that there is evidence of Granger causality from variable X to variable Y. This means that past values of variable X can help us predict future values of variable B better than we could by only looking at past values of variable Y.

Granger causality can be used to estimate the relationships between multiple variables in a VAR model. It can help identify which variables are driving changes in other variables, and which variables are being affected by other variables. Granger causality can also help identify feedback loops and other dynamic interactions among the variables in the model.

In summary, the VAR model and Granger causality are powerful tools for analyzing the relationships between multiple time series variables. They provide a framework for modeling dynamic interactions among variables and testing for causal relationships between them.

3. Adapted Model Used in This Paper

In Japan's case, the VAR model contains five variables: Real GDP Growth Rate, Interest Rate, Government Spending as a percentage of GDP, Age Dependency Ratio, and the Balance of Trade. These variables represent economic performance, monetary policy, fiscal policy, demographic changes, and international competition, respectively.

GDP growth rate is denoted as $G$; Interest rate is denoted as $i$; government spending as a percentage of GDP is denoted as $S$; age dependency ratio is denoted as $A$; and the balance of trade is denoted as $BOT$.

The set of the equations to represents the interrelationships of those variables will be:

$$G_t = c_1 + \beta_{11,1}G_{t-1} + \beta_{12,1}i_{t-1} + \beta_{13,1}S_{t-1} + \beta_{14,1}A_{t-1} + \beta_{15,1}BOT_{t-1} + \varepsilon_{1,t}$$

$$i_t = c_2 + \beta_{21,1}G_{t-1} + \beta_{22,1}i_{t-1} + \beta_{23,1}S_{t-1} + \beta_{24,1}A_{t-1} + \beta_{25,1}BOT_{t-1} + \varepsilon_{2,t}$$

$$S_t = c_3 + \beta_{31,1}G_{t-1} + \beta_{32,1}i_{t-1} + \beta_{33,1}S_{t-1} + \beta_{34,1}A_{t-1} + \beta_{35,1}BOT_{t-1} + \varepsilon_{3,t}$$

$$A_t = c_4 + \beta_{41,1}G_{t-1} + \beta_{42,1}i_{t-1} + \beta_{43,1}S_{t-1} + \beta_{44,1}A_{t-1} + \beta_{45,1}BOT_{t-1} + \varepsilon_{4,t}$$

$$BOT_t = c_5 + \beta_{51,1}G_{t-1} + \beta_{52,1}i_{t-1} + \beta_{53,1}S_{t-1} + \beta_{54,1}A_{t-1} + \beta_{55,1}BOT_{t-1} + \varepsilon_{5,t}$$

This VAR equation represents a system of equations that captures the dynamic relationships between the different economic variables. The coefficients $\beta$ in the equation represent the impact of each of these variables on the other variables in the system. First, the equation set reveals how one variable is affected by the lagged value of itself. For example, the coefficient $\beta_{11,1}$ in the equation for $G_t$ represents the impact of lagged real GDP growth on the current period's real GDP growth. Similarly, the coefficient $\beta_{22,1}$ in the equation for $i_t$ represents the impact of lagged interest rates on the current period's interest rates. This equation set also shows us the impact of changes in one variable on the other variables in the system. For example, an increase in the real GDP growth rate in

the last period $G_{t-1}$ may have an impact on the other variables in the system for the current period such as interest rates $i_t$ (with the coefficient $\beta_{21,1}$), government spending as percentage of GDP $S_t$ (with the coefficient $\beta_{31,1}$), the age dependency ratio $A_t$ (with the coefficient $\beta_{41,1}$), and the balance of trade $BOT_t$ (with the coefficient $\beta_{51,1}$). By estimating the coefficients $\beta$ in the VAR equation, we can quantify the magnitude of these impacts.

The adapted VAR Model in a matrix form will be:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_t Y_{t-k} + E$$

where

$$Y_t = \begin{bmatrix} G_t \\ i_t \\ S_t \\ A_t \\ BOT_t \end{bmatrix}$$

$$A = \begin{pmatrix} \beta_{11,j} & \cdots & \beta_{15,j} \\ \vdots & \ddots & \vdots \\ \beta_{51,j} & \cdots & \beta_{55,j} \end{pmatrix}, j = 1,2,\dots,k.$$

**k is the order of lag and it will be determined automatically by Stata*

## Chapter 3: Data and Test Result

This chapter will further explore the factors mentioned in the context by applying the VAR model to assess their relative impact on Japan's economic performance during the lost decades. Part I describes the data used in the model and how they are correlated to the historical events; part II describes some other variables that are collinear with the net export in the model but also important to look at; part III presents the result from the VAR model and the Granger causality Test; and part IV concludes the findings.

I. Data used in VAR model

The data used to present each of the factors is determined by a thorough review of the relevant literature, as well as the availability and reliability of data sources. In selecting the variables to include in the VAR model, the study seeks to capture the key drivers of Japan's recession while ensuring that the data used are robust and accurate. Annual data, primarily obtained from the World Bank, serves to capture overarching changes throughout the years. Meanwhile, the employment of quarterly data in the VAR model augments the sample size, thereby enhancing the accuracy and reliability of the derived outcomes.

a. *Dependent Variable*

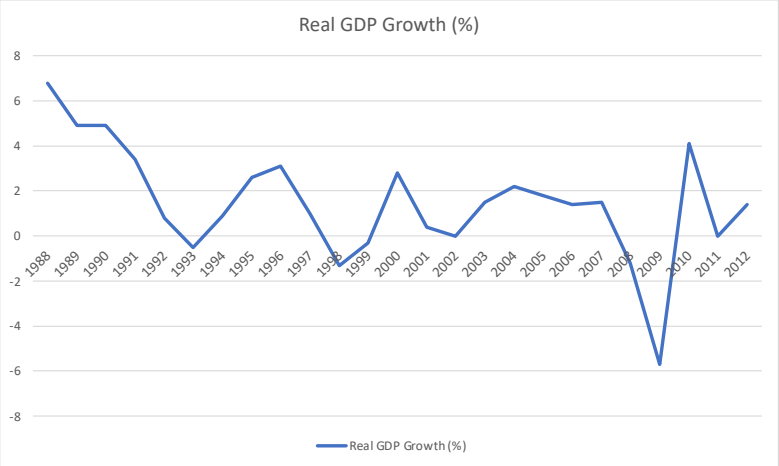

*Figure 1: Japan's GDP Growth Rate, 1988-2012*[8]

Figure 1 shows Japan's Real GDP growth rate from 1988 to 2012. The graph illustrates periodic fluctuation with a downturn trend, which indicates the economic stagnation within this period. Japan experienced high growth during the late 1980s, with Real GDP growth rates of 6.8% in 1988, 4.9% in both 1989 and 1990. Starting from 1991 Japan's economy began to slow down, with growth decreasing to 3.4%. In 1993, the economy contracted by 0.5%, indicating a recession. From 1994 to 1997, the economy slightly recovered, but it did not last long. Japan entered into another recession in 1998 with a -1.3% growth rate. The economy struggled to recover, with fluctuating growth rates of -0.3% in 1999, 2.8% in 2000, 0.4% in 2001, and no growth in 2002. From 2003 to 2007, the Japanese economy experienced a mild growth, with growth rates ranging from 1.4% to 2.2%. The economy seemed to stabilize, but growth rates were not as high as in the late 1980s. The economy contracted by 1.2% in 2008 due to the Global Financial Crisis and suffered a sharp decline of 5.7% in 2009. The economy began to recover after the crisis, with growth of 4.1% in 2010. However, growth slowed again to 0% in 2011 and 1.4% in 2012.

In short, Japan's economy is characterized by a fluctuating and slow growth, with an average growth rate of 0.9% since 1991.

b. *Independent Variables*

i. Monetary Policy—interest rate

[8]Original Data Source: World Bank. Access: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=JP

Interest rate is a key economic indicator used by central banks to implement monetary policy and manage the money supply and in the economy. Interest is the cost of borrowing, or the award of savings for households and businesses. When the central bank lowers interest rates, it makes borrowing cheaper to encourage spending and investing, which can stimulate economic activity. Conversely, when a central bank raises interest rates, it makes borrowing more expensive and can cool down inflationary pressures in the economy.

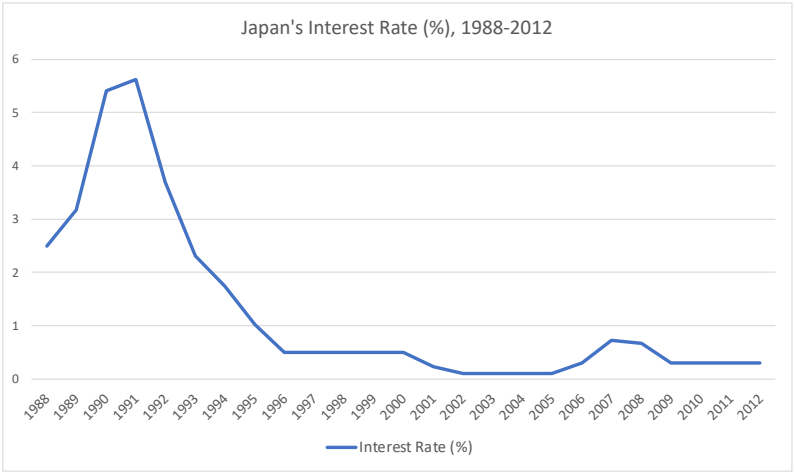


*Figure 2[9]: Japan's Interest Rate (%), 1998-2012*

Japan's interest rate sharply decreased since the collapse of the real estate bubble and has been stable around 0.5% since 1996. This trend corresponds to the liquidity trap mentioned in the literature review that the monetary policy is powerless since the interest rate could no longer be lowered. Interest rates first increased from 2.5% in 1988 to 5.625% in 1991 could be attributed to the

[9] Original Data: monthly interest rate provided by Bank of Japan. Access: https://www.stat-search.boj.or.jp/ssi/mtshtml/ir01_m_1_en.html.
Annual interest rate is calculated by the author by taking the average.

central bank's attempts to control inflation and cool down the overheated economy during the period of strong economic growth in the late 1980s. Higher interest rates tend to slow down borrowing and spending, thus helping to contract the inflation. Soon after, the bubble burst and Japan encountered the economic slowdown and recession. In response to the sudden change, the central bank lowered interest rates to stimulate borrowing and spending, aiming to revive economic growth. Unfortunately, Japan's economy entered a prolonged period of stagnation, known as the "Lost Decade". To combat deflation and stimulate growth, the central bank implemented near-zero interest rates, which remained in place for almost a decade. Interest rates ranged from 0.5% in 1996 to 0.1% in 2005. Since 2005, As the economy showed signs of mild growth, the central bank cautiously increased interest rates to 0.3% in 2006 and 0.72% in 2007, attempting to maintain price stability while supporting growth. In response to the Great Financial Crisis in 2008, the central bank lowered interest rates again to stimulate investment and consumption, aiming to mitigate the crisis's effects. Interest rates decreased from 0.67% in 2008 to 0.3% in 2009.

In summary, Japan's interest rate changes can be primarily attributed to the central bank's efforts to manage inflation, stimulate economic growth, and maintain price stability. During periods of strong growth or inflation concerns, interest rates were increased, while during periods of economic slowdown or deflation, interest rates were lowered to support growth and spending.

ii. Fiscal Policy—government spending (% of GDP)

Government spending is a key indicator used in fiscal policy, which refers to the use of government spending and taxation to influence the economy. Fiscal policy is often used to stabilize the economy during periods of recession or inflation, and to promote long-term economic growth.

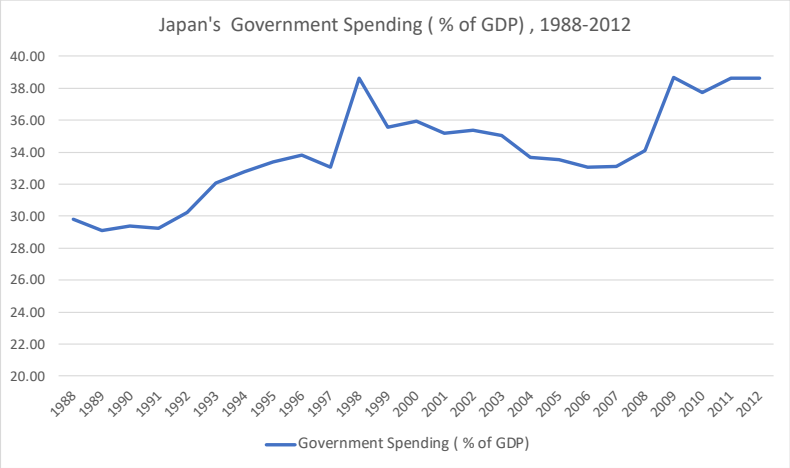


*Figure 3[10]: Japan's Government Spending (% of GDP), 1988-1012*

Japan's government spending demonstrates an overall upward trend, with a gradual decrease from 2000 to 2006 and a sharp increase in 1997. The fluctuation indicates that Japan's fiscal policy is unstable. The small decrease in 1996 and the sudden increase in 1997 corresponds to the situation mentioned in the literature review that the Japanese government cut the government spending when they saw a sign of recovery and that irrational action hit the consumer confidence again in 1997. The second noticeable increase of government spending as a percentage of GDP is in 2008 in response to the Great Financial Crisis.

iii. Demographic Changes—Age dependency ratio

[10] Original Data: International Monetary Fund. Access: https://www.imf.org/external/datamapper/exp@FPP/JPN/%20ESP

The age dependency ratio is an important indicator for understanding demographic changes and their potential impact on society and the economy. A high age dependency ratio means that there are relatively more dependents (children and elderly) in the population, which can place a strain on social services, healthcare systems, and pension systems. Conversely, a low age dependency ratio means that there are relatively fewer dependents in the population, which can have positive effects on economic growth and the labor market. Word Bank defines the age dependency ratio as "the ratio of dependents—people younger than 15 or older than 64—to the working-age population—those ages 15-64. Data are shown as the proportion of dependents per 100 working-age population"[11].

Analyzing age dependency ratio data can help policymakers and researchers understand the demographic trends in a population, plan for the future needs of the labor market and social services, and assess the potential economic impact of changes in the age structure of the population.

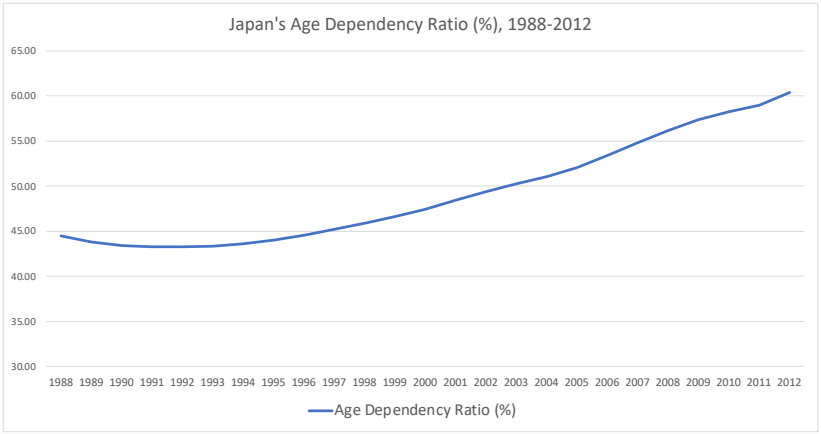


*Figure 4: Japan's Age Dependency Ratio (%), 1988-2012.*

[11] Word Bank. https://databank.worldbank.org/metadataglossary/gender-statistics/series/SP.POP.DPND

Japan's age dependency ratio continuously increased between 1988 and 2012, with the most significant growth occurring from 2001 onwards. This trend indicates a growing proportion of dependents in Japan's population, which could increase the burden on the working-age population.

iv. International Competitiveness—Balance of Trade

Examining Japan's Balance of Trade over time provides valuable insights into the changing landscape of the country's international competitiveness. The evolution of Japan's export and import patterns reveals its ability to adapt and respond to the demands of the global market. From a strong focus on manufacturing industries in the past, Japan has gradually shifted towards high-precision technology and the automotive and electronics sectors.

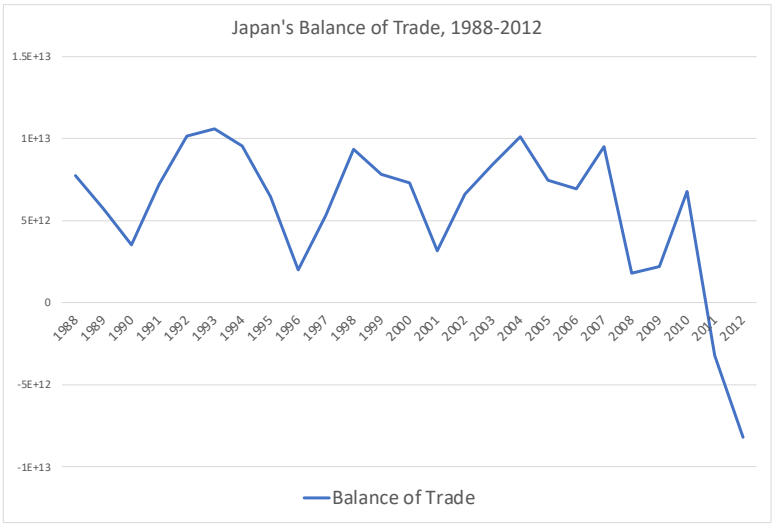


*Figure 5[12]: Japan's Balance of Trade, 1988-2012*

[12] Original Data: World Bank. Access: https://data.worldbank.org/indicator/NE.RSB.GNFS.CN?locations=JP

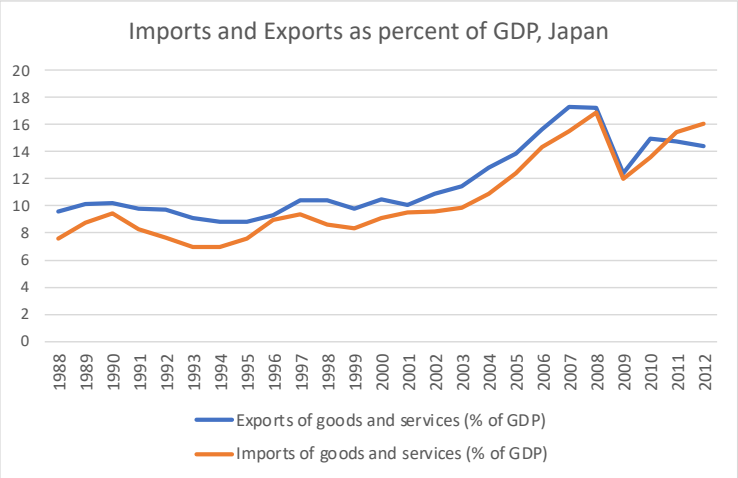


*Figure 6[13]: Japan's Imports and Exports as a percentage of GDP, 1988-2012*

Japan's Balance of Trade from 1988 to 2012 displayed an initial decline, followed by a period of fluctuations, and then a substantial downturn in the late 2000s, eventually reaching a negative value in 2011. The decline of balance of trade may have resulted from a decrease in international competitiveness, changes in consumer preferences, or the impact of global economic crises, such as the 2008 financial crisis. The negative balance of trade suggests that Japan's economy could have been under pressure due to the increased reliance on imports and reduced export revenues. Because balance of trade is a bidirectional figure that is related to both imports and exports, looking at the breakdown categories of imports and exports might give some useful information.

## II. Other Important Figures

[13] Original Data: World Bank. Access: exports: https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?locations=JP; imports: https://data.worldbank.org/indicator/NE.IMP.GNFS.ZS?locations=JP.

*a*. Import changes over time*:*

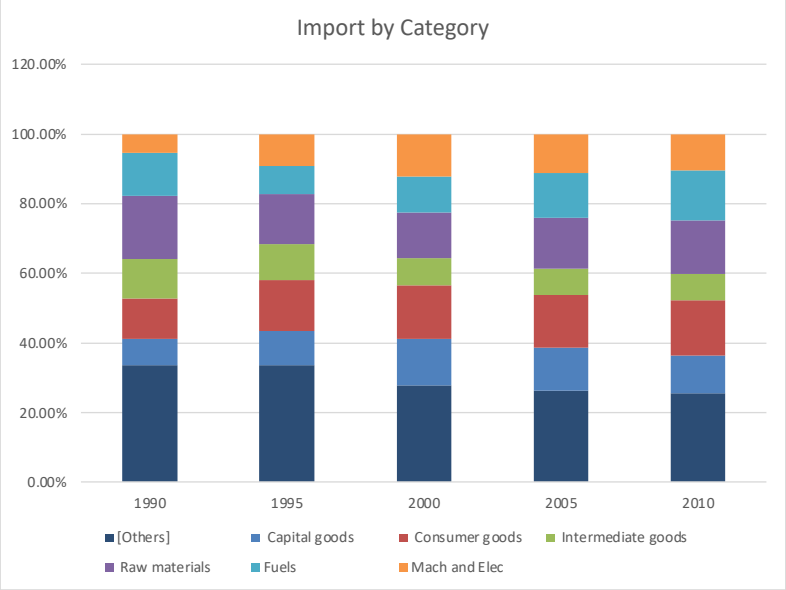


*Figure 7*[14]*: Japan's Import by Category*

The observed augmentation in the import proportion of consumer goods can be attributed to the changing demographics and consumption patterns in Japan. As the nation experiences an aging population, there is an anticipated surge in demand for healthcare, personal care, and associated products. However, due to the insufficient information on the breakdown of the consumer goods, the hypothesis that demographic changes are the reasons of increased imports of consumer goods remains inconclusive.

The decline in the import share of intermediate goods could be linked to Japan's transition from a manufacturing-based economy to a more service-oriented economy. It could also be due to the transfer of manufacturing and assembly industries to the neighboring countries and regions, like Thailand, Taiwan, India, and etc.

[14] Original Data: World Bank. Access: https://data.worldbank.org/indicator/NE.RSB.GNFS.CN?locations=JP

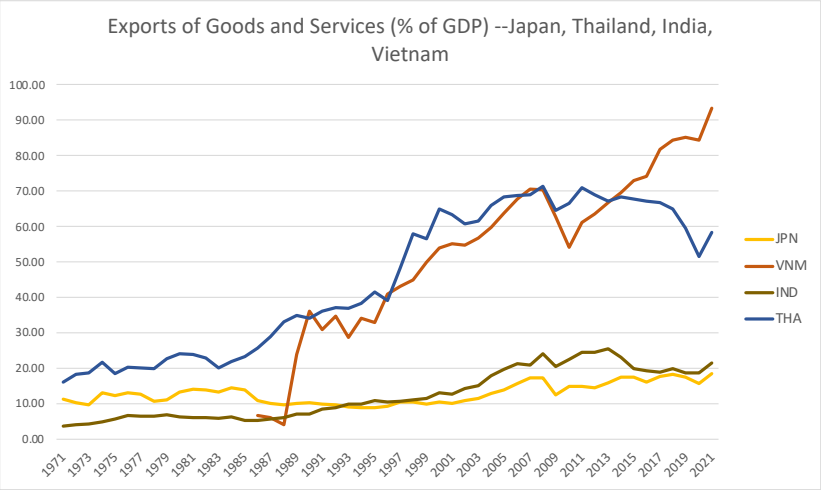


*Figure 8*[15]*: Exports of goods and services as a percentage of GDP.*

*(Japan, Thailand, India and Vietnam)*

Figure 8 suggests that exports became a more and more important role in neighboring Asian countries. Vietnam's economy has been gradually taken over by the export sector since 1980; India's export sector also steadily developed. Compared to these developing countries, Japan's exports take a relatively fixed portion of the economy. The increasing competitiveness in the international trade section might result in a decrease in Japan's exports and an increase in imports due to cheaper prices.

b. Exports changes over time

[15] Original Data from World Bank: https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?locations=JP-TH-IN-VN

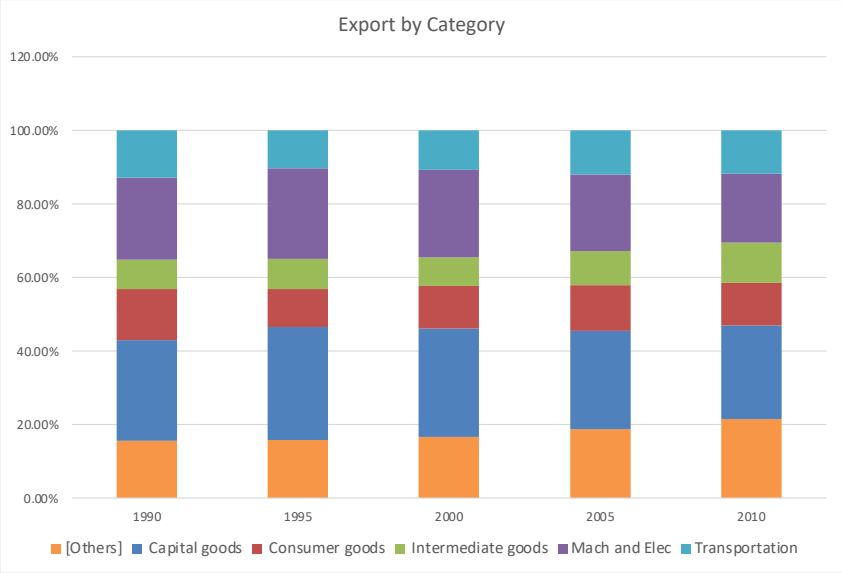


*Figure 9[16]: Japan's Export by Category*

The exports share of consumer goods, textiles, and clothing has experienced a decline, as illustrated in Figure 9. This downturn may be attributed to the raise of competitiveness from other nations, particularly those in Asia, as well as evolving consumer preferences in the global marketplace.

The export share of intermediate goods has seen an increase from 8.00% in 1990 to 10.96% in 2010, indicating Japan's export sector's shift from manufacturing to high-precision parts production. This growth may also be due to a surge in demand for Japanese components and parts across various industries, with the automotive and electronics sectors being particularly notable.

Japan's export share of machinery and electronics was considerably high during the 1990s and early 2000s, reflecting the country's competitive advantage in high-tech industries. The decrease in Japan's export share from 22.33% in 1990 to 18.76% in 2010 aligns with the literature review findings, which suggest that Japan

[16] Original Data: World Bank. Access: https://data.worldbank.org/indicator/NE.RSB.GNFS.CN?locations=JP

did not invest sufficiently in the early phases of its transition towards high-precision technology exports, especially in the semiconductor industry.

In conclusion, the fluctuations in export and import shares over time offer valuable insights into Japan's demographic changes and the rise of international competition. However, to establish causal relationships, further Granger causality tests should be conducted.

III. VAR Tests and Granger Causality Wald Tests

a. Period of 1988-2000

i. Stationary Check—Dicky-Fuller Test

The findings from the DF (Dickey-Fuller) test demonstrate that the real GDP growth exhibits stationarity. Consequently, it is required to obtain the first differences for the age dependency ratio, interest rate government expenditure, and balance of trade variables to make them stationary. Upon obtaining the first differences, the rest of the variables (government expenditure, balance of trade, demographic change and interest rates) over the period exhibit stationary characteristics.

Before the granger causality test, the stationary check is run for the entire VAR model with five variables, and the result shows that the VAR model satisfies the stability condition.

ii. Granger Causality Test Result

A VAR model was estimated using a sample of data from the first quarter of 1988 to the fourth quarter of 2000, which includes five variables: GDP growth rate, government spending, balance of trade, demographic changes, and

interest rates. The Granger causality Wald tests were performed pairwise for each combination of dependent variable and excluded variable. The null hypothesis for the Granger causality test is that the excluded variable does not Granger-cause the dependent variable.

Table 3.1: Granger causality Wald Test Result

| Granger causality Wald tests | | | | |
|---|---|---|---|---|
| **Equation** | **Excluded** | **chi2** | **df** | **Prob > chi2** |
| GDPGrowthRate | GovtSpending | 1.9537 | 2 | 0.377 |
| GDPGrowthRate | NetTrade | 5.1878 | 2 | 0.075* |
| GDPGrowthRate | DemographicChange | 11.614 | 2 | 0.003** |
| GDPGrowthRate | Interest Rate | 13.083 | 2 | 0.001** |
| GDPGrowthRate | All | 33.167 | 8 | 0.000 |

*p < 0.1, **p < 0.05, ***p < 0.01

The Granger causality Wald test indicates that the demographic change, net trade and the interest rate Granger-cause the slow GDP growth rate from 1988 to 2000 within the 10% confidence interval. Other relationships were not found to be statistically significant.

b. Period of 2001-2012

i. Stationary Check—Dicky-Fuller Test

The findings from the Dickey-Fuller (DF) test demonstrates that the real GDP growth exhibits stationarity. Consequently, it is required to obtain the first differences for the age dependency ratio, interest rate government expenditure, and balance of trade variables to make them stationary. Upon obtaining the first differences, the rest of the variables (government expenditure, balance of trade, demographic change and interest rates) over the period exhibit stationary characteristics.

Before the granger causality test, the stationary check is run for the entire VAR model with five variables, and the result shows that the VAR model satisfies the stability condition.

ii. Granger Causality Test Result

A VAR model was estimated using a sample of data from the first quarter of 1988 to the fourth quarter of 2000, which includes five variables: GDP growth rate, government spending, balance of trade, demographic changes, and interest rates. The Granger causality Wald tests were performed pairwise for each combination of dependent variable and excluded variable. The null hypothesis for the Granger causality test is that the excluded variable does not Granger-cause the dependent variable.

Table 3.2: Granger causality Wald Test Result

| Granger causality Wald tests | | | | |
|---|---|---|---|---|
| Equation | Excluded | chi2 | df | Prob > chi2 |
| GDPgrowthrate | DemographicChange | 1.5415 | 2 | 0.463 |
| GDPgrowthrate | Interest Rate | 2.139 | 2 | 0.343 |
| GDPgrowthrate | GovtSpending | 1.6588 | 2 | 0.436 |
| GDPgrowthrate | NetTrade | 5.0312 | 2 | 0.081* |
| GDPgrowthrate | ALL | 10.495 | 8 | 0.232 |

*p < 0.1, **p < 0.05, ***p < 0.01

The Granger causality Wald test indicates that the balance of trade Granger-cause the slow GDP growth rate from 2001 to 2012 within the 10% confidence level. Other relationships were not found to be statistically significant.

## IV. Conclusion

The collected data show that Japan faced a challenging economic situation from 1998 to 2012. In terms of monetary policy, Japan's interest rate kept close to zero that rendered the interest rate ineffective as an adjustment tool; in terms of fiscal policy, the

Japanese government's eagerness to address the government deficit led to the instability in the fiscal policy. In other words, Japanese governments reduced expenditures at the earliest indication of economic recovery and urgently compensated for the cuts when the situation unexpectedly worsened. The population kept aging, and the burden on the working population increased year by year. Last but not least, Japan's balance of trade decreased from positive to negative. A detailed data set shows that the decrease in the balance of trade is due to the increase in imports and the loss of competitiveness in the global market.

The Granger causality test results show a noticeable difference between the two periods in terms of relationships between various factors and the GDP growth rate. At the 10% confidence interval, we can infer that in the first period (1988-2000), demographic change, balance of trade, and interest rate were the factors that Granger-caused the low GDP growth rate. In the second period (2001-2012), we only observe a weak Granger causality relationship between the GDP growth rate and the balance of trade. This change in relationships suggests that the underlying dynamics between these factors and the GDP growth rate may have evolved between the two periods. However, the balance of trade appears to be a consistent variable that influences the real GDP growth rate, indicating that Japan's loss of competitiveness in the global market plays a role in Japan's long stagnation from 1988 to 2012.

It is surprising to observe that demographic change does not Granger-cause Japan's low growth rate in the second period, even as the age dependency ratio continues to rise, with the most significant growth occurring from 2001 onwards. A plausible explanation, from a statistical perspective, is that when we make the data stationary by

taking the first difference of the time-series variable, we lose some long-run trend information. Taking the difference of a time-series variable removes the linear trend present in the data, which means the upward trend of the age dependency ratio over decades is not revealed in the model. Therefore, the age dependency might have a long-term effect on Japan's low growth rate, but there is no causal effect in the short term (within the lag period). In addition to the statistical explanation, Figure 8 also shows that the output gap fluctuates with the capital input gap rather than the labor input gap. In other words, if we simplify Japan's output as the Cobb-Douglas production function[17] that only considers labor and capital as inputs, the capital input has a larger impact on the output level over this period. The reason why capital has a more significant impact on the output might be the development of automation. As automation technologies advance, capital investments in machinery and equipment become more critical for production processes, sometimes replacing or reducing the need for labor inputs. Within this context, when Japan's age dependency ratio increases and the workforce is shrinking, the overall output level may not necessarily decrease.

[17] The Cobb-Douglas production function is an economic model that represents the relationship between the output of a production process and the inputs used, specifically capital (K) and labor (L). Developed by Charles Cobb and Paul Douglas in 1928.

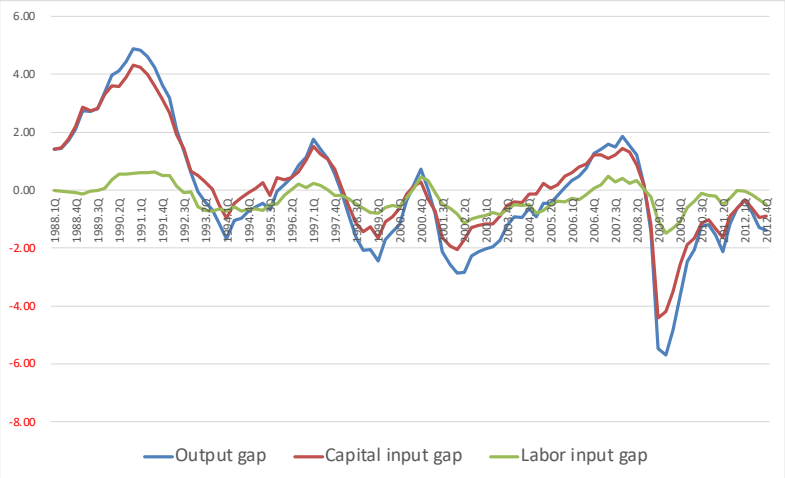


*Figure 10*[18]*: Japan's output gap, capital input gap, and labor input gap, 1988-2012.*

There is existing literature confirming the potential for sustainable growth in output level facing a declining population. Sasaki (2023) uses a growth model that incorporates automation capital and the findings suggest that per capita output can experience positive, constant growth if the saving rate is high. A higher saving rate means that more funds are available for investment in automation capital, which can increase the productivity of the labor force. As a result, a positive long-term growth rate of per capita output can be achieved even in the face of declining population, as long as the saving rate is high enough to offset the negative effects of population decline on labor force growth.

[18] Original Data: Bank of Japan Research Data. Access: https://www.boj.or.jp/en/research/research_data/gap/index.htm

## Chapter 4: Applications

1. Policy Suggestions on Japan's Stagnation

The balance of trade is statistically significant throughout both periods, which indicates the loss of international competitiveness as the primary driving factor behind Japan's slow economic growth. One of the reasons that Japan gradually lost competitiveness is the lack of investment in the semiconductor sector during the upgrading period in the late 1990s (Uno, 2022). The lack of investment in the semiconductor sector during a critical period highlights the importance of recognizing and prioritizing key industries to maintain competitiveness in the global market. During the economic recession, the investment should be made to enlarge future production, which was first proposed in Keynesian economics. However, adhering to the orthodox economic perspective on government spending, which states that expenditure arises from revenue, it becomes challenging to invest in large-scale projects during a period of slow growth. In this case, the government can consider introducing policies attracting foreign direct investment such as pursuing bilateral and multilateral trade agreements to open new markets for Japanese products and services. Facilitate foreign direct investment (FDI) by simplifying regulations and offering incentives to attract multinational corporations to invest in Japan. Although it might cause loss in the future, it can help Japan maintain a leading position. The bilateral and multilateral trade agreements will also alleviate the problem of rising international competition, turning rivals into partners and creating a win-win situation.

When the government has not taken action for years and the economy remains weak, rebuilding consumer confidence becomes increasingly difficult. In addition to a

prolonged struggle, Japan's unique cultural concept of “mono no aware” (物の哀れ) makes Japanese citizens more inclined to take a pessimistic view of the future. The other two significant factors obtained from the study, high age dependency ratio and the liquidity trap, are all related to the future expectation. As Krugman stated, the most crucial aspect when an economy enters a liquidity trap is to restore consumer confidence. Hyman Minsky also highlights the importance of consumer confidence in the economic recession. A pessimistic view on the future prevents not only an increasing birth rate from occurring, but also engenders a decline of consumption and investment from the private sector. Considering Japan’s situation, it is essential to maintain a stable expansionary fiscal policy and implement additional measures to rebuild consumer confidence, stimulate private sector consumption and investment, and address the demographic challenges. Some recommendations include: 1. Monetary policy and financial sector reform. The Bank of Japan should explore unconventional monetary policy tools, such as forward guidance and yield curve control, to counter the liquidity trap and boost economic growth. Additionally, strengthening the financial sector's stability and resilience can help restore investor and consumer confidence. 2. Enhancing the social safety net. Strengthen social safety programs, such as unemployment benefits and income support, to alleviate the financial burden on households, especially for the elderly and those with low incomes. This can contribute to a more optimistic outlook and encourage spending. 3. Public awareness campaigns. Launch public awareness campaigns that emphasize the potential for economic growth, resilience, and a brighter future. This can help counter the prevailing pessimistic view and encourage more optimistic expectations among the Japanese population. By adopting these measures,

Japan can work towards rebuilding consumer confidence, addressing demographic challenges, and fostering a more optimistic view of the future, ultimately leading to sustainable economic growth.

2. What to Take from Japan's Stagnation

Learning from Japan's experience is essential, particularly given its status as the world's third-largest economy by nominal GDP. Japan has been a crucial player in international trade and investment, technological advancements, and innovation. Its economic policies, successes, and challenges have far-reaching implications for the global economic landscape. Studying Japan's economic history, including its periods of rapid growth and stagnation, provides valuable insights into the dynamics of economic development, the role of effective policy interventions, and the importance of maintaining competitiveness in key industries.

Capitalistic economies should learn from Japan's experience and ensure the identification and prioritization of key industries that drive economic growth and maintain international competitiveness. For example, a nation with a strong technology sector should focus on investing in research and development, infrastructure, and education to sustain its competitive edge in the global market. In the case of Japan, a lack of investment in the semiconductor sector during a critical period led to a decline in competitiveness, which serves as a cautionary tale for other economies. Governments should also maintain stable expansionary fiscal policies to stimulate private sector consumption and investment and address demographic challenges when facing a continuous downturn in growth. Ultimately, the goal is to restore consumer confidence and promote consumption and investment.

## Conclusion

The findings of the research reveal that during the first period (1988-2000), demographic changes, net trade and interest rates Granger caused the low growth rate, suggesting that an aging population combined with ineffective monetary policy and a decreasing balance of trade played a critical role in shaping Japan's low growth rate. In the second period (2001-2012), net trade emerged as the primary factor Granger caused the low growth rate, highlighting the increasing importance of international competition in the context of a globalizing economy. The balance of trade appears to be the all-way-through factor in these two periods. In addition to the Granger causality test result, the data collected shows that Japan was facing an unfavorable economic condition with an aging population, ineffective government policies, and diminishing international competitiveness in the global market.

The initial assumption of this paper concerning the Lost Decade, positing that inefficient policies contributed to the low growth rate of Japan from 1988 to 2000, is inconclusive. Confronted with issues such as an aging population and diminished international competitiveness, the effectiveness of monetary and fiscal policies is limited. The assumption regarding the period from 2001 to 2010, which proposes that the loss of international competitiveness decelerates the economic growth rate, is validated by the second VAR model.

From the analysis we suggest, not only to the Japanese government, but also other economies, to encourage investment in key industries especially during a recession. Additionally, rebuilding consumer confidence is crucial; this can be achieved through unconventional monetary policies, strengthening social safety net programs, and launching public awareness campaigns.

In conclusion, this study offers another way of analysis of the factors contributing to Japan's Lost Decade through the application of a Vector Autoregression (VAR) model to two distinct periods: 1988-2000 and 2001-2012. The findings reveal that demographic changes, net trade, and interest rates were critical drivers of Japan's low growth rate during the first period, while net trade, with its increased significance in a globalizing economy, emerged as the primary factor affecting growth during the second period. The balance of trade was identified as a consistent factor across both periods. The implications of this study extend beyond Japan, as the insights gained from this analysis may be useful for other advanced economies facing similar challenges, such as aging populations, liquidity traps, high government debt, and increasing international competition. By understanding the complex interactions between demographic, policy, and international factors, policymakers and academics can better address and potentially mitigate the risks associated with periods of prolonged economic stagnation.

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## Data Source

Annual GDP growth rate of Japan:

https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=JP

Quarterly GDP growth rate of Japan from 1988.01.01 to 1994.04.1:

https://tradingeconomics.com/japan/gdp-growth

Quarterly GDP growth rate of Japan from 1994.04.01 to 2012.10.1:

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Annual **government spending as a percentage of GDP** of Japan:

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Quarterly government spending of Japan from 1988.01.01 to 1994.04.1:

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Annual **interest rate** of Japan: Author's Calculation

Quarterly interest rate of Japan: https://fred.stlouisfed.org/series/IR3TCD01JPQ156N

Monthly interest rate of Japan https://www.stat-search.boj.or.jp/ssi/mtshtml/ir01_m_1_en.html

Annual **Age Dependency Ratio** of Japan:

https://data.worldbank.org/indicator/SP.POP.DPND?locations=JP

Quarterly Age Dependency Ratio of Japan: Author's calculation.

Formula: $\frac{Total\ population - working\ age\ population}{working\ age\ population} \times 100\%$

Quarterly working age (15-64) population:

https://fred.stlouisfed.org/series/LFWA64TTJPQ647S

Annual **Balance of Trade** of Japan:

https://data.worldbank.org/indicator/NE.RSB.GNFS.CN?locations=JP

Quarterly Balance of Trade of Japan:

https://fred.stlouisfed.org/series/XTNTVA01JPQ664S

## Appendix 1: VAR Model Data

| | Real GDP Growth (%) | Interest Rate (%) | Age Dependency Ratio (%) | Balance of Trade | Government Spending ( % of GDP) |
|---|---|---|---|---|---|
| 1988 | 6.8 | 2.5 | 44.48 | 7.7306E+12 | 29.81 |
| 1989 | 4.9 | 3.17 | 43.84 | 5.697E+12 | 29.12 |
| 1990 | 4.9 | 5.4 | 43.42 | 3.5265E+12 | 29.36 |
| 1991 | 3.4 | 5.625 | 43.25 | 7.2381E+12 | 29.22 |
| 1992 | 0.8 | 3.69 | 43.27 | 1.01765E+13 | 30.24 |
| 1993 | -0.5 | 2.3125 | 43.38 | 1.06171E+13 | 32.08 |
| 1994 | 0.9 | 1.75 | 43.62 | 9.5508E+12 | 32.78 |
| 1995 | 2.6 | 1.02 | 44.00 | 6.4828E+12 | 33.40 |
| 1996 | 3.1 | 0.5 | 44.53 | 2.0224E+12 | 33.81 |
| 1997 | 1 | 0.5 | 45.21 | 5.3478E+12 | 33.08 |
| 1998 | -1.3 | 0.5 | 45.92 | 9.3588E+12 | 38.63 |
| 1999 | -0.3 | 0.5 | 46.64 | 7.8442E+12 | 35.57 |
| 2000 | 2.8 | 0.5 | 47.44 | 7.3064E+12 | 35.95 |
| 2001 | 0.4 | 0.23 | 48.41 | 3.158E+12 | 35.19 |
| 2002 | 0 | 0.1 | 49.41 | 6.6282E+12 | 35.39 |
| 2003 | 1.5 | 0.1 | 50.27 | 8.4122E+12 | 35.04 |
| 2004 | 2.2 | 0.1 | 51.09 | 1.01019E+13 | 33.68 |
| 2005 | 1.8 | 0.1 | 52.09 | 7.465E+12 | 33.52 |
| 2006 | 1.4 | 0.3 | 53.39 | 6.9485E+12 | 33.06 |
| 2007 | 1.5 | 0.72 | 54.81 | 9.5004E+12 | 33.12 |
| 2008 | -1.2 | 0.67 | 56.18 | 1.8031E+12 | 34.11 |
| 2009 | -5.7 | 0.3 | 57.39 | 2.2221E+12 | 38.69 |
| 2010 | 4.1 | 0.3 | 58.23 | 6.7667E+12 | 37.74 |
| 2011 | 0 | 0.3 | 58.95 | -3.2137E+12 | 38.63 |
| 2012 | 1.4 | 0.3 | 60.39 | -8.2146E+12 | 38.64 |

## Appendix 2: Import over time data

| Product Group | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|
| Total (in $US, 000) | 457200232 | 662473827 | 753833575 | 1023704865 | 1376046934 |
| Capital goods | 7.69% | 10.04% | 13.30% | 12.30% | 10.85% |
| Consumer goods | 11.53% | 14.48% | 15.41% | 15.07% | 15.73% |
| Intermediate goods | 11.47% | 10.41% | 7.90% | 7.63% | 7.56% |
| Raw materials | 17.96% | 14.33% | 13.02% | 14.61% | 15.42% |
| Animal | 3.46% | 3.92% | 2.95% | 2.09% | 1.63% |
| Chemicals | 3.07% | 3.38% | 3.12% | 3.26% | 3.89% |
| Food Products | 1.76% | 2.19% | 1.91% | 1.79% | 1.65% |
| Footwear | 0.39% | 0.55% | 0.48% | 0.42% | 0.42% |
| Fuels | 12.42% | 8.14% | 10.28% | 13.00% | 14.47% |
| Hides and Skins | 0.82% | 0.67% | 0.55% | 0.49% | 0.41% |
| Mach and Elec | 5.44% | 9.10% | 12.25% | 11.10% | 10.34% |
| Metals | 3.51% | 2.99% | 2.15% | 2.52% | 2.40% |
| Minerals | 2.08% | 1.44% | 1.12% | 1.56% | 2.48% |
| Miscellaneous | 3.66% | 3.56% | 4.09% | 4.13% | 3.66% |
| Plastic or Rubber | 0.84% | 0.95% | 0.99% | 1.15% | 1.32% |
| Stone and Glass | 2.58% | 1.89% | 1.39% | 1.22% | 1.19% |
| Textiles and Clothing | 3.08% | 3.83% | 3.23% | 2.69% | 2.38% |
| Transportation | 2.48% | 2.40% | 1.82% | 1.86% | 1.42% |
| Vegetable | 2.61% | 2.39% | 1.85% | 1.56% | 1.57% |
| Wood | 3.18% | 3.33% | 2.19% | 1.56% | 1.22% |
| | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |

*Original Source: Word Integrated Trade Solution by World Bank.*

*https://wits.worldbank.org/CountryProfile/en/Country/JPN/StartYear/1988/EndYear/2012/TradeFlow/Import/Indicator/MPRT-TRD-VL/Partner/WLD/Product/all-groups*

**This table is calculated by author*

## Appendix 3: Export over time data

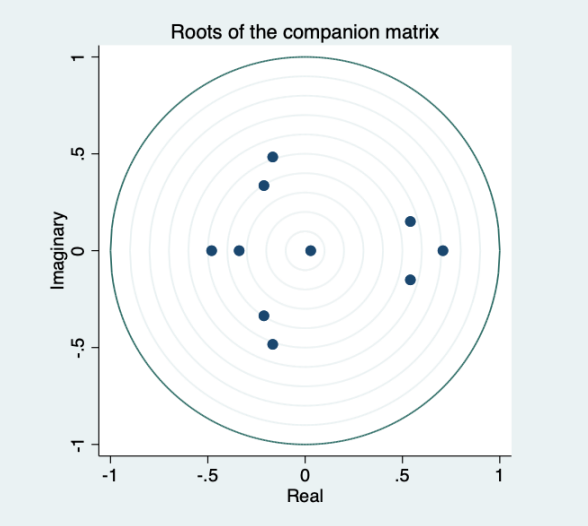
| Product Group | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|
| Capital goods | 27.45% | 30.70% | 29.46% | 26.73% | 25.47% |
| Consumer goods | 13.88% | 10.32% | 11.51% | 12.43% | 11.59% |
| Intermediate goods | 8.00% | 8.17% | 7.89% | 9.23% | 10.96% |
| Raw materials | 0.20% | 0.18% | 0.25% | 0.49% | 0.65% |
| Animal | 0.07% | 0.05% | 0.06% | 0.08% | 0.10% |
| Chemicals | 2.52% | 2.96% | 3.13% | 3.62% | 3.79% |
| Food Products | 0.19% | 0.17% | 0.15% | 0.15% | 0.19% |
| Footwear | 0.03% | 0.02% | 0.02% | 0.01% | 0.01% |
| Fuels | 0.22% | 0.29% | 0.16% | 0.38% | 0.87% |
| Hides and Skins | 0.07% | 0.04% | 0.02% | 0.02% | 0.02% |
| Mach and Elec | 22.33% | 24.54% | 23.61% | 20.78% | 18.76% |
| Metals | 3.45% | 3.31% | 2.84% | 3.93% | 4.70% |
| Minerals | 0.07% | 0.09% | 0.04% | 0.05% | 0.06% |
| Miscellaneous | 4.78% | 4.91% | 6.25% | 5.99% | 5.82% |
| Plastic or Rubber | 1.60% | 1.81% | 1.84% | 2.24% | 2.81% |
| Stone and Glass | 0.64% | 0.68% | 0.74% | 0.81% | 1.46% |
| Textiles and Clothing | 1.24% | 0.99% | 0.87% | 0.69% | 0.57% |
| Transportation | 12.73% | 10.38% | 10.78% | 12.01% | 11.74% |
| Vegetable | 0.08% | 0.05% | 0.04% | 0.04% | 0.05% |
| Wood | 0.46% | 0.36% | 0.34% | 0.32% | 0.37% |
| Total | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |

*Original Source: Word Integrated Trade Solution by World Bank.*

*https://wits.worldbank.org/CountryProfile/en/Country/JPN/StartYear/1988/EndYear/2012/TradeFlow/Export/Indicator/XPRT-TRD-VL/Partner/WLD/Product/all-groups*

**This table is calculated by author.*

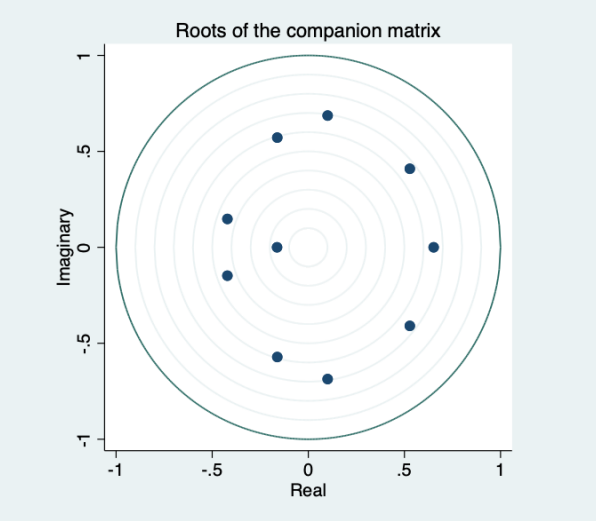
## Appendix 4.1: Stability test result of VAR models (1988-2000)




*All the eigenvalues lie inside the unit circle.*

*VAR satisfies stability condition.*

**Appendix 4.2: Stability test result of VAR models (2001-2012)**




*All the eigenvalues lie inside the unit circle.*

*VAR satisfies stability condition.*

**Appendix 5.1: Stata code of period 1988-2000**

```
*import data from period 1988-2000
clear
```

```
import excel "/Users/mingchesun/Desktop/Fred Data.xlsx", sheet("1988-2000") firstrow clear

*generate and set the time variable
gen time =_n
tsset time

*DF test for stability
dfuller GDPGrowthRate
dfuller GovtSpending
dfuller NetTrade
dfuller AgeDep
dfuller InterestRate

*obtain the first differences of the non-stationary variables
gen DGovtSpent=d.GovtSpending
gen DBOT=d.NetTrade
gen Ddemographic=d.AgeDep
gen DInt=d.InterestRate

*DF test for stability
dfuller DGovtSpent
dfuller DBOT
dfuller Ddemographic
dfuller DInt

*Vector Autoregression Test
var GDPGrowthRate DGovtSpent DBOT Ddemographic DInt

*stationary check for the VAR model
varstable, graph

*granger causulity test
Vargranger

*import data from period 1988-2000
```

**Appendix 5.2: Stata code of period 2001-2012**

```
*import data from period 2001-2012
clear
import excel "/Users/mingchesun/Desktop/Fred Data.xlsx", sheet("2001-2012") firstrow

*generate and set the time variable
gen time =_n
tsset time

*make balance of trade in billions
```

```
gen BOT= NetTrade/1000000000000

*DF test
dfuller GDPgrowthrate
dfuller AgeDependency
dfuller InterestRate
dfuller GovtSpendingbillionYen
dfuller BOT

*obtain the first differences of the non-stationary variables
gen Ddemographic=d.AgeDependency
gen DInt=d.InterestRate
gen DGovtSpent=d.GovtSpendingbillionYen
gen DBot=d.BOT

*DF test
dfuller Ddemographic
dfuller DInt
dfuller DGovtSpent
dfuller DBot

*Vector Autoregression Test
var GDPgrowthrate Ddemographic DInt DGovtSpent DBot

*stability check for the VAR model
varstable

*granger causulity test
vargranger
```