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(JESNA)

THE JOURNAL OF ECONOMETRIC STUDY OF NORTHEAST ASIA is interested primarily in publishing articles on econometric analysis of the Northeast Asian region(s), or related regions, including various types of modeling, econometric studies, and the development of a body of data, such as for national accounts, input-output tables, flow-of –funds accounts, and various indices of prices and quantities, etc.

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Paying a Tribute to the Memory of Prof. Lawrence R. Klein (Nobel Prize Laureate Economist); Honorary Editor-in-Chief of JESNA: Prof. Klein and North-East Asia

Editor-in-Chief, Shuntaro Shishido

We have been noti ed that Prof. Lawrence Klein, Emeritus Professor of the University of Pennsylvania, who served as an honorary Editor-in-chief for this journal, died at the age of 93 on October 20, 2013. It was a great loss worldwide for intellectuals, particularly for economists, and people in economic and political elds. Prof. Klein was not only a promoter, but also a founder and creator of the econometric model in economics.

It was his great achievement that enlightened people all over the world that economic measures are not simply the work of politicians, but succeed only when a model of econometrics is applied as a scienti c instrument.

Due to efforts made by the Professor and his followers, we learned that for people to be free from poverty, and for the purpose of logical allocation as well as development of national resources, the model of econometrics is an indispensable instrument.

In the autumn of 1999, Prof. Klein was invited to the North-East Asian International Conference in Niigata sponsored by ERINA (Economic Research Institute for Northeast Asia). In the conference he emphasized how important it was for regional peace and economic development to develop the economy of North-East Asia. To realize this he insisted on the importance of carrying out international studies, leaving a deep impression on people.

This journal, JESNA, was rst published to commemorate the Professor’s visit and accepting a position as its honorary committee chairman. Since then he had strongly supported JESNA’s publishing activities.

In retrospect, the life of Prof. Klein made outstanding contributions in the elds of developing and extending econometric models, particularly in terms of policy application, in the elds of academic services and practical cooperation. From short term economic up to medium and long-term analysis, as well as economic forecasting and simulation analysis of specially designated areas, and furthermore, as the focus for models of multi-national world and policy analysis, the Professor devoted the latter half of his life to international cooperation with the United Nations.

On the other hand while Prof. Klein had been particularly interested in the Japanese economy, he developed, in the 1960s, together with Prof. Shinichi Ichimura’s group at Osaka University, a quarterly macro-economic model of Japan for the rst and the largest scale.

In addition, he also developed several macro-models of Japanese economy including demographic growth since the Meiji period, and macro-metric models of various types of Japanese economy.

In his proposal for Japan’s macro-economic policies of the Japan-US relationship early in the 1970s, he proposed a policy program of “connective locomotives by the three countries of Japan, US and Germany", and in the latter half of the 1980s, he offered many valuable proposals to Japan's policymaking authorities, such as participating in a joint proposal for 430 trillion yen public investment in 10 years, out of his concern that Japan might have to plunge into deflation after the collapse of the bubble economy, and also recently setting up a growth goal for Japan to escape from deflationary trend, a proposal for 4% growth of real GDP.

At the same time, while arguments over the American economy were important, in an interpretation of global inflation after the worldwide oil shock in the 1970s, monetarists from anti-Keynesian groups considered the importance of the money supply, and challenged his interpretation. Prof. Klein and his followers fought back against them by applying the theory of import cost-push inflation, thereby prevailing over their opponents. Also, despite criticism of the inflationary tendency of macro-models, the Professor and his followers emphasized the neutrality of the macro-econometric-model, in dealing with counter-cyclical polity and his counter argument also prevailed.

On the other hand, regarding the over-emphasis of demand side in the macro-models, the mainstream of macro-metric model economists with the Professor as its nucleus refuted all sorts of criticism, and even introduced the role and operation of IT based on production function, leading to endogenizing of the floating exchange rate which resulted in the self-destruction of monetarist opponents. It was Prof. Klein's real value that he always came up with counter-arguments as well as constructive proposals through both theories and empirical evidences.

Research groups related to JESNA, following Prof. Klein's philosophy that sound economic development is achievable only through the mutual understanding and cooperation of North-East Asian countries, hereby undertake to make further efforts, and we all sincerely pray for the soul of the departed Prof. Klein.

Game Theoretical Simulations of the Exchange Rate Policy Using a Global Macroeconometric Model

Taiyo Ozaki*

Abstract

We examined the impacts of the exchange rate policy on GDP under the game theoretical framework which implies a single-player case, a cooperative case and a Nash case. Against the commonly accepted story that the coordination can always yield gains, we found that the optimal exchange rate policy differs by game type and the characteristics of the economy, especially how the country depends on the trade.

The magnitude of the adjustment of the exchange rate is in the following order;

[Nash case > cooperative case > single-player case].

Although the Nash case may require the largest adjustment costs in many economies, it does not necessarily mean that the contribution to the world economy of the Nash game should be less than that of the cooperative adjustment because it boosts the US economy most, which is linked to EU growth and has the dominant part of the world economy.

The effects boosting the exports through the depreciation of the currency vary from nations and types of the game. Chinese economy has the largest effects if she could act as a single-player. A competitive exchange rate adjustment, the Nash game, will bene t the US economy most, whereas Japan prefers the modest cooperative game.

KEYWORDS: new Keynesian model, global macroeconometric model, game theoretical simulation, exchange rate policy

JEL classi cation: E47, E62

1. Introduction

In September 2008, the Lehman crisis occurred, followed by a steep recession lasting for several years. During such periods, if major countries try to reset their exchange rate policies to compensate for the declining economy, what type of global adjustment of the exchange rate is desirable? We examined the characteristics of the exchange rate schemes through a game theoretical framework using the actual global macroeconometric model.

Using the optimal control techniques, we tested the impacts under such game types as the competitive Nash and the cooperative and single player cases. The model used herein is a small new Keynesian global macroeconometric model, which involves 4 countries and one aggregated area, namely, China, Japan, Korea, the US, and the Euro zone, and includes almost 240 equations with forward expectation partly and bilateral trade models.

Dynamic optimization technics and game theoretical simulations, especially the case

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of dynamic iterative/sequential games are well matched technically in calculating DP problem and evaluating loss functions or pay-off matrices to reach the equilibrium conditions.

Preceding researches which deal with the empirical analysis in this area are rather few and can be found, for example, in Kawai (1993), Frey (2006), Wu (2004), McNeil and Asilis (2002) and Henry (1998), etc..

Kawai (1993) argued that international coordination of regime choice might be necessary to ensure optimal outcomes of the world, using the small two-country model. Frey (2006) analysed the conditions under which coordination/non-coordination is attractive to a country using an experimental model. He insists that results depend on the relative sizes of the country and the large country always has a preference for policy coordination with the small country. Wu (2004) tried to nd the optimal strategy among two different authorities in Singapore that is, National Wage Council and the Monetary Authority. His result is almost same as the previous ones that the Nash-rule equilibrium is unstable and the non-Nash rule becomes more meaningful. These results are all coming from static experimental models and assert the coordination may bene t the welfare, however, as we show later, the coordination does not always yield the optimal solution in reality.

Meanwhile, an unique analysis that makes use of a linear quadratic control method is the case of McNeils and Asilis (2002), in which they treat with the macroeconomic policy games between France, Germany, Italy and Spain. In this paper they argue that the non-cooperative use of broad money targets brings signi cant welfare gains comparing to the cooperative exchange rate targets. Our analysis has a similar technical framework to this approach, however, of course, aims and the econometric model used herein are quite different.

2. Methodology of the optimal control and the game

2.1 Loss function

When policy-makers attempt to achieve certain targets, such as GDP growth, in ation rate, and unemployment rate, how should policy instruments be managed? There may be several sets of objectives and instruments. We de ne the basic control problems by minimising the following loss function:

$$\min_{I_t} \sum_{t=1} \left(y_t - y_t^*\right)' w_t \left(y_t - y_t^*\right)$$
$$st.$$
$$f\left(y_t,\, x_t\,,\, I_t\,;\, \theta\right) = 0 \qquad (1)$$

where y is a vector of objective variables and y^* is a vector of strategic targets, which is a subset of endogenous variables. w is a weight matrix, and I is the set of instrument/control variables as a subset of exogenous variables x . The optimal control solution can be obtained iteratively as a function of *y* , $I=(y,x;\theta)$.

Several cases may exist, the most simple of which is the case with one target and one corresponding instrument/control. This situation is a “single-player game”. However, in many cases, there may be more than one policy-maker trying to pursue each goal. If the objectives are combined into one target through negotiation and coordination, the optimal policy for each player will be assigned to maximise/minimize the joint loss function. This case is called a “cooperative game”. We should note that a solution in this case does not always converge uniquely because the rank condition is not satis ed in general. If an agent tries to forestall the plans of his or her opponents, the agent should alter the moves repeatedly when the condition is changed under uncertainty. This case can be called a “Nash game”.

Later, we offer actual applications of the single-player, cooperative, and Nash games regarding the exchange rate policy regime.

In reality, the loss function could be rewritten to involve a dumping or penalising factor to suppress the time-inconsistent policy uctuations.

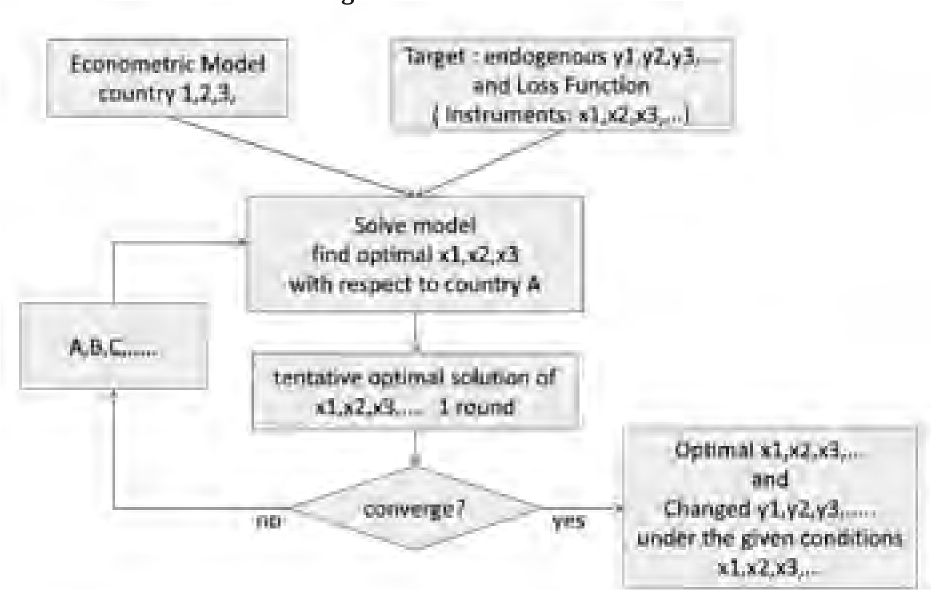
$$\min_{I_t} \sum_{t=1} \left[\left(y_t - y_t^* \right)' w_t \left(y_t - y_t^* \right) + \lambda_t \left(I_t - I_{t-1} \right)' \left(I_t - I_{t-1} \right) \right] \qquad (2)$$

where, I_t is a vector of instruments.

2.2 Flow of the game

Flow of the game is quite same for all types of games except the de nition of the loss function and a set of instruments. Each player begins with the initial settings and solves the DP problem simultaneously to evaluate the loss function at the rst step, and carries iteratively alternation until converging.

Figure 1 Flow of the Game



2.3 Calculation method

A general form of the nonlinear model is as follows,

$$f_i\left(y_t,\cdots,y_{t-p},x_t,\,u_t\;;\theta\right)=0,\;t=1,\cdots,T\;, \tag{3}$$

and we obtain the solution using iteratively numerical method that is $\min_i\left|y_{it}^s-y_{it}^{s-1}\right|\leq\varepsilon$

To solve this, we used *Newton's Method* which uses 1st derivatives of the model, in which we consider the Taylor expansion around the point $y = y$

$$f_i\left(\overline{y}_t,\cdots,y_{t-p},x_t,u_t\,;\theta\right)+\frac{\partial f_i}{\partial y_t'}f_i\left(y_t-\overline{y}_t\right)=0 \tag{4}$$

Using the *Jacobian matrix* following

$$J_t=\frac{\partial f_i}{\partial y_t'}=\begin{pmatrix}\frac{\partial f_1}{\partial y_{it}} & \cdots & \frac{\partial f_1}{\partial y_{nt}}\\ \vdots & \ddots & \vdots\\ \frac{\partial f_n}{\partial y_{it}} & \cdots & \frac{\partial f_n}{\partial y_{nt}}\end{pmatrix}, \tag{5}$$

We calculate the s-th solution $y_{it}^s\;s=1,\ldots,S$ iteratively until converging to the certain ε,

$$y_{it}^s=\overline{y}_{it}^{s-1}-J_{s-1}^{-1}f\left(y_{it}^{s-1},\ldots\right) \tag{6}$$

If the model contains forward looking variables, the formulation above may change. The expectation at time $t + k$ is

$$y_{t+k|t-1}^e=E\left(y_{t+k}\,|\,\Omega_{t-1}\right) \tag{7}$$

$$y_{t+k}=y_{t+k|t-1}^e+\varepsilon_{t+k} \tag{8}$$

If we assume $E\left(\varepsilon_{t+k}\right)=0$, then we obtain a simple 'model consistent' estimates of future values $y_{t+k}=y_{t+k|t-1}^e$.

We reset the nonlinear model with 1 period lead time to be,

$$f_i\left(y_t,y_{it+1|t-1}^e,y_{t-1},x_t,\,u_t\;;\theta\right)=0 \tag{9}$$

The expectation is replaced to the actual value in reality, and can be rewritten as follows,

$$f_i\left(y_t,y_{it+1},y_{t-1},x_t,\,u_t\;;\theta\right)=0 \tag{10}$$

The difference equation system can be interpreted as the simultaneous equation system having $n \times T$ stacked variables.

$$\begin{cases} f_i\left(y_{i1}, y_{i2}, y_{i0}, x_1, u_1 \;;\theta\right) = 0 \\ f_i\left(y_{i2}, y_{i3}, y_{i1}, x_2, u_2 \;;\theta\right) = 0 \\ \cdots \\ f_i\left(y_{iT}, y_{iT+1}, y_{iT-1}, x_T, u_T \;;\theta\right) = 0 \end{cases} \tag{11}$$

$$i = 1,\ldots,n \quad t = 1,\ldots,T$$

For solving the stacked system with 1-period lag and lead for example, we expand the *Jacobian matrix* to have block tri-diagonal elements

$$J_t = \frac{\partial f}{\partial y_t'}, \quad F_t = \frac{\partial f}{\partial y_{t+1}'}, \quad B_t = \frac{\partial f}{\partial y_{t-1}'}, \tag{12}$$

$$J = \begin{pmatrix} J_1 & F_1 & & 0 \\ B_2 & \ddots & \ddots & \\ & \ddots & \ddots & F_{T-1} \\ 0 & & B_T & J_T \end{pmatrix} \tag{13}$$

The *Newton method* can be also applied for the solution of the model.

To calculate these system we set the terminal conditions as $y_{i,T+j} = y_{i,T}$ which are outside the solution period. Though the terminal conditions are somehow arbitrary, solutions re ect the structures of the equilibrium which the error correction term involves.

The technical assistance can be obtained from Salemi (2006), and Fair (2003). The software (a model solver) used here is “Winsolve 4.0”, developed by Pierse (2007) at Surrey University, which may be the only software that can handle the optimal control problem with multi-targets and multi-instruments, in which the large nonlinear econometric model with forward looking variables is available.

3. Small global model

3.1 Integration of short-term demand shocks and long-term equilibrium

Recent macro models have similar features that integrate short-time Keynesian dynamics with long-term neo-classical supply-side equilibrium, such as the OECD’s new global model (Kaline Herve, Nigel Pain et.al., 2011) or that used by Henry and Pagan (2004).

The presence of nominal rigidities in wage and price settings serves to slow the process of adjusting to external events such that the output is largely demand-driven in the short term but supply-driven in the long term.

3.2 Flexible bilateral trade model

We adopted a bilateral trade model that includes not only the income/price effects between two countries but also the indirect substitution or complementary effects of a third country. To carry out this end in the plain forms, we estimated the “share in nominal dollars” $s_{ij} = T_{ij} / M_j$ of the trading partners derived from the translog cost function instead of adopting a conventional trade model, in which the total cost is, in this case, the nominal total imports.

3.3 Econometric features

An important characteristic of this model is the use of an ECM (error correction model) formulation that complies with both long-term equilibrium and short-term shocks, with the error correction term denoting the long-term equilibrium relation between key variables that represents the co-integration process, and other explanatory variables represent a variety of shocks.

Although a forward-looking formulation is not necessarily required, the model usually contains the model-consistent expectations Ey_{t+j}.

3.4 Key equations

We propose a New Keynesian macroeconometric model composed of the following key behavioural equations.

$$C\left(y,r,\pi,wf\right)+I\left(y,r,\pi\right)+G+X-M=y \tag{14}$$

$$y^{*}=f\left(L,K\right) \tag{15}$$

$$T_{ij}/M_j=f\left(y_j,p_i/p_j,\ldots,p_k/p_j\right),\ X_i=\sum_j T_{ij},\ M_j=\sum_i T_{ij} \tag{16}$$

$$\pi=f\left(E\pi_{t+1},\ y-y^{*}\right) \tag{17}$$

$$r=f\left(r_{t-1},\ \pi-E\pi_{t+1},\ y-y^{*}\right) \tag{18}$$

$$L=f\left(y,\ w/p\right) \tag{19}$$

$$p_{IF}=f\left(w,\ p_M,\ p\right) \tag{20}$$

$$p_C=f\left(w,\ p_{IF},\ p\right) \tag{21}$$

where C is real consumption, I is real fixed investment, G is real government expenditures, X is real exports, M is real imports, y is real GDP, y^* is potential GDP, wf is financial wealth, π is inflation rate, r is long-term interest rate, L is number of employees, w is wage rate, K is capital stock, p is implicit GDP deflator, Pc is CPI, P_{IF} is fixed investment deflator or PPI, P_X is export price (exogenous), and P_M is import price.

In reality, the model has almost 240 equations, including 5 countries/areas: China Japan, Korea, the US and the EU. Its sample period is from 1990Q1 to 2010Q4. For this study, the exchange rate is treated as exogenous and the key instrument. Details are described in Ozaki (2013).

3.5 Interdependence between countries

We show the main characteristics of the model to make clear how the interdependence between countries operates. First, taking the diffusion of the economic impacts to the other countries through the overall fiscal multiplier, average of own multipliers of the US, Japan and China range from 1.25 to 1.35 and the US has significant effects on Japan and China, which have multipliers of 0.12 and 0.61 respectively. However, interdependent relations are quite asymmetric. The trends in the Chinese economy have potentially a great influence on world markets, but at this moment, the effects on the GDP of developed countries are rather small and limited. The Korean economy is integrated greatly with China through the supply chain of intermediate goods and has become to complement the Chinese economy.

Interdependence may vary due to the estimated parameters of the structural equations. The following tables show the partial elasticity of the relative price combinations and the elasticity of GDP regarding imports of China, Japan and the US. The trade function includes both effects of bi-lateral and third-country relations, for example, a rise in the export price of Japan will cause the slowdown of imports of China from Japan followed by various changes in third-country relations such as increase of imports from Korea and EU, and so on.

So Table 2 also presents the complement and/or substitute relation between countries. A rise in export prices of China, for example, results in a reduction in China's exports, which will simultaneously cause a reduction in Korea's exports. Therefore, China and Korea can be said to "complements" each other, on the other hand, a decline in US exports will lead to an increase in the exports of all other nations/area, which indicates that these countries are "substitutes". Documents are partly quoted from Ozaki (2013).

Table 1 International Diffusion of Fiscal Shock

	US	Japan	EU	China	Korea
US expansion	1.28	0.12	0.01	0.61	0.31
Japan	0.01	1.25	0.00	0.26	0.10
EU	0.01	0.06	1.59	0.19	0.13
China	0.01	0.02	0.00	1.35	0.18
Korea	0.00	0.01	0.00	0.03	1.46

(*) effects on other countries by 1% expansion of GDPV at the 1st year average(%)

Table 2 Partial Elasticity of the Trade Share of Relative Prices and GDP

(Imports of China)

1% rise in export price of ...	JP→CN	US→CN	KR→CN	EU→CN
Yen (JP)	−0.05	+0.02	+0.14	+0.25
Dollar (US)	+0.18	−0.15	+0.41	+0.31
Won (KR)	−0.01	−0.14	−0.13	−0.59
Euro (EU)	+0.01	+0.09	−0.08	−0.07
Elasticity of GDP of China	0.39	0.38	0.82	0.08

(Imports of Japan)

1% rise in export price of ...	CN→JP	US→JP	KR→JP	EU→JP
RMB (CN)	−0.31	+0.33	−1.23	+0.17
Dollar (US)	+1.71	−0.81	+0.13	+0.28
Won (KR)	−1.34	+1.07	−0.21	+0.04
Euro (EU)	+0.29	+0.57	+0.25	−0.02
Elasticity of GDP of Japan	1.77	0.15	0.40	0.05

(Imports of the US)

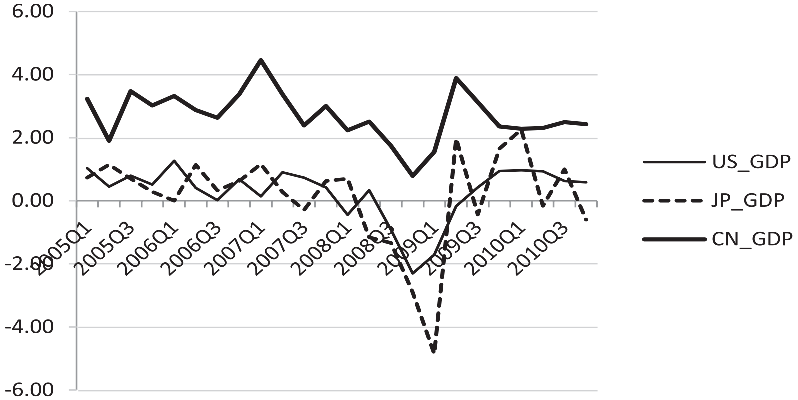
1% rise in export price of ...	CN→US	JP→US	KR→US	EU→US
RMB (CN)	−0.20	+0.18	−0.24	−0.89
Yen (JP)	+0.78	−0.65	+0.78	+0.12
Won (KR)	+1.13	+0.42	−0.34	−0.22
Euro (EU)	−0.25	+0.16	+0.06	−0.04
Elasticity of GDP of USA	0.28	1.56	1.47	0.10

4. Game theoretical simulation analyses

4.1 Setting up the game

We assume that China, Japan, and the US (3 players) aimed to increase the real GDP by 1% during the periods from 2008Q3 to 2009Q3 solely by depreciating the currency value of the yuan, yen, and dollar, respectively. Of course, many stimulus packages were actually imposed during that time in each country, but we used a highly simpli ed policy measure for the purposes of this study to make clear the effects of the exchange rate policy independently. GDP growth itself may not be the actual policy target for a developed country in reality, in ation target or reduction of the current account de cit can be deemed more relevant, whereas, the Lehman shock moved governments, especially the government of China to aim at maintaining the high growth rate to compensate the steep drop at that time. This is why we adopt the growth rate as a policy goal. Besides this, one can point out that setting up the exchange rate as a policy instrument seems too much simple and

Figure 2 Changes in Real GDP (%)



unrealistic to analyse an actual monetary policy, though, every country clings to induce implicitly the exchange rate to be depreciated to the certain level through various channels. Therefore, we regarded the exchange rate as the common and lucid policy instrument for each country. It is expected even a simple scheme and the experimental simulation can bring some economic characteristics of the nation in the light.

We dynamically simulated the model with forward-looking variables from 2007Q1 to 2010Q4, including the above periods. Using the optimal control techniques, the optimal regulator problem, we calculated the optimal path of the exchange rates of each player.

The games examined here are as follows,

a) A single-player game: each government makes a move as an individual/independent player. The other players are the mere followers to a speci c policy leader, who may not make some counter actions, and can hardly achieve the goals or sometimes get worse. This does not assure a stable equilibrium, but only a temporal and partial solution.

b) A cooperative game: 3 players have a single aggregated target to achieve their common objectives as,

$$L = \sum \sum (w_{tj}(GDP_{tj} - GDP_{tj}^{taget})^2). \qquad (22)$$

$j = CN, JP, US$

Here, weights are arbitrary and affect greatly the ef ciency of calculation. If we succeed in reaching the goal ($L = 0$), every players have the same gain, that is, 1% growth path. This means the cooperative equilibrium.

c) A Nash game: 3 players make each move iteratively without negotiation under the given conditions set and forced by their adversaries. At the rst stage, each player can 't reach the goal ($L_j \neq 0$) and alters its policy each other, and repeat until converging, $L_j = 0$ for all j is attained. This is a sequential Nash equilibrium.

One thing we should note is a topic concerning the exchange rate of the US, US dollar is of course the numeraire and is usually not treated the same as other currencies. However, we treat this as one of exogenous variables in model speci cation as if it is a real variable (that is US_RXD as well as other currencies), which has the value of 1.0. For this reason, US export price, for example, is dually de ned as US_PX for the domestic use and US_PX$, (US_PX$=US_PX/US_RXD(=1)) for the trade models. Every country model including the US model contains the same structures. In the control problem, it can be simply regarded as one of controllable instrument, which has the value different from 1.0 and is consistent with the optimized target.

Figure 3 China's Optimal Exchange Rate (Yuan/$)

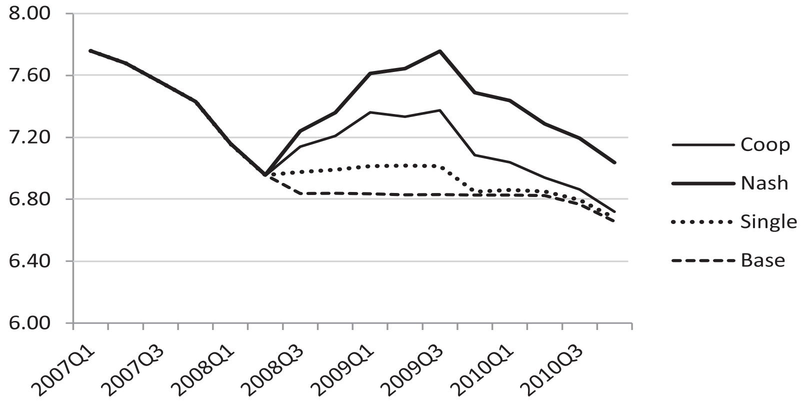


Figure 4 Japan's Optimal Exchange Rate (Yen/$)

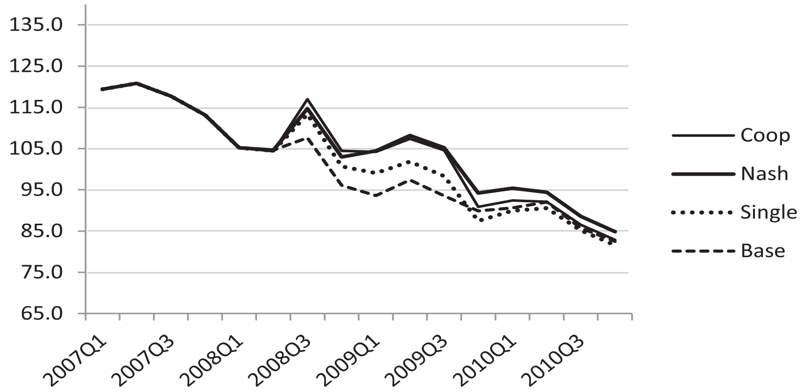
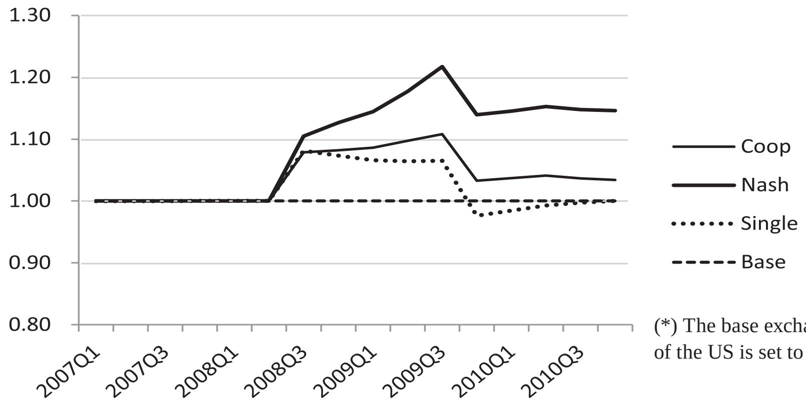


Figure 5 US Optimal Exchange Rate ($)



(*) The base exchange rate of the US is set to 1.0.

4.2 Optimal exchange rate

Obviously, the depreciation of each currency will drive the economy mainly by expanding exports. The width of adjustment of the exchange rate is clearly narrow if independent moves can be performed. In contrast, the Nash case indicates that it needs excess action to pursue the target; consequently, it has an overshooting loss. Comparing the Nash game with the cooperative game, the latter will be moderate for all players.

The Nash case shows that the adjustment after the period 2009Q4 takes longer and has the tendency to become depreciative.

4.3 How does the single game affect the other countries' performance?

No single authority can change its position on the exchange rate without being perceived by the other authorities in reality, especially for the major countries studied herein. However, it is important to know the partial effects.

When China makes a move independently, of course, China reaches the goal of 1% growth, and Korea's GDP growth will rise as almost higher as China, re ecting the

Figure 6 GDP Impact of China's Single Move

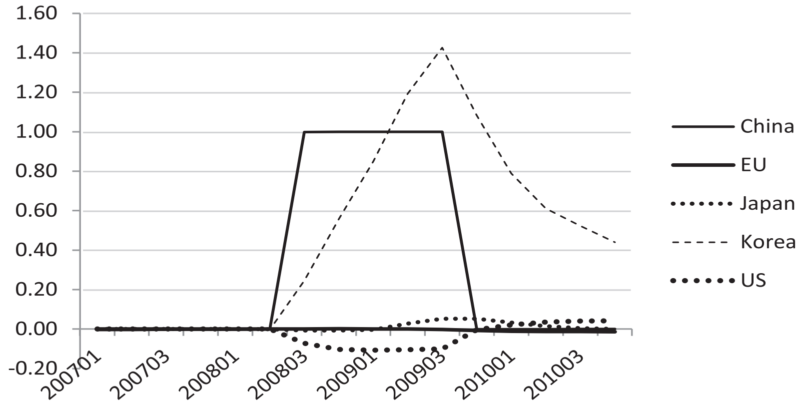
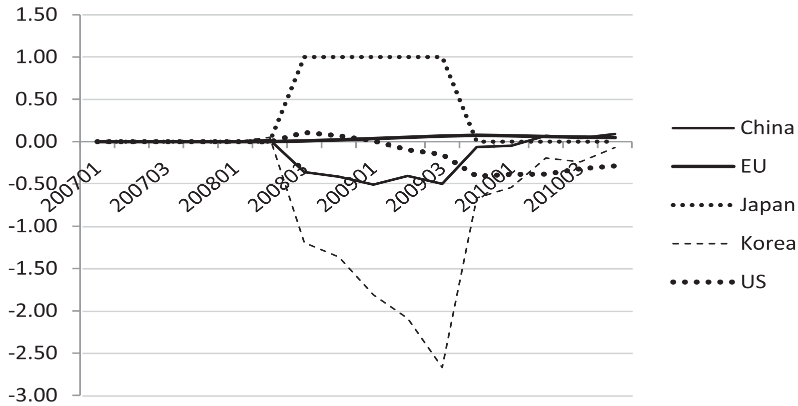


Figure 7 GDP Impact by Japan's Single Move



complementary integration of the manufacturing industry of Korea with China. In contrast, the US economy will suffer by 0.1%, and the impact remains within relatively a low level, on the other hand, it helps Japan's GDP slightly in the long run.

Japan's move will cause the decline of all other economies, whereas a US move reduces the GDP of export-oriented countries, such as China, Japan, and Korea, while raising the EU economy coincidentally with the US economy.

Generally the magnitude of the impact is highest in the case of the US and what we call "beggar-my-neighbour" effects can be observed widely except the case of China.

4.4 How does the cooperative/Nash game affect the other counties?

Comparing the cooperative game to the Nash game, the Nash game produces the greater impacts on the tertiary countries, such as the EU. This difference denotes the possibility that international coordination does not always yield gains. This result is quite different from the conventional theory quoted previously, in which coordination is highly bene cial. Although the Nash solution may require excessive adjustment costs, the gains also become greater for the world economy.

Figure 8 GDP Impact by the US' Single Move

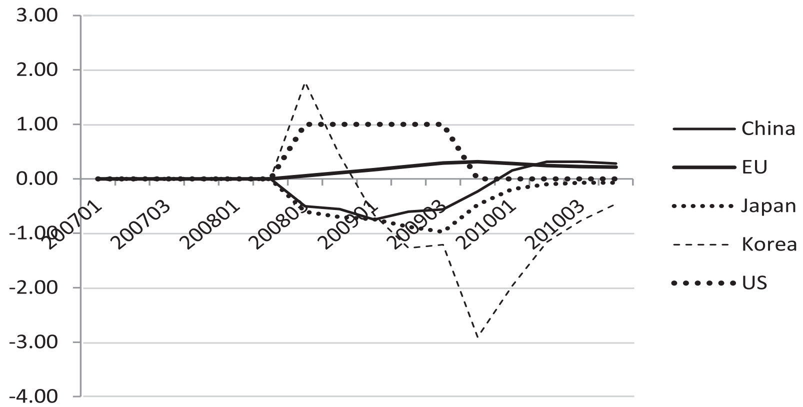
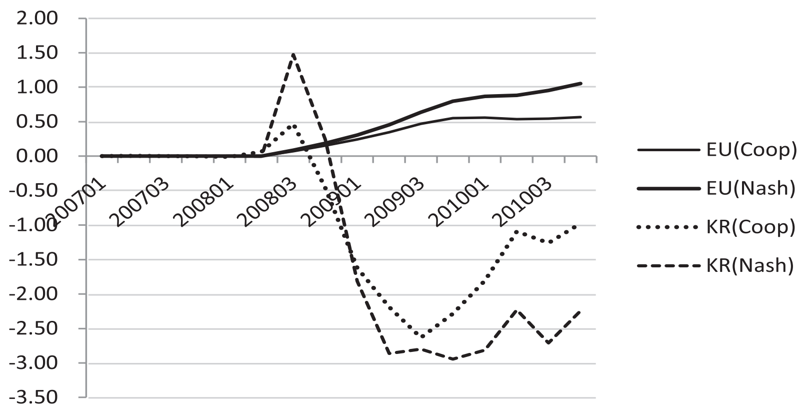


Figure 9 Impact on the GDP of the EU and Korea (Cooperative/Nash Case)

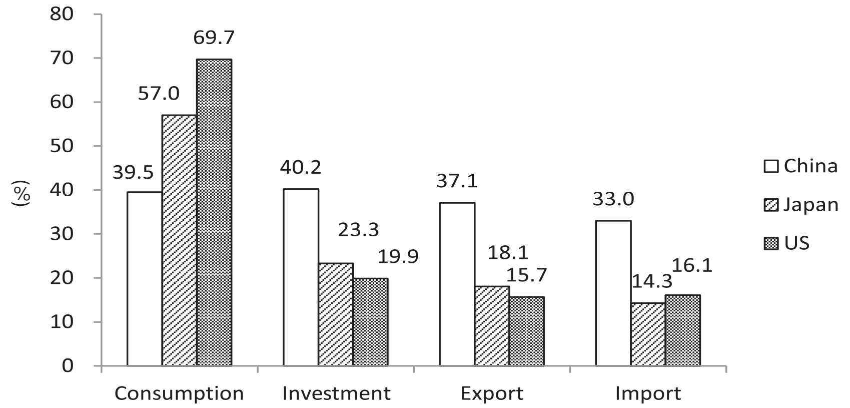


4.5 How does the game affect the demand structures?

First, we show brie y the demand structures of China, Japan and the US at the year 2005, which denote percentages of the main element of the nominal GDP. As is well known, Chinese economy has the peculiar features that it greatly depends on the external economy and the investment. As a result, even today, attention of stabilizing the currency yuan is of primary importance for China.

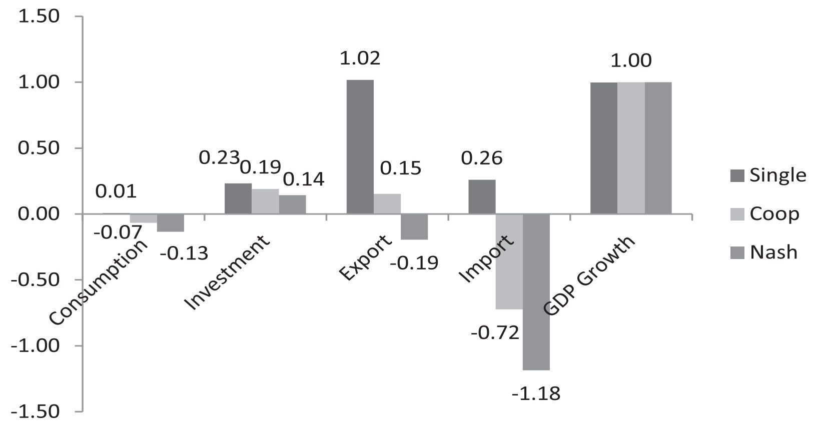
Depending on the domestic demand characteristics and trading patterns of each country, the import/export structures are affected quite differently. For example, Korea strongly depends on the Chinese economy and keeps in step with China. The same thing is true for EU, which owes much to the US economy, and China will adjust its trade structure against the depreciation of other currencies to maintain 1% growth by reducing income leakage to foreign countries. China maintains its GDP by reducing imports rather than increasing exports. Even if the depreciation of the yuan could be approved, it does not help

Figure 10 Demand Structures



(*) % of each major element of nominal GDP at 2005

Figure 11 China's Demand Structure by Game Type



(*) The contribution of each demand category in %

Figure 12 Japan's Demand Structure by Game Type

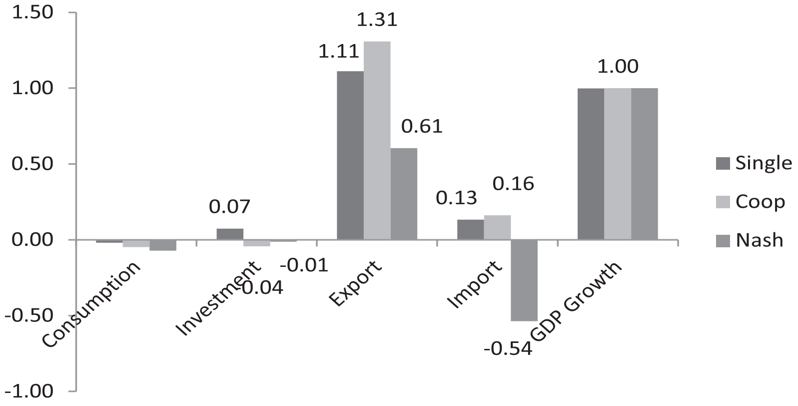
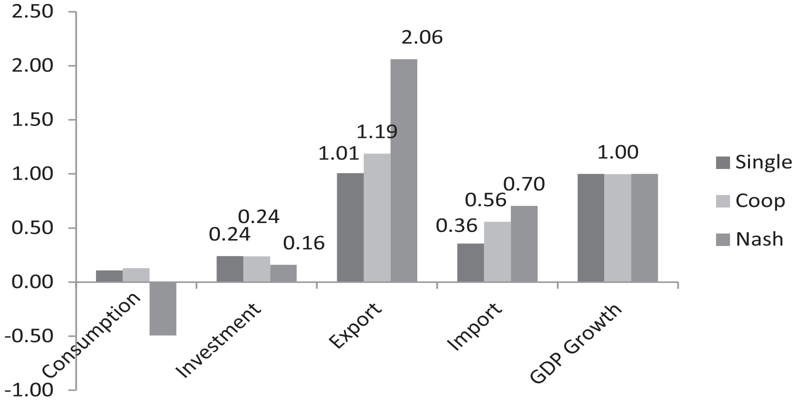


Figure 13 US Demand Structure by Game Type



to expand Chinese exports.

The depreciation of all major currencies will promote the exports of Japan; however, the cooperative game has effects on the exports that are twice as high as those for the Nash game. The moderate coordination solutions seem to apply to Japan. Regarding the US economy, the competitive Nash solution can boost exports, which offers the most advantageous results for the US economy.

As we have shown above, the most suitable exchange rate policy for a speci c country is not generally determined in advance. The single-player game is appropriate for China, the cooperative game for Japan, and the Nash game for the US.

Regarding domestic demands, both of consumption and investments can be damaged most in the case of Nash due to the rise in long term interest rates.

6. Concluding remarks

We examined the impacts of the exchange rate policy on GDP under the game theoretical framework. We assumed that China, Japan, and the US had changed their exchange rate policies to compensate the sharp decline from 2008Q3 to 2009Q3 using three games: the single-player, cooperative, and Nash games.

The optimal exchange rate policy differs by game type and the characteristics of the economy, especially how the country depends on trade. The width of the currency movement is greatest for the case of the Nash game to achieve the same targets, whereas the single-player game is the lowest case. Although the Nash case may require the largest adjustment costs in many economies, it does not necessarily mean that the contribution to the world economy of the Nash game should be less than that of the cooperative adjustment because it boosts the US economy most, which is linked to EU growth.

China is one of the most export-oriented countries and may prefer the sole depreciation of the yuan without being notified. Regardless of the game type, the depreciation of other major currencies will be negative for the Chinese economy. A competitive exchange rate adjustment, the Nash game, will benefit the US economy most, whereas Japan prefers the modest cooperative game.

It is quite interesting that these tendencies seem to reflect each nation's mentality.

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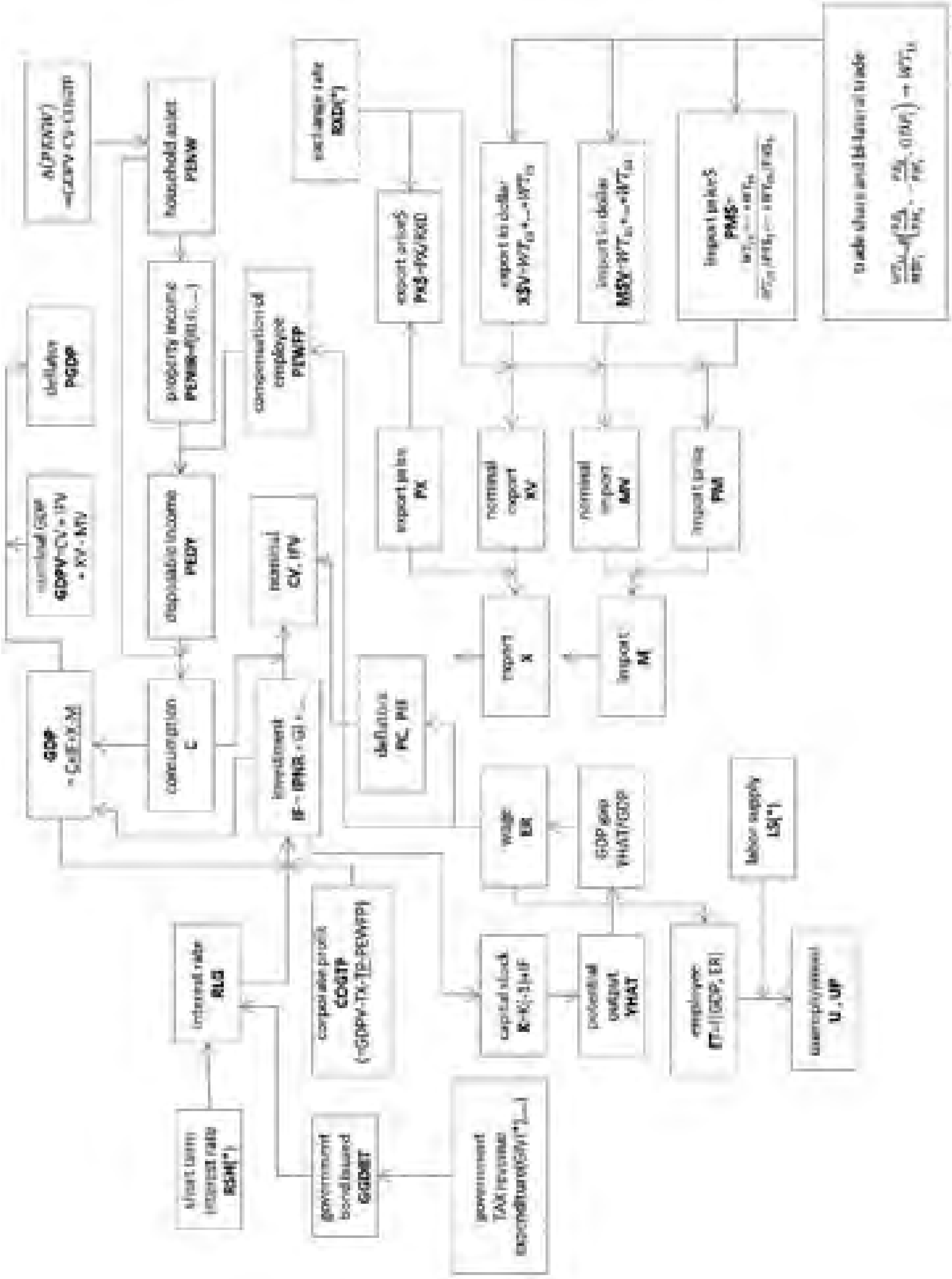
Appendices

Appendix A

Diagram of the global macroeconometric model. (Quoted from Ozaki, 2013)



Appendix B

List of Equations with respect to Japan Model. (Quoted from Ozaki, 2013)

Equations in the other country model are quite similar to the following speci cations.

(GDP)

JP_GDP = JP_C + JP_IF + JP_GC + JP_X   JP_M
JP_GDPV = JP_CV + JP_IFV + JP_GCV + JP_XV   JP_MV + JP_GDPVZ
JP_CV = JP_C * JP_PC / 100
JP_IFV = JP_IF * JP_PIF / 100
JP_GI = JP_GIV / JP_PIF * 100
JP_GC = JP_GCV / JP_PC * 100

(Consumption)

DLOG(JP_C) =   0.553   0.163*(LOG(JP_C(1))   (3.85 + 0.74*LOG(JP_PEDY(1))
+0.26*LOG(JP_PENW(1) /JP_PC(1)))) + 0.0405*DLOG(JP_PEDY) + 0.0745*DLOG(JP_PEDY(1))
+ 0.192*DLOG(JP_PENW/JP_PC)   0.679*DLOG(JP_PC/JP_PC(1))   0.0019*DLOG(JP_RSH)
JP_PEDY = JP_PEDYV / JP_PC * 100
JP_PEDYV = JP_PEWFP + JP_PENIR + JP_GCGPE + JP_PEOCR + JP_PEOY   JP_TY   JP_TSS
JP_PENW =   1915.4 + 1.47*(JP_PEDYV   JP_CV) + JP_PENW(1)
JP_PEWFP = JP_ER * (JP_ET   JP_ES) / 1000
JP_PENIR =   2565.9 + 0.547*(0.5*(((1 + JP_RLG/100)^0.25)   1) + 0.5*(((1 + JP_RSH/100)^0.25)
1))*JP_PENW(1)
LOG(JP_PEOY) =   41.9 + 1.95*LOG(JP_ER*JP_ES) + 1.64*LOG(JP_GDPV)

(Investment)

DLOG(JP_IPNR) =   0.0876   0.0246*(LOG(JP_IPNR(1))   LOG(JP_GDP(1)) + 0.05*LOG(JP_RLG))
+ 0.0986*DLOG(JP_IPNR(1)) + 0.723*DLOG(JP_GDP) + 0.120*DLOG(JP_COGTP/JP_PIF)
1.86*DLOG(JP_PIF/JP_PIF(1))   0.01*LOG(JP_RLG/JP_PIF)
JP_IF = JP_IPNR + JP_GI + JP_IPRD + JP_IFZ
JP_COGTP = JP_GDPV   JP_PEWFP   JP_TX   JP_TP   JP_TC   JP_PEOCR   JP_PEOY   JP_COZ
JP_K = (1.0   JP_DELTA) * JP_K(1) + JP_IPNR

(Export and Import)

JP_M$V = 12805.0 + 1.04*(WT_CNJP + WT_KRJP + WT_USJP + WT_EUJP + WT_RWJP)
JP_MV = 0.001*JP_M$V*JP_RXD
JP_M = 100*JP_MV/JP_PM
JP_X$V =   1053.5 + 1.01*(WT_JPCN + WT_JPKR + WT_JPUS + WT_JPEU + WT_JPRW)
JP_XV = 0.001*JP_X$V*JP_RXD
JP_X = 100*JP_XV/JP_PX

(Trade Share)

LOG(WT_CNJP/JP_M$V) =   31.69   0.308*LOG((CN_PX/CN_RXD)/(JP_PM/JP_RXD))
+ 1.71*LOG((US_PX/US_RXD)/(JP_PM/JP_RXD))   1.34*LOG((KR_PX/KR_RXD)/(JP_PM/
JP_RXD))
0.284*LOG((EU_PX/EU_RXD)/(JP_PM/JP_RXD)) + 1.774*LOG(JP_GDP)
LOG(WT_EUJP/JP_M$V) =   2.873 + 0.696*LOG(WT_EUJP(1)/JP_M$V(1))
+ 0.166*LOG((CN_PX/CN_RXD)/(JP_PM/JP_RXD)) + 0.281*LOG((US_PX/US_RXD)/(JP_PM/
JP_RXD))
+ 0.0383*LOG((KR_PX/KR_RXD)/(JP_PM/JP_RXD))   0.0175*LOG((EU_PX/EU_RXD)/
(JP_PM/JP_RXD))
+ 0.0474*LOG(JP_GDP)
LOG(WT_KRJP/JP_M$V) =   7.019   1.238*LOG((CN_PX/CN_RXD)/(JP_PM/JP_RXD))
+ 0.134*LOG((US_PX/US_RXD)/(JP_PM/JP_RXD))   0.206*LOG((KR_PX/KR_RXD)/(JP_
PM/JP_RXD))

+ 0.246*LOG((EU_PX/EU_RXD)/(JP_PM/JP_RXD)) + 0.399*LOG(JP_GDP)
LOG(WT_USJP/JP_M$V) = 0.976 + 0.337*LOG((CN_PX/CN_RXD)/(JP_PM/JP_RXD))
0.813*LOG((US_PX/US_RXD)/(JP_PM/JP_RXD)) + 1.066*LOG((KR_PX/KR_RXD)/(JP_PM/JP_RXD))
+ 0.572*LOG((EU_PX/EU_RXD)/(JP_PM/JP_RXD)) + 0.146*LOG(JP_GDP)

(Price)

JP_PM$ = 60.0 + 0.412*((WT_CNJP + WT_KRJP + WT_USJP + WT_EUJP + WT_RWJP)/(WT_CNJP/(CN_PX$*1.11)
+ WT_KRJP/KR_PX$ + WT_USJP/(US_PX*1.10) + WT_EUJP/EU_PX$ + WT_RWJP/(US_PMFU*86/54)))
+ [AR(1) = 0.89]
JP_PM = 1.0*JP_PM$*JP_RXD/100
JP_PX$ = 1.0*100*JP_PX/JP_RXD
DLOG(JP_PIF) = 0.00117 0.00236*(LOG(JP_PIF(1)) 0.1*LOG(JP_ER(1)) 0.9*LOG(JP_PM(1)))
+ 0.218*DLOG(JP_PIF(1)) + 0.575*DLOG(JP_PIF(2)) + 0.0613*DLOG(JP_ER) + 0.0764*DLOG(JP_PM)
+ 0.0616*DLOG((1 + JP_TXRA))
DLOG(JP_PC) = 0.1117 0.0662*(LOG(JP_PC(1)) 0.7*LOG(JP_ER(1)) 0.3*LOG(JP_PIF(1)))
+ 0.123*DLOG(JP_PC(1)) + 0.169*DLOG(JP_PIF) + 0.00746*DLOG(JP_PM) + 0.0898*DLOG(JP_ER)
+ 0.650*DLOG((1 + JP_TXRA))
JP_PGDP = 100 * JP_GDPV / JP_GDP

(Wage)

DLOG(JP_ER) = 0.306 0.0439*(LOG(JP_ER(1)) + LOG(JP_YHAT(1)/JP_GDP(1))) + 0.331*DLOG(JP_ER(4))
0.145*DLOG(JP_YHAT/JP_GDP)

(Potential Output)

LOG(JP_YHAT) = 9.769 + 0.125*LOG(JP_K) + 0.0378*LOG(JP_ET) + [AR(1) = 0.983]

(Labor)

DLOG(JP_ET) = 0.106 0.0121*(LOG(JP_ET(1)) 0.22*LOG(JP_GDP(1)) + 0.15*LOG(JP_ER(1)/JP_PGDP(1)))
+ 0.464*DLOG(JP_ET(1)) + 0.217*DLOG(JP_GDPV) 0.0568*DLOG(JP_ER/JP_PGDP)
JP_U = 1.00*JP_LS 1.00*JP_ET
JP_UP = 1.637 + 1.00*JP_U/JP_LS*100 0.00000186*JP_UP(1)

(Interest Rate)

JP_RLG = 2.881 + 0.840*JP_RLG(1) + 0.1307*(0.5*JP_RSH + 0.5*US_RSH) + 2.839*(JP_GDPV/JP_GDPV(1))
+ 0.0073*(JP_GGDBT/JP_GDPV)

(Government)

JP_TY = JP_TYR * (JP_PEWFP + JP_PENIR + JP_GCGPE + JP_PEOCR + JP_PEOY)
JP_TX = (JP_TXR + JP_TXR B) * JP_CV + JP_TXFU
JP_TP = JP_TPR * JP_PEWFP
JP_TSS = JP_TSSR * JP_PEWFP
LOG(JP_TC) = 5.39 + 0.377*LOG(JP_TCRR*JP_COGTP)
LOG(JP_GCGPE) = 8.314 + 0.541*LOG(JP_PC/JP_PC(4)) + 0.133*LOG(JP_U) + 0.00683*TREND
JP_GREV = JP_TY + JP_TX + JP_TP + JP_TC + JP_GDIR + JP_TSS + JP_GREVZ
JP_GEXP = JP_GCV + JP_GIV + JP_GCGPE + JP_GDIP + JP_GEXPZ
JP_GB = JP_GREV JP_GEXP
JP_GGDBT = JP_GGDBT(1) JP_GB + JP_DBTPOL

Appendix C

List of Variables

Main data source is Oxford Economics Global Data Bank, and the variable list below is also quoted from Oxford Economics with respect to the Japan model, however, the variable names are the same as in all the other countries' models, for example, JP_C, CN_C, ...Abbreviation codes for the country are US, JP (Japan), EU, CN (China), KR (South Korea), WT (trade between *i* and *j*)

Indicator code	Indicator	Units	Scale	Source
C	Consumption, private, real, LCU	Yen	Billions: 2005 Prices	Economic and social Research Institute\CEIC
COGTP	Company profits, LCU	Yen	Billions	Ministry of Finance\CEIC
CREVZ	Miscellaneous Government Revenue, LCU	Yen	Billions	Ministry of Finance\CEIC
CV	Consumption, private, nominal, LCU	Yen	Billions	Economic and social Research Institute\CEIC
DBTPOL	Policy instrument, Government debt, gross, LCU			usually set to 0
ER	Earnings, quarterly total, LCU	Yen per empl	Thousands	Ministry of Health, Labour and Welfare\CEIC
ES	Employment, Self-employed	Person	Thousands	Ministry of Health, Labour and Welfare\CEIC
ET	Employment, total	Person	Thousands	Statistical Bureau\CEIC
GB	Government balance, LCU	Yen	Billions	Organization for Economic Cooperation & Development
GC	Consumption, government, real, LCU	Yen	Billions: 2005 Prices	Economic and social Research Institute\CEIC
GCGPE	Personal sector transfers from central government, LCU	Yen	Billions	Organization for Economic Cooperation & Development
GCV	Consumption, government, nominal, LCU	Yen	Billions	Economic and social Research Institute\CEIC
GDIR	Interest receipts, government, LCU	Yen	Billions	Organization for Economic Cooperation & Development
GDP	GDP, real, LCU	Yen	Billions: 2005 Prices	Economic and social Research Institute\CEIC
GDPV	GDP, nominal, LCU	Yen	Billions	Economic and social Research Institute\CEIC
GEXP	Government expenditure, total, LCU	Yen	Billions	Organization for Economic Cooperation & Development
GEXPZ	Miscllaneous Government expenditure, total, LCU	Yen	Billions	Organization for Economic Cooperation & Development
GGDBT	Government debt, gross, LCU	Yen	Billions	Bank of Japan\CEIC
GGDBTD	Government debt, domestic, LCU	Yen	Millions	International Monetary Fund\Haver Analytics
GI	Investment, government, real, LCU	Yen	Billions: 2005 Prices	Economic and social Research Institute\CEIC
GIV	Investment, government, nominal, LCU	Yen	Billions	Economic and social Research Institute\CEIC
GNIP	Interest payments, government, net, LCU	Yen	Billions	Organization for Economic Cooperation & Development/ Haver Analytics
GREV	Government revenue, total, LCU	Yen	Billions	Organization for Economic Cooperation & Development
IF	Investment, total fixed investment, real, LCU	Yen	Billions: 2005 Prices	Economic and social Research Institute\CEIC
IFV	Investment, total fixed investment, nominal, LCU	Yen	Billions	Economic and social Research Institute\CEIC
IFZ	Investment, miscellaneous, nominal, LCU	Yen	Billions	Economic and social Research Institute\CEIC
IPNR	Investment, private sector business, real, LCU	Yen	Billions: 2005 Prices	Economic and social Research Institute\CEIC
IPRD	Investment, private dwellings, real, LCU	Yen	Billions: 2005 Prices	Economic and social Research Institute\CEIC
K	Capital stock, real, LCU	Yen	Billions: 2005 Prices	Organization for Economic Cooperation & Development\Haver Analytics
LS	Labour supply	Person	Thousands	Statistical Bureau\CEIC
M	Imports, goods & services, real, LCU	Yen	Billions: 2005 Prices	Economic and social Research Institute\CEIC
M$	Imports, goods & services, constant prices and exchange rate, US$	US$	Millions: 2005 Prices	Economic and social Research Institute\CEIC\Federal Reserve Board
M$V	Imports, goods & services, nominal, US$	US$	Millions	Economic and social Research Institute\CEIC\Federal Reserve Board
MV	Imports, goods & services, nominal, LCU	Yen	Billions	Economic and social Research Institute\CEIC
PC	Consumption, private deflator	Index	2005=100	Statistical Bureau\CEIC

PEDY	Income, personal disposable, real, LCU	Yen	Billions: 2005 Prices	Organization for Economic Cooperation & Development\Haver Analytics
PEDYV	Income, personal disposable, nominal, LCU	Yen	Billions	Organization for Economic Cooperation & Development\Haver Analytics
PENIR	Net interest receipts, LCU	Yen	Billions	Bank of Japan\CEIC
PENW	Net wealth, household sector (end-quarter), LCU	Yen	Billions	Bank of Japan\CEIC
PEOCR	Other personal income, LCU	Yen	Billions	Bank of Japan\CEIC
PEOY	Other income, LCU	Yen	Billions	Bank of Japan\CEIC
PEWFP	Wages and salaries, LCU	Yen	Billions	Economic and social Research Institute\CEIC
PGDP	GDP deflator	Index	2005=100	Economic and social Research Institute\CEIC
PIF	Investment deflator	Index	2005=100	Economic and social Research Institute\CEIC
PM	Import deflator, total	Index	2005=100	Economic and social Research Institute\CEIC
PM$	Import deflator, total, US$	Index	2005=100	Economic and social Research Institute\CEIC
PMFU	Import deflator, fuels	Index	2005=100	Bank of Japan\CEIC
PX	Export deflator, total	Index	2005=100	Economic and social Research Institute\CEIC
PX$	Export deflator, total, US$	Index	2005=100	Economic and social Research Institute\CEIC
RLG	Interest rate, Bonds Yield: Government Bonds: Newly Issued: 10 Years: Month	%		Ministry of Finance Japan \Haver Analytics
RSH	Interest rate, short-term	%		British Bankers' Association\Haver Analytics
RXD	Exchange rate, period average	Yen per US$		Federal Reserve Board\CEIC
TC	Tax revenue, corporate, LCU	Yen	Billions	Organization for Economic Cooperation & Development
TCRR	Tax rate, corporate	%		Ministry of Finance
TP	Tax revenue, employer social security contributions, LCU	Yen	Billions	Organization for Economic Cooperation & Development
TPR	Rate of Tax revenue, employer social security contributions, LCU			
TSS	Income tax, LCU	Yen	Billions	Ministry of Finance
TSSR	Rate of Income Tax			
TX	Tax revenue, expenditure, LCU	Yen	Billions	Organization for Economic Cooperation & Development
TXR	Rate of Tax revenue, expenditure, LCU			
TXFU	Tax revenue, expenditure on fuels, LCU	Yen	Billions	Oxford Economics calculations
TXRA	Tax revenue, tentative for simulation test			
TY	Tax revenue, income, LCU	Yen	Billions	Organization for Economic Cooperation & Development
TYR	Rate of Tax revenue, income, LCU			
U	Unemployment	Person	Thousands	Statistical Bureau\CEIC
UP	Unemployment rate	%		Statistical Bureau\CEIC
X	Exports, goods & services, real, LCU	Yen	Billions: 2005 Prices	Economic and social Research Institute\CEIC
X$V	Exports, goods & services, nominal, US$	US$	Millions	Economic and social Research Institute\CEIC\Federal Reserve Board
XV	Exports, goods & services, nominal, LCU	Yen	Billions	Economic and social Research Institute\CEIC
YHAT	Potential output, LCU	Yen	Billions: 2005 Prices	Organization for Economic Cooperation & Development
WT_ab	Trade between 'a' and 'b', nominal, US$	US$	Millions	IMF DOT, 'a''b' are US JP EU CN KR

On Japan's Growth Potential and the GDP Gap: A Comparison of Shishido and Niwa Estimates with Of cial Ones

Soshichi Kinoshita*

Abstract

The potential output or the GDP Gap of the Japanese economy has become an important indicator for judging the short-run and long run trend of the depressed Japanese economy since the late 1990s. The Cabinet Of ce, Government of Japan (CAO) and the Bank of Japan (BOJ) have of cially released their estimates at the quarterly base. Dissenting from these of cial estimates, Shishido and Niwa estimated it independently, and, proposed the alternative macroeconomic policies to escape from the depressed state of the Japanese economy. This paper examines, focusing on Shishido and Niwa estimates the sources of their differences with the of cial ones from three points of view; factor shares, TFP growth rate and potential factor inputs. It is shown that the differences are mostly dissolved by applying the common assumption on these three factors in the calculation.

KEYWORDS: Japan's GDP Gap; Potential Output; Aggregate Production Function; Labor Share

JEL Classi cations: E1

1. Introduction

Since the bubble burst in the early 1990s, the Japanese economy has been in the prolonged period of poor performance in which real GDP growth has averaged 1 percent per year over the decades. Many studies have been done on the causes behind the growth slowdown theoretically and empirically; whether it was caused by either demand side factors or supply side ones.

Kazuo Sato (2001) reviewed critically the estimates of Japan's GDP potential and the derived GDP gap, focusing on the Shishido and Niwa estimates in relation to of cial ones by BOJ and CAO. He pointed out the inappropriateness of private gross and net capital stock estimates used in their studies, and the difference in the assumption on technical change was the main factor to cause the difference in potential GDP and GDP gap estimates. He concluded that both Shishido and Niwa overestimated the GDP gap, while of cial estimates were underestimated.[1]

This paper re-examines the GDP gap estimates by Shishido and Niwa based on the updated data covering the 2000s, and show the sources of their overestimation against the of cial ones.

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[1] Sato (2001). He reviewed two groups of sharply contrasting estimates of Japan's GDP gap, one of which was CAO and BOJ, named optimists, the other was Shishido and Niwa, called pessimists.

2. Measurement of the GDP Gap

The GDP gap is an indicator to measure the demand-supply imbalance of macro economy, de ned as

GDP gap= (actual GDP/potential GDP 1)×100 (1)

where potential GDP is the GDP that can be produced by an economy if all its resources of production are utilized at the average level of the past usage. When actual GDP is equal to potential GDP, the GDP gap is zero, otherwise becomes positive or negative.

The crucial point in the measurement is how to calculate the potential output. The most popular method used in the studies is based on production function approach, especially the usage of Cobb=Douglas production function in the following,

$$Y_t = A_t K_t^a L_t^b \quad (2)$$

Here the determinants of real GDP(*Y*) are capital input (*K*), labor input (*L*) and total factor productivity (*A*). Two elasticity parameters, *a* and *b* determine the contributions of *K* and *L* to output. There are two ways to specify the two parameters, the rst is to estimate directly the Cobb=Douglas function with the Ordinary Least Squares method, where A_t is assumed to grow at an exponential rate (e^{ct}). The other is to derive the parameters from the factor shares of *K* and *L* by assuming the equilibrium conditions in the factor market with constant return to scale. In both cases, potential GDP is calculated by inserting the potential levels of *K*, *L* and the past trend of TFP into the production function.

The procedure adopted by CAO to derive potential GDP is summarized in the following.

Potential inputs of capital and labor are de ned as follows,

Potential input of capita:
 xed capital stock×potential rate of capital utilization (3)

Potential input of labor:
population aged 15 or over×potential rate of labor force participation
× (1 rate of structural unemployment)×potential hours of work (4)

The potential GDP estimates are heavily depending on the assumed levels of potential inputs of *K*, *L* and the treatment of technical progress.

Here, potential levels of labor force participation rate and hours of works are computed as the trend components obtained by using Hodrick=Prescott lter to the observed variables. As for the potential rate of capital utilization, the actual operation rates of manufacturing and non-manufacturing industries are adjusted to exclude the cyclical factors by making regression of these variables with TANKAN survey data of BOJ.[2] The rate of structural unemployment is estimated using UV analysis to differentiate structural unemployment from cyclical unemployment based on the relationship between the unemployment rate and the vacancy rates.[3,4]

[2] TANKAN survey is an abbreviation of the Short-term Economic Survey of Enterprises in Japan.

[3] As for the concrete method to allocate the reta of unemployment into cyclical unemployment and structural-frictional one, see the appendix note in the Annual Report o Economy and Public Finance 2006 and Useful Labor Statistics 2012.

[4] BOJ re-examined the estimation method of GDP gap at the end of 2005 and since 2006 almost same procedure as CAO has been taken to calculate the gap.

3. Case of Shishido

Shishido measured the potential GDP by estimating an aggregate production function of Cobb=Douglas type with the time series data from 1973 to 2004 and concluded that the Japan's GDP gap at 2007 was much larger than the of cial estimates. He proposed furthermore that to ll the large gap, aggressive demand management policies of Keynesian type was urgently needed.[5]

He estimated the following aggregate production function for the period from 1973 to 2004,

$$\begin{array}{llll} Ln(GDP)=3.8693+0.26439*\ln(KPG(\ 3))+0.81743*\ln(L*LHRTL)\ \ 0.15392*\ln(URATE) \\ \qquad\qquad (7.5844) \qquad\qquad (7.9002) \qquad\qquad (\ 7.817) \end{array}$$

$$\begin{array}{ll} +0.1255\ln\ (KGGSNA/KGGSNA\ (\ 1))\ +0.01846*TREND \qquad (5) \\ (1.3115) \qquad\qquad\qquad (14.2054) \\ \qquad\qquad Adj R^2 = 0.9988 \qquad DW=1.8477 \end{array}$$

where KPG=gross xed business capital stock, L= number of workers, LHRTL=hours of works, URATE=rate of unemployment, KGGSNA=public xed capital stock, TREND=time trend. Numerical values shown below the estimated parameters are t-values.

In this equation, the values of the elasticity of production with respect to capital and labor are 0.264 and 0.817 respectively, and the sum of them is 1.08 showing the existence of a weak scale economy. The rate of unemployment might have been included as a proxy of the rate of capital utilization. The growth rate of TFP, as measured by time trend, is 1.8% at the annual average rate over the whole sample period.

To apply the CAO procedure -explained above to Shishido's estimates of the potential output, we re-estimated his production function with the data from 1981 to 2004.

The result is as follows,

$$\begin{array}{ll} Ln(GDP)=\ 4.1915+0.2283*\ln(KGP(\ 1))+1.1459*\ln(L*LHRTL)\ \ 0.1054*\ln(URATE) \\ \qquad\qquad (7.5290) \qquad\qquad (9.8115) \qquad\qquad =\ 6.8877) \end{array}$$

$$\begin{array}{ll} +0.01532*TREND \qquad\qquad\qquad (6) \\ (7.2383) \\ \qquad\qquad Adj R^2 = 0.9983 \qquad DW=2.0292 \end{array}$$

To measure the potential output with the production function, Shishido assumed full utilization rate of capital (100 %) and the potential capital stock is set equal to actual capital stock. As for the potential labor input, total hours of works in 1980 (170 hours per month) are equated with the potential hours of work, and structural unemployment rate is set to the average rate of unemployment, 2.1% (observed in the latter half of 1970s), and potential labor participation rate is equated with the actual rate. The potential factor inputs thus determined and the estimated TFP of 1.5% are combined to calculate the potential output, where factors of production are fully employed.

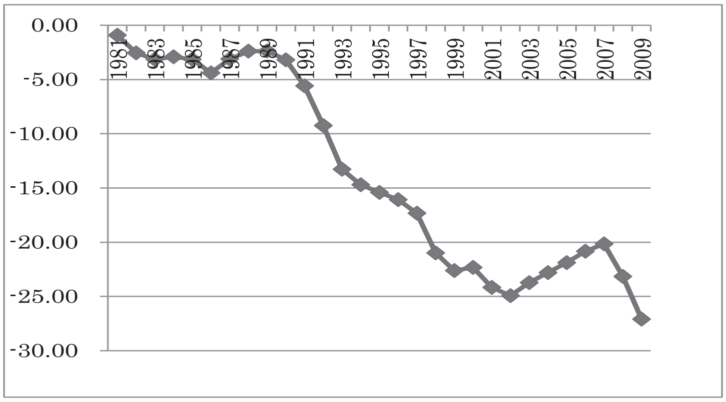
[5] Shishido (2004, 2010). Both Shishido (2004) and Shishido (2010) estimated the same type of Cobb=Douglas production function for the periods, 1957-1998 and 1973-2004 respectively.

It is shown in Figure 1 that the GDP gap calculated from the Shishido's potential output has become quite large since the end of bubble economy around 1992, and increased from one digit to two digits level, 20% in 2007.[6] This gap was larger than the of cial ones because it does not take into account of both the statutory reduction in working hours from 1988, and the upward trend of structural unemployment observed since the latter half of 1990s.

However if we apply the CAO assumptions on potential inputs and TFP growth to Shishido's model, an alternate GDP gap (case2) is obtained as shown in Figure 2, where time series properties are very similar to that of CAO.[7]

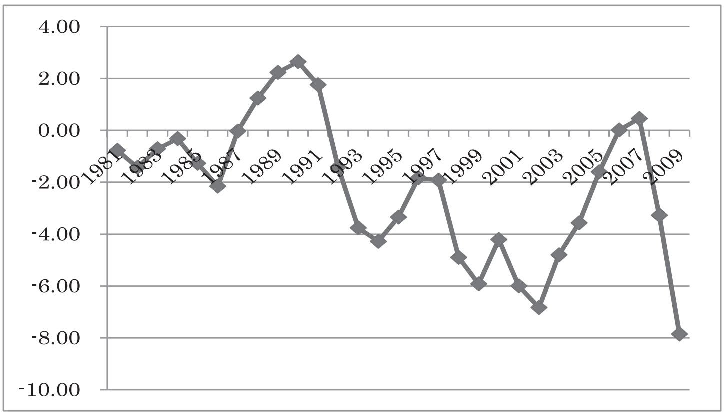
Figure 2 shows that GDP gaps were positive in the bubble period due to the excess demand over potential supply, and almost zero from 2006-2007. It turned into negative after the Lehman shock in 2008. However the gap is around 8%, much smaller than his original estimates of 20%. The GDP gaps uctuate within one digit order over the whole period after 1980.

Figure 1 GDP Gap: Shishido's Estimates (case 1)



(%)

Figure 2 GDP Gap: Shishido's Estimates (case 2)



(%)

[6] Shishido showed the GDP gap estimates only for the extrapolation period (2007-2020), not for interpolation period. But the widening tendency of the gap is maintained.

[7] Shishido (2004) showed the GDP gap estimates only for the extrapolation period (2007-2020), not for interpolation period. But the widening tendency of the gap is maintained.

4. The Case of Niwa

Niwa also measured the GDP gaps for almost the same period as Shishido did. His results diverged farther from the of cial estimates as compared to Shishido. [8]

His GDP gap depends on a Cobb=Douglas production function with constant return to scale and endogenous technical progress. De ning M =total factor input, K=capital input, L=labor input and A=total factor productivity index (TFP), his production function is written as,

$$GDP = A_t \times M_t \quad (7)$$

$$M = K_t^a \times L_t^b \quad (8)$$

where M is a geometric mean of K and L weighted by elasticity parameters, a and b. He took the case of constant return to scale, $a+b=1$.

As for the productivity factor, he didn't use TFP estimates derived from Solow residuals, but assumed that TFP growth, g(A) is proportional to the GDP growth, g(GDP) as follows,

$$d=g(A)/g(GDP) \quad (9)$$

where d is a proportional factor given exogenously. As g(GDP)is the sum of g(A) and g(M), this implies that g(A) is determined proportionally by g(M). As a result, potential GDP and GDP gap had tendency to be calculated larger when larger value is set for the parameter d, accordingly higher technical progress.

Labor share of National Income is set equal to output elasticity of labor, b, using the equilibrium condition of factor market. He examined two cases based on the System of National Account 1985 as shown in Table 1.

The potential input of labor is derived from actual labor force, which includes the structural unemployment (set equal to actual unemployment) and hour of works xed at the level of 1970. On the other hand, potential capital input is given by the private gross xed capital with full utilization (100%) of capital. As for the technical progress, the case of 1/3.5 is taken here among the four alternative cases.

Table 1 Labor Share: Cases of Niwa's Estimate[9]

case	De nition of labor share	Labor share	Capital share
Original weight	Employee's income/GDP	0.544	0.456
Adjusted weight	Adjusted employees income/GDP	0.58	0.42

Note: adjusted employees income =compensation of employees and 0.549* operating surplus of unincorporated enterprises. 0.549 is the labor share of private incorporated enterprises for 1985. See the Appendix on the details of alternative de nition of labor share.

[8] Niwa (2000, 2006). Niwa (2000) covered the period 1970-1997 and Niwa (2006) extended to samples from 1970 to 2004.

[9] As regards the de nition of the factor shares in the SNA, alternative formulae are proposed and utilized in the study. See the details in Appendix.

Figure 3 GDP Gap: Niwa's Estimate (case 1, original case)

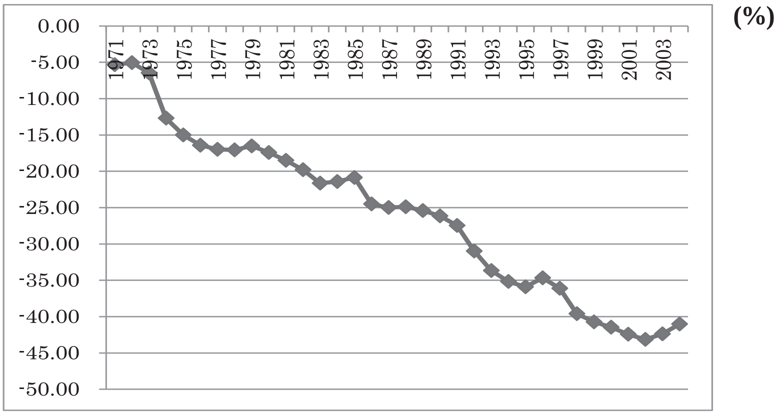


Figure 4 Niwa's Estimate (case2, capital share is set at 0.33)

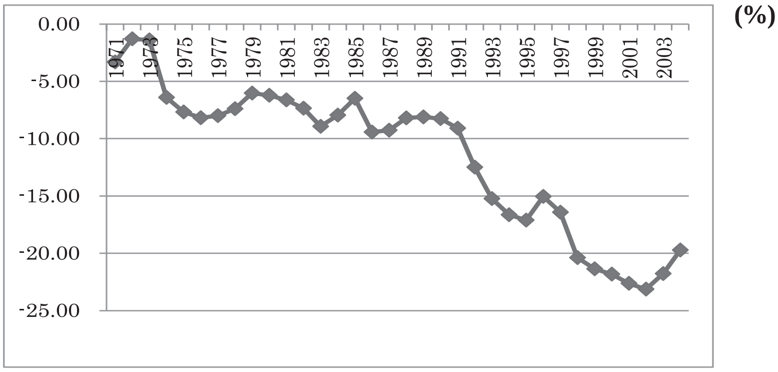


Figure 3 shows the calculated GDP gaps based on Niwa's assumption of potential factor inputs and technical progress. GDP gap here have been widened to about 15% since the latter half of 1970s, and peaked near 45% in 2002. The GDP gaps in the early 2000s were ten times larger than those of CAO.

The large Niwa's GDP gaps is comparing to those of CAO might be highly dependent on the his assumptions of

(1) Labor share and technical progress

(2) Potential inputs of capital and labor.

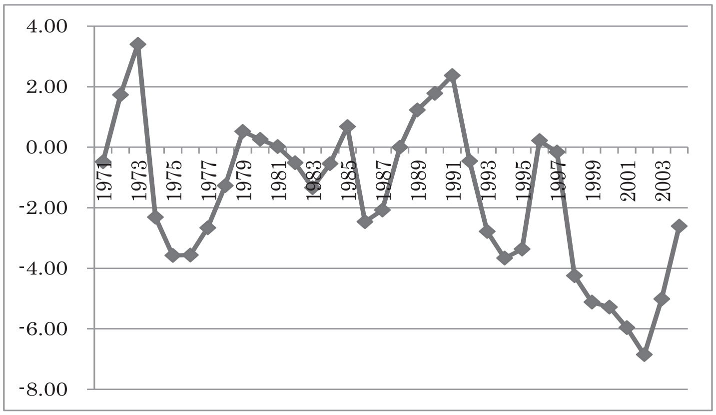
To examine the in uence of different assumptions on capital share, CAO's share, 0.33, was used in place of the original share. As depicted in Figure 4, the decreasing values of capital share from 0.456 to 0.33 resulted in the reduction of potential GDP, and revised GDP gap reaches by 20% in 2000.

Further, Figure 5 shows the GDP gap obtained when the potential inputs of capital and labor were adjusted to the CAO procedure. It is concluded that the adjusted Niwa's estimates (case 3) are comparable to the of cial ones, and cyclical movements since the 1970s are within the one digit level.[10]

[10] Kamata and Masuda (2000) surveyed the effects of the measurement errors in factor shares and other key statistics on the GDP gap estimates based on an aggregate production function. The capital stock data used by Niwa was found to be higher by 0.2% at the average annual growth rate than the updated CAO estimate. In the comparison, Niwa's capital stock data was replaced by the updated one.

Figure 5 Niwa's Estimates (based on the CAO procedure except for *g*(A)

(%)



5. Comparisons of Alternative Estimates of the GDP Gap

CAO has released the GDP gap estimates for business indicator in the *Indexes of Business Conditions* monthly and *Annual Report on the Japanese Economy and Public Finance*. Also BOJ has been associated with the analytical issues related to potential output and GDP gap, and utilizes her own GDP gap estimates for judging business and price trend.

In calculating the potential output for GDP gap, CAO and BOJ use almost the same procedure explained above except for private xed capital stock data. CAO uses the "Gross Capital Stock of Private Enterprises" data compiled by the Economic and Social Research Institute, while BOJ changed stock data to the net xed capital stock of JIP (Japan Industry Productivity) data base at the Research Institute of Economy Trade & Industry. The reason pointed by BOJ is the overestimates of Gross Capital Stock data.

Two estimates of GDP gap can be compared in Figure 6, where BOJ series are smaller than CAO ones, with wider difference in the period of bubble economy from 1988 to 1992.

Shishido's GDP gap (case 2), re-calculated by the author using the CAO procedure, is compared with CAO in Figure 7, where cyclical patterns are quite similar between the two estimates, but Shishido's gap is larger by 1~2% after the bubble burst. This may be due to

Figure 6 GDP Gap Estimates: CAO vs. BOJ

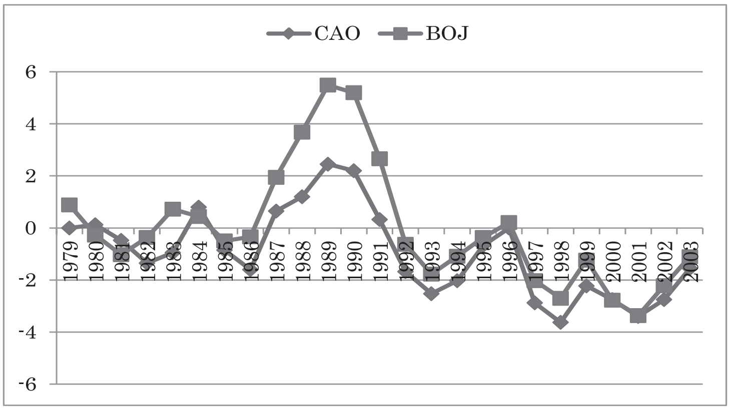


Figure 7 A Comparison of GDP Gap: Shishido vs. CAO

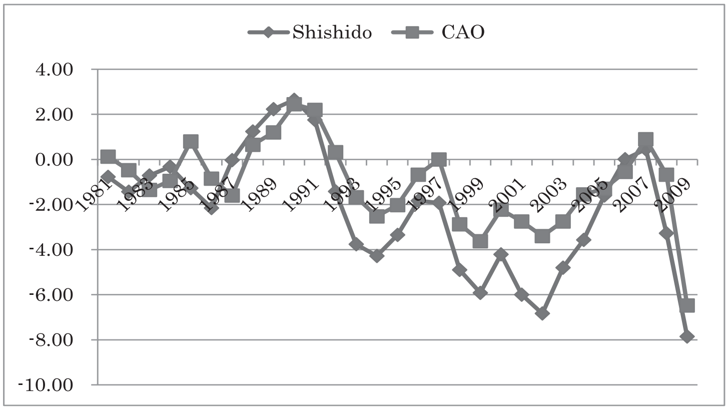
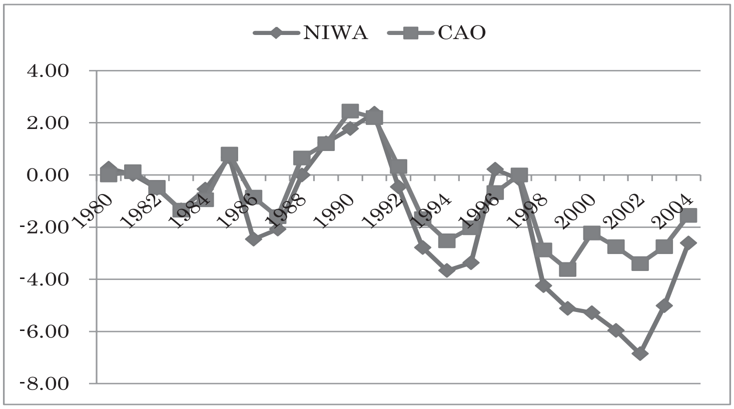


Figure 8 A Comparison of GDP Gap: Niwa vs. CAO



the difference in the estimated production elasticity and TFP growth rate.[11]

Niwa's estimate revised by the author using the CAO procedure is shown in Figure 8. It is seen from here that until 1991 the two series followed the almost same pattern, and since then had a tendency to diverge from each other. The main reason lies in the treatment of technical progress. He assumed a proportional factor between economic growth and technical progress. In this paper, we examined only the case that *d* is set at 1/3.5. The difference of his estimates becomes larger than CAO if *d* is set larger than 1/3.5.

6. Concluding remarks

This paper revisited the GDP gap issues raised by Shishido and Niwa and examined the differences between their estimates and of cial ones by referring to the relevant production parameters including technical progress and de nition of the potential factor inputs. The observed differences in the gaps can be almost accounted for by the differences in the assumptions for estimates when recalculated by the author using the common procedure of potential GDP adopted by CAO.

[11] CAO estimates the elasticity of production from factor share, and TFP growth rate from Solow's residuals.

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Appendix: Alternative de nition of labor share in the National Account

In the UN System of National Account, GDP at the income side is de ned as follows,

GDP=compensation of employees + operating surplus and mixed income+ taxes on productions and imports   subsidies + consumption of xed capital

The labor share is typically de ned as a ratio of compensation of employees to an output measure such as GDP, and calculated as the following formula,

LS= compensation of employees/GDP

In order to measure the true contribution of labor to output, some adjustments are required both to the numerator and denominator. First, in the numerator, a large part of the operating surplus of unincorporated enterprises (mostly self-employed) should be added as the labor income. Second, tax on production and imports and imputed service of owner-occupied dwellings need to be excluded from the denominator.

As for the estimation of labor income of unincorporated enterprises, two methods are available: one is to assume that the average compensation per hour of self-employed person equals that of a wage earner (case a), and the other is to apply the labor share of corporates to that of operating surplus of unincorporated enterprises (case b).

The following results are obtained for the alternative labor share in Table 1.

Appendix Table 1 A comparison of labor share: 1980- 2009

	Labor share average	Standard deviation	Capital share average
Unadjusted compensation of employees/GDP	0.5304	0.0014	0.4696
Adjusted compensation of employees(case a)/GDP	0.6511	0.0392	0.3489
Adjusted compensation of employees(case b)/Y	0.6734	0.0165	0.3266

Note: Y=GDP – (tax on production and imports + imputed service of owner-occupied dwellings).

Prolonged De ation and Structural Change in the Labor Market in Japan

Sei Kuribayashi*

Abstract

Japan's economy has fallen into de ation since the middle of the 1990s. It is one of main objectives of so-called Abenomics to overcome this prolonged de ation in two years or so. We divide the entire period from 1981 to 2012 into three basic periods: the periods 81-91, 92-97, and 98-12. We estimated general price equations, and macro-economic relations such as Phillips curve and Okun's law in the labor market, and tested structural change between these periods. We found structural change of these equations between the periods 81-91 and 92-12. Prolonged de ation exerted a great in uence on the labor market in Japan. Some experimental calculations with our estimated equations tell us that cumulative 10% growth rate will be required to overcome present prolonged de ation, although the price target of 2% will not be reached.

KEYWORDS: Prolonged De ation, Structural Change in the Labor Market, CPI Equation, Phillips Curve, Okun's Law, BOJ's 2% In ation Targeting.

JEL classi cations: E24, E31

1. Introduction

Recently, the question of how to overcome prolonged de ation has become a major issue in Japan. So-called "Abenomics" has attracted attention not only domestically but also internationally. Therefore, we have to know what economic factors decisively in uence general prices in a quantitative manner. It is theoretically and widely debated whether monetary factors such as money supply, or real ones such as output gap, mainly matter in general price determination.

The purpose of this paper is to estimate general price equations and macro-economic relationships in the labor market in Japan, and quantitatively assess economic growth and other factors required to overcome Japan's prolonged de ation.

The organization of this paper is as follows: in section 2, after brie y describing the movements of general prices and related indicators, we estimate general price equations and test structural change between the period prior to the burst of the bubble and the post-bubble era; in section 3, we estimate macro-economic relationships in the labor market and also test structural change; lastly, we examine economic growth and other main factors required to overcome the prolonged de ation based on the estimated equations in the nal section.

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2. Price Equations

In the 1970s, two oil shocks brought about high in ation in Japan as well as other major countries in the world. Japan's economy somehow managed to weather the second oil shock and avoided double-digit in ation, unlike in the rst one. After the two oil shocks, Japan's in ation in terms of consumer prices decelerated from 7.8% in 1980 to near zero percent in the middle of the 1990s, except in peak years in the bubble era.

De ation is internationally de ned as an economic situation in which general prices decline for more than or equal to two years consecutively. In general, we consider the consumer price index (CPI), private consumption de ator or GDP de ator (PGDP) as a representative indicator of general prices. In Japan, the CPI (all items) and the private consumption de ator started to fall consecutively year by year around 1998, and the PGDP has declined since around 1995. That is to say, Japan's economy has been in de ation for more than fteen years since the late 1990s.

Figure 1 illustrates annual rates of increase in the CPI, the PGDP, the compensation of employees per capita (wage, hereafter), and the GDP gap. We divide the entire period from 1981 to 2012 into three basic periods in this paper: "middle-growth" from 1981 to 1991 (81-91), "bubble-aftermath" from 1992 to 1997 (92-97) and "prolonged-de ation" from 1998 to 2012 (98-12). As seen in Figure 1, the rates of increase in the CPI have been below zero since 1999 and those in the PGDP since 1995. Since we consider GDP de ator is the most appropriate economic indicator for general prices, it is reasonable to assume that Japan's economy fell into de ation in the middle of the 1990s. In particular Japan's de ation has worsened since 1998 as wages started to decrease consecutively.

Table 1 shows the average annual rate of increase in price-related indicators for each period. In the 81-91 period, Japan's economy grew at the average rate of 4.6%. Import prices declined at the average rate of 6.8%, which re ected a 6.7% annual drop of crude oil price and 6.3% annual appreciation of the yen. Wages increased at the rate of 3.5%, which was slightly higher than the rate of increase in productivity (3.4%). The GDP gap, which is measured by the ratio of the difference between potential and actual GDP to potential GDP, uctuated cyclically at the level of 1.9%. The Bank of Japan (BOJ) reduced the of cial discount rate consecutively from 1981 to 1988, and accommodated the money supply

Figure 1 Prices, Wage, and GDP gap

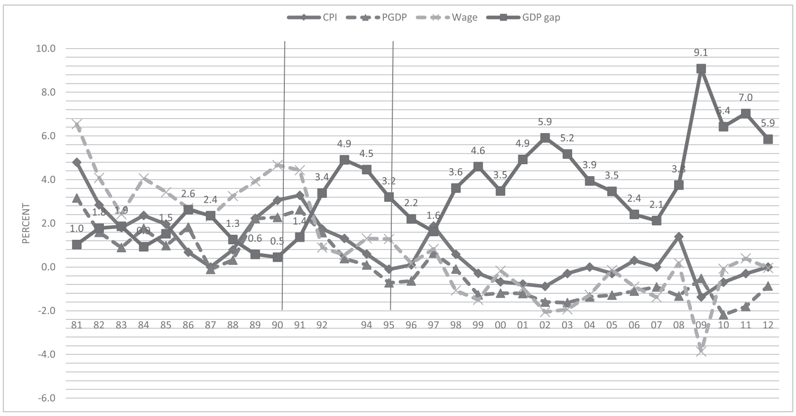

Table 1 Average Annual Rate of Increase in Sub-periods

(Percent)

Sub-period	CPI	CGPI	Import price Index	Exchange rate	Average crude price	Wage rate	Productivity	GDP de ator
81-91	1.77	0.79	6.84	6.29	6.65	3.49	3.37	1.35
92-97	0.74	1.13	1.44	2.78	0.52	0.87	0.97	0.10
98-12	0.23	0.14	2.43	2.65	14.72	1.09	1.01	1.27
Reference								
95-12	0.13	0.08	2.25	1.35	12.63	0.94	1.02	1.13

Sub-period	Real growth rate	Nominal growth rate	M2+CD	Monetary base	Total employment	Employees	Unemployment rate, average, (minimum and maximum)
81-91	4.63	6.05	9.07	7.78	1.22	1.98	2.49 (2.1, 2.8)
92-97	1.34	1.45	2.25	4.65	0.37	1.13	2.93 (2.2, 3.4)
98-12	0.75	0.53	2.29	4.91	0.22	0.25	4.63 (4.1, 5.4)
Reference							
95-12	0.79	0.35	2.48	5.77	0.18	0.27	4.41 (2.9, 5.4)

Note: 1. CPI denotes consumer price index, CGPI denotes corporate goods price index and M2+CD denotes M2+certi cated deposits.
2. Productivity is de ned as the ratio between real GDP and total employment.

required for the average growth of 4.6%. As a result, the CPI increased on average at 1.8%. But Japan's economy was in so-called disin ation. That is to say, the rate of increase in the CPI reduced year by year from 4.8% in 1981 to 0% in 1987, although the CPI increased at the rate of around 3% at the peak of the bubble era.

In the period 92-97, Japan's economy stagnated with an average growth of 1.3%, and the GDP gap became very high in the rst three years, although rather high growth in 1996 and 1997 reduced it to a level a little bit higher than the average in the previous period. Import prices declined at the average rate of 1.4% and wages increased at the average rate of 0.9%. The CPI increased at the average rate of 0.7%, which would have been lower unless the consumption tax rate had been raised by two percentage points in April 1997. The BOJ eased its monetary policy after the burst of the bubble, and lowered the of cial discount rate consecutively from 6.0% in 1991 to 0.5% in 1997. The money supply increased at the average rate of 2.2%. Japan's economy fell into de ation in 1995 in terms of the GDP de ator.

In the 98-12 period, Japan's economy slipped into a de ationary spiral, and the GDP gap widened with an upward trend as can be seen in Figure 1. The average growth-rate in this period was further reduced to 0.8%, although Japan's economy grew at the rate of about 2% over the ve years from 2003 to 2007. As a result, the CPI declined at the average rate of 0.2%, and the PGDP at the average rate of 1.3%, despite the fact that import prices increased at 2.4%, and the BOJ relaxed restrictions by adopting a zero interest, quantitative monetary policy. In particular, the PGDP has decreased every year since 1995.[1]

[1] Actually the PGDP increased at 0.6% only in 1997. But if the consumption tax rate had not been raised, it would not have risen.

Taking into account the above-mentioned trends in price-related economic indicators, we estimated price equations by the ordinary method of least squares, and the estimated results are shown in Table 2. We regressed both the CPI and the PGDP with respect to the GDP gap, the unit labor cost, the money supply, and the exchange rate over the periods 81-12 and 92-12. We also tried to include import prices in the explanatory variables, but we could not obtain the expected positive coef cients, and these are not shown in Table 2.

For the entire sample period, we obtained expected signs for coef cients on all

Table 2 Price Equations

	Constant	GDP gap	Unit labor cost	Money supply	Exchange rate	R^2	s	d	Sample period	Chow test
CPI										F
EQ1	0.79	0.1236	0.4397			0.74	0.74	0.92	1981-2012	
	1.88	1.25	5.18							F=4.15
	1.57	0.3064	0.2907			0.50	0.62	1.58	1992-2012	P=0.0158
	4.22	3.97	3.03							
EQ2	2.04	0.4145	0.4289	0.0443		0.75	0.72	1.55	1981-2012	
	4.55	5.28	5.31	0.94						F=2.73
	1.85	0.2864	0.2754	0.1564		0.50	0.62	1.63	1992-2012	P=0.0527
	4.01	3.60	2.84	1.03						
EQ3	1.03	0.3552	0.4011		0.0075	0.78	0.67	1.63	1981-2012	
	1.66	4.84	5.27		2.36					F=2.49
	0.92	0.2852	0.2962		0.0051	0.48	0.64	1.62	1992-2012	P=0.0699
	0.61	3.09	3.00		0.44					
EQ4	1.04	0.3562	0.4011	0.0019	0.0076	0.78	0.68	1.63	1981-2012	
	1.62	4.49	5.17	0.04	2.09					
PGDP										
EQ1	1.54	0.4410	0.4167			0.65	0.87	1.54	1981-2012	
	5.13	5.73	4.29							F=5.19
	0.14	0.1909	0.2561			0.20	0.81	1.31	1992-2002	P=0.0061
	0.78	0.07	0.06							
EQ2	0.50	0.3133	0.4007	0.1321		0.71	0.80	1.75	1981-2012	
	1.00	3.60	4.48	2.52						F=2.15
	0.46	0.1685	0.2389	0.1749		0.19	0.82	1.27	1992-2012	P=0.1061
	0.75	1.61	1.87	0.88						
EQ3	0.10	0.3174	0.3766		0.0091	0.70	0.81	1.5	1981-2012	
	0.14	3.58	4.10		2.36					F=2.96
	2.63	0.0999	0.2796		0.0220	0.25	0.78	1.29	1992-2012	P=0.0406
	1.42	0.88	2.30		1.55					
EQ4	0.30	0.2670	0.3786	0.0954	0.0060	0.72	0.79	1.68	1981-2012	
	0.41	2.93	4.25	1.66	1.44					

Note: 1. All variables are measured in percent.
2. R^2 is coef cient of determination adjusted for degrees of freedom, s is standard deviation and d is Durbin-Watson ratio.
3. Figures under coef cients are t-values.

explanatory variables except money supply in equation 4 for CPI. Also, most coef cients are statistically signi cant at the 5% level. The money supply is not signi cant in both the CPI and PGDP equations. This is because of various roundabout transmission routes of monetary policy. As shown in Table 2, we also estimated all equations except equation 4 over the period 92-12 which includes both 92-97 and 98-12, and conducted a Chow breakpoint test between the periods 81-91 and 92-12. We found evidence of structural change at the 5% signi cance level for equation 1 of CPI and nearly so for equation 2 of CPI, as F-statistics and P-values in the last column of Table 2 indicate. As far as PGDP is concerned, structural change is noticed in equations 1 and 3. We could not obtain statistically better estimation results for the latter period than for the entire period. All in all, the GDP gap and the unit labor cost in uenced the CPI most signi cantly in Japan. The exchange rate has a statistically signi cant although not so in uential impact on the CPI, but we could not nd empirically that the money supply was a signi cant factor in general price determination. This would be because the BOJ's monetary policy did not control money supply directly, and it was endogenously determined in the past.

3. Okun's Law

We estimated Okun's law which shows a macro-economic relationship between unemployment and output. According to previous studies in the literature of Japan's economy, there exists a stable relationship between the rst differences of unemployment rate($\Delta u_t = u_t - u_t$-1) and growth-rate(g_t): $\Delta u_t = a + bg_t$. Based on this, we estimated Okun's equations over various periods and tested structural change using the Chow test, and F-statistics ant P-values are shown in the last column of Table 3. The Chow test gives evidence of the structural changes of Okun's law between the periods 81-91 and 92-12, and also between the periods 81-97 and 98-12.

The second to last column shows values of growth-rate required for maintaining unemployment at the previous year level for each sample period. Take equation 5 for example. 1.4% growth is needed to keep unemployment at the previous year level for the period 98-12. Naturally, a comparison between equations 4 and 5 implies that the lower the average unemployment for a sample period, the higher the growth-rate required to keep it.

One of the distinctive features in the Japanese labor market is a steady increase in irregular workers such as part-timers and dispatched temporary workers since the middle of the 1980s due to deregulation in the labor market. The ratio of irregular employees to total employees rose year by year consecutively, from 15.3% in 1984 to 35.2% in 2012. When we included the irregular worker ratio in the explanatory variables in the Okun equations, therefore, we obtained equations 8 and 9 which tted the observation data better than the other equations. The estimated coef cients of the growth-rate are almost the same in comparison with equations 3 and 9. That is to say, the inclusion of irregular workers in the equations does not change the impact of the growth-rate on unemployment. On the one hand, an increase in the irregular worker ratio reduces the growth-rate required to keep unemployment unchanged.

Table 3 Okun's Law

Δ u	Constant (a)	Growth-rate (b)	ratio of irregular workers	DUM	R^2	s	d	Sample period	a/(-b)	Chow test
EQ1	0.2847	0.0885		0.8378	0.43	0.27	0.94	1981-2012	3.2	
	4.39	4.55		2.98						
EQ2	0.5068	0.1099			0.39	0.18	2.04	1981-1991	4.6	F=4.39
	2.66	2.72								
EQ3	0.2663	0.1435		0.8524	0.57	0.27	0.85	1992-2012	1.9	P=0.0041
	4.00	4.81		3.03						
EQ4	0.3458	0.0775			0.44	0.17	1.64	1981-1997	4.5	F=6.80
	4.17	3.65								
EQ5	0.2141	0.1551		0.8072	0.64	0.29	1.04	1998-2012	1.4	P=0.0041
	2.65	4.74		2.68						
EQ6	0.4173	0.1273			0.52	0.17	1.43	1992-1999	3.3	F=2.96
	6.28	2.91								
EQ7	0.1550	0.1408		0.7395	0.60	0.28	1.09	2000-2012	1.1	P=0.0807
	1.74	4.10		2.46						
EQ8	1.0755	0.1294	0.0293	0.6256	0.71	0.20	1.26	1984-2012		
	5.71	7.85	4.40	2.96						
EQ9	0.9922	0.1431	0.0261	0.6620	0.68	0.23	1.28	1992-2012		
	3.57	5.55	2.67	2.61						

Note: 1. Growth-rate and ratio of irregular workers are measured in percent.
2. R^2 is coef cient of determination adjusted for degrees of freedom, s is standard deviation and d is Durbin-Watson ratio.
3. DUM is a dummmy variable for data irregularity, taking value 1 for 2011 and 0 otherwise.
4. Figures under coef cients are t-values.

4. Phillips Curve

The scatter in the rate of increase in wages and unemployment over the period 81-12 is shown graphically in Figure 2. We can observe a gradual downward sloping relationship between two variables for the period 81-91. On the other hand, we can see an almost horizontally stretching relationship around the 0.9% rate of increase in wages for the period

Figure 2 Unemployment and Changes in Wage

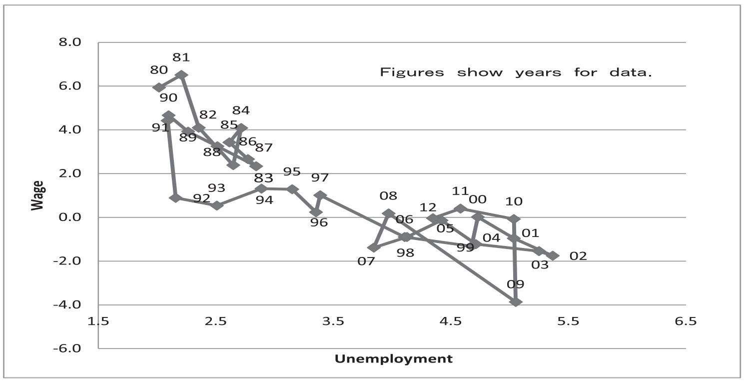

Table 4 Phillips Curve

Wage rate	Constant (a)	Unemployment (b)	CPI	DUM	R^2	s	d	Sample period	a/(b)	Chow test
EQ1	7.2827	1.7281		2.3693	0.74	1.19	0.93	1981-2012	4.2	
	9.88	8.62		1.89						
EQ2	12.2822	3.4430			0.51	0.84	1.49	1981-1991	3.6	F=24.38
	4.89	3.39								
EQ3	2.9610	0.7768		2.8993	0.70	0.68	1.64	1992-2012	3.8	P=0.0000
	4.13	4.54		4.03						
EQ4	3.8045	0.9300	0.7602	1.8974	0.81	1.02	0.89	1981-2012		
	3.21	3.24	3.46	1.76						
EQ5	3.1409	0.3864	0.7384		0.79	0.55	1.95	1981-1991		F=14.03
	1.03	0.36	3.57							
EQ6	3.2414	0.8414	0.0926	2.9797	0.68	0.70	1.73	1992-2012		P=0.0000
	2.72	3.03	0.30	3.79						

Note: 1. CPI denotes the rate of increase in CPI. u and CPI are measured in percent.
2. R^2 is coef cient of determination adjusted for degrees of freedom, s is standard deviation and d is Durbin-Watson ratio.
3. DUM is a Rehman shock dummmy variable, taking value 1 for 2009 and 0 otherwise.
4. Figures under coef cients are t-values.

92-97, and a slightly declining relationship for the period 98-12. We estimated both ordinary and augmented Phillips curves over the entire and two sub-periods based on the above mentioned observation. The estimated Phillips equations are listed in Table 4. We also tested structural change using the Chow test, which is presented in its last column. Both Phillips curves changed structurally between the periods 81-91 and 92-12. But we could not get satisfactory estimates of coef cients for the augmented Phillips curves for the period 92-12. The second to last column for equations 1 to 3 shows the values of unemployment at which wages do not change on average over the period. Take equation 3 for example. If the unemployment is 3.8%, wages will not change. If the unemployment comes down to 3.0%, wages will increase at the rate of about 0.6%.

5. Concluding Remarks

Taking into account the fact that the CPI in Japan has never increased at the rate of more than 1.7% since 1992 and decreased in most years, it seems to be an enormous challenge to achieve the price stability target of 2% over the next two years or so. Let us try to make two rough experimental calculations with our estimated equations. Since structural change is detected for macro-economic relationships in the labor market, the estimated regressions over the period 92-12 are basically used in the following calculation.

Case 1: We assume values for wages, the unit labor cost and the GDP gap to be 3.0%, 0.6% and 0.6% respectively, referring to actual economic situations around the middle of the 1980s. Equation 1 of CPI for the period 92-12 gives us a value of 1.6% for the rate of increase in the CPI. In order for wages to increase at the assumed rate of 3.0%, unemployment has to be 2.5% based on equation 1 of the Phillips curve[2] . We have to reduce unemployment

[2] Since the actual rates of increase in wages is less than 1.3% in the period 92-12, we use equation 1 of the Phillips curve.

by 1.8 percentage points from 4.3% in 2012 to attain the unemployment of 2.5%. According to equation 3 of Okun's law, a growth of 14.4% will be required cumulatively. That means we need 2% growth for about seven years, or 3% growth for about ve years. Consequently, this economic growth situation will bring down the GDP gap to less than 1%.

Case 2: Actually, real GDP grew at the rate of 9.5% over the ve years from 2003 to 2007. We therefore assume Japan's economy will expand at the rate of 10% cumulatively from 2013 on; that is to say, 2% annual growth for ve years, or 2.5% for four years, and the GDP gap is assumed to be reduced by 3.8 percentage points from 5.9% in 2012 to 2.1%, just like over the period 03-07. Based on equation 3 of Okun's law, unemployment will be reduced by 1.2 percentage points from 4.3% in 2012 to 3.1%. Substituting 3.1% for the unemployment of equation 1 of the Phillips curve, we get 1.9% for the rate of increase in wages, which is assumed to lead to the 0.5% increase in unit labor cost. As a result, we obtain a value of 1% for the rate of increase in the CPI.

The above two cases tell us that Japan's economy require a steady long-term economic growth of more than 2% to overcome the deep-rooted prolonged de ation, although the price target of 2% will not be reached.

The BOJ adopted a 2% in ation targeting monetary policy in January 2013, in April 2013 introduced "Quantitative and Qualitative Monetary Policy Easing", and changed the main operating target for monetary market operation from an overnight call rate to a monetary base in order to achieve the in ation target of 2%. In particular, the BOJ's new monetary policy aims to work on people's expectations. The effects of Abenomics including the drastic change in the BOJ's monetary policy to overcome de ation remain to be seen.

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The Macroeconomic Effectiveness of Resilience Investment in the Context of Earthquake Risk

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Abstract

Many people fear that Japan will continue to experience massive earthquakes, and many believe that the Japanese economy is experiencing de ation. Public investment is important for both reducing and preventing damage from natural disasters. Some view such investment as a countermeasure that will not only increase the resilience with which Japan deals with disasters but also facilitates the nation's recovery from de ation. Others have voiced concern that public investment will detract from the economic ef ciency of Japan. Taking into account the probability of earthquake occurrence and extent of damage, this study analyzed the macroeconomic effects of public investment and examined whether public investment could increase the resiliency and economic ef ciency of Japan.

KEYWORDS: Public investment, Great earthquake, Economic ef ciency, Resilience

JEL Classi cation: H20, H61, H68

1. Introduction

Japan faces the constant risk of major earthquakes, and predictions of these events, such as the Capital earthquake and Nankai Trough earthquake, have been made. The Central Disaster Prevention Council estimated as many as 320,000 fatalities from the Nankai Trough earthquake and as many as 11,000 deaths from the Capital earthquake (Japanese Cabinet Of ce, 2009). Another model predicted much more damage from the Capital earthquake, estimating the number of deaths at 150,000 (Nankai Trough Earthquake Study Measures Working Group, 2012). In a 1988 report, the Central Disaster Prevention Council estimated the probability of the occurrence of a 7-magnitude great earthquake within the next 30 years at 70% for a Capital earthquake and at 88% for a Tokai earthquake (Central Disaster Management Council Japan, 1988). Given the increased probability of a major earthquake, public investment in the country's infrastructure (e.g., maintenance of the transportation system and reinforcement of the seismic design of buildings) has recently emerged as a very important factor in disaster prevention and mitigation. Thus, a system for developing resilience to minimize the damage from a natural disaster through accurate risk prediction and the construction of public works is needed. Issues related to economic growth can also be considered within this framework.

"Resilience" is an important concept when considering the future economic growth of Japan. Indeed, without a system to enable resilient responses to local and global risk factors,

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neither governments nor private companies can grow in the context of the current highly competitive environment. Resilience has emerged repeatedly as an important topic related to the domestic and global economy.

However, others believe that the notion of resilience is antithetical to economic rationality and effectiveness. According to this line of thinking, if limited funding is allocated to the development of resilience in the context of the risk of earthquakes, the resulting uncertainty would decrease the competitiveness of nations and businesses. In reality, risk is present in all economic situations. Therefore it is possible to manage risk, and risk is necessary for economic growth.

Although some investment is needed to develop resilience, overinvestment leads to a decrease in competitiveness. Therefore, the level of investment should correspond to the risk of disaster. Great risk will require heavy investment, whereas less serious risk might permit less investment. Owing to Japan's high risk for a major earthquake, public investment is necessary to maintain resilience in the face of this kind of future disaster. Public investment in resilience may be regarded as "resilience investment."

In this study, we investigated the appropriate level of resilience investment in the context of economic growth targets and the occurrence probability of damage from a major earthquake. Additionally, we developed models based on the macro-economic simulation model used for analysis by the Japanese government. Finally, we examined the level of resilience that would reduce the risk to Japan's macroeconomy and ascertained the level of resilience appropriate for the sustainable development of the Japanese economy.

2. Methodology

2.1 Scenario Analysis

To demonstrate the macroeconomic effect of public investment, we employed scenario analysis to compare the occurrence with the absence of an earthquake. This analysis also considered macroeconomic simulation models in which an investment in resilience was or was not made to measure resilience effects.

We estimated the potential effect of two disasters, a Capital earthquake and a Nankai Trough earthquake. As shown in Table 1, the damage from each disaster was measured in terms of a variety of categories and classi ed under two divisions. "Direct damage" was measured in terms of numbers of dead and injured, disruption of the infrastructure (including homes, roads, railways, the water supply, and sewage systems), and damage to private facilities. "Indirect damage" included such factors as decreases in exports and rapid increases in imports due to the demand for materials and alternative energy. Some of the predicted values of damage presented in Table 1 were based on the extant literature (marked with asterisks), whereas other values were estimated in this study. Estimation of indirect damage requires an appropriate period of observation following a disaster; this period consists of the time until the affected area returns to a normal level of economic activity. "Duration of damage" was also considered indirect damage and is presented in Table 2.

The projected magnitude of the major earthquake in these scenarios is presented as "an average value obtained from the trend of past earthquakes," and the probability of

Table 1 Estimated Damage from Major Earthquakes

Index		Capital Earthquake	Nankai Trough Earthquake	Great East Japan Earthquake
Direct Damage	Number of deaths (people)	11,000	266,000	19,553
	Number of injuries (people)	210,000	334,000	5,943
	Destroyed, burned buildings	850,000	1,214,000	128,927
	Unemployment (people)	1,070,000 *	593,000 *	179,254
	Social capital stock (trillion yen)	8.99 *	14.2 *	7.24
	Housing stock (trillion yen)	35.1*	48.3*	5.20
	Private sector stock (trillion yen)	88.2*	35.1*	3.62
	Accessibility (Disruptions of transport network)	Metropolitan Expressway-Aqua line	Tomei Expressway	Sendai Airport Access line
Indirect Damage	Total private consumption	12.6 trillion yen decrease*	62.3 trillion yen decrease*	3.6 trillion yen decrease
	Exports of goods and services	12.9% decrease *	12.1% decrease *	2.7% decrease
	Imports of goods and services	(Material) 1.3 trillion yen increase * (Energy) No increase **	(Material) 1.9 trillion yen increase * (Energy) 5.2 trillion yen increase	(Material) 0.2 trillion yen increase * (Energy) 5.2 trillion yen increase
	Utilization rate	17.9% decline *	9.9% decline *	3.0% decline

* As estimates have not been published, estimates in this study were based on previous studies (see Expert Committee for Capital Earthquake, 2005; Nankai Trough Earthquake Study Measures Working Group, 2012, 2013; Kansai Institute for Social and Economic Research, 2011; Foundation for Real Estate Information Network for East Japan, 2012; Japanese Cabinet Of ce 2005, 2012, and 2013; The Bank of Tokyo-Mitsubishi UFJ, 2011; Japanese Ministry of Internal Affairs and Communications, Japanese Ministry of Land, Infrastructure and Transport, 2010; Mizuho Research Institute, 2011).

** We assumed that a nuclear power plant would not be located in areas affected by the Great East Japan Earthquake and hypothesized that alternative energy demands would not occur.

*** Based on data from the Japanese government, private sector capital investment was taken to be proportional to the rate of operation (Japanese Cabinet Of ce, 2011).

occurrence is also described as “about 88% within 30 years” (Japanese Cabinet Of ce, 2012). Therefore, although the actual size of an earthquake cannot be determined, our estimates are probably highly accurate. Our simulations valued damages based primarily on mean values from Table 1, and we used the probability distribution of occurrence to measure stochastic changes in earthquake size. Because the scenarios must also consider maximal damages, the use of only mean values is not suf cient (i.e., reports estimate 150,000 deaths in the event of a Capital earthquake; mean values lead to estimates of 110,000 deaths). Additionally, the initial occurrence of the two earthquakes (Capital earthquake and Nankai Trough earthquake) were set to vary according to a probability density function (see Figure 1) obtained from published occurrence probability gures. The probability gures were derived from a Poisson process (The Headquarters for Earthquake Research Promotion, 2010). We identi ed two scenarios: one based on “A Resilience plan for Japan,” published by the Japanese government, and the other on a government plan to invest 200 billion yen over 10 years for a resilience system. We examined the following two scenarios: (1) an investment of 20 trillion yen per year over a 10-year period and (2) an investment of half that amount.

In this study, we assumed that damages, both direct and indirect, would be reduced by resilience investment. Improvements in the earthquake-proof infrastructure (e.g., roads, railways, and buildings) could decrease loss of life, disruptions to the traf c network, and

Table 2 Duration of Indirect Damage

Index	Duration	Basis
Exports of goods and services	5 years	· Data on the period of recovery from the shocks before business activities returned to baseline show a decrease in corporate profits of about 30% during the 3 years after a supply-chain disruption compared with the general situation. It is assumed that the disruption will continue for 5 years.
Total private consumption	5 years	· It is assumed that consumer consumption awareness depends on income. Therefore, total private consumption can be assumed to equal the recovery from a disruption in the supply chain for exported goods and services.
Imports of goods and services	Material: 10 years Energy: 3 years	· Imports of goods and services goals for 10 years until the completion of reconstruction. However, these are initially dependent on external demand and gradually become dependent on domestic procurement. · In the case of energy dependence, a 3-year period will be needed before resuming operations; this is based on the case of the Great East Japan earthquake.
Utilization rate	3 years	· The decline in utilization capacity caused by the Great East Japan Earthquake has not yet been resolved. However, the utilization rate has been increasing since November 2012, and it will reach a level similar to that before the earthquake at the end of 2013. This decline in utilization is expected to continue for 3 years.

****: As estimates have not been published, our estimates were based on previous studies (see Hendricks and Singhal, 2005; Japanese Cabinet Of ce, 2009; Japanese Ministry of Health, Labour and Welfare, 2012).

Figure 1 Probability Density Function for the Initial Occurrence of an Earthquake

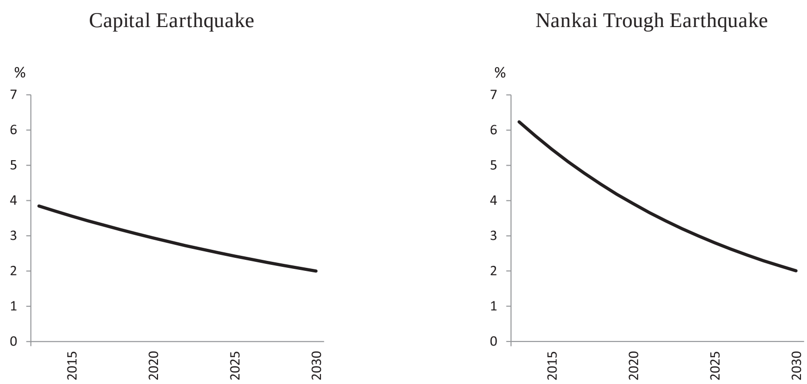

Figure 2 Overview of the Macroeconometric Simulation Model

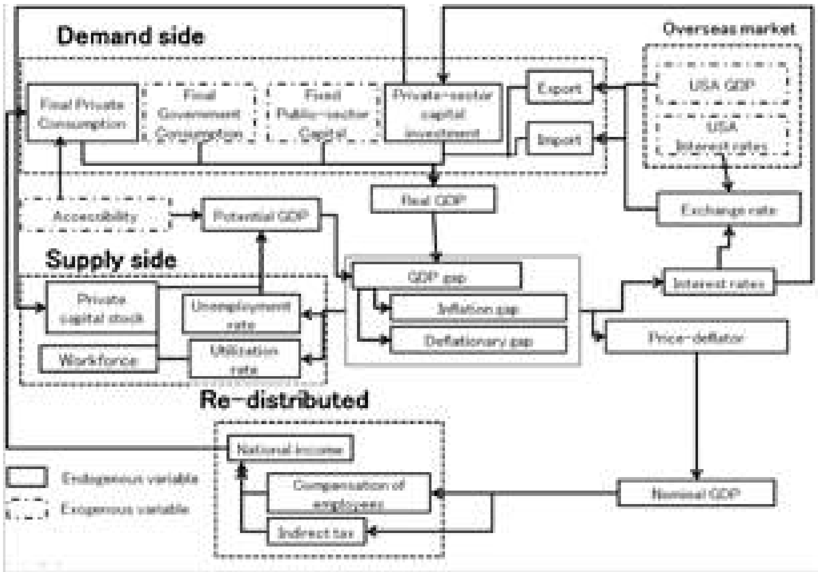

Table 3 Assumed Damages from Great Earthquakes after Resilience Investment

Index		Capital Earthquake	Nankai Trough Earthquake
Direct Damage	Number of deaths (people)	4,000 *	52,000
	Number of injuries (people)	77000*	81,300*
	Destroyed, burned buildings	325,000	288,900
	Unemployment (people)	390,000*	121,000*
	Social capital stock (trillion yen)	3.45*	12.5*
	Housing stock (trillion yen)	13.4*	25.7*
	Private sector stock (trillion yen)	6.32*	18.6*
	Accessibility (Disruptions of transport network)	Metropolitan Expressway - Aqua line	Tomei Expressway
Indirect Damage	Total private consumption	4.5 trillion yen decrease	13.0 trillion yen decrease
	Exports of goods and services	3.7% decrease	4.6% decrease
	Imports of goods and services	(Material)	(Material)
		0.5 trillion yen increase	0.4 trillion yen increase
		(Energy)	(Energy)
		No increase	No increase
	Utilization rate	6.5%	2.0%

losses of social capital, housing, and the private sector from fires and tsunamis. If direct damage can be minimized, it may also be possible to decrease indirect damage. We referenced some predicted values, such as anticipated deaths from a Nankai Trough earthquake under a resilience system, and estimated other values, including direct and indirect damages, by anticipating the conditions that would obtain under a resilience-oriented system. Additionally, we created a hypothetical scenario involving a nuclear power plant that was severely damaged by a Great East earthquake but that operated continually (Table 3).

2.2 Modeling

We simulated a macroeconomic model to measure resilience and effectiveness under the aforementioned assumptions. The macroeconomic model used in this study was based on a model adopted, and later revised, by the Japanese government (Hino et al., 2012) to compute the effects of improved infrastructure on the nation's macroeconomy. The model demonstrates that domestic demand is expanded by resilience investment and that accessibility is increased by the development of transportation networks. As a consequence, private consumption is improved and GDP ultimately increases. Conversely, it is demonstrable that an increased unemployment rate, decreased supply due a reduced capacity utilization rate, and decreased demand due to reduced temporary private consumption, results in a reduction in the GDP.

Investment in public works increases inflation by a factor of 1.65 and deflation by a factor of 5.26 (Fujii, 2012). The aforementioned macroeconometric model estimated a similar effect on inflation and deflation. However, our advanced model accounts for the inflation/deflation effect from the GDP gap between supply and demand and the difference in the multiplier effect. We measured the effect of resilience investment by focusing on changes in the GDP, tax revenue, and labor population using the advanced macroeconomic simulation model. We also considered the impact of resilience investment on Japan's current deflationary and inflationary trends; in a hypothetical situation, there is no distinction between inflation and deflation.

2.3 Estimation Results of Macroeconomic Model

The macroeconomic model proposed in this research is composed of many sub-models. In this paper, the authors present some of the estimation results for important economic variables related to macroeconomic simulation. These results are shown in Tables 4, 5, 6, 7, and 8. First, Table 4 shows potential GDP as a production function. As adjusted R^2 is high, the estimated results represent a sufficiently good fit. Second, Table 5 shows private final consumption expenditures, represented of the consumption function, and this model is also a sufficiently good fit. Table 6 presents the estimated results related to the labor force. The estimated results of models of indirect and current taxes are show in Tables 7 and 8. Tax revenue was defined as the sum of these taxes. In this study, current taxes included tax income and wealth, and indirect taxes were based on the SNA data provided by the Japanese Cabinet Office; however, social insurance premiums were not included in this model.

Table 4 Estimated Parameters of the Potential GDP Model

ln(Y) = c(1)+(1.0−c(2)))*ln(KFP*ROU)+c(2)*ln(WT*LF*(1−UR))+c(3)*ln(ACC)

Term	Constant term	KEP*ROU	ACC	Adjusted R^2	D.W.
Parameter	−9.388	0.686	1.068	0.991	0.205
t-value	−2.90	11.3	2.97		

Y: Potential GDP, KFP: Private sector capital stock, ROU: Capacity utilization, WT: Working time, LF: Labor force, UR: Unemployment rate, ACC: Accessibility.

Table 5 Estimated Parameters of the Private Final Consumption Expenditure Model

ln(R_1)=c(1)+c(2)*ln(YDV)+c(3)*ln(GAP1)+c(4)*ln(GAP2)
+c(5)*ln(ACC)+c(6)*DR20012007

Term	Constant term	YDV	GAP1	GAP2	ACC	DR20012007	Adjusted R^2	D.W.
Parameter	−16.771	0.456	0.954	0.288	2.532	0.015	0.988	1.47
t-value	(−24.1)	23.6	2.45	4.26	26.6	3.32		

R_1: Private final consumption expenditure, YDV: Disposable income, GAP1: Inflation gap, GAP2: Deflation gap, ACC: Accessibility, DR20012007: Dummy variable.

Table 6 Estimated Parameters of the Labor Force Model

Ln(LF)=c(1)+c(2)*ln(POP)+c(3)*ln(YWV/POP)+c(4)*DC2004

Term	Constant term	POP	YDW/POP	DC2004	Adjusted R^2	D.W.
Parameter	2.250	0.626	0.213	−0.006	0.994	0.496
t-value	2.05	5.20	0.213	−2.20		

LF: Labor force, POP: Population, YDW: Compensation of employees, DC2004: Dummy variables.

Table 7 Estimated Parameters of the Indirect Tax Model

Dln(ITAXV)=c(1) +c(2)*Dln(N_0)+c(3)*DC2000

Term	Constant term	N_0	DC2000	Adjusted R^2	D.W.
Parameter	0.018	0.772	−0.026	0.764	1.463
t-value	2.64	5.46	−2.64		

ITAXV: Indirect tax, N_0: Nominal GDP, DC1999: Dummy variables.

Table 8 Estimated Parameters of Current Taxes Model

Dln(TYPV)=c(1)+c(2)*Dln(N_0)+c(3)*DC1999

Term	Constant term	N_0	DC1999	Adjusted R^2	D.W.
Parameter	−0.060	2.288	0.069	0.488	2.101
t-value	−2.62	5.15	2.25		

TYPV: Current taxes, N_0: Nominal GDP, DC1999: Dummy variables.

3. Analysis

3.1 Investment of 200 trillion yen

As shown in Figure 3, when 200 trillion yen is invested for resilience, there is no GDP uctuation over the subsequent 10 years [Case A: no earthquake and no investment]. However, there is a risk of earthquake in a real situation. If an earthquake occurs, the GDP decreases. As seen in the third case [Case C: average earthquake and no investment], the GDP is reduced greatly after 2014, to 470 trillion yen, because of the possibility that a Nankai Trough earthquake will occur in 2013 or 2014. The difference between cases A and C is the expected value of the economic damage caused by the earthquake. This difference is approximately 60 trillion yen per year, with a cumulative cost of approximately 510 trillion yen after 10 years as shown in Table 9. When calculated per capita, individual income will have been reduced by approximately 4 million yen over a period of 10 years. Our analysis also found that approximately 550 trillion yen would be lost per capita, with GDP increasing to 710 trillion yen. It is estimated that it may require ~23 years for the line separating cases A and C to be crossed. This would mean a return of the GDP to its original level following a cumulative decline of 720 trillion yen and a loss of tax revenue amounting to approximately 50 trillion yen. Additionally, it is possible that the labor force and the available xed capital would be damaged by the disaster, which may decrease the GDP, leading to in ation, and thereby partially suppress the multiplier effect. However, in this study, the effects of the disaster on both the demand and the supply sides were calculated based on data on the economic damage related to the Great East Japan Earthquake, and so on. Thus, the demand and supply GDPs estimated in this paper may not be realistic.

This analysis considered only an average earthquake; the possibility of more serious damage by a major earthquake should also be considered. Therefore, a simulation with an occurrence probability of approximately 10% damage, a “worst-case” scenario, was also computed.

In the fth case [Case E: massive earthquake and no investment], the GDP will decline, nally reaching 450 trillion yen. The total reduction in the GDP over 10 years will equal 740 trillion yen, a 6 million yen loss in income per capita. Tax revenue losses over 10

Figure 3 Estimated GDP (with a resilience investment of 200 trillion yen)

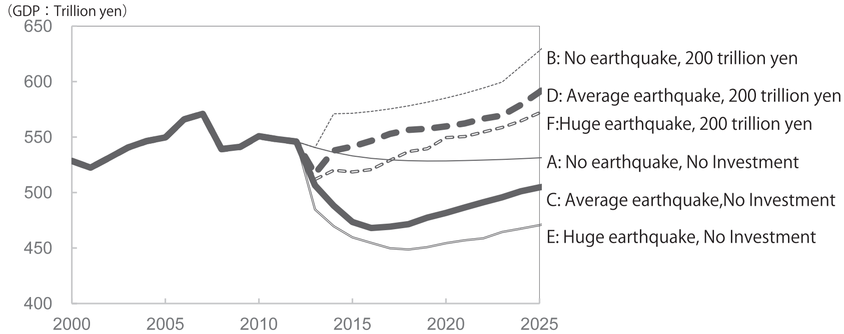

Table 9 Macroeconomic Effects of Resilience Investment (with a resilience investment of 200 trillion yen)

Case	Disaster	Resilience investment	Cumulative GDP for 10 Years (trillion yen)	Cumulative tax revenue for 10 Years (trillion yen)	Workforce after 10 years (ten thousand)
Case A	No	No	5,313.8	677.0	6,404.1
Case B	No	200 trillion yen	5,794.4	798.5	6,569.0
Case C	Average Scale	No	4,799.4	611.2	6,341.0
Case D	Average Scale	200 trillion yen	5,506.2	729.1	6,510.0
Case E	Huge Scale	No	4,572.6	554.7	6,279.2
Case F	Huge Scale	200 trillion yen	5,374.5	679.8	6,557.6

years will equal 85 trillion yen. Computed values are cumulative over one decade, but when one considers that the damage will continue for 11 more years, the seriousness of such a disaster for the Japanese economy becomes more apparent.

Predictions indicate that the probability of a major earthquake is very high, lending credence to predictions of signi cant Japanese economic losses in the future (i.e., losses of approximately 4-6 million yen per person over 10 years).

This study also modeled the extent to which damage could be mitigated through the promotion of resilience investment. The investment scenario considered involved 20 trillion yen over a 10-year period. As mentioned above, the GDP loss caused by a major earthquake would be approximately 60 trillion yen per year in the rst case. However, as presented in in Figure 3, the fourth case [Case D: average earthquake and investment of 200 trillion yen], which involved a 200 trillion yen investment in a resilience system, indicated that economic growth would continue, that the economy would overcome the damage, and that the GDP would increase by 600 trillion yen over the subsequent 10 years. This suggests that resilience investment not only minimizes economic damage and lls the gaps associated with de ation but also leads to economic growth. Thus, these data show that a resilience investment of 200 trillion yen would result in economic growth in Japan as well as minimize the damage caused by a major earthquake. The positive impact was calculated as 710 trillion yen over one decade and as approximately 1,870 trillion yen over 20 years when we compared cases C and D. Table 11 presents a comparison of the ratio of tax revenues to nominal GDP with and without a resilience investment 10 years earlier. The data reveal a 3.3% improvement in the absence of a resilience investment. Additionally, Table 10 summarizes the multiplier effect of the resilience investment per year. These data indicate that the maximum value of the multiplier given the risk of an earthquake is 4.25.

Our estimates also indicated that resilience investment would result in an increase in tax revenues. Simulation results indicated that increased tax revenues would total 200 trillion yen after 13 years. The positive effects demonstrated by simulation analysis would require an enormous investment on the part of the Japanese government. However, as this tax analysis shows, a 200 trillion yen nancial expenditure could be recouped within 13 years.

The maximum estimated damage resulting from a major earthquake would include 150,000 deaths in the case of a *Capital earthquake* and 320,000 deaths in the case of a

Table 10 Multiplier Effect of Investment per Year (with a resilience investment of 200 trillion yen)

	No Earthquake			Average earthquake			Huge earthquake		
	Real GDP	Nominal GDP	Potential GDP	Real GDP	Nominal GDP	Potential GDP	Real GDP	Nominal GDP	Potential GDP
1st year	1.74	1.63	0.26	2.49	2.06	0.98	2.52	2.12	1.77
2nd year	1.92	1.89	0.38	3.40	2.93	1.58	2.95	2.52	1.95
3rd year	2.11	2.19	0.54	3.93	3.46	1.72	3.30	2.87	2.17
4th year	2.30	2.49	0.74	4.18	3.77	1.84	3.96	3.49	2.55
5th year	2.47	2.79	0.94	4.25	3.97	2.03	4.41	3.92	2.94
6th year	2.65	3.09	1.17	4.01	3.87	2.13	4.43	3.95	3.18
7th year	2.83	3.38	1.41	3.90	3.88	2.28	4.76	4.22	3.42
8th year	3.03	3.67	1.67	3.79	3.84	2.43	4.67	4.13	3.67
9th year	3.25	3.97	1.95	3.77	3.85	2.62	4.79	4.20	3.96
10th year	3.49	4.29	2.26	3.69	3.78	2.70	4.71	4.12	4.13

Table 11 Tax Revenue-to-nominal GDP Ratio 10 Years after Resilience Investment (with a resilience investment of 200 trillion yen)

	No investment	Investment
No earthquake	14.0%	16.0%
Average earthquake	13.9%	17.2%
Huge earthquake	13.3%	15.6%

Nankai Trough earthquake. Direct and indirect damages would also increase signi cantly as the scale of the earthquake increased.

Without resilience investment, we estimate that the GDP would decline by 70 trillion yen over the 10 years following a maximum-scale earthquake. Additionally, a decline in tax revenue of approximately 11 trillion yen, along with negative effects on national life and economic activity in Japan, would also be expected.

With a resilience investment of 200 trillion yen, the GDP would continue to gradually increase at a level similar to that estimated for the economic activities following the occurrence of an average-scale earthquake, even in the case of a maximum earthquake event. The cumulative 10-year GDP would increase to nearly 800 trillion yen as compared with the case where no resilience investment occurred. Additionally, the tax revenue-to-nominal GDP ratio would improve, reaching 2.3%, and the multiplier effect of the resilience investment would increase to 4.79. Additionally, the difference in tax revenues would equal nearly 120 trillion yen over 10 years, and the 200 trillion yen of resilience investment could be recovered from the resulting increase in tax revenues after 15 years.

To summarize, a resilience investment of 200 trillion yen over 10 years would minimize the damage caused by an earthquake, ll the de ationary gap by expanding domestic demand, and grow the Japanese economy, even in the event of a *Capital earthquake* or *Nankai Trough earthquake*. Thus, an investment of 200 trillion yen can result in both resilience and ef ciency in a de ationary economy.

3.2 Investment of 100 trillion yen

We next considered the case in which the government invests 100 trillion yen in resilience over a period of 10 years. The scale of the hypothetical earthquake was the same as in the 200-trillion investment scenario. The simulation results are presented in Figures 4 and 5. When 100 trillion yen is invested for resilience, the trend in the GDP differs signi cantly from that in the 200-trillion investment model. The difference in the 10-year cumulative GDP between the 100-trillion investment cases (Case B and D) and the no-investment cases (Case A and C) equaled 280 trillion yen. A comparison of the differences between cases F and B and between cases E and A revealed that the difference in the cumulative 10-year GDP was ~420 trillion yen as shown in Table 12. The positive impact of a 100-trillion investment is 420 trillion yen in cases of an average earthquake (Case C and D). However, when 200 trillion yen is spent for resilience, the positive impact on the GDP was calculated to be 710 trillion yen over a decade. This indicates that an additional investment of 100 trillion yen makes a signi cant difference in the scale of the economic impact.

Figure 4 Estimated GDP (with a resilience investment of 100 trillion yen)

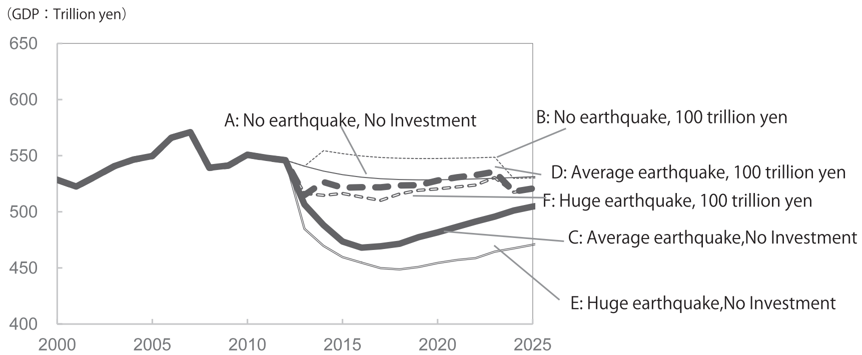

Figure 5 Estimated GDP (with a resilience investment of 200 trillion yen, no de ation)

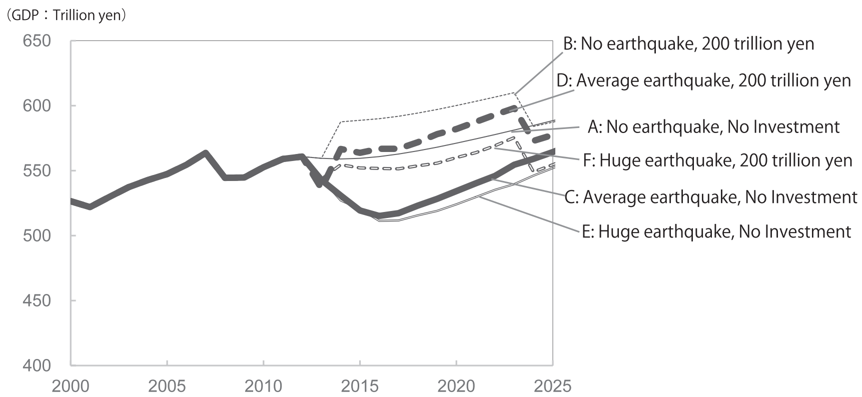

Table 12 Macroeconomic Effects of Resilience Investment (with a resilience investment of 100 trillion yen)

Case	Disaster	Resilience Investment	Cumulative GDP for 10 Years (trillion yen)	Cumulative tax revenue for 10 Years (trillion yen)	Workforce after 10 years (ten thousand)
Case A	No	No	5,313.8	677.0	6,404.1
Case B	No	100 trillion yen	5,483.5	717.1	6,449.7
Case C	Average Scale	No	4,799.4	611.2	6,341.0
Case D	Average Scale	100 trillion yen	5,247.1	655.6	6,404.0
Case E	Huge Scale	No	4,572.1	554.7	6,279.2
Case F	Huge Scale	100 trillion yen	5,164.5	624.5	6,380.1

In each of the three cases (Case B, D and F) that assumed an investment of 100 trillion yen, there was either no change or a small decline in the GDP trends, according to the scale of earthquake. This result was notably different from that of the of 200-trillion investment scenarios, which produced an increasing trend. Under conditions of a massive earthquake, the GDP might decline by 450 trillion yen, which would in uence the Japanese macroeconomy. Additionally, Table 14 summarizes the tax revenue-to-nominal GDP ratio, which would increase to 0.1%, and Table 13 summarizes the multiplier effect of resilience investment per year. This result indicates that the maximum value of the multiplier under conditions of the risk of an earthquake would be 5.28.

Table 13 Multiplier Effect of Investment per Year (with a resilience investment of 100 trillion yen)

	No earthquake			Average earthquake			Huge earthquake		
	Real GDP	Nominal GDP	Potential GDP	Real GDP	Nominal GDP	Potential GDP	Real GDP	Nominal GDP	Potential GDP
1st year	1.82	1.70	0.25	3.83	3.13	1.58	4.50	3.66	4.16
2nd year	1.88	1.85	0.35	4.80	3.96	2.31	5.67	4.60	4.22
3rd year	1.89	1.97	0.45	5.38	4.37	2.70	5.85	4.71	4.37
4th year	1.89	2.09	0.55	5.25	4.15	2.94	6.03	4.84	4.63
5th year	1.90	2.19	0.63	5.20	4.21	3.15	6.72	5.39	4.99
6th year	1.90	2.28	0.70	4.63	3.80	3.11	6.83	5.43	5.18
7th year	1.90	2.35	0.76	4.62	3.86	3.25	6.60	5.15	5.44
8th year	1.89	2.41	0.81	4.41	3.72	3.33	6.51	4.99	5.69
9th year	1.88	2.46	0.85	4.14	3.51	3.32	6.51	4.91	5.99
10th year	1.88	2.50	0.88	4.00	3.37	3.27	6.60	4.89	6.15

Table 14 Tax Revenue-to-nominal GDP Ratio 10 Years after Resilience Investment (with a resilience investment of 100 trillion yen)

	No investment	Investment
No earthquake	14.0%	14.3%
Average earthquake	13.9%	14.0%
Huge earthquake	13.3%	13.7%

These results indicate that a resilience investment of 100 trillion yen would not be sufficient to prevent deflation in the event of a major earthquake. There was no change in the GDP even in case B; over time, the GDP would decline due to decreases in investment, especially in 2023, when the resilience investment ended. It would be impossible to cover the deflationary gap with an investment of 100 trillion yen, but such an investment would not lead to economic growth. We projected that tax revenues would increase by approximately 40 trillion yen over 10 years; this is lower than the tax revenues in the case of a 200-trillion investment, but is higher than it would be if no investment were made.

If a major earthquake were to hit the country when it was not emerging from deflationary economic conditions, economic activities would be decreased by direct and indirect disaster damage and result in decreased demand and an increase in the deflationary gap. Ultimately, such a quake would probably lead to a decrease in the GDP.

To summarize, it would be difficult to achieve resilience and efficiency following a major earthquake with an investment of 100 trillion yen. Simulation results indicated that this level of investment could negatively influence Japanese financial conditions.

3.3 Investment without Deflation

In the previous section, we considered resilience investment in circumstances of deflation and concluded that large-scale public investment could cover the deflationary gap, resulting in both resilience and efficiency. We also simulated the macroeconomic effect of resilience investment assuming that Japan was in a situation of inflation without a deflationary gap.

Again, we considered the case of a resilience investment of 200 trillion yen over 10 years (See Figure 5 and Table 15). Were a major earthquake to occur in a situation where the government has promoted a base scenario corresponding to the third case [Case C: average earthquake and no investment], the GDP would decline by 40 trillion yen with a cumulative cost of 420 trillion yen after 10 years and of 520 trillion yen after 20 years. This is a serious result, but it is an acceptable risk when compared with the deflationary model (510 trillion yen after 10 years and 710 trillion yen after 20 years). When compared with case D (i.e., average earthquake and investment of 100 trillion yen), the positive impact was calculated as 710 trillion yen over 10 years, and the maximum value of the multiplier of the investment would increase to 2.58. However, these effects are smaller than they would be with deflation (see Table 16).

Conversely, it is possible to reduce risk with resilience investment. Comparisons between the fourth and second scenarios [Case D: average earthquake and investment of 200 trillion yen and case B: no earthquake and investment of 200 trillion yen] and between the third and first scenarios [Case C: average earthquake and no investment and case A: no earthquake and no investment] showed approximately 220 trillion yen cumulative over 10 years, and GDP of 21 trillion yen in 2023. This comparison demonstrates the remediation of damages to the macroeconomy when compared with the case in which no resilience investment is made. Moreover, after 10 years, the GDP would be at a higher level than the current GDP. Even when we considered a maximum damage situation, the GDP would remain at the current level after 10 years.

However, when the case involving inflation is compared with that involving deflation, we can see that the effect of resilience investment is signi cantly smaller in the former, and the trend in the GDP also differs greatly between the scenarios. If we promote resilience investment when there is no de ationary gap, the GDP will increase due to the expansion of domestic demand caused by 10 years of investing, but the GDP will decrease when investment ends. Additionally, as seen in Figure 5, the growth of the GDP would decrease due to "crowding out." Private investment is also strong in the in ationary case, where no de ationary gap exists. In a de ationary environment, large-scale government funding places nancing pressure on the private sector. This negates any economic stimulus effect,

Table 15 Macroeconomic Effects of Resilience Investment (with a resilience investment of 200 trillion yen, no de ation)

Case	Disaster	Resilience Investment	Cumulative GDP for 10 Years (trillion yen)	Cumulative tax revenue for 10 Years (trillion yen)	Workforce after 10 years (ten thousand)
Case A	No	No	5,658.0	774.3	6,517.6
Case B	No	200 trillion yen	5,918.8	834.3	6,569.1
Case C	Average Scale	No	5,238.0	696.9	6,470.9
Case D	Average Scale	200 trillion yen	5,721.8	779.2	6,530.6
Case E	Huge Scale	No	5,130.2	675.4	6,427.4
Case F	Huge Scale	200 trillion yen	5,550.6	746.1	6,496.0

Table 16 Multiplier Effect of Investment per Year (with a resilience investment of 200 trillion yen, no de ation)

	No Earthquake			Average Earthquake			Huge Earthquake		
	Real GDP	Nominal GDP	Potential GDP	Real GDP	Nominal GDP	Potential GDP	Real GDP	Nominal GDP	Potential GDP
1st year	1.43	1.36	1.43	1.79	1.51	1.79	1.37	1.09	1.37
2nd year	1.46	1.41	1.46	2.22	1.81	2.22	1.59	1.21	1.59
3rd year	1.46	1.43	1.46	2.58	2.07	2.58	2.02	1.55	2.02
4th year	1.45	1.45	1.45	2.48	1.91	2.48	1.99	1.48	1.99
5th year	1.45	1.47	1.45	2.44	1.86	2.44	1.91	1.40	1.91
6th year	1.45	1.49	1.45	2.49	1.90	2.49	1.84	1.35	1.84
7th year	1.45	1.51	1.45	2.39	1.81	2.39	1.80	1.34	1.80
8th year	1.45	1.53	1.45	2.37	1.80	2.37	1.71	1.29	1.71
9th year	1.44	1.55	1.44	2.35	1.79	2.35	1.70	1.32	1.70
10th year	1.44	1.57	1.44	2.18	1.65	2.18	1.79	1.45	1.79

Table 17 Tax Revenue-to-nominal GDP Ratio 10 Years after Resilience Investment (with a resilience investment of 200 trillion yen, no de ation)

	No Investment	Investment
No earthquake	14.9%	15.4%
Average earthquake	14.5%	15.1%
Huge earthquake	14.0%	14.8%

even when the government makes a huge investment. This was observed only in the de ationary case; in such a scenario, the earthquake damage is minimized and, at the same time, grows the Japanese economy. These effects do not exist under in ationary conditions.

The simulation also indicated that tax revenues would also increase due to GDP growth of 60 trillion yen over 10 years; there is a decline in the GDP after the investment period ends, with an attendant decrease in tax revenues. Such decreased tax revenues would make it dif cult to recover an investment of 200 trillion yen. The basic trends when an investment of 100 trillion yen is made under de ationary conditions are similar to those when an investment of 200 trillion yen is made, as shown in Figure 6 and Table 18, 19, 20.

However, as noted at the beginning of this section, economic conditions characterized by the presence of in ation and the absence of a de ationary gap do not exist in reality. This virtual case was presented to compare the macroeconomic effects of resilience investment with those of de ation.

Figure 6 Estimated GDP (with a resilience investment of 100 trillion yen, no de ation)

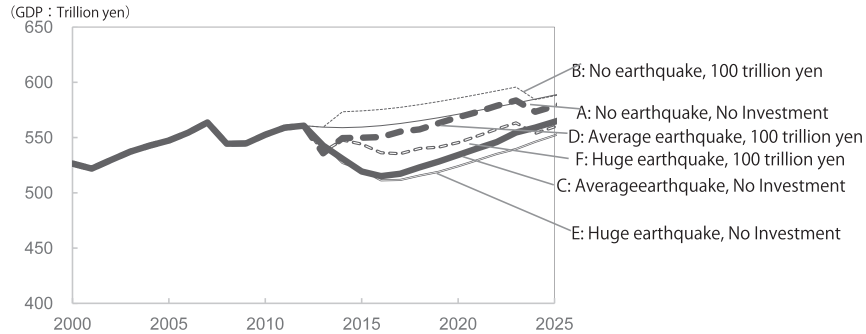

Table 18 Macroeconomic Effects of Resilience Investment (with a resilience investment of 100 trillion yen, no de ation)

Case	Disaster	Resilience Investment	Cumulative GDP for 10 Years (trillion yen)	Cumulative tax revenue for 10 Years (trillion yen)	Workforce after 10 years (ten thousand)
Case A	No	No	5,658.0	774.3	6,517.6
Case B	No	100 trillion yen	5,789.0	834.3	6,569.1
Case C	Average Scale	No	5,238.0	696.9	6,470.9
Case D	Average Scale	100 trillion yen	5,721.8	742.7	6,505.2
Case E	Huge Scale	No	5,130.2	675.4	6,427.4
Case F	Huge Scale	100 trillion yen	5,419.5	702.0	6,468.7

Table 19 Multiplier Effect of Investment per Year (with a resilience investment of 100 trillion yen, no de ation)

	No earthquake			Average earthquake			Huge earthquake		
	Real GDP	Nominal GDP	Potential GDP	Real GDP	Nominal GDP	Potential GDP	Real GDP	Nominal GDP	Potential GDP
1st year	1.43	1.37	1.43	1.87	1.38	1.87	2.06	1.56	2.06
2nd year	1.47	1.42	1.47	3.05	2.29	3.05	2.37	1.66	2.37
3rd year	1.46	1.44	1.46	3.53	2.56	3.53	2.49	1.61	2.49
4th year	1.46	1.46	1.46	3.81	2.67	3.81	2.37	1.39	2.37
5th year	1.46	1.48	1.46	3.44	2.25	3.44	2.46	1.43	2.46
6th year	1.46	1.50	1.46	3.48	2.23	3.48	2.24	1.24	2.24
7th year	1.46	1.53	1.46	3.42	2.16	3.42	2.14	1.17	2.14
8th year	1.45	1.55	1.45	3.29	2.05	3.29	2.18	1.25	2.18
9th year	1.45	1.57	1.45	3.28	2.07	3.28	2.24	1.36	2.24
10th year	1.45	1.59	1.45	2.91	1.76	2.91	2.36	1.53	2.36

Table 20 Tax Revenue-to-nominal GDP Ratio 10 Years after resilience investment (with a resilience investment of 100 trillion yen, no de ation)

	No Investment	Investment
No Earthquake	14.9%	12.8%
Average Earthquake	14.5%	14.7%
Huge Earthquake	12.4%	12.2%

4. Conclusion

In this study, we theoretically and quantitatively examined the conditions that would lead to economic resilience, ef ciency, and economic growth in the event of a future disaster. Using an advanced macroeconomic simulation model, we analyzed the effects of resilience investments of 200 trillion and 100 trillion yen, simulating the conditions of a Capital earthquake and a Nankai Trough earthquake. Four main ndings were obtained from this study.

First, using predictions published in a Japanese government report, we calculated that the GDP would probably decrease to 60 trillion yen as a result of either a *Capital earthquake* or *Nankai Trough earthquake* event. The 10-year cumulative value would decrease sharply to 510 trillion yen. Notably, this estimated loss is a stochastic average value expected from a variety of situations including both the occurrence and the absence of an earthquake. These results strongly indicate the need for preparation that views a future earthquake event as the default condition.

Appropriate resilience investment related to the occurrence of an earthquake can minimize damage and also facilitate an escape from de ationary conditions. Economic growth can also be maintained in spite of a major earthquake event. An investment of 200 trillion yen for 10 years, will reduce damage to the macroeconomy and also act as an effective economic stimulus. Our study estimated that this level of investment would contribute 600 trillion yen to the GDP by 2025. However, the third nding of this study was that an investment of 100 trillion yen would be insufficient to fill the deflationary gap caused by a disaster and would have only a minor economic stimulus effect.

We also considered a hypothetical situation where no deflationary gap exists. Simulations demonstrated that resilience in the context of disaster could be achieved through investment, but that the economic stimulus effect would be limited by “crowding out.” However, an investment of 100 trillion yen over a 10-year period could substantially mitigate damage to the GDP. It is important to note that although the model parameters were estimated based on real data, the numerical results described above were calculated based on specific assumptions. Therefore, further study is needed to verify whether the required level of investment depends on the extent of damage to the GDP.

By modifying the scale of investment to fill the deflationary gap, it is possible not only to build a resilience system but also to maximize efficiency in the service of economic growth.

Based on the scenarios described above, we conclude that assertions that “economic efficiency (rationality) and resilience conflict with each other and that there is a trade-off is between these two” are not valid under conditions of deflation and in situations involving a high risk of an earthquake. In these situations, sufficient resilience investment can lead to efficient economic growth and the development of a system that protects the economy against the impact of earthquakes. As a result of Japan’s deflationary economic environment and the probability of a major disaster, the nation faces significant economic risk. Therefore, a policy of public investment for economic growth and resilience is strongly indicated.

Future work is needed to test and elaborate on the presuppositions of this study. Additional work is also needed to determine the most effective levels of investment in various regions. This study demonstrates that resilience investment can contribute to building a robust national economy capable of withstanding risk and emerging from deflation.

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A Survey of the Arguments Concerning China’s GDP Statistics*

Jie Li**

Abstract

This paper examines the arguments concerning China’s GDP statistics and the three retroactive revisions of GDP by the National Bureau of Statistics of China. The survey of the past two decades shows the possibility that China’s of cial GDP gures have been underestimated conservatively rather than overestimated as the media have suggested since 2000. This paper also considers the consistency between Gross Regional Product and GDP in Japan and China.

KEYWORDS: China’s of cial GDP, Gross Regional Product, System of National Accounts, System of Material Product Balances

JEL classi cations: P24

1. Introduction

Since its economic reform in 1978, China has achieved high economic growth. However, the transition to a socialist market economy from a planned economy has also been a process of moving to a System of National Accounts (SNA hereafter) from a System of Material Product Balances (MPS hereafter). Against this background, interest in China’s GDP statistics is high, although distrust in these gures is also strong.

This paper examines the arguments concerning China’s GDP statistics. The topics covered include the upward adjustments of 30% or more in China’s of cial GDP by the World Bank in its publications from 1994 to 1998 and the upward adjustment of approximately 10% by Maddison (1998). The paper also assesses the various criticisms and commentaries on China’s GDP statistics by scholars and the media in the United States, Europe, Japan, and China since 2000. In addition, the rebuttal of some of these criticisms and adjustments and the three retroactive revisions of GDP by the National Bureau of Statistics of China (NBS hereafter) are discussed. The presented survey shows that China’s GDP statistics may have been underestimated conservatively rather than overestimated as the media suggest.

This paper also considers the consistency between the Gross Regional Product (GRP hereafter) estimated by local governments and GDP estimated by the central governments in Japan and China as well as the problems of estimating GDP based on the concept of MPS.

2. Upward Adjustments to China’s GDP by the World Bank between 1994 and 1998

The national income statistics provided by the MPS system in the planned economy

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period in China were well known. Since the economic reform, however, because services such as nance and insurance, real estate, communications and broadcasting, education, and research have grown rapidly, NBS has launched a study of GDP, which has been central to the SNA system since the early 1980s. In order to overcome the defects in the MPS system, which did not cover the production activities of non-physical services, NBS began to estimate GDP as an index in 1985. In 1993, NBS abolished estimates based on the MPS system and moved to the SNA system. This action was in uenced by the external changes in the early 1990s in the former Soviet Union and in Eastern European countries that no longer conformed to the MPS system as well as the internal changes made at the 14th Party Congress, which set the introduction of market mechanisms as the reform target for China's economic system.

The World Bank (1991) report declared that there are shortcomings in the fundamental concepts, survey scope, and survey methods of the provision of the National Accounts Statistics in China. Speci cally, the fundamental concept is deeply rooted in MPS, the survey scope still focuses on material production, and the survey method provides traditional administrative production reporting. In addition, the price system still shows many of the characteristics of a planned economy, while the prices of many products are under the government's control. Therefore, all these factors have led to the underestimation of GDP statistics and the overestimation of economic growth.

Based on this report, the World Bank (1993) upwardly adjusted its 1992 GDP gure for China by more than 30%[1]. This upward adjustment continued until 1998. In January 1999, China's Ministry of Finance and NBS visited the World Bank and submitted a request to cancel the adjustment to China's GDP statistics. In March of the same year, the World Bank visited Beijing to consult on this issue with NBS.

Table 1 shows the evaluations and adjustments to China's GDP statistics by the World Bank and the rebuttal of these adjustments by NBS[2]. The World Bank's adjustments were made from three aspects. First, an adjustment based on the inconsistencies in the data in China's statistical system (1.6% increase in GDP). Second, scope adjustments based on the balance of input-output tables (11.7% increase in GDP). Third, combined valuation adjustments owing to the impact of the price system (18.3% increase in GDP). For each adjustment item, with the exception of some items such as housing services[3], NBS countered sequentially.

[1] At the time, because there was no great difference between the GDP and GNP of China, the World Bank's adjustments were made based on GDP statistics.

[2] The rebuttal by NBS is derived from the papers by Xu, a central member of the Chinese consultation team who was later promoted to the national accounts manager of NBS. For example, Xu (1999a) was awarded China's '9th (2000) Sun Yefang Economic Science Paper Award' and '5th (2000) National Statistics Scienti c Research excellent results (paper) rst prize'. The consultation history is shown in most detail in Xu (2000).

[3] For the underestimation of China's housing services, see Li (2013b, c).

Table 1 Evaluations and Adjustments by the World Bank and the Rebuttal by NBS

Item	Evaluation and Adjustments by the World Bank	Rebuttal by NBS
1. Consistency Adjustments		
(1) Households' Grain Use	China's statistical practices have generally valued rural households' consumption of grain produced on the farm at prices lower than free-market prices. Its assumption here results in a 20% increase in the valuation of all grain consumption. The resulting effect on household consumption expenditure is an increase of 1.6% and the effect on GDP is 0.8%.	According to the stipulation of calculating China's agriculture statistics in 1995, farmers' use of their own grain should be calculated according to the comprehensive average selling price, namely the average price of all kinds of grain either purchased by the government or sold on the market. This price reflects the purchasing prices of the government and market prices. In recent years, bumper harvests in China have lowered the market price of grain to such a degree that the government has had to set higher purchasing prices in order to protect the interests of farmers. Therefore, the comprehensive average price cannot be lower than market prices. The assumption of the low prices of own-use grain does not tally with the current situation; the 20% upward adjustment will thus lead to an overestimation of GDP.
(2) Change in Inventory	Change in inventory consists of output that cannot be sold (at the price at which output is calculated). As a result, change in inventory is larger than it would be under consistent reporting. The report assumes that change in inventory is nearly one-third lower than the reported figure, which results in a 1.6% downward adjustment to GDP.	In the late 1980s, a downward adjustment to change in inventory was acceptable. However, since the 14th Party Congress, which targeted the introduction of market mechanisms to reform China's economic system, many changes have occurred. The decision making of enterprises is mainly dominated by market demand and profit maximization. Abandoning products or selling at low prices happens less often than before. Therefore, the adjustment rate is no longer reasonable.
(3) Welfare Services within Enterprises	The World Bank assumes that 10% of the labour force in enterprises is engaged in providing these services, and that this labour force shifts to marketized services, leading to a 1.6% increase in GDP.	In recent years, one of the most significant components of enterprise reform has been the marketizing of welfare services in enterprises; the proportion of employees of enterprises that engages in these services is declining gradually. Therefore, the assumed 10% is too high.
(4) Depreciation Charges	China tends to use relatively low depreciation charges because it assumes long lives for fixed assets based more on physical wear and tear than obsolescence. Therefore, the World Bank assumes a 31% increase in depreciation charges. However, the charges have no effect on GDP.	In administrative units and non-profit institutions, an increase in depreciation would lead directly to an increase in gross value added. Therefore, the adjustments of depreciation influence GDP.
(5) Government Subsidies for Enterprise Losses	China's statistical conventions record this as a negative component in total GDP. The World Bank recognizes that it should be treating those items as government purchases of goods and services for distribution to their targeted recipients, and thus that this should be a positive item included in the government's final expenditure. As such, the government's final expenditure increases by 7% and total GDP rises by 0.8%.	No comments.

2. Scope Adjustments		
(1) Grain Output	The grain planted areas are underreported by as much as one-tenth to one-third (compared with planted areas measured by using satellite photos). At the same time, the yield estimates of the grain crops in sampled areas may be too high. Combining these two factors, it assumes a 10% upward adjustment in grain output, and the effect on GDP is 0.9%.	The data estimated from satellite images include fields with an angle over 25 degrees, flood lands, irrigation canals and ditches, and roads between fields. In practice, those fields should not be regarded as normal planted areas. The difference from China's official data is thus not as large as that estimated by the World Bank. Moreover, in addition to the survey of grain output through agriculture statistics, the rural household survey also compiles a table of the agriculture production of rural households and a balance table of the grain of rural households. These tables reflect the production of rural households, stock of grain at the beginning of the year, income of grain during the year, expenditure on grain during the year, and stock of grain at the end of the year. Based on the facts above, the data on grain output tallies with the real situation.
(2) Vegetable Output	The output value calculated does not reflect the fact that output in physical terms varies from period to period or that market forces encourage production in nonpeak seasons when prices are higher. Moreover, there is no accurate measure of the planted area. Considering these factors, a 30% upward adjustment for vegetable output is made.	In fact, the regular agriculture statistics of China tend to overestimate agriculture production. The results of the agriculture census indicate that the output of meat in the 1996 annual report was 22% higher than real production. The overestimation of the amount of pigs, oxen, and sheep was 20.7%, 21.1%, and 21.8%, respectively. This leads to the overestimation of total output and the value added of agriculture. Therefore, a downward adjustment of GDP should be made.
(3) Township and Village Industry	Industry output at or below the village level seems to be moderately underreported because such enterprises generally have fewer financial records and are not usually covered by the regular statistical reporting system directly managed by NBS. The rapid growth in township and village industry and some degree of tax evasion have also resulted in underreporting. However, some local officials tend to overreport output in order to embellish their accomplishments. Combining these factors, it assumes a 10% to 15% upward adjustment in this area, with the effect on GDP an increase of 0.6%.	The results of the third industrial census of China show that the total output value of township and village industrial enterprises (including township, village level, cooperative, private and individual rural industrial enterprises) from the regular statistics was overestimated by 1,800 billion yuan (1995). This accounts for 40% of the total output value of rural industry. This is contradictory to the judgement of the World Bank; therefore, a downward rather than an upward adjustment should be made.
(4) Rural Services	The shortage of resources in rural areas to supervise sample data collection, to ensure adequate incentives for respondent participation, and to process the results means that it is conceivable that survey-based data reflect as little as two-thirds of actual rural household service-related transactions. According to this assumption, it assumes a 50% upward adjustment for human services (education, health, and social services) and a 60% upward adjustment for other services (transport, commerce, and entertainment). The effect on GDP is a rise of 6.5%.	The judgement on China's rural service statistics and data adjustment are based on the statistical situation in the late 1980s or early 1990s. However, the first tertiary census conducted from 1993 to 1995 surveyed all services sectors, including rural services. At the same time, upward adjustments were made according to historical GDP data. In fact, the adjustment is even stronger than that made by the World Bank.

(5) Housing Services	Data on housing services suffer from problems of both scope and valuation. Urban and rural housing services present concerns over inadequate statistical system scope. China estimates the value added of housing services from data on square meters of housing by using different categories and per-square meter rental-rate approximations based on depreciation in the structures according to estimates of original construction costs. In general, both construction cost estimates and depreciation rates are low. Nor do surveys cover the housing services of rural-registered residents that live in cities. The most significant issue is the inadequate survey coverage of rural housing areas. Beginning with a rough estimate that the statistical network of China captures from two-thirds to three-quarters of all housing in China, the assumed adjustment is 40%, and the effect on GDP is 1.5%.	No comments.
3. Valuation Adjustments		
	Because of China's distorted price system, rates of return to capital and land are much higher for industry than they are for other sectors. The highest rates of return are for consumer manufacturing, while the lowest are in services and the coal industry. Farming also has relatively low rates of return to capital and land. Further price reform in China would alter this pattern of sector profitability. The World Bank aims to adjust the rates of return to capital and land of each sector to become close to the national average. The importance of the textiles industry in China's foreign trade means that the price change for textiles is assumed to be zero. The prices for housing services and other real estate are upwardly adjusted and the prices for consumer manufacturing other than textiles downwardly adjusted. Based on the 1987 input-output table, these adjustments lead to an 18.3% upward adjustment of GDP.	Since the beginning of the 1990s, China has targeted establishing a socialist market price mechanism. Breakthrough was made in price reforms, and the distorted price structure has clearly improved. For instance, from 1990 to 1997, prices in the services sector and coal industry, which are regarded to have the lowest rates of return to land and capital by the World Bank, increased by 222% and 206%, respectively. Prices in consumer manufacturing and the textiles industry, which are regarded to have the highest rates of return to land and capital, only increased by 96.8% and 60.3%, respectively. Moreover, according to an international price comparison of 33 representative commodities conducted by a related ministry, in November 1998, the prices for 22 kinds of selected commodities are higher than those on the world market accounting for 69%. Tremendous changes have been made in price mechanism, price scale, and price structure. If the World Bank still relies on the 1987 input-output table to make price adjustments to various sectors, it will also lead to the overestimation of GDP.

Note: This table is based on World Bank (1993) and Xu (1999a, 1999b, 2000).

Table 2 China's GNP per capita according to the World Bank (in U.S. dollars)

Year	1992	1993	1994	1995	1996	1997	1998
Figures before consultation	470	490	540	620	750	860	930*
Figures after consultation	390	410	450	520	620	710	750

Note: Data on 1998 is the expected publication gure before consultation.
Source: Xu (2000).

In addition to the consultation with NBS, the program was prepared by NBS for the World Bank mission, visiting poor areas in Henan Province to consider living standards such as health and education levels. Through this consultation and consideration, the World Bank concluded that the basis for adjusting GDP no longer existed. It indicated that it would follow a typical method for releasing China's GNP per capita in its publications by directly using China's of cial data and that it would no longer make any adjustments. After this consultation, the World Bank also used China's of cial data to amend its previously adjusted gures of China's GNP per capita.

Table 2 compares China's GNP per capita gures published by the World Bank before and after the consultation. It shows that until 1998, the World Bank upwardly adjusted China's GDP by more than 30%, whereas it estimated GDP in subsequent years by relying on the adjusted GDP in 1992 and the of cial growth rates of GDP. Note that the gures after consultation are the of cial GDP values converted into US dollars at the exchange rate.

3. Adjustments to China's GDP by Maddison (1998)

Maddison (1995) examined Chinese economic performance in general, while his later book specialized in China's economic growth (Maddison, 1998). In his study of China's GDP in 1952–1995, Maddison used the 1987 input-output table of China to adjust the value added of some sectors[4] and extrapolated these results to other years. According to the quantitative analysis, he concluded that China's of cial statistics overestimated economic growth but underestimated GDP.

Moreover, during China's economic reform and opening up period (1952–1977), its annual average growth rate should have been 7.5% instead of the 9.9% quoted in the of cial statistics. Similarly, for the 1978–1995 period, the annual average growth rate should have been 4.4% rather than 6.1% and 5.6% instead of 7.6% for 1952 to 1995. In terms of sectors, agricultural growth was underestimated, while the in ation rates of industry and other services were underestimated; therefore, the growth rates of these sectors were overestimated.

In terms of the volume of GDP in the base year (1987), the of cial gure was 1,196.25 billion yuan compared with Maddison's 1,319.28 billion yuan. The latter was 123.03 yuan higher than the former, or 10.3% more. In terms of sectors, the value added of agricultural was adjusted upward by 19% and that of other services by 33% compared with the of cial

4 The estimates for mining and manufacturing provided by Maddison (1998) are based on the study of Wu (1997).

statistics.

Interestingly, having thoroughly studied Maddison’s estimates of economic growth in China from 1952 to 1995, Xu (1999b) pointed out that the upward adjustments in agricultural and other services of Maddison were based on the misinterpretation of facts[5]. This nding was similar to the rebuttal made for the upward adjustments in China’s GDP by the World Bank.

To avoid China’s economic growth being perceived as a threat to the world by other countries, Deng Xiaoping presented the famous foreign policy of ‘keeping a low pro le’. However, this guideline may have been applied to create GDP statistics.

4. Arguments concerning China’s GDP since 2000

Since 2000, the high growth in the global economy has led to China’s economy growing stronger day by day. As the interest of the world in China’s economy increased, China’s GDP statistics began to receive more attention. As NBS wanted, much of the criticism of China’s GDP statistics was that they had been overestimated rather than underestimated as the World Bank said.

In the wake of the distrust of China’s GDP statistics in the mass media around the world, Rawski (2001) questioned whether China’s economy had actually achieved a high growth rate (7–8% between 1998 and 2001 according to the of cial statistics). The criticism was based on inconsistencies in government statistics. Given the decrease in the employment growth rate and energy consumption, he concluded that the true economic growth rate would have been between 2% and 4% in this period. Rawski’s (2001) ndings were widely published by major media outlets in the UK[6] and the US[7,8]. In Japan, this topic was also greatly taken up[9,10].

The response to these criticisms also varied. Against Rawski’s (2001) nding of a mismatch between energy consumption data and the economic growth rate, Ren (2002) discussed the relationship between the energy consumption growth rate and economic growth in Germany, the UK, the US, Japan, and South Korea. The author pointed out that all these countries had also found mismatches between these two indices over time. He also questioned Rawski’s (2001) way of setting the upper limit of economic growth by using the growth rate of domestic air passenger traf c. Xu (2003) also discussed the ndings of Rawski (2001) and the many commentaries concerning it, and pointed out that Rawski (2001) had been mistaken for China’s statistical survey system.

Klein and Ozmucur (2002) conducted a principal component analysis on Chinese statistical data on energy, iron and steel, transportation, communication, agriculture, exports and inputs, government spending, wages, and in ation. The result of the analysis showed that the change to the of cial GDP and the change to the principal component were highly consistent. The authors also pointed out that the determinants of economic growth are diverse and that it is impossible to interpret the overall economic situation in a large

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5 See Xu (1999b) for the view of NBS here.
6 See Economist (2002).
7 See Liu (2002).
8 See Balfour (2002).
9 See SAPIO editorial department (2002).
10 See Iwase (2002).

country such as China by examining individual indicators.

In Japan, after the ‘China distrust’ special feature, numerous articles were presented, such as Onishi (2002), Zhang (2002), and Ogawa (2003a, b). In particular, 1998 became a focus. While the Chinese government had targeted a growth rate of 8% that year, the of cial statistics were slightly below 0.2%. Suspicion of statistics doctoring was discussed because of this.

As an extension of the discussion about the distrust of China’s GDP statistics, Kojima (2003) criticized the lack of consistency between the GDP statistics published by the central and local governments. In addition, Takahashi (2004) questioned whether Chinese GDP retrospective estimates verify the creation of China’s GDP based on statistical tests. He pointed out that China’s GDP statistics have been analogized based on the total concept of social production in the MPS and that these are fundamentally different from value added, the essential feature of GDP in the SNA concept. Therefore, China’s GDP statistics are not comparable with those of developed countries. These points are discussed further below.

4.1 Consistency between GDP and GRP

After Kojima (2003), this issue was taken up widely in the Japanese media[11]. The criticisms may have stemmed from the difference between Japan and China in terms of the relationship between the central and regional statistics.

In Japan, the mechanism to create statistics is decentralized in each ministry in response to the administrative needs at the central level, while the centralized mechanism is strong between the central and regional levels.

By contrast, at the central level in China, the mechanism to create statistics in NBS is centralized, but it is decentralized in the context of the central and regional levels. Although regional statistics-creating organizations are susceptible to the involvement of region governments, they have considerable independence from the central statistics organization[12].

Detractors might imagine the process of creating GDP to be as follows: GRP in each region is estimated rst and then the GDP of the country is calculated as an aggregate value. Therefore, the total value of GRP must match GDP. However, generally, the statistical resources possessed in each region are relatively poor compared with the national level. Therefore, few countries adopt this estimation method.

SNA creates GDP manually in order to cover the country’s overall economic position. The description of regional accounts runs to only two pages at the end of the 800-plus-page manual. The dif culty of regional accounts is captured in the following statement:

‘Allocating the transactions of multi-regional units between various regions raises more dif culties. Even when these transactions are physically locatable, like output, it is necessary to actually value intra-corporate ows between establishments located in different regions.’ (from 1993SNA, 19.91)

[11] See Maie (2005). During this study, I conducted an email interview with the Mainichi Economist editorial department and received the following response: The authenticity of Chinese GDP has long been pointed out. The growth rates of January to September this year by region were published in late October. However, lower than average growth rates for the country were only seen in Beijing and Shanghai; therefore, integrity problems have been noted.

[12] On China’s statistical system, see Zhao and Yamada (1993).

Further, the manual recommends creating regional accounts as follows:

'It is up to the countries themselves to devise their own regional accounts and statistical indicators, taking into consideration their specific circumstances, data system and resources which might be devoted to this work.' (from 1993SNA, 19.96)

In Japan, GDP statistics are positioned as the most important government statistics based on the Statistics Law, but GRP is calculated by each prefecture independently. This GDP expenditure approach is used as a reference value in the country, but because the relevant statistics cannot be supported in each province, GRP production has to be estimated. For this process, GDP is first estimated and then a proportion of GRP is estimated by using the country-level value. Therefore, the GRP of each province is published a year later than GDP.

Given the inconsistency between GDP in the government statistics and the GRP of each province estimated as independent businesses, after the inflation problem of GRP in the early 1990s, the Economic and Social Research Institute (Cabinet Office, Government of Japan) aimed to match GDP and the sum of the GRP as closely as possible and publish this together[13].

In China, GDP has been estimated from 1985, while the GRP of provinces and cities has been estimated independent of GDP consistently. In other words, NBS estimates GDP, whereas each region's statistical organization estimates GRP. Further, the basic statistics estimated are also different between the central government and local governments.

In China's traditional reporting system, statistical tables aggregated the statistical administrations, but these were susceptible to illegal operations in each aggregation stage. In 1990, NBS reviewed the aggregation method, and the important statistical tables began to use the direct counting method. NBS also founded a research team that reported directly.

Table 3 shows the difference between GDP and the sum of GRP in China and Japan. In both countries, the sum of GRP is larger than GDP for all years. The difference in China is much larger than that in Japan, particularly in 2002 to 2004, as noted by Maie (2005) and Kojima (2003).

As a way of assessing this problem with China's GDP, the arguments that GRP has been overestimated are common[14]. In other words, regional statistical organizations overestimate the statistics for local governments. However, this is only one aspect. This padding and the insufficiency of data on the economic situation are severe issues. In fact, in 2004 the difference between GDP and GRP reached 19.26%; however, based on the results of the first economic census, China's GDP was revised up to 16.81%, closing the difference with GRP. Moreover, it has been pointed out that this upward revision is not enough, because there is a lot of leakage in the economic census[15]. The same expansion was offered in 2008 in the second economic census.

Although the central government would like to 'keep a low profile', local governments are obsessed about improving their performance, and thus they do not cooperate. This may be the reason why it has been widely reported that only local statistics are overestimated.

[13] For example, the exchange of views is encouraged between the heads of prefectural accounts at regular training meetings. The proportion of the regional accounts is estimated by using that of the national accounts.

[14] For recent discussions, see Xiao (2010) and Ding (2010).

[15] See Chen (2006) and Maie (2006).

Table 3 Comparison of the difference between GDP and the sum of GRP (%)

Year	Differencein Japan	Differencein China
2001	3.50	9.71
2002	3.39	11.74
2003	2.67	15.46
2004	3.75	19.26
2004*		4.82
2005	3.66	7.95
2006	4.24	8.76
2007	3.93	7.12
2008	4.36	8.83
2008*		6.14
2009	3.62	7.16
2010	3.24	8.93

Note: Difference is calculated as the sum of GRP/GDP – 1 × 100. In addition, in the economic censuses of 2004 and 2008, no * means the number estimated before the economic census, while * means the number estimated after the economic census.
Sources: For Japan, *the National Accounts* and *Prefectural Accounts* by the Economic and Social Research Institute. For China, 2000 to 2004 estimates are based on *China Statistical Yearbook (2005)*; 2004* to 2008 estimates are based on *China Statistical Yearbook (2009)*; and 2008* to 2010 estimates are based on *China Statistical Yearbook (2011)*.

4.2 Estimates based on the MPS concept

According to Takahashi (2004), under SNA, activities traded in the market are de ned as production boundaries in the system. However, as MPS focuses on physical production, production is limited to agriculture, forestry, sheries, industry, construction, and the services directly related to the production of these goods. In other words, retail trade, wholesale trade, and freight transport are included in production, but nancial services, health services, public utilities, and education are considered to be relocation[16].

Until 1991, China used an indirect method based on the estimates of the MPS concept to create GDP. For the value added of physical production, this involved adding the consumption of xed capital to the net output of the MPS concept and deducting the input of non-material services. That of non-physical production was estimated by using nancial information on the government, tax revenue documents, and statistics for employment and salaries[17]. Since 1992, however, this approach has shifted to a method of estimating GDP directly from various statistics.

In 1971, the MPS system was approved by the United Nations as a suitable international system that should be widely spread alongside SNA. Therefore, it is not possible to criticize the estimation method of China that derived GDP from MPS estimates. However, the concerns about the comparability of GDP statistics between developed countries and China raised by Takahashi (2004) are similar to those about China's GDP underestimate raised by World Bank (1991).

In summary, the argument concerning China's GDP is that the media including Chinese media is overwhelmingly of the belief that GDP is overestimated, whereas some experts think the opposite.

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[16] See United Nations (1971).
[17] For the estimation method of GDP in the initial introduction of SNA, see Yue (1989), Zhang (1993), and Xu (2000).

5. The trend of retroactive amendments to China's GDP

After the first economic census in 2004, China's GDP was revised upward by 16.8%. This revision was reported widely in the Japanese media. Actually, China's GDP has been retroactively amended three times, as shown in Table 4. In Japan, the basis of GDP is the estimates of GDP under the expenditure approach; the difference from the estimates of GDP under the production approach is then recorded as a statistical discrepancy. However, China publishes GDP estimates (expenditure approach) as a reference, whereas the basis of GDP is the aggregate of the value added sector, which is estimated by using the income approach or the production approach[18].

Table 4 shows the retroactive amendments of China's GDP production series. China began to estimate GDP in 1985 (historical data on 1978 to 1984 were estimated in 1986–1988). After economic reform, the privately owned tertiary industry showed the highest growth, such as the commercial, food and drinks, and transportation sectors. Since the MPS system had been employed for a long time, the capture of statistics on the actual situation, especially given the expansion and diversification in the tertiary industry, was very poor. As stated before, the underestimation of value added in the tertiary industry, especially in the non-physical services industry, was often pointed out. In response, the first tertiary industry census was conducted in 1993, after which amendments to GDP were made as far back as 1978. Based on the upward adjustment of 32% for the tertiary industry's value added, 1993 GDP was revised upward by 10%, as shown in Table 4. The adjustment rate of 10% was considerable internationally, but still low compared with the upward revision of 32% by the World Bank (1993).

Thereafter, the first economic census on all economic activities in the secondary and tertiary industries was performed in 2004 and secondary amendments to GDP were also made. Furthermore, there were other changes, such as the census recorded the additional paid services performed by housekeeping staff, introduced FISIM, and changed the depreciation rate used for owner-occupied housing[19]. While the media were reporting that China's GDP had been overestimated[20], the upward revision of 16.8% to 2004 GDP was published in December 2005; 92.6% of the total revision was due to the tertiary industry. Moreover, the ratio of tertiary industry GDP rose from 31.9% to 40.7%.

In spite of this significant upward revision, the media claimed that the revised GDP was still underestimated. For example, Maie (2006) stated the following: 'Because small and medium-sized entities have been developed, especially in China, there is a possibility of leaking in the economic census. In addition, some SMEs not included in the scope of the statistical survey, such as shops that have 60 or fewer employees, hotel of 40 people or less, transportation firms, and construction firms that are not equipped with a licence.'

Further, according to Chen (2006): 'The expansion of GDP was increased by the service industry, which was included in the economic census for the first time.' He added: 'There is still a lot of leakage in the survey. Although the range of services has expanded, it has not grasped the outdated idea. In addition, since the ratio of tertiary industry GDP in India is 55%, the revised values may still be underestimated.'

In addition, the underestimation of housing services in China was also pointed out by

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18 For the differences in the GDP estimation methods of Japan and China, see Li (2012).

19 For the content of the revision, see Xu (2006).

20 See Chen (2006).

Table 4 The adjustment of historical Chinese GDP data by NBS

Year	Pre-revised GDP (in billions of yuan) *1	Adjustment rate after the first tertiary industry census (%) *2	Adjustment rate after the first economic census (%) *3	Adjustment rate after the second economic census (%) *4	Revised GDP (in billions of yuan)
1978	3,588	1.00	0.58		3,645
1980	4,470	1.10	0.62		4,546
1985	8,527	5.10	0.58		9,016
1986	9,688	5.30	0.72		10,275
1987	11,307	5.80	0.80		12,059
1988	14,074	6.10	0.77		15,043
1989	15,998	5.70	0.49		16,992
1990	17,681	4.80	0.65		18,668
1991	20,188	7.10	0.76		21,781
1992	24,363	9.30	1.07		26,923
1993	31,380	10.00	2.02		35,334
1994	46,759		3.08		48,198
1995	58,478		3.96		60,794
1996	67,885		4.85		71,177
1997	74,463		6.06		78,973
1998	78,345		7.73		84,402
1999	82,067		9.27		89,677
2000	89,468		10.89		99,215
2001	97,315		12.68		109,655
2002	105,172		14.41		120,333
2003	117,390		15.70		135,823
2004	136,876		16.81		159,878
2005	183,217			0.94	184,937
2006	211,924			2.07	216,314
2007	257,306			3.31	265,810
2008	300,670			4.45	314,045

Note: Adjustment rate is revised GDP/pre-revised GDP – 1 × 100.
Sources: *1. The 1978 to 1993 gures are based on *China Statistical Yearbook (1994)* ; 1994 to 2004 are based on *China Statistical Yearbook (1995)*; and 2005 to 2008 are based on *China Statistical Yearbook (2009)*.*2. Revised GDP after the rst tertiary industry census is based on *China Statistical Yearbook (2005)* .*3. Revised GDP after the rst economic census is based on *China Statistical Yearbook (2006)* .*4. Revised GDP after the rst economic census is based on *China Statistical Yearbook (2010)*.

World Bank (1993). From 2% in the previous revision, the ratio of real estate industry value added in GDP was revised up signi cantly to 4.5%, but still much lower than the 12.2% in Japan. In terms of value, from 271.2 billion yuan in the previous revision, China's real estate industry value added grew by 2.6 times to 717.4 billion yuan, but this is still less than one-sixth of Japan[21].

After the second economic census in 2008, third amendments to GDP were made, resulting in an increase of 4.4%. As with the earlier revisions, mostly because of the upward revision of the tertiary industry, the ratio of the tertiary industry value added GDP was 41.8%, representing a rise of 1.7% but still much lower than Japan (71%).

Table 5 shows the retroactive amendments of Japanese estimates of GDP (under the expenditure approach). For data comparability, I limit comparison estimates to 1993 SNA

[21] For the underestimation of housing services in China, see Li (2013a, b).

Table 5 The adjustment of historical Japanese GDP data by the Economic and Social Research Institute (in billions of yen)

Year	GDP base 1995*1	GDP base 2000*2	Adjustment rate (%)
1998	514,595	502,973	-2.26
1999	507,224	495,227	-2.37
2000	511,462	501,068	-2.03
2001	505,847	496,777	-1.79
2002	497,897	489,618	-1.66
2003	497,485	490,544	-1.40
Year	GDP base 2000*3	GDP base 2005*4	Adjustment rate (%)
2004	498,328	493,566	-0.96
2005	501,734	493,485	-1.64
2006	507,365	496,472	-2.15
2007	515,520	503,437	-2.34
2008	504,378	492,905	-2.27
2009	470,937	463,253	-1.63

Note: Adjustment rate calculated as before.
Sources: *1. Based on *Annual Report on National Accounts (2005)*; Economic and Social Research Institute, Cabinet Of ce.*2. Based on *Annual Report on National Accounts (2006)*.*3. Based on *Annual Report on National Accounts (2011)*.*4. Based on *Annual Report on National Accounts (2012)*; In view of the comparability to the GDP base 2000, FISIM is excluded here.

only. The adjustment ratio of China is as large as that shown in Table 4, but that of Japan is much smaller than China, as shown in Table 5. The adjustment trends for Japan and China are reversed: all downward in Japan, but all upward in China.

6. Conclusion

Based on the results of the adjustments and the arguments concerning China's GDP statistics, the underestimate of China's GDP pointed out by the World Bank in the early 1990s was intrinsically correct. Moreover, the arguments that China's GDP statistics were overestimated, which have been widely covered in the media since 2000, were deployed in the direction in which NBS wants as a result.

Many of the arguments concerning China's GDP statistics are related to the economic growth rate, which is calculated based on real GDP. In this paper, I focused on nominal GDP (current year's prices GDP). For the methodological issues with estimating China's real GDP, please see Li (2013d).

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