Analysis on the Effects of Housing Relevant Taxation as a Macroprudential Policy Tool

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by

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Abstract

This study conducted a comprehensive analysis on the impact of housing relevant taxations on the target variables of financial stability such as house price and credit levels while considering its adverse impact on the output and welfare differences between households. Thereby, the study has analyzed its effectiveness as a macroprudential policy tool and checked the potential costs of using this taxation for achieving financial stability. It has been shown that a tax rate increase, whether it is temporal or permanent, can effectively lower house prices and credit levels. Even if there was an early decline in output level after the changes in the tax rate, this adverse effect can be mitigated in the medium run due to capital accumulation. Also, setting a proper tax rule by considering the house price increase can stabilize the housing market when there is a positive housing preference shock or a productivity shock. However, welfare changes between households were not be fairly distributed after each tax policy implementation. Therefore, it is advisable for the policy authority to combine an appropriate redistribution scheme with taxation by paying attention to the potential welfare changes of the households when they choose to use housing taxation in pursuing of macro-financial stability.

Key words: Macroprudential Policy, Fiscal Policy, Housing Taxation, Welfare, Inequality

Contents

1 Introduction

Given the importance of the housing assets to the household,[1]the housing relevant market has been a target of conducting macroprudential policy after the last financial crisis. Policy authorities have implemented various types of approaches such as Loan-to-Value or Debt-to-Income requirements to enhance financial stability by limiting the excessive rise in property (house) prices and by curbing the growth of the household debt compared to the GDP. In seeking of similar purpose, many countries use housing relevant taxations, especially for lessening the immoderate increase in house prices (OECD and KIPF, 2016). In fact, as shown in Figure 1, it appears that OECD countries' housing relevant tax revenues have a negative correlation with a house price increase. The graph tells us the countries where has a smaller average increase in national-wide house prices between 2010 and 2019 have larger tax revenues that can be applied to housing transactions or property holding compared to their GDP level. It would imply the possibility of housing taxation as a macroprudential policy tool for cooling down the asset prices when the government adequately uses it.

Figure 1: Housing Relevant Tax Revenues / GDP ratios and House Prices

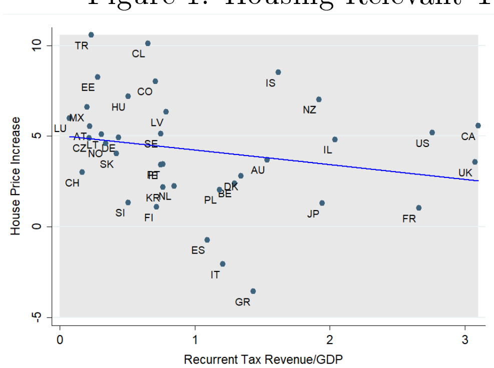


Figure 1.1: Recurrent Tax[a]

[a]The tax imposed on holdings of immovable property. This is classified as '4100' within OECD methodology for Government Revenue Statistics.

Sources: OECD

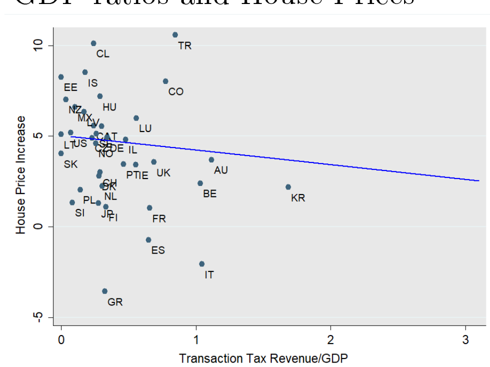


Figure 1.2: Transaction Tax[a]

[a]The tax imposed on financial and capital transactions. This is classified as '4400' within OECD methodology for Government Revenue Statistics.

However, as argued in Forbes (2020), in order to have its validity as an effective macroprudential policy tool, there should be an additional assessment about its 'unintended con-

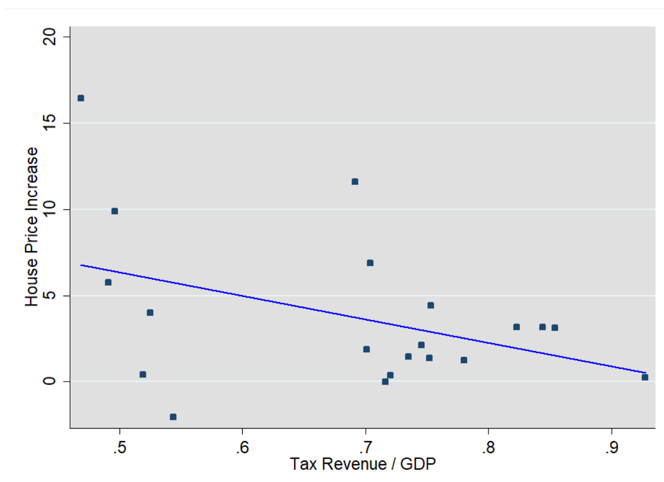
[1]The dwellings take 81% of the households and NPISHs' 'produced assets' on average in fourteen OECD countries, AU, CA, CZ, FI, FR, HU, IL, JP, KR, LV, MX, SE, UK, US, where announces related data about the household asset.

sequences' that can undermine the efficacy of the policy and would cause another type of macroeconomic vulnerability. Therefore, it is imperative to understand the effect of potential macroprudential tools from a comprehensive perspective. Even if there is a suggestion that property tax is less malignant to economic growth and its cost due to possible side effects is lower than other taxations (Norregaard, 2013), using housing tax for moderating the housing property market can interrupt the real economic activity such as household consumption and investment decision since it can act as a limitation on household's feasible resources for economic activity. A stagnant output growth due to these effects would act as another source of financial instability as it could make the household depends more on the borrowings. Moreover, equity issues that are related to this fiscal policy operation also need to be discussed. This is because inequality between economic agents can be a beginning of a financial vulnerability, as argued in Perugini et al. (2015) and Paul (2018), and there is a growing number of studies on the connection between inequality and macro-financial instability. Therefore, for the policy authorities who choose housing tax in seeking financial stability, it is advisable for them to come up with appropriate fiscal operations to tackle potential inequality issues in the policy implementation.

Motivated by these discussions, the research aims to verify the following question on the operations of the macroprudential policy by using the housing relevant taxations. First, how is the effect of the housing relevant taxation on financial stability variables such as house prices and credit growth? Can empirical evidence that the policy has been effective to cool down the housing price be validated? Can we establish a valid tax rule that may counter a soar in housing demand stemmed from changes in macroeconomic conditions? Second, what are the possible unintended consequences or costs of using housing taxations for achieving financial stability? In other words, how does it influence the output, consumption, and investment? Last, how can the policy affect the inequality in terms of the welfare of the economic agent, and what is the best fiscal policy operation to make the households equally share the welfare changes? To answer these research questions, I will construct a New-Keynesian Dynamic Stochastic General Equilibrium (DSGE) framework. The housing market and various fiscal tools will be added to the model for adequate discussion, and numerical exercises will be conducted based on this structure. After generating a tax shock that is occurred for the purpose of suppressing house price increase, the model will check the dynamic response of each macroeconomic variable for assessing the validity of using housing taxation as a means of macroprudential policy. Also, the analysis will study the feasibility of using a tax rule to tame a rise in house prices due to a housing preference shock or a productivity shock. In these experiments, I will check each optimal case for enhancing welfare gains and for minimizing inequality of welfare changes among different redistribution scenarios.

For these quantitative exercises, I will refer to South Korea's ("Korea" hereafter) economy for parametric calibrations, where has real estate takes an important portion of the household's assets, and so various types of housing relevant taxations are imposed on the housing market[2]. Korea has recently experienced a surge of house price increase[3], and so there is a discussion on the issue of the increase in property tax rates to settle down their housing market and its effectiveness. As a matter of fact, a time series data in the period from 2000 to 2019 shows that there has been a negative relationship between Korean housing taxation revenues, especially for recurrent tax, and house price increases that imply there would be a significant effect of housing tax on house price. Thus, this research can check this possible causal impact and also can draw a meaningful conclusion that helps Korea conduct a more sound policy operation.

Figure 2: Housing Relevant (Recurrent) Tax Revenues / GDP ratios and House Price Increase in Korea



Sources: OECD

Even though the numerical analyses focus on Korea's case, the study is expected to have external relevances given the rise in house prices around the world during the COVID-19 crisis[4]. Thus, this study would help policy authorities to find the best tax policy operations

[2]The history of South Korean housing taxation operation will be suggested in Appendix F.

[3]According to Kookmin Bank's statistics, Korea faces an 8.35 % increase in house prices during 2020, and this is the highest rate of house price rise after the last financial crisis. The increase rate in 2021 so far is 7.42% compared to the end of last year, thus the rising trend in house price is continuing in Korea.

[4]OECD countries' rise in real house price index marked the highest increase rate (4.7%) in 2020 after the last financial crisis.

and can enhance the legitimacy of the policy implementations to respond to overheating of the housing market if they choose to use housing relevant taxations as their macroprudential policy tool.

The contents of this research are as follows. I will briefly review the related literature in the next section. Then, I will set up a model for the main discussion. After constructing the model, I will conduct an analysis on the tax shock to check its efficacy and potential cost. The analysis will be extended to the situation of a housing preference shock and a productivity shock with different tax policy rules. During these analyses, I will discuss the welfare implication and possible equity issues. Last, I will sum up the results and draw a conclusion for the desirable policy operations.

2 Literature Review

Several studies have tried to empirically discuss the impact of taxation as a macroprudential policy tool. They have focused on the investigation of the validity of taxation for achieving financial stability. Due to the lack of empirical evidence and a relatively short history of macroprudential policy, the studies using empirical methodology uses panel datasets that are regional or country level. First, Kuttner and Shim (2013) show that adopting a tougher measure in housing taxations can make a negative impact on house prices by using a panel dataset of 57 countries. Blöchliger et al. (2015) present a similar outcome on this subject. They argue that there is a negative correlation between a 1% rise in property tax and house price. They find the degree of the effect can be different in each country. Thus, these studies advocate using the taxations for settling down the housing market. However, contrasting evidence was found in Aregger et al. (2012). They showed that taxation on housing capital gain would be connected to more volatility in house prices. Therefore, the conflicting conclusion may suggest a difference in the effect in various policy jurisdictions, or it would imply a potential data issue in empirical research.

Considering the data limitations, it is not easy to understand the causal effect of housing taxation on the macroeconomic variables in empirical studies. Thus, it is more common to use a theoretical model for analyzing the impacts of macroprudential policies. Given the possibility that the policy can generate a ripple effect on the entire economy, the research employs a structural model to discuss its impact in a general equilibrium framework. To this end, a stream of research is following theoretical modeling of an influential work by Iacoviello (2005) that consolidates the housing sector and the structure of collateral constraint with the mechanism of the financial accelerator by Kiyotaki and Moore (1997). A representative feature of the research is that the model contains two or three households who have distinctive characteristics in their discount factor or resource constraint. Also, housing stock can be traded in the model as an objective of the households' maximization problem. The 'Iacoviello-type' model, Iacoviello and Neri (2010), Rubio and Carrasco-Gallego (2014) and Punzi and Rabitsch (2016), share these features each other. To discuss the impact of housing taxations, previous research has incorporated taxations systems into the structure of the model that is suggested above. For example, Alpanda and Zubairy (2016) studied the efficacy of housing-relevant policy instruments to the macroeconomy in a dynamic general equilibrium model. They generated a permanent change in these policy tools and analyzed its results. It showed that a rise in housing property tax can reduce the household debt but it can cause a side effect of output loss. This outcome was confirmed in Alpanda and Zubairy (2017) that use a small open economy RBC-DSGE model. They represented limiting the household indebtedness by using an increase in tax rate can be possible but its cost is also large since it can lead to a significant output loss. Thus, they are standing in the position of opposing using taxation as a macroprudential policy tool. Meanwhile, Rabanal (2018) suggested a contrasting result about the side effect of taxation. Among the analysis, it shows that a tax shock that is applied to the housing acquisition of domestic buyers can cause a fall in the Credit-to-GDP ratio, but it does have only a limited impact on the output. A similar implication was concluded by Mora-Sanguinetti and Rubio (2014). They found a tax rate increase can have a negative effect on both house prices and GDP growth, but the reduction in GDP growth is confined to a short-term period. In conclusion, the studies use a DSGE model draws a similar conclusion on the efficacy of taxation to the variables related to financial stability, but the view on the side effect of using taxation, an adverse impact to the output, is not coinciding.

In discussions on welfare effects of taxations, the previous studies discussed the effect of tax on capital or labor income in DSGE frameworks, and welfare implications are differed by the object of taxation and the structure of the economy. For example, Kim and Kim (2018) studied an optimal tax policy in each of a closed economy and an open economy. They have shown that setting a countercyclical tax rule to react to a positive productivity shock would be optimal in terms of the welfare gain in the closed economy, but this is not the case for the open economy. Unal (2015) also measures the effect of capital income tax on macroeconomic variables and welfare in a small open economy DSGE model. It has found a paradoxical effect of the tax that an increase in the tax rate on capital gain would result in a welfare gain in terms of consumption. The literature that analyses the effect of housing relevant taxations is still scarce. Funke and Paetz (2016) study a welfare implication of using the LTV rule and taxation to stabilize the house price bubbles in a DSGE model with two different types of households. After setting a central banks' welfare function that is a weighted sum of variance in inflation and output, they found that using a tax rule to tame a house price increase can cause a larger central bank's loss when they put more importance on the variance of output. This welfare loss can be reduced as the government concerns longer periods of house price trends. However, they have not shown the inequality issues in the welfare between the agent. Alpanda and Zubairy (2016) show a difference in welfare among agents. It suggests that a result of the changes in the welfare of each agent after increasing the property tax rate. Among three households in this study, the only renters who cannot purchase a housing stock can be benefited from taxation. Nevertheless, they do not discuss the welfare implication in different fiscal operation scenarios. Thus, studying this subject would be meaningful.

3 The Model

The model constructed in this research is a New Keynesian model with a household under the borrowing constraint by the housing collateral. The basic model structure is similar to that of Iacoviello type models such as Rubio and Carrasco-Gallego (2014). However, the model has distinctive features. First, the model explicitly includes the government policy side. As the main purpose of the research is to discuss the possibility and their functions of housing relevant taxation as a macroprudential policy tool, households are subject to pay tax for their new acquisition of housing stocks and the retaining of previous housing assets. These tax revenues will be the base for government policy operation. A detailed explanation for government policy operation will be given in further discussion. Second, the model allows for the capital accumulation and household's decision for investment, which were absent from Rubio and Carrasco-Gallego (2014). By doing so, we can check how the investment will react toward the changes in the tax policies and also identify possible investment distortions that would be generated by the taxation.

3.1 Household

There are two types of households, saver and borrower, in the model. Each household type is denoted by subscript s and b, respectively. The households share the same form of utility functions, but their discount factor is different. A household who is slightly more patient becomes the saver and the other household will become the borrower. The exact number of each discount factor will be given in the calibration section. The saver directly lends money to the borrower, without any financial intermediaries, and receives the interest rate for it. On the other hand, the borrower takes a loan from the saver and pays the interest rate in return for the borrowing. The borrower cannot make a loan as much as they want to do so due to the borrowing constraint. This constraint is determined by the housing collateral values and the trend of credit growth of the economy.

3.1.1 Saver (Patient Household)

The saver decides the level of consumption ($C_{s,t}$), housing ($H_{s,t}$), labor supply ($N_{s,t}$), loans to borrower (b_t) and capital accumulation (K_t) to maximize the lifetime utility given below subject to the budget constraints. Here, I_t is the investment in physical capital, q is the relative price of housing, R is an interest rate, π is inflation, W_s is the real wage for the saver's labor, and r is the real rental rate of capital. The saver is assumed to own intermediate goods producers, so they can use a profit (F_t) from them. Also, Tr is a transfer from the government which can be zero when the government does not allocate it for the saver.

$$\max_{C_{s,t},H_{s,t},N_{s,t},b_t,K_t} E_0 \sum_{t=0}^{\infty} \beta_s^t [\log(C_{s,t}) + j_t \log(H_{s,t}) - \frac{N_{s,t}^{\eta}}{\eta}]$$

$$s.t\ C_{s,t}+I_t+b_t+(1+\tau_t^{tc})q_tH_{s,t} = \frac{R_{t-1}b_{t-1}}{\pi_t}+W_{s,t}N_{s,t}+r_tK_{t-1}+(1-\tau_t^{p})q_tH_{s,t-1}+F_t+Tr_{s,t} \quad (1)$$

$$K_t = (1-\delta)K_{t-1} + I_t\left[1 - \frac{\psi}{2}(\frac{I_t}{I_{t-1}} - 1)^2\right] \quad (2)$$

In the household's utility function, the housing preference shock j follows the process, $\log(j_t) = (1-\rho_j)\log(j_{ss}) + \rho_j \log(j_{t-1}) + u_t^j$. As can be seen from (2), it is assumed that there is an adjustment cost for investment, $\frac{\psi}{2}(\frac{I_t}{I_{t-1}} - 1)^2$, as in Christiano et al. (2005) and Rabanal (2018). In a steady-state, this adjustment cost become 0. After solving the saver's maximization problem[5], we can draw the first order conditions that are given below.

$$W_{s,t} = C_{s,t}N_{s,t}^{\eta-1} \quad (3)$$

$$\frac{j_t}{H_{s,t}} = \frac{1}{C_{s,t}}(1+\tau_t^{tc})q_t - E_t\beta^s\left(\frac{1}{C_{s,t+1}}(1-\tau_{t+1}^{p})q_{t+1}\right) \quad (4)$$

[5]All relevant derivations of equations for the model are given in Appendix A.

$$\frac{1}{C_{s,t}} = \beta^s E_t \frac{1}{C_{s,t+1}} \frac{R_t}{\pi_{t+1}} \tag{5}$$

$$\frac{\mu_t}{C_{s,t}} = \beta^s E_t \frac{1}{C_{s,t+1}} (r_{t+1} + \mu_{t+1}(1-\delta)) \tag{6}$$

$$1 = \mu_t \left(1 - \frac{\psi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 - \psi \frac{I_t}{I_{t-1}}\left(\frac{I_t}{I_{t-1}} - 1\right)\right) + \beta^s E_t \frac{C_{s,t}}{C_{s,t+1}} \mu_{t+1} \left(\frac{I_{t+1}}{I_t}\right)^2 \psi \left(\frac{I_{t+1}}{I_t} - 1\right) \tag{7}$$

Each first-order condition represents the saver's decision making. (3) is the labor supply decision of the saver, and (4) shows the saver's housing demand. (5) is the intertemporal choice of the saver's consumption, the Euler equation of the saver. (6) determines the saver's capital supply to the intermediate goods firms, and the saver makes the investment decision in accordance with the equation (7). μ_t in equations (6) and (7) is the Lagrange multiplier applied to the capital accumulation, (2). μ_t is 'Tobin's Q' that implies the relative price of the capital compared to the consumption goods.

3.1.2 Borrower (Impatient Household)

The borrower's optimization problem looks similar to that of the saver. This type of household chooses its own consumption ($C_{b,t}$), housing ($H_{b,t}$) and labor supply ($N_{b,t}$) to maximize the lifetime utility. However, other than the budget constraint, the borrower faces the collateral constraint (9) as well. Here, W_b is the real wage from the borrower's labor supply.

$$\max_{C_{b,t},H_{b,t},N_{b,t}} E_0 \sum_{t=0}^{\infty} \beta_b^t [\log(C_{b,t}) + j_t \log(H_{b,t}) - \frac{N_{b,t}^{\eta}}{\eta}]$$

$$s.t\ C_{b,t} + \frac{R_t b_{t-1}}{\pi_t} + (1+\tau_t^{tc}) q_t H_{b,t} = W_{b,t} N_{b,t} + b_t + (1-\tau_t^{p}) q_t H_{b,t-1} + Tr_{b,t} \tag{8}$$

$$E_t \frac{R_{t+1}}{\pi_{t+1}} b_t \leq LTV_t E_t q_{t+1} H_{b,t} \tag{9}$$

The solution for the optimization problem will give us the borrower's labor decision (10), housing demand (11), and Euler equation (12) below. In the equation (11) and (12), $\lambda_{b,t}$ indicates the Lagrange multiplier to the borrowing constraint, (9).

$$W_{b,t} = C_{b,t} N_{b,t}^{\eta-1} \tag{10}$$

$$\frac{j_t}{H_{b,t}} = \frac{1}{C_{b,t}}(1+\tau_t^{tc})q_t - E_t\beta^b\left(\frac{1}{C_{b,t+1}}(1-\tau_{t+1}^p)q_{t+1}\right) - \lambda_{b,t}LTV_tE_t\left(\frac{q_{t+1}\pi_{t+1}}{R_{t+1}}\right) \tag{11}$$

$$\frac{1}{C_{b,t}} = \beta^b E_t\left(\frac{1}{C_{b,t+1}}\frac{R_{t+1}}{\pi_{t+1}}\right) + \lambda_{b,t} \tag{12}$$

3.2 Firms

3.2.1 Final Good Producer

The final good (Y_t) producer is operating in a competitive market that uses all intermediate goods for production. It purchases intermediate goods and aggregates the goods in accordance with the production function (13). In this production, ϵ represents the elasticity of substitution among the intermediate goods, $Y_t(z)$, that is larger than 1.

$$Y_t = [\int_0^1 Y_t(z)^{\frac{\epsilon-1}{\epsilon}}dz]^{\frac{\epsilon}{\epsilon-1}} \tag{13}$$

Using the production function and intermediate goods, the final good producer chooses how much levels of each intermediate goods they purchase given the price of each intermediate goods. Thus, they will maximize the profit given in below.

$$\max_{Y_t(z)} P_tY_t - \int_0^1 p_t(z)Y_t(z)dz$$

The profit maximization problem gives us the demand function for each intermediate goods z, $Y_t(z) = Y_t\left(\frac{P_t(z)}{P_t}\right)^{-\epsilon}$. Also, the aggregate price level is $P_t = [\int_0^1 P_t(z)^{1-\epsilon}dz]^{\frac{1}{1-\epsilon}}$.

3.2.2 Intermediate Goods Producers

The intermediate goods producers are in monopolistic competitions and supply their own goods to the final good producer. Each firm can fully lend the accumulated capital and should employ labor from both households. The production functions are given as follows.

$$Y_t(z) = A_tK_{t-1}(z)^{\omega}N_{s,t}(z)^{\alpha(1-\omega)}N_{b,t}(z)^{(1-\alpha)(1-\omega)} \tag{14}$$

Here parameters α and ω that means the share of capital and labor income take values between 0 and 1. Also, A_t represents the technology shock that follows the process of $\log(A_t) = \rho_A \log(A_{t-1}) + u_{A,t}$.

The intermediate goods producers solve the following problem to minimize their production cost. Here, $\Phi_t(z)$ means the real marginal cost of the production $Y_t(z)$.

$$\min_{N_{s,t}(z), N_{b,t}(z), K_{t-1}(z)} W_{s,t}N_{s,t}(z) + W_{b,t}N_{b,t}(z) + r_t K_{t-1}(z) \\ + \Phi_t(z)(Y_t(z) - A_t K_{t-1}(z)^{\omega} N_{s,t}(z)^{\alpha(1-\omega)} N_{b,t}(z)^{(1-\alpha)(1-\omega)})$$

The solution for the minimization problem draws the demand for labor and capital that are shown below.

$$W_{s,t} = \frac{\Phi_t(z)\alpha(1-\omega)Y_t(z)}{N_{s,t}(z)} \tag{15}$$

$$W_{b,t} = \frac{\Phi_t(z)(1-\alpha)(1-\omega)Y_t(z)}{N_{b,t}(z)} \tag{16}$$

$$r_t = \frac{\Phi_t(z)\omega Y_t(z)}{K_{t-1}(z)} \tag{17}$$

Using the factor demands and production function, we can derive the form of the real marginal cost as $\Phi_t(z) = \frac{1}{A_t}\left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha}\frac{1}{\omega}\left(\frac{r_t}{W_{s,t}}\right)^{\omega} W_{b,t}^{1-\alpha} W_{s,t}^{\alpha}$. Thus, the marginal cost is not different for each producer. Since the technology structures for each intermediate goods producer are analogous and they face identical marginal cost, the intermediate goods producers are symmetric so we can write the equation (15), (16), and (17) without index z.

Moreover, the intermediate producers will set their prices in a Calvo-Yun setting. Thus, it is assumed that the firms cannot change their price with a probability of θ in each period and they can adjust their price with a probability of $1-\theta$. Under this staggered price setting, the intermediate goods producer's price-setting problem is not static, so they maximize the present value of the lifetime profit given the demand for each intermediate good.

$$\max_{P_t^*(z)} \sum_{k=0}^{\infty} \theta^k E_t[M_{t,t+k}(\frac{P_t^*(z)}{P_{t+k}} Y_{t+k}(z) - \Phi_{t+k} Y_{t+k}(z))]$$

$$s.t.\, Y_t(z) = Y_t \left(\frac{P_t(z)}{P_t} \right)^{-\epsilon} \tag{18}$$

$M_{t,t+k}$ represents the stochastic discount factor[6], and Φ is the producer's nominal cost. After solving the maximization problem and taking steps of derivations, we can have the New-Keynesian Phillps curve.

$$\hat{\pi}_t = \beta_s E_t \hat{\pi}_{t+1} + \frac{(1-\theta)(1-\theta\beta_s)}{\theta} \hat{MC}_t \tag{19}$$

As we already have seen from the cost minimization problem, the marginal cost is $MC_t = \Phi_t(z) = \frac{1}{A_t} \left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha} \frac{1}{\omega} \left(\frac{r_t}{W_{s,t}}\right)^{\omega} W_{b,t}^{1-\alpha} W_{s,t}^{\alpha}$. Also, the variable denoted in 'hat' means that percentage deviation of the variable from the steady-state.

Furthermore, it should be noted that the saver can have the profit of the intermediate goods producers, F_t. The profit is defined as the revenue minus cost in the real term and so it can be given as follow.

$$F_t = Y_t - W_{s,t} N_{s,t} - W_{b,t} N_{b,t} - r_t K_{t-1} \tag{20}$$

3.3 Macroeconomic Policies

3.3.1 Monetary Policy

The central bank operates monetary policy under the standard Taylor rule. The interest rate is adjusted to respond to the inflation level, output growth, and interest rate in the previous period. In this rule, ρ stands for the interest rate smoothing parameters. ϕ_π^R is the degree of response of interest rate to the inflation. Meanwhile, ϕ_y^R is the parameter that shows how much the central bank reacts to output growth. These parameters will take a value between 0 and 1. There is an exogenous monetary policy shock, $u_{R,t}$, that is a white noise process that changes the interest rate. The monetary policy rule is as follows.

$$R_t = R_{t-1}^{\rho} \left(\pi_t^{1+\phi_\pi^R} \left(\frac{Y_t}{Y_{t-1}} \right)^{\phi_y^R} R \right)^{1-\rho} exp(u_{R,t}) \tag{21}$$

[6] This can be derived from equation (5) and it can be written as$M_{t,t+k} = \beta_s^k \left(\frac{C_{s,t}}{C_{s,t+k}} \right)$

3.3.2 LTV Rule

As in Rubio and Carrasco-Gallego (2014), the borrower is under the Taylor-type LTV rule. Thus, the LTV rule is determined by considering the credit growth of the economy. If the credit growth rate is high, the LTV ratio becomes smaller than that in the steady-state to limit the level of new borrowings. The LTV measure will be loosened if the credit growth rate gets lower. This type of decision rule for LTV requirements can reflect the real practice of the macroprudential policy authority of countries includes Korea. The parameter ϕ_b^{LTV} below in the LTV rule equation decides the degree of responsiveness to the credit growth for determining the LTV limit.

$$LTV_t = LTV_{ss}\left(\frac{b_t}{b_{t-1}}\right)^{-\phi_b^{LTV}} \tag{22}$$

3.3.3 Fiscal Policies

The government operates fiscal policies by using tax revenues from households. There are two possible types of government fiscal operations. First, as a simple case, the government can conduct dissipative spending to purchase the final goods (G_t). Then, government's budget constraint is shown below.

$$G_t = \tau_t^{tc} q_t(H_{s,t} + H_{b,t}) + \tau_t^{p} q_{t-1}(H_{s,t} + H_{b,t}) \equiv GR_t \tag{23}$$

Otherwise, the government can make a transfer to each household. The government will decide how they will distribute the tax revenues between two households in this case. In this case, the government's budget constraint can be written as follows.

$$TR_t = \tau_t^{tc} q_t(H_{s,t} + H_{b,t}) + \tau_t^{p} q_{t-1}(H_{s,t} + H_{b,t}) \equiv GR_t \tag{24}$$

The government's revenues, which is on the right side of the equation (24), are used for transfers to the household (TR_t). A fraction ($\lambda \in [0,1)$)[7] of TR_t belongs to the saver and

[7] λ should be strictly smaller than 1 to have a stationary steady-state. If it is equal to 1, the borrower's labor supply can be explosive.

another portion of the total transfer is allowed to the borrower. Thus, the level of transfer that each household can have is written in the following.

$$TR_{s,t} = \lambda TR_t \tag{25}$$

$$TR_{b,t} = (1-\lambda) TR_t \tag{26}$$

Finally, the government can determine how they set the ratio for the housing relevant taxes. There are two different types of housing tax, transaction tax and property tax. The transaction tax, τ^{tc}, simplifies registration tax and acquisition tax that are required to pay when a buyer purchases a new housing stock in Korea. The way of adopting this tax into the model is referred a method in Best and Kleven (2018). Also, property tax, τ^{p}, represents the tax on housing assets as in Alpanda and Zubairy (2016). This method will exemplify Korea's housing property tax and Comprehensive real estate holding tax. Korean fiscal authority imposes a duty on the profit margin on purchase and sale, thus, this approach with two types of tax can reflect this taxation as well. As in Rabanal (2018), the taxes are assumed to basically follow the AR(1) process around their steady-state level. Based on this framework, we can further reflect the possibility of an adjustment of the tax ratios by considering house price increases as the housing relevant tax rate has been responsive to house prices (Blöchliger et al. 2015)[8]. In these circumstances, the tax rate can be determined in the ways below.

$$\tau_t^{tc} = (1-\rho^{tc1})\tau_{ss}^{tc} + \rho^{tc1}\tau_{t-1}^{tc} + \rho^{tc2}\left(\log(q_t) - \log(q_{t-1})\right) + u_t^{tc} \tag{27}$$

$$\tau_t^{p} = (1-\rho^{p1})\tau_{ss}^{p} + \rho^{p1}\tau_{t-1}^{p} + \rho^{p2}\left(\log(q_t) - \log(q_{t-1})\right) + u_t^{p} \tag{28}$$

In the case that the government is not disturbed by the house price increases, the coefficients ρ^{tc2} and ρ^{p2} will be zero.

[8] We can explore the possibility of using the tax rate for cooling down the phase of credit growth in the numerical experiment. In that case, the term related to the credit growth, $\rho^{tc3}\left(\log(b_t) - \log(b_{t-1})\right)$ and $\rho^{p3}\left(\log(b_t) - \log(b_{t-1})\right)$ will be added to (27) and (28), respectively, and ρ^{tc3} and ρ^{p3} will not be zero if the government considers credit growth. The relevant outcome will be given in the Appendix.

3.4 Market Clearing Condition

The final good market is cleared when the production is equal to the demand that is represented by the sum of each agent's expenditure on the final goods and investment adjustment cost. In accordance with the government's fiscal policy operations, the final good market is cleared as follows.

$$\begin{cases} Y_t = C_{s,t} + C_{b,t} + I_t + adj.cost_t & if\ TR_t = GR_t \\ Y_t = C_{s,t} + C_{b,t} + I_t + G_t + adj.cost_t & if\ G_t = GR_t \end{cases} \tag{29}$$

As assumed the housing stock of the economy is normalized as 1, the housing market clearing condition is given in the (30).

$$H_{s,t} + H_{b,t} = 1 \tag{30}$$

Also, the factor market is cleared when its supply and demand are equal. For, the labor and capital market, the following conditions have to be met.

$$N_{s,t} = \frac{MC_t}{W_{s,t}}\alpha(1-\omega)Y_t \tag{31}$$

$$N_{b,t} = \frac{MC_t}{W_{b,t}}(1-\alpha)(1-\omega)Y_t \tag{32}$$

$$K_{t-1} = \frac{MC_t}{r_t}\omega Y_t \tag{33}$$

4 Numerical Analysis I - Tax Shock and Implications

In this section, I have conducted a numerical analysis to check the policy effectiveness and possibility of housing taxation as a macroprudential policy tool. To this end, first, I will discuss the reasoning of choosing paramatric values of the model that are essential for numerical exercise. After that, I will introduced the welfare measure that is used in this analysis. Then, I will check the response of the variables that are the target of financial stability such as house price and credit after generating a tax shock in the modelled economy. Also, the response of other macroeconomic variables, output, consumption, and investment will be analyzed to discuss the potential cost of using the tax policies. After checking its robustness, I will discuss its welfare implications and study alternative fiscal policy operations regarding the fairness issues.

4.1 Calibration

As we discussed, we will conduct the numerical analysis by referring Korean economy. To this end, the parametric values of the model have been chosen to match the feature of the economy between 2002 to 2019. Korea began to have autonomy in macro-policy operations after they had completed the repayment schedule of the IMF bailout in Aug 2001. Thus, Korea had started to actively regulate the housing market by using LTV requirements after 2002. This is the reason I chose this time span for the reference of the analysis. A period in the modelled economy means a quarter. The detailed parametric value is given in Table 1. Between 2002 to 2019, the annual interest rate was 2.78%, thus $\beta^s$is set to 0.9932 to get a quarterly gross interest rate of 1.0068. To make the borrower has a loan from the saver, the borrower's discount factor, 0.98, is chosen lower than this number. Also, ω and δ are 0.42 and 0.05, respectively, to have a consistency with investment to output (=consumption + investment + government expenditure) ratio of the Korean national account data with its steady-state value of the model. Accordingly, the baseline case of fiscal operation is that government purchases final goods by using their tax revenues. Jss and $LTVss$ are determined to meet the relevant data as well and these were set to 0.059 and 0.95. The relevant criteria were the aggregate market price of the housing of Korea to GDP ratio and credit to GDP ratio. The steady-state value of tax was calibrated to get the same result as the value of tax revenue to output ratio. The comparison of the steady-state value and the data is suggested in Table 2. Other parameters were calibrated by using relevant literature that uses or estimates quarterly based values. First, parameters related to monetary policy and LTV rule, ρ, ϕ_π^R, ϕ_y^R and ϕ_b^{LTV}, are determined under the results from Jung and Mok (2019) that measures optimal policy parameters that maximize social welfare in Korea's case. Thus, these are 0.9, 0.7, 0.0, and 1, respectively. As suggested in the same literature, the parametric values for the inverse of Frisch elasticity of the labor supply, η was chosen as 2. Also, the parameter for price rigidity, θ, was set to 0.75 by referring Park and Song (2013) which suggests a survey result that Korean firms have a tendency of changing their price of the goods once a year. The parameters for autocorrelation of the exogenous shock, ρ^{tc1}, ρ^{p1}, ρ_A and ρ_J was chosen by referring the relevant literature, Rubio and Carrasco-Gallego (2014), Rabanal (2018), and Gatt (2018). The value for ϵ was chosen to get the steady-state mark-up rate as 20%. Last, the investment adjustment cost was determined to be 7.7 that is an estimation result by Bae (2013).

Table 1: Parameter Values

Description	Parameter	Value
Inverse of elasticity of the labor supply	η	2
Discount factor for the Saver	β^s	0.9932
Discount factor for the Borrower	β^b	0.98
Saver's relative income share to the Borrower	α	0.54
Capital income share	ω	0.42
Capital depreciation rate	δ	0.05
Investment adjustment cost	ψ	7.7
Elasticity of substitution between intermediate goods	ϵ	6
1-Probability of adjusting prices	θ	0.75
Interest rate smoothing parameter	ρ	0.9
Response of the interest rate to inflation	ϕ_π^R	0.7
Response of the interest rate to output growth	ϕ_y^R	0.0
Response of the LTV to credit growth	ϕ_b^{LTV}	1
steady-state level of LTV requirement	LTV_{ss}	0.95
Persistency of the transaction tax shock	ρ^{tc1}	0.95
Persistency of the property tax shock	ρ^{p1}	0.95
steady-state level of the transction tax	τ_{ss}^{tc}	0.006
steady-state level of the property tax	τ_{ss}^{p}	0.006
Persistency of the technology shock	ρ_A	0.95
Persistency of the housing preference shock	ρ_J	0.96
steady-state level of the housing preference	Jss	0.059

Table 2: Comparison of the Steady-state Value of the Model and Data

Ratios	Data	Model
$\frac{C+G}{Y}$	0.683	0.692
$\frac{I}{Y}$	0.317	0.308
$\frac{q(H_s+H_b)}{Y}$	2.064	2.079
$\frac{q(H_s+H_b)(\tau_{ss}^{tc}+\tau_{ss}^{p})}{Y}$	0.025	0.025
$\frac{b}{Y}$	0.679	0.606

4.2 Welfare Measure

To numerically measure the welfare of the households in a stochastic simulation, I used the second-order perturbation method,[9] given in Schmitt-Grohe and Uribe (2004). By using it, I can properly compute the agent's welfare as it reflect the effect of uncertainty inherent in the economy. However, during the deterministic simulation, I directly put the simulated values for consumption, housing and labor supply in each household's welfare function. From the households' maximization problem, we know the form of the utility function, so the households' welfare at time t can be written as follows, respectively.

$$W_{s,t} = E_t \sum_{p=0}^{\infty} \beta_s^{t+p} [\log(C_{s,t+p}) + j_{t+p} \log(H_{s,t+p}) - \frac{N_{s,t+p}^{\eta}}{\eta}] \tag{34}$$

$$W_{b,t} = E_t \sum_{p=0}^{\infty} \beta_b^{t+p} [\log(C_{b,t+p}) + j_{t+p} \log(H_{b,t+p}) - \frac{N_{b,t+p}^{\eta}}{\eta}] \tag{35}$$

Thus, we can compute the welfare level in each scenario of the policy implementations. However, comparing the different levels of welfare is not easy to intuitively understandable, I calculated the consumption equivalence of the households. This shows the welfare gain or cost in terms of consumption, and can be given as follows.

$$CE_s = \exp((1 - \beta_s)(W_s^P - W_s^*)) - 1 \tag{36}$$

$$CE_b = \exp((1 - \beta_b)(W_b^P - W_b^*)) - 1 \tag{37}$$

Here, W^p is the welfare level computed in a certain distribution regime when there is a fluctuation by an exogenous shock that is relevant to tax or housing preference. W^* is the welfare level that can be obtained in a steady-state of the economy or a benchmark case. Also, CE represents a welfare gain or loss that is measured in percentage difference from the consumption level for every period that can be utilized in the steady-state.

[9] This is the method that solves the system in second-order approximation and computing the welfare by using this solution and the approximated welfare function. During the exercise, I used techniques embedded in Dynare to solve the model and compute welfare levels.

4.3 Analysis on Tax Shocks

4.3.1 Temporary Tax Shock

- Impulse Response Analysis with a Temporary Tax Shock

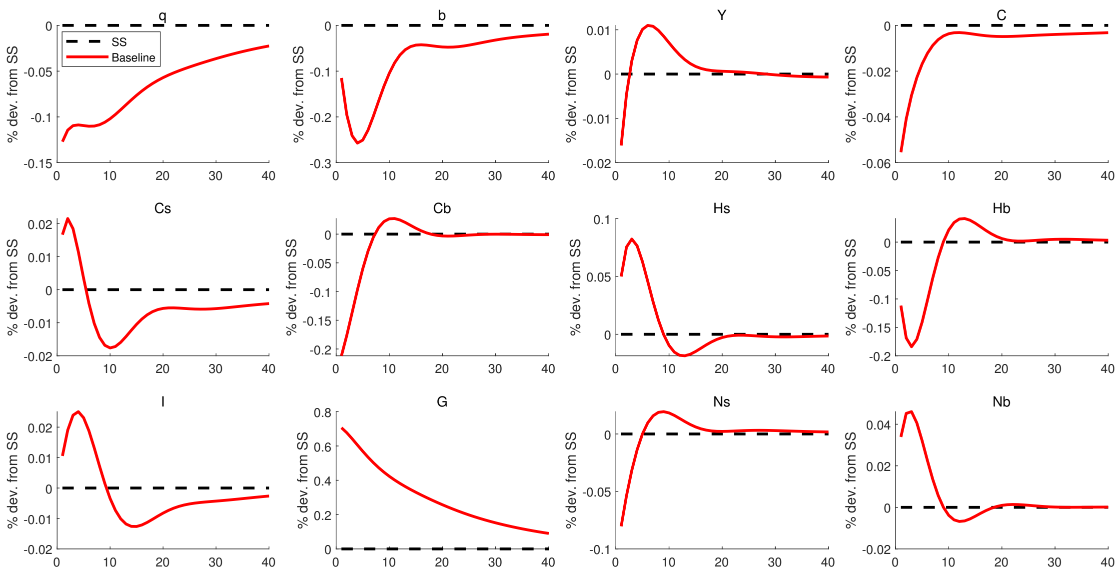
The dynamics of the macroeconomic variables after a positive 1% standard deviation of property tax shock[10] are given in Figure 3. Here, as a benchmark, I analyze the case of dissipative government expenditures. The red solid line represents the responses of the variables. After this unanticipated tax shock, house prices are instantaneously decreased since there is a reduction in housing demand by both households as they face a higher cost of housing. The initial decline in house prices tightens the borrower's collateral constraint hence it cuts the level of credits as well. After these early changes, credit is returning back to its steady-state level more promptly than house price. As predicted, government spending was expanded with a tax increase and it crowded out aggregate consumption. The dynamics of consumption, labor supply, and housing for each household are different, respectively. Due to the tightened borrowing constraint, the borrower had to decrease the level of consumption in final goods and housing stocks. Also, they have to work more time to cover the lack of resources resulting from the decline of the available credit. On the other hand, the saver can experience a larger level of consumption and housing right after the shock. They can use the resources that may be lent to the borrower in the case of no tax shock. In addition, since the supply of housing stock is fixed, the saver ends up buying houses that cannot be purchased by the borrower. This patient household put more resources into the capital accumulation and so investment shows an initial increase after the shock as well. Given the limitation on the credit to the borrower by the LTV requirement, the saver can expect a smaller return from the credit to the impatient household. This made the saver choose to invest in the physical capital and it functions as a quick recovery of the output.

As time passes, however, the saver's consumption goes below the steady-state level due to a tax burden from the increased tax rate and house purchases. The initial increase in capital accumulation also lowers the return on investment since marginal productivity of capital becomes smaller. It additionally limits the saver's budget constraint since they own capital in this economy. It is connected to more labor supply from the saver after the early reduction of it. On the contrary, the borrower's consumption level converged to the steady-state level relatively quickly to the saver. During the transition after the shock, the macroeconomic

[10] The impulse response function after a 1% increase of transaction tax shock is almost analogous. There is a slight difference in the level of deviation but it is not significant. These results will be given in Appendix C.

policies, Taylor and LTV rule, gradually relaxed the collateral constraint of the borrower as interest rate decreased and LTV requirement becomes less limited. The recovery of the house prices also improves the borrower's financial conditions.

Figure 3: Impulse Response Functions after an Unanticipated Tax shock (with Government Purchases)

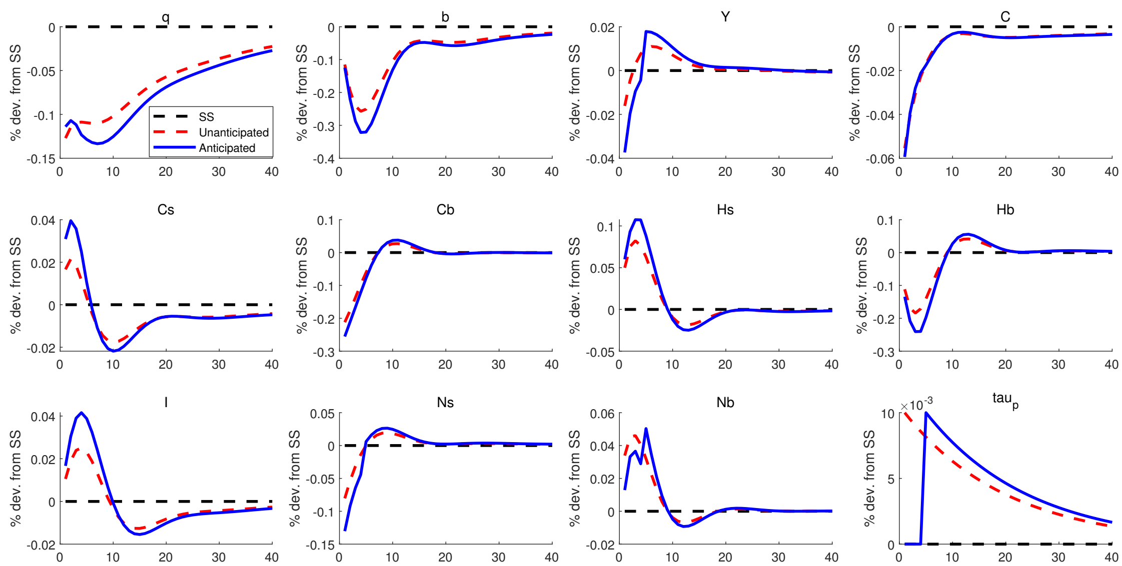


In reality, tax adjustment schedules are announced before it is actually implemented due to administrative reasons. By considering this possibility, I have analyzed the case that housing tax increase is noticed to the public 4 periods before it is executed. This will give us more robust conclusion. During the exercise, it was assumed that a 1% standard deviation of property tax shock was informed in advance[11]. Then, the property tax rate follow the process of $\tau_t^p = (1-\rho^{p1})\tau_{ss}^p + \rho^{p1}\tau_{t-1}^p + \rho^{p2}\left(\log(q_t) - \log(q_{t-1})\right) + u_t^p + v_{t-4}^p$. Here, v_{t-4}^p is a stochastic process that is publicly available for economic agents at time t-4. This is also assumed to be independent with u_t^p. The response of the variables to the anticipated tax shock work under the same mechanism as that in the case of the unanticipated tax shock. When each household is informed of the tax increase, they expect their lifetime cost of housing can rise. This causes an immediate reduction in house demand and it leads to a decline in house prices. Since house price is related to the collateral constraint of the

[11]The results of the transaction tax shock are similar and it is given in Appendix C as well.

borrower, the credit level that the impatient household can have is also fallen. Thus, the borrower will face a tighter resource constraint and it leads to the early decline in their housing and final goods consumption. Meanwhile, the saver can use the resource that is not lent to the borrower for their own consumption and housing, and they can invest more in physical capital. Consequently, the impulse response functions in this scenario show similar dynamics with that of the unanticipated shocks even though the anticipated shocks make higher volatility in each variable. Therefore, the impact of the tax shock can be reconfirmed in the case when we have news about the tax change.

Figure 4: Comparison of the Impulse Response Functions after Tax Shocks (with Government Purchases)



The impact of tax shock would be differed by the parameter for the Taylor rule. For example, Born et al. (2013) shows that the response of the variables to a fiscal shock can depend on Taylor rule parameters. By considering this possibility, I have changed the monetary policy parameters and check the response of the variables after the tax shock. From the baseline that sets $\phi_\pi^R = 0.7$ and $\phi_\pi^Y = 0.0$, I have modified the parameters as the central bank put more weight on the output growth (Higher values on ϕ_π^Y) and pay less attention on inflation (Smaller values on ϕ_π^R). As can be seen in Figure 5, we can observe small differences in the dynamics of each variable with different parametric values, and it is insignificant. Thus, the impact of the tax shock does not much depend on the Taylor rule. A similar result also can be found when we use an anticipated tax shock. Figure 6 shows that the response of each variable does not depend on the differences in Taylor rule parameters.

Figure 5: Comparison of the Impulse Response Functions after an Unanticipated Tax Shocks (with Government Purchases)

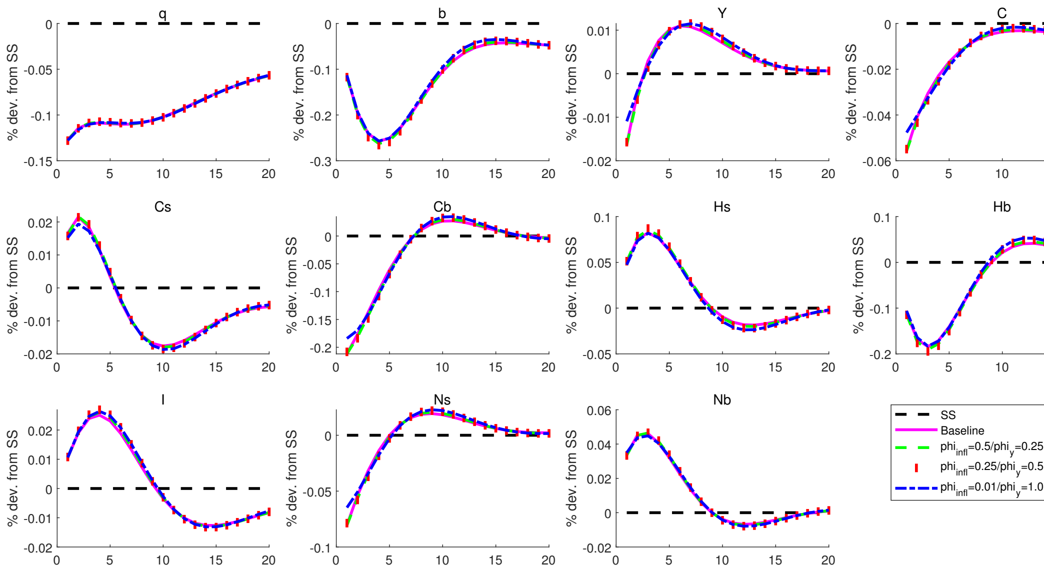
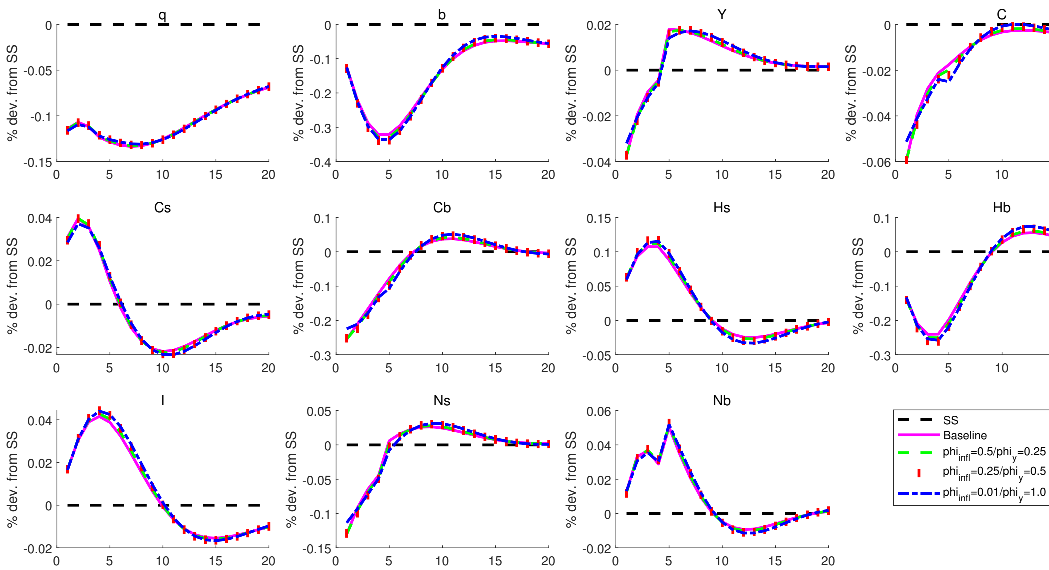


Figure 6: Comparison of the Impulse Response Functions after an Anticipated Tax Shocks (with Government Purchases)



- Welfare Analysis with a Temporary Tax Shock

So far we have checked the effectiveness of a temporary tax shock and its possible negative side effect on the macroeconomic variables. However, using a tax shock which is whether fully announced or not can have a welfare implication as it generates uncertainty to each household. Therefore, we can compare the welfare level in the deterministic economy that the government does not cause an unpredictable change in taxation and that in the economy of having a possibility that a stochastic tax shock can be generated. The computed welfare in this stochastic steady-state and the welfare changes from the deterministic state is given in Table 3. As we can see from the table, for both cases, the borrower loses their welfare and the saver can have welfare gain from the tax shock. It can be understood as in the economy with a tax shock, the saver can have a precautionary motive, and accordingly, they will increase their savings and labor supply. This gives the borrower an opportunity to use more resources for their own final goods consumptions and housing purchases. As suggested in Table 3, the welfare changes between two agents can be larger when the government uses news shock for the tax changes since the economy will face a higher volatility in this environment.

Table 3: Welfare measured in the Case of a Temporary Tax Shock

	W_s^P	W_s^*	W_b^P	W_b^*	CE_s	CE_b	$CE_s + CE_b$	$\lvert CE_s - CE_b \rvert$
Unanticipated	12.48	12.72	-48.27	-48.91	-0.002	0.013	0.011	0.015
Anticipated	7.75	12.72	-47.13	-48.91	-0.033	0.036	0.003	0.070

These welfare disparities between the agent give us the motive to find an alternative approach in distributing the tax revenues if the government seeks to achieve fairness between the agent. With this concern, I have analyzed welfare implications in the circumstance when the government chooses to allocate the tax revenues to each agent as a form of transfer. By doing so, I can possibly discuss the way of mitigating the problem generated from using a temporary tax shock. This will be done by using five possible values for the parameter, λ, that stands for the distributions. The parameters will be dispersed in an interval of 0.25 from 0 to 0.99[12][13]. The computed welfare changes with different distribution operations are given in Table 4 and Table 5. This shows the welfare changes from the deterministic steady-state that uses its own fiscal operation with different distributional parameters to a stochastic steady-state that uses a tax shock. Thus, an important assumption is that the economy was initially in a steady-state with its own fiscal policy scheme. As given in Table 4, the economy can get most welfare gains by using an unanticipated stochastic shock when it transfers 25% of tax revenues to the saver. However, for fairness matters, it is better to operate fiscal policy by purchasing final goods. There is no better case for minimizing the welfare difference between the agents than the case of government consumption. Meanwhile, in the case of the anticipated tax shock, the distribution scheme with $\lambda = 0.75$ is definitely better than the dissipative government expenditures since it reduces the difference in consumption equivalence and gets a better level in welfare gain in the economy as a whole. With consideration on the fact that the economy with $\lambda = 0.75$ achieves higher social welfare[14] (-0.832) than that (-0.892) of wasteful government purchases, moving to the fiscal operation with $\lambda = 0.75$ before generating a tax shock would be desirable for the government in terms of the improving the welfare.

[12] When $\lambda = 1$, C_2 in Appendix B will become zero. In this case, the steady-state will take an infinite value. Thus, I chose $\lambda = 0.99$ as a circumstance that the saver receives most of the tax revenues.

[13] The impulse response functions in using the transfers are not much different from that of the government expenditures, and the results are given in the Appendix.

[14] As in Rubio and Carrasco (2014), it can be defined as $W = (1 - \beta_s) * W_s + (1 - \beta_b) * W_b$.

Table 4: Welfare measured in the Case of an Unanticipated Tax Shock

	W_s^P	W_s^*	W_b^P	W_b^*	CE_s	CE_b	$CE_s + CE_b$	$\lvert CE_s - CE_b \rvert$
$\lambda = 0.00$	7.91	8.85	-40.33	-41.72	-0.006	0.028	0.022	0.034
$\lambda = 0.25$	10.29	11.83	-41.92	-43.62	-0.010	0.035	0.024	0.045
$\lambda = 0.50$	12.71	14.81	-43.78	-45.59	-0.014	0.037	0.023	0.051
$\lambda = 0.75$	15.21	17.78	-45.98	-47.62	-0.017	0.033	0.016	0.051
$\lambda = 0.99$	17.72	20.63	-48.50	-49.65	-0.020	0.023	0.004	0.043

Table 5: Welfare measured in the Case of an Anticipated Tax Shock

	W_s^P	W_s^*	W_b^P	W_b^*	CE_s	CE_b	$CE_s + CE_b$	$\lvert CE_s - CE_b \rvert$
$\lambda = 0.00$	3.46	8.85	-40.97	-41.72	-0.036	0.015	-0.021	0.051
$\lambda = 0.25$	7.82	11.83	-42.88	-43.62	-0.027	0.015	-0.012	0.042
$\lambda = 0.50$	11.72	14.81	-44.74	-45.59	-0.021	0.017	-0.004	0.038
$\lambda = 0.75$	15.24	17.78	-46.62	-47.62	-0.017	0.020	0.003	0.038
$\lambda = 0.99$	18.32	20.63	-48.49	-49.65	-0.016	0.023	0.008	0.039

4.3.2 Permanent Tax Shock

- Transition Dynamics after a Permanent Tax Increase

In practice, tax adjustment is likely to infrequently happen and the newly determined tax rate would be maintained for some years. Considering this possibility, I have conducted an analysis in the circumstance of a permanent tax increase in property tax[15]. For this experiment, it is assumed that the economy is in a steady-state with a property tax rate of 0.006 as given in table 1 ($\tau_{ss}^p = 0.006$). At period 1, a tax rate will be adjusted to 0.016 ($\tau_{ss}^p = 0.016$), so there will be a 1%p increase in the property tax rate. This change is fully expected by the agent and so both households have perfect foresight. Thus, as time passes, the economy will converge to a new steady-state with a new property tax rate, and then there will be fluctuations of the macroeconomic variables during the transition to the new steady-state. I will check the simulated series of macroeconomic variables after the tax rate

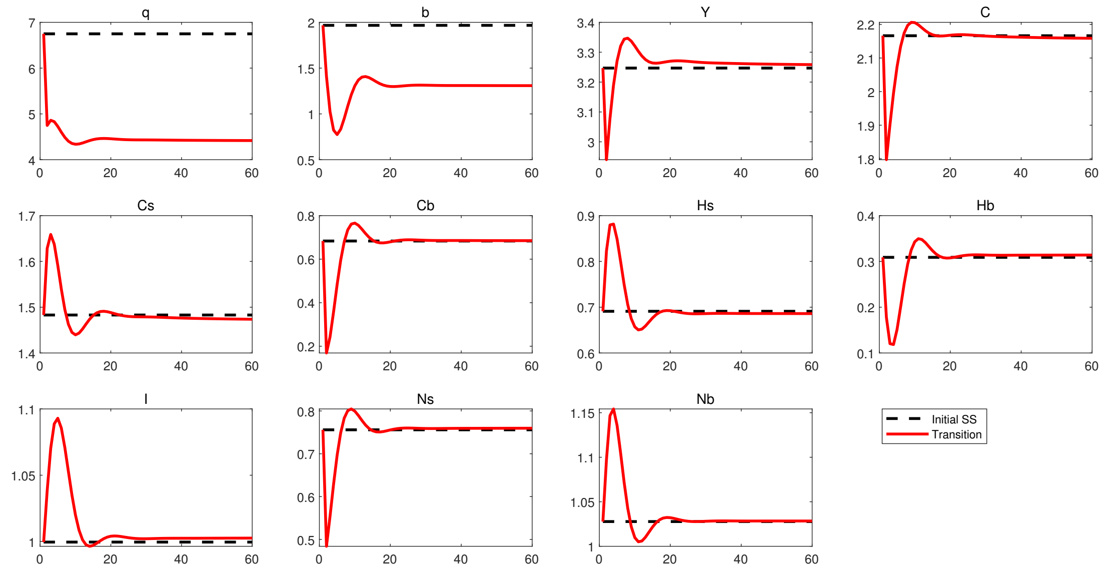
[15]The results for transaction tax will be given in the Appendix.

increase. Given in Figure 7, a higher tax rate leads to a decrease in house prices (6.7489 $\rightarrow$ 4.4140) and credit levels (1.9671 $\rightarrow$ 1.3079) in the long run[16]. Since the output level in both steady-states is almost identical (3.2469 $\rightarrow$ 3.2567), we would conclude that the property tax rate adjustment makes a neutral impact on the output level in the long run, which is analogous to the claim by Norregaard (2013) that the property tax rate has less malevolent to the economic growth.

However, the variables are fluctuating until they reach the new steady-state level of the economy. Above all, the dynamics of the consumption, housing and labor supply for each household shows distinctive movements. The pattern of the variables after the shock shows similar trajectories with the case of the stochastic simulation. An increase in the tax rate raises the cost of housing for both households and so housing demand becomes smaller. This makes a prompt reduction in house prices, accordingly, it lowers the level of credit for the impatient household. Therefore, the borrower cuts their consumption and housing level down due to the lack of funds. Meanwhile, the saver can use the resources that are not lent to the borrower for their own consumption and they experience a larger level of consumption and housing right after the tax adjustment. In addition, the saver has less incentive to supply labor, and this causes the early fall in output level. Since the saver cannot make deposits to the borrower, they have to increase investment in physical capital. This causes growth in investment after the tax increase, and it helps rapid recovery of the output level. Furthermore, the households will achieve different levels of the variables in the new steady-state. These disparities in consumption, housing, and labor supply during the transition and the new steady-state imply the difference in welfare between the agents.

[16] The steady-state levels of all variables under different tax rates and distribution policies are shown in the Appendix.

Figure 7: Transition Dynamics of the Economy after a Permanent Tax Increase



- Welfare Analysis with a Permanent Tax Increase

The transition dynamics results suggest a difference in welfare between two households as we discussed. To understand this issue numerically, I computed the welfare gain and loss of each agent by using the methods given in 4.2. Here, W_s^P and W_b^P are the sum of the discounted utility of 100 periods during the transition of the economy plus discounted infinite sum of the welfare in each period in the new steady-state for the saver and the borrower, respectively. Also, W_s^* and W_b^* stands for the welfare level that each household is attainable if the initial steady-state is maintained. As given in Table 6, both borrowers and savers will lose welfare after the tax rate increase. This is because the saver will arrive at the new steady-state that gives them a lower level of consumption and housing and a bigger level of labor supply after the tax adjustment. For the borrower, they will face a reduction in consumption and housing at the early stage after the tax rate increase, and they have to supply a slightly higher level of labor, which is a reason for disutility, in the new steady-state. There is no gain for the borrower from precautionary savings that would happen in the stochastic simulation. In the deterministic simulation, thus, the borrower also experiences a welfare loss.

Furthermore, Table 6 compares the welfare changes when the government makes transfers to each household instead of using the tax revenues for their own final goods purchase. The results, thus, show how each household's welfare will differ as the economy is initially in a steady-state in accordance with the different values of lambdas. As we can see, when the saver receives most of the tax revenue, the welfare of the economy after the tax increase can be maximized. However, this transfer scheme cannot achieve fairness between agents. Rather, the equality in welfare change after the tax increase is possible when the saver gets 25% of tax revenues. In this case, the economy will experience a welfare loss as a whole but the agent will share the welfare loss as equally as possible. Therefore, when the government has an intention to reduce the steady-state level of house price and credit level, it would be most preferable when three-quarters of tax revenues are distributed to the borrower. Intuitively, the tax change made a negative impact on the borrower's welfare, accordingly, it would be better to reduce their loss by allocating more portion of the resources to them. Despite this possibility, the transfer to the borrower should not be excessive since it would furtherly undermine the saver's welfare.

Table 6: Welfare measured in the Case of a Permanent Tax Increase

	W_s^P	W_s^*	W_b^P	W_b^*	CE_s	CE_b	$CE_s + CE_b$	$\lvert CE_s - CE_b\rvert$
G	12.12	12.72	-52.48	-48.91	-0.040	-0.069	-0.109	0.029
$\lambda = 0.00$	7.51	8.85	-43.39	-41.72	-0.087	-0.033	-0.120	0.054
$\lambda = 0.25$	11.09	11.83	-45.71	-43.62	-0.049	-0.041	-0.090	0.008
$\lambda = 0.50$	14.66	14.81	-48.12	-45.59	-0.010	-0.049	-0.060	0.039
$\lambda = 0.75$	18.21	17.78	-50.64	-47.62	0.030	-0.058	-0.029	0.088
$\lambda = 0.99$	21.61	20.63	-53.16	-49.65	0.069	-0.068	0.002	0.137

5 Numerical Analysis II - Macroeconomic Shocks and Taxation as a Stabilizer

In this section, I will conduct an analysis of the possibility in using a kind of tax rule to tame the housing market fluctuations in different scenarios that the economy experiences macroeconomic shocks. For the exercises below, I will focus on the case that set a tax rate by considering house price increases[17]. By doing so, I will discuss the validity of using housing

[17] As discussed, we can think about a case that the government considers credit growth in their tax rate decision. Given in the Appendix, however, there are not many significant differences in the results when a housing preference shock occurs even if the government reacts to the credit growth as well. When the

taxations as an automatic stabilizer of the housing market. Also, I will find the welfare implications of using a tax in these circumstances. The same parametric values will be used as introduced in 4.1 and identical methods for measuring welfare will be used as in 4.2.

5.1 Housing Preference Shock

5.1.1 Impulse Response Analysis

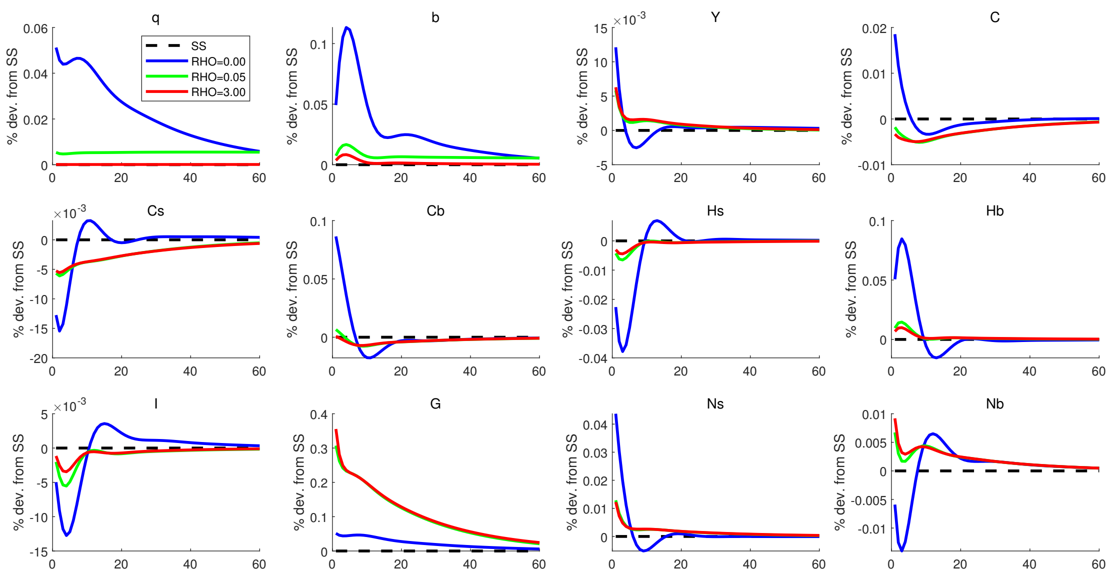
Figure 8 shows the impulse response functions after a positive housing preference shock of 3.6% variance under dissipative government spending. The figure compares three possible situations under different tax parameters. The solid blue line represents there is no tax rule that counters changes in house prices ($\rho^{tc2} = \rho^{p2} = 0$). Without a tax rule, a housing preference shock increases house prices since it expands the housing demand. The rise of house prices eases the borrower's constraints therefore they can initially spend more on consumption and housing. This is possible because it raises credit to the borrowers so the saver does not have sufficient resources to maintain the original steady-state level of consumption and investment. The lack of resources make the saver supply more unit of labor and so it makes early output growth. However, as time passed, the decline in labor supply by the borrower and the deficiency of investment has a negative effect on the production of the final goods. All these responses toward a shock had been settled and the variables had been converged to their initial steady-state level.

The case of setting a tax rule against a rise in house prices can reduce the level of fluctuations. The solid green line is the case of choosing this parametric values as 0.05 ($\rho^{tc2} = \rho^{p2} = 0.05$) and the solid red line shows the case of adopting the parametric values aggressively as 3.00 ($\rho^{tc2} = \rho^{p2} = 3.00$). This means the tax authority automatically raises both tax rates if they observe a positive rate of rising house prices. Implementing this tax rule suppresses house price and credit growth to the level that is lower than that of the circumstance without a tax rule. Housing taxation can successfully counter the housing demand by raising the number of resources that are needed to purchase a new house. The same mechanism with the no-tax rule can be applied to the dynamics of the real macroeconomic variables but the degree of deviation from steady-state was smaller than the case without a tax rule. A notable feature is that it takes much time for the house prices to return back to

economy experiences a productivity shock, the differences in setting a tax rule cause early disparities in the fluctuation of house prices and credit levels. For simplicity, I will mainly explore the case that the government chooses tax rates by only taking into account house prices. All relevant results are given in Appendix E.

the steady-state level even though the policy successfully restrained the early hike in house prices unless setting the tax rule parameters sufficiently high. Therefore, we can conclude that using a tax rule by considering the house price trend needs to be sufficiently strong in order to do not cause a higher level of the house price for a long time. This gives us an implication that the policy authority should have the accuracy to measure the impact of housing demand shock to avoid unintended increases in house prices which can be persistently continued. Also, imposing this rule can be valid only when the time that is needed to deal with the legislation procedures for adjusting the tax rate does not exceed a quarter of a year.

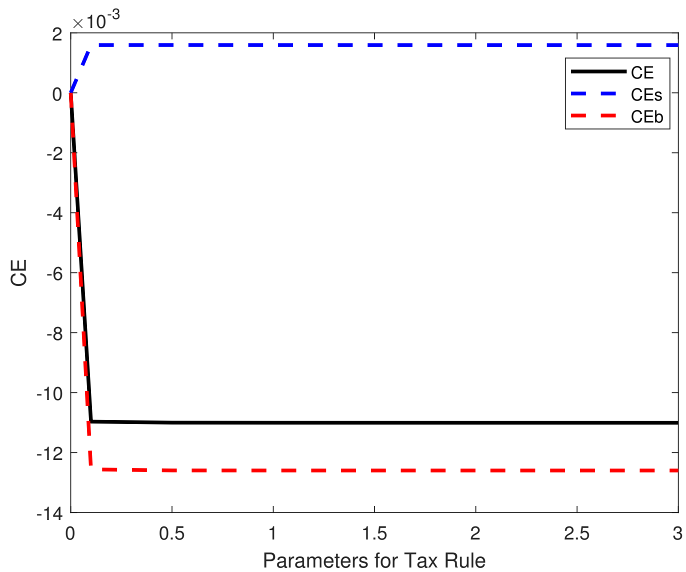
Figure 8: Impulse Response Functions after a Housing Preference Shock



5.1.2 Welfare Implications

Using a tax rule against a housing preference shock has a contrasting impact on households' welfare. Figure 9 illustrates this outcome. Here, I have normalized the welfare level in the case that the economy does not have any tax rule to counter a house price increase as 0. As we can observe from the figure, a tax increase leads to welfare gains for the saver. This is opposing for the borrower and it will face welfare losses as the government sets tighter rules. Without a rule, the saver has to prepare for the occurence of housing preference shock that leads to a decrease in their consumption level and more savings. Also, the saver will suffer from the bigger volatility of the economy. However, these losses can be disappeared as the government sets a rule that makes the economy become far less fluctuate. It has an adverse impact on the borrower's welfare because the rule can take away the borrower's opportunity of getting a more affordable level of debt. After set the parameters 0.1 for ρ^{tc2} and ρ^{p2}, the additional changes in welfare for each agent are quite small. Thus, a higher tax rate can effectively settle the overheating of house price increase without causing a further distributional effect.

Figure 9: Consumption Equivalence for different Parametric Values of Tax Rule



Suppose now that the government sets the tax parameters equal to 3.00 that is sufficient to suppress house price increases resulted from the preference shock. Then, if the government would like to distribute the tax revenues instead of using them for their own expenditures, how is the welfare change for each household after a housing preference shock? It can be checked by comparing the welfare outcome with different redistribution policies of the economy when the tax rule is operating. As a baseline scenario, W_s^* and W_b^* stands for the welfare level that is attainable when there is no tax rule even if there would be an occurrence of the housing preference shock. Also, W_s^P and W_b^P represent the welfare of each household that the housing market stabilizer is working on. Therefore, CE shows welfare changes from a benchmark case without a tax rule to using an automatic tax stabilizer. The outcome of this analysis is given in Table 7. As we can see, the saver can get welfare gain and the borrower loses their welfare for all scenarios and this is the analogous result with Figure 9. When the saver has a larger level of transfers, their welfare gain in mitigating the fluctuation of the economy is also growing. Welfare changes for the borrower are not much differentiated by parameters, thus, the welfare loss in the whole economy becomes less and less until λ goes up and reaches 0.75. On the other hand, the welfare changes will be more equally divided when λ gets the smallest value. This is the case that the saver can have a welfare gain from using a macroprudential policy rule but this gain will be fully offset by not receiving any revenues from the government even if the saver should pay the tax. Given that the borrower will have welfare loss for all cases, setting $\lambda = 0$ can minimize the difference in welfare change.

Table 7: Welfare measured in each Fiscal Operation Scenario in the Case of a Housing Preference Shock ($\rho^{tc2} = \rho^{p2} = 3.00$)

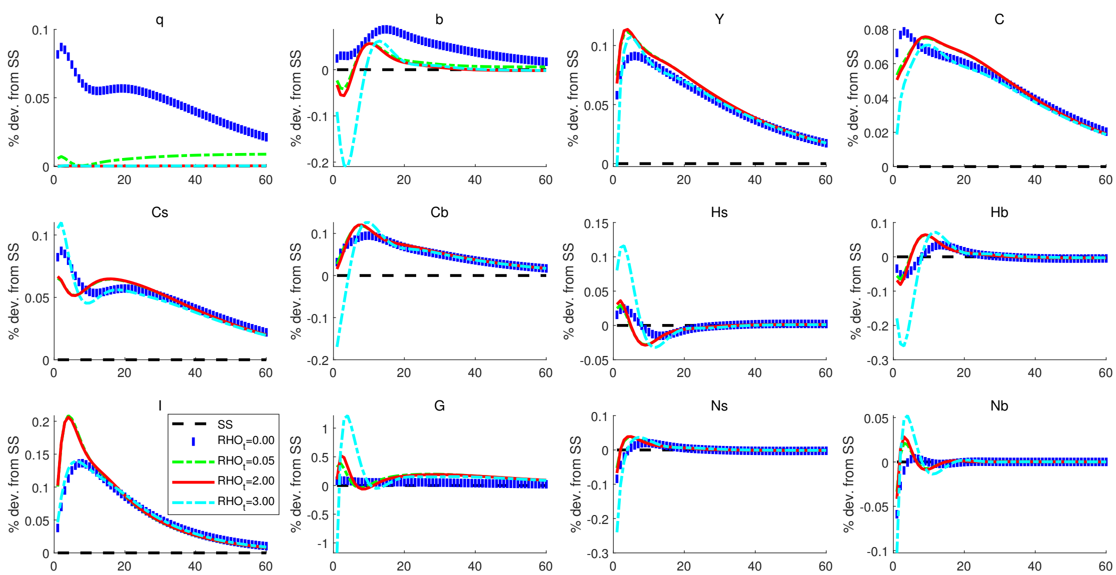
	W_s^P	W_s^*	W_b^P	W_b^*	CE_s	CE_b	$CE_s + CE_b$	$\lvert CE_s - CE_b \rvert$
G	10.58	10.34	-50.01	-49.38	0.002	-0.013	-0.011	0.014
$\lambda = 0.00$	5.41	5.44	-41.00	-40.38	0.000	-0.012	-0.013	0.012
$\lambda = 0.25$	9.46	9.27	-43.36	-42.75	0.001	-0.012	-0.011	0.013
$\lambda = 0.50$	13.42	13.08	-45.81	-45.20	0.002	-0.012	-0.010	0.014
$\lambda = 0.75$	17.33	16.86	-48.39	-47.75	0.003	-0.013	-0.009	0.016
$\lambda = 0.99$	21.05	20.47	-51.02	-50.30	0.004	-0.014	-0.010	0.018

5.2 Productivity Shock

5.2.1 Impulse Response Analysis

An experiment in the occurrence of a productivity shock was conducted under the fiscal operation that government spends its tax revenues to purchase the final goods. The impulse response functions are given in Figure 10. As we can see, a 10% increase of standard deviation in a productivity shock generates a favorable effect on the economy. Without a tax rule, the shock immediately enhances output, consumption, and investment level, and this is represented in the blue bar of the figure below. With this boosted productivity, the economy can achieve better production so it leads to a decrease in labor supply from both households. Better productivity causes a superior level of factor income and so investment to the physical capital accumulation becomes larger. Also, households can experience a higher consumption level thanks to enhanced productivity. The shock expands the demand for housing for both agents and this makes an increase in house prices and credit levels. When policy authority uses an automatic tax adjustment, the dynamics of output, consumption, and investment show the same pattern as that in the absence of the tax rule. However, when a stronger tax rule is implemented, both households' consumption for final goods was limited because their resource constraints were hampered. The increase in the cost of housing due to the tax hike deterred housing demand for both households but the impact is stronger to the borrower since they are under the collateral constraint, accordingly their expenditure on housing stocks was limited. This leads to an increase in physical capital investment by the saver since they also cannot make a loan to the borrower. A notable feature in Figure 10 is that when the government sets a stronger parameter ($\rho^{tc2} = \rho^{p2} = 3.00$), each household will confront higher volatility in consumption, level of housing stocks, and labor supply. This would incur a difference in welfare level between the two agents. This possibility will be check furtherly in the next subsection. Thus, setting the parameter as $\rho^{tc2} = \rho^{p2} = 2.00$ might be preferable since it does not cause a house price increase and much credit growth, and also it is not connected to larger fluctuations in the variables for household's utility. It should be also noted that an insufficient response ($\rho^{tc2} = \rho^{p2} = 0.05$) to the house price increase may cause a persistent deviation of the house price from its steady-state level.

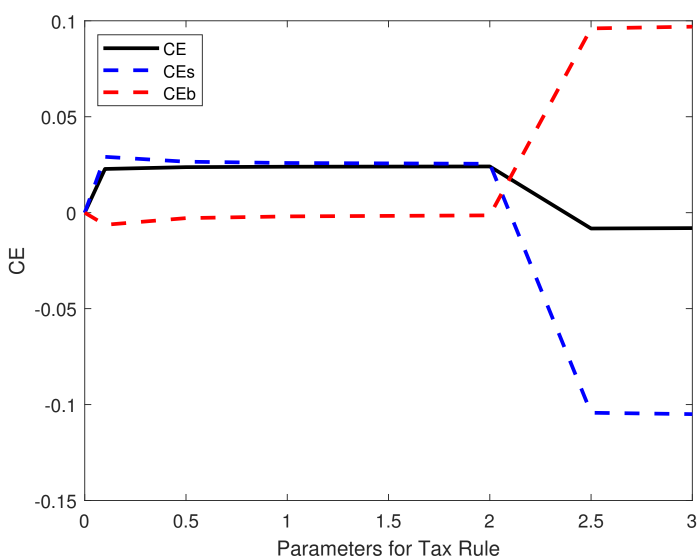
Figure 10: Impulse Resonse Functions after a Productivity Shock



5.2.2 Welfare Implications

In Figure 11, The welfare level with a positive technology shock and missing a tax rule is normalized to zero. As the tax policy authority tries to limit the house price increase by setting a higher parametric value for the tax rule, the saver can be benefited from a mild response but the borrower losses a bit of its welfare. This is because the saver faces less volatility in consumption and labor supply, and so there is less incentive to have precautionary savings. This gives the saver uses more resources for their own purpose. In contrast, it means the borrower will have a reduction in the level of borrowings so they experiences a welfare loss. However, the disparity in the level of welfare gain and loss by each household becomes smaller as the government sets higher weights on the house price increase, and if the reaction to the house price increase is too strong and higher than $\rho^{tc2} = \rho^{p2} = 2.00$, the saver starts to lose their welfare and the borrower begins to get gains in welfare. The enhanced rule to counter the house price increase cause a greater degree of uncertainty in consumption for the saver and so the saver tries to deal with it by using more savings. This generates a welfare gain for the borrower as they can use this fund for their utility maximization.

Figure 11: Consumption Equivalence for different Parametric Values of Tax Rule



Now I will analyze the welfare and equity implication of using different fiscal operations when the government considers setting a tax rule. Here, W_s^* and W_b^* is the welfare level when the rule is absent and there is the productivity shock. Moreover, W_s^P and W_b^P means the welfare level for each agent under different parameters for redistribution when the productivity shock happens and an automatic tax adjustment is operating. As we have observed in Figures 10 and 11, an excessive tax response can make an undesirable impact on social welfare gains. Thus, I will choose the case of $\rho^{tc2} = \rho^{p2} = 2.00$ which is efficient in limiting house price increase and does not occur a welfare reversal between the agents or reduction in social welfare level.

Interpreted by Table 8, the sum of welfare gain by both households is maximized when the government does not distribute its tax revenues to the households. This coincides with the optimal case for fairness. Thus, without considering a possible welfare difference in the steady-state, using a tax rule with the dissipative government spending would be the best in terms of maximizing the welfare gain of the economy and also minimizing the inequality in welfare gain between households when house price rises by a productivity shock.

Table 8: Welfare measured in each Fiscal Operation Scenario in the Case of a Productivity Shock ($\rho^{tc2} = \rho^{p2} = 2.00$)

	W_s^P	W_s^*	W_b^P	W_b^*	CE_s	CE_b	$CE_s + CE_b$	$\|CE_s - CE_b\|$
G	14.29	10.59	-47.47	-47.40	0.025	-0.001	0.024	0.027
$\lambda = 0.00$	-5.88	7.04	-35.22	-40.13	-0.084	0.103	0.019	0.187
$\lambda = 0.25$	-0.92	10.13	-38.18	-42.07	-0.072	0.081	0.009	0.153
$\lambda = 0.50$	4.41	13.20	-41.36	-44.07	-0.058	0.056	-0.002	0.114
$\lambda = 0.75$	9.74	16.26	-44.51	-46.14	-0.043	0.033	-0.010	0.076
$\lambda = 0.99$	14.54	19.18	-47.37	-48.20	-0.031	0.017	-0.014	0.048

6 Concluding Remarks

Motivated by the existing studies and empirical evidence that house prices can be curbed by taxations, this study has comprehensively discussed the macroeconomic impact, including household welfare changes, of using housing relevant taxation as a macroprudential policy tool. To this end, the research sets up an NK-DSGE model with two different types of households and a housing market and tried to match its steady-state value with the Korean economy for the numerical exercises. During the experiment, various fiscal operation schemes were suggested and dissipative government expenditure was chosen as a benchmark case. Under this framework, the economy first faces a tax shock that is temporal or permanent.

A temporary tax shock can effectively suppress house prices and credit levels. There was an initial decrease in output but this reduction was quickly recovered due to the increase in physical capital accumulation and labor supply by the borrower. This impulse response results are robust and similar dynamics can be found when the shock was announced 4 periods before it happens and when the economy has different combinations of the Taylor Rule parameters. The anticipated tax shock generates a higher degree of volatility so it causes a welfare reduction by the saver. This raises issues in fairness between agents, and it would be more desirable for the government to transfer 75% of tax revenues to the saver to minimize the welfare changes between the agent after the anticipated shock. Moreover, a permanent increase in the tax rate also helps the economy achieves a lower level of house price and credit. Despite the fluctuation during the transition to the new steady state of the economy, the tax adjustment does not cause much changes in output, consumption, and investment level in the long run. The simulated series in various fiscal operations shows that welfare gain after the adjustment can be maximized when the saver receives most of the tax resources. However, it is best to allocate only 25% of the tax revenues to the saver if the government would like to equally distribute the welfare loss after the tax rate increase.

Also, the economy experienced a housing preference shock or a productivity shock that would generate a surge in the house price. At this experiment, the potential effectiveness of using the tax as an automatic stabilizer of the housing market was discussed. When there is a housing tax rule that is countercyclical to the house price increase, the degree of rising in house price after a positive housing preference and a productivity shock can be limited at the early stage. In the circumstance of having a tax rule, fluctuations for each variable after a housing preference shock can be smaller than the case of not using this rule. In contrast, this was not the case for the technology shock. If the fiscal authority takes the excessively strong response to the house price increase, some of the macroeconomic variables showed more volatility. Moreover, it should be noted that if the response to the house price increase is not sufficient, house prices can be higher than their steady-state level for a long time. Therefore, suppressing a house price increase generated by a housing preference shock and a productivity shock is depending on the accuracy in measuring the impact of this house demand shock, and also it is based on the assumption that the inside lag of determining the new tax rate is sufficiently short. It is suggested that the tax rule gives a welfare gain for the saver and it causes a loss for the borrower. However, in the case of the productivity shock, there will be a reversal in the welfare gain and loss between the agents if the reaction toward the house price increase is too much heavy. There is a trade-off between optimality in achieving higher welfare gain for the economy as a whole and fairness when a housing preference shock happens. This is not the case for the productivity shock as operating the fiscal policy by purchasing final goods is best for both optimality and equality.

In conclusion, the housing relevant taxations can be used as a macroprudential policy tool for cooling down the housing market. It would not cause much adverse effect to the economy in the medium run if we consider output as a representative index in measuring the welfare of the economy. However, to effectively use the taxations as a valid policy tool, it is essential for the fiscal authorities to have a capability in understanding the housing market trend, and also they should have an ability to respond to the housing market without any delay. Moreover, it is important to note that the disparities in the welfare changes for households after using the tool are inevitable. The fiscal policy authority, therefore, should combine a proper redistribution policy with housing taxation with careful consideration of potential outcomes in welfare changes of each agent. Furthermore, continuous discussion for an additional policy intervention to complement the housing taxations will be important. This will remain for future research.

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A Derivations of the First Order Conditions and Equations

- Saver's Problem

$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta_s^t [\log(C_{s,t}) + j_t \log(H_{s,t}) - \dfrac{N_{s,t}^{\eta}}{\eta} + \lambda_{s,t}[\frac{R_{t-1}b_{t-1}}{\pi_t} + W_{s,t}N_{s,t} + r_t K_{t-1} + (1 - \tau_t^p)q_t H_{s,t-1} + F_t + Tr_{s,t} - C_{s,t} - I_t - b_t - (1+\tau_t^{tc})q_t H_{s,t} + \mu_t((1-\delta)K_{t-1} - K_t + I_t \left[1 - \frac{\psi}{2}(\frac{I_t}{I_{t-1}} - 1)^2\right])]]$

$\Rightarrow \frac{\partial L}{\partial C_{s,t}} = \beta_s^t \frac{1}{C_{s,t}} + \beta_s^t \lambda_{s,t}(-1) = 0, \therefore \lambda_{s,t} = \frac{1}{C_{s,t}}$

$\Rightarrow \frac{\partial L}{\partial H_{s,t}} = \beta_s^t(\frac{j_t}{H_{s,t}} + \lambda_{s,t}(1+\tau_t^{tc})(-q_t)) + E_t \beta_s^{t+1} \lambda_{s,t+1}(1-\tau_{t+1}^p)q_{t+1} = 0$ and $\lambda_{s,t} = \frac{1}{C_{s,t}}$
$\therefore \frac{j_t}{H_{s,t}} = \frac{1}{C_{s,t}}(1+\tau_t^{tc})q_t - E_t \beta^s \left(\frac{1}{C_{s,t+1}}(1-\tau_{t+1}^p)q_{t+1}\right)$

$\Rightarrow \frac{\partial L}{\partial N_{s,t}} = \beta_s^t(-N_{s,t}^{\eta-1}) + \beta_s^t \lambda_{s,t} W_{s,t} = 0$ and $\lambda_{s,t} = \frac{1}{C_{s,t}}, \therefore W_{s,t} = C_{s,t} N_{s,t}^{\eta-1}$

$\Rightarrow \frac{\partial L}{\partial b_t} = \beta_s^t(-\lambda_{s,t}) + E_t \beta_s^{t+1} \lambda_{s,t+1} \frac{R_t}{\pi_{t+1}} = 0$ and $\lambda_{s,t} = \frac{1}{C_{s,t}}, \therefore \frac{1}{C_{s,t}} = \beta^s E_t \frac{1}{C_{s,t+1}} \frac{R_t}{\pi_{t+1}}$

$\Rightarrow \frac{\partial L}{\partial K_t} = \lambda_{s,t}\mu_t(-1)\beta_s^t + E_t \beta_s^{t+1} \lambda_{s,t+1}(r_{t+1} + \mu_{t+1}(1-\delta)) = 0$ and $\lambda_{s,t} = \frac{1}{C_{s,t}}, \therefore \frac{\mu_t}{C_{s,t}} = \beta^s E_t \frac{1}{C_{s,t+1}}(r_{t+1} + \mu_{t+1}(1-\delta))$

$\Rightarrow \frac{\partial L}{\partial I_t} = \beta_s^t(\lambda_{s,t}(-1) + \lambda_{s,t}\mu_t(1 - \frac{\psi}{2}(\frac{I_t}{I_{t-1}} - 1)^2 - \psi(\frac{I_t}{I_{t-1}} - 1)\frac{I_t}{I_{t-1}}) + E_t \beta_s^{t+1}(\lambda_{s,t+1}\mu_{t+1}\psi \frac{I_{t+1}^2}{I_t^2}(\frac{I_{t+1}}{I_t} - 1)) = 0$ and $\lambda_{s,t} = \frac{1}{C_{s,t}}$
$\therefore 1 = \mu_t \left(1 - \frac{\psi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 - \psi \frac{I_t}{I_{t-1}}\left(\frac{I_t}{I_{t-1}} - 1\right)\right) + \beta^s E_t \frac{C_{s,t}}{C_{s,t+1}} \mu_{t+1} \left(\frac{I_{t+1}}{I_t}\right)^2 \psi \left(\frac{I_{t+1}}{I_t} - 1\right)$

- Borrower's Problem

$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta_b^t [\log(C_{b,t}) + j_t \log(H_{b,t}) - \dfrac{N_{b,t}^{\eta}}{\eta} + \lambda_{d,t}[W_{b,t}N_{b,t} + b_t + (1-\tau_t^p)q_t H_{b,t-1} + Tr_{b,t} - C_{b,t} - \frac{R_t b_{t-1}}{\pi_t} - (1+\tau_t^{tc})q_t H_{b,t}] + \lambda_{b,t}[LTV_t q_{t+1} H_{b,t} \frac{\pi_{t+1}}{R_{t+1}} - b_t]]$

$\Rightarrow \frac{\partial L}{\partial C_{b,t}} = \beta_b^t \frac{1}{C_{b,t}} + \beta_b^t \lambda_{d,t}(-1) = 0, \therefore \lambda_{d,t} = \frac{1}{C_{b,t}}$

$\Rightarrow \frac{\partial L}{\partial H_{b,t}} = \beta_b^t(\frac{j_t}{H_{b,t}} + \lambda_{d,t}(1+\tau_t^{tc})(-q_t) + \lambda_{b,t} E_t LTV_t q_{t+1} \frac{\pi_{t+1}}{R_{t+1}}) + E_t \beta_b^{t+1} \lambda_{d,t+1}(1-\tau_{t+1}^p)q_{t+1} = 0$ and $\lambda_{d,t} = \frac{1}{C_{b,t}}$
$\therefore \frac{j}{H_{b,t}} = \frac{1}{C_{b,t}}(1+\tau_t^{tc})q_t - E_t \beta^b \left(\frac{1}{C_{b,t+1}}(1-\tau_{t+1}^p)q_{t+1}\right) - \lambda_{b,t} LTV_t E_t \left(\frac{q_{t+1}\pi_{t+1}}{R_{t+1}}\right)$

$\Rightarrow \frac{\partial L}{\partial N_{b,t}} = \beta_b^t(-N_{b,t}^{\eta-1}) + \beta_b^t \lambda_{d,t} W_{b,t} = 0$ and $\lambda_{d,t} = \frac{1}{C_{b,t}}$, $\therefore W_{b,t} = C_{b,t} N_{b,t}^{\eta-1}$

$\Rightarrow \frac{\partial L}{\partial b_t} = \beta_b^t(-\lambda_{d,t} - 1) + E_t \beta_b^{t+1} \lambda_{d,t+1} \frac{R_{t+1}}{\pi_{t+1}} = 0$ and $\lambda_{d,t} = \frac{1}{C_{b,t}}$, $\therefore \frac{1}{C_{b,t}} = \beta^b E_t \left(\frac{1}{C_{b,t+1}} \frac{R_{t+1}}{\pi_{t+1}} \right) + \lambda_{b,t}$

- Final Goods Producer's Problem

The final goods producer's objective function is $P_t Y_t - \int_0^1 P_t(z) Y_t(z) dz = P_t (\int_0^1 Y_t(z)^{\frac{\epsilon-1}{\epsilon}} dz)^{\frac{\epsilon}{\epsilon-1}} - \int_0^1 P_t(z) Y_t(z) dz$.

Taking derivatives above expression with respect to $Y_t(z)$,
$\Rightarrow P_t Y_t^{1/\epsilon} Y_t(z)^{-1/\epsilon} = P_t(z)$, $\therefore Y_t(z) = Y_t \left(\frac{P_t(z)}{P_t} \right)^{-\epsilon}$

- Intermediate Goods Producers' Problem

(1) $\mathcal{L} = W_{s,t} N_{s,t}(z) + W_{b,t} N_{b,t}(z) + r_t K_{t-1}(z) + \Phi_t(z)(Y_t(z) - A_t K_{t-1}(z)^{\omega} N_{s,t}(z)^{\alpha(1-\omega)} N_{b,t}(z)^{(1-\alpha)(1-\omega)})$.

$\Rightarrow \frac{\partial L}{\partial N_{s,t}(z)} = W_{s,t} + \Phi_t(z)(-\alpha(1-\omega) A_t K_{t-1}(z)^{\omega} N_{s,t}(z)^{\alpha(1-\omega)-1} N_{b,t}(z)^{(1-\alpha)(1-\omega)}) = 0$
$\therefore W_{s,t} = \frac{\Phi_t(z)\alpha(1-\omega)Y_t(z)}{N_{s,t}(z)}$

$\Rightarrow \frac{\partial L}{\partial N_{b,t}(z)} = W_{b,t} + \Phi_t(z)(-(1-\alpha)(1-\omega) A_t K_{t-1}(z)^{\omega} N_{s,t}(z)^{\alpha(1-\omega)} N_{b,t}(z)^{(1-\alpha)(1-\omega)-1}) = 0$
$\therefore W_{b,t} = \frac{\Phi_t(z)(1-\alpha)(1-\omega)Y_t(z)}{N_{b,t}(z)}$

$\Rightarrow \frac{\partial L}{\partial K_{t-1}(z)} = r_t + \Phi_t(z)(-\omega A_t K_{t-1}(z)^{\omega-1} N_{s,t}(z)^{\alpha(1-\omega)} N_{b,t}(z)^{(1-\alpha)(1-\omega)}) = 0$
$\therefore r_t = \frac{\Phi_t(z)\omega Y_t(z)}{K_{t-1}(z)}$

(2) For maximizing discounted lifetime profit, the intermediate goods producers' objective function is

: $\sum_{k=0}^{\infty} \theta^k E_t M_{t,t+k} (\frac{P_t^*(z)}{P_{t+k}} Y_{t+k}(z) - \Phi_{t+k} Y_{t+k}(z))$ s.t $Y_{t+k}(z) = Y_{t+k} (\frac{P_t^*(z)}{P_{t+k}})^{-\epsilon}$

Taking derivatives above expression with respect to $P_t^*(z)$,

$\Rightarrow \sum_{k=0}^{\infty} \theta^k E_t M_{t,t+k} Y_{t+k} (\frac{1}{P_{t+k}^{1-\epsilon}} (1-\epsilon) P_t^*(z)^{-\epsilon} + \Phi_{t+k} (\frac{1}{P_{t+k}})^{-\epsilon} \epsilon P_t^*(z)^{-\epsilon-1}) = 0$

$\Rightarrow \sum_{k=0}^{\infty} \theta^k E_t M_{t,t+k} Y_{t+k} (1-\epsilon) (\frac{P_t^*(z)}{P_{t+k}})^{-\epsilon} (\frac{P_t^*(z)}{P_{t+k}} - \frac{\epsilon}{\epsilon-1} \Phi_{t+k}) = 0$

$\Rightarrow \sum_{k=0}^{\infty} \theta^k E_t M_{t,t+k} Y_{t+k} (\frac{P_t^*(z)}{P_{t+k}})^{-\epsilon} (\frac{P_t^*}{P_{t+k}} - \frac{\epsilon}{\epsilon-1} \Phi_{t+k}) = 0$ ($\because 1-\epsilon$ is a constant)

$\Rightarrow \sum_{k=0}^{\infty} \theta^k E_t M_{t,t+k} Y_{t+k}(z) (\frac{P_t^*(z)}{P_{t+k}} - \frac{\epsilon}{\epsilon-1}\Phi_{t+k}) = 0$ ($\because$ $Y_{t+k}(z) = Y_{t+k}(\frac{P_t^*(z)}{P_{t+k}})^{-\epsilon}$)

$\Rightarrow \sum_{k=0}^{\infty} \theta^k E_t M_{t,t+k} Y_{t+k} (\frac{P_t^*}{P_{t+k}} - \frac{\epsilon}{\epsilon-1}\Phi_{t+k}) = 0$ ($\because$ all intermediate goods producers are symmetric)

$\Rightarrow \sum_{k=0}^{\infty} (\theta\beta_s)^k E_t \Lambda_{t,t+k} Y_{t+k} (\frac{P_t^*}{P_{t+k}} - \frac{\epsilon}{\epsilon-1}\Phi_{t+k}) = 0$ ($\because$ $M_{t,t+k} = \beta_s^k \left(\frac{C_{s,t}}{C_{s,t+k}}\right)$ and define $\Lambda_{t,t+k} = \frac{C_{s,t}}{C_{s,t+k}}$)

After log-linearization around steady state with zero net inflation ($P = P^*$),

$\Rightarrow \sum_{k=0}^{\infty} (\theta\beta_s)^k E_t \Lambda Y (1 + \hat{\Lambda}_{t,t+k} + \hat{Y}_{t+k}) (\frac{P^*}{P}(1 + \hat{P}_t^* - \hat{P}_{t+k}) - \Phi\frac{\epsilon}{\epsilon-1}(1 + \hat{\Phi}_{t+k})) = 0$

$\Rightarrow \sum_{k=0}^{\infty} (\theta\beta_s)^k E_t (1 + \hat{\Lambda}_{t,t+k} + \hat{Y}_{t+k} + \hat{P}_t^* - \hat{P}_{t+k}) = \sum_{t=0}^{\infty} (\theta\beta_s)^k E_t \Phi \frac{\epsilon}{\epsilon-1}(1 + \hat{\Lambda}_{t,t+k} + \hat{Y}_{t+k} + \hat{\Phi}_{t+k})$ ($\because \Lambda Y$ is a constant)

$\Rightarrow E_t \sum_{k=0}^{\infty} (\theta\beta_s)^k \hat{P}_t^* = E_t \sum_{k=0}^{\infty} (\theta\beta_s)^k (\hat{P}_{t+k} + \hat{\Phi}_{t+k})$ ($\because$ $\Phi\frac{\epsilon}{\epsilon-1} = 1$)

$\Rightarrow \hat{P}_t^* E_t \sum_{k=0}^{\infty} (\theta\beta_s)^k = E_t \sum_{k=0}^{\infty} (\theta\beta_s)^k (\hat{P}_{t+k} + \hat{\Phi}_{t+k})$

$\Rightarrow \hat{P}_t^* = (1 - \theta\beta_s)(\hat{P}_t + \hat{\Phi}_t) + (1 - \theta\beta_s) E_t \sum_{k=1}^{\infty} (\theta\beta_s)^k (\hat{P}_{t+k} + \hat{\Phi}_{t+k})$

$\Rightarrow \hat{P}_t^* = (1 - \theta\beta_s)(\hat{P}_t + \hat{\Phi}_t) + \theta\beta_s(1 - \theta\beta_s) E_t \sum_{k=1}^{\infty} (\theta\beta_s)^k (\hat{P}_{t+k+1} + \hat{\Phi}_{t+k+1})$

$\Rightarrow \hat{P}_t^* = (1 - \theta\beta_s)(\hat{P}_t + \hat{\Phi}_t) + \theta\beta_s E_t \hat{P}_{t+1}^*$ ($\because$ $E_t \hat{P}_{t+1}^* = (1 - \theta\beta_s) E_t \sum_{k=1}^{\infty} (\theta\beta_s)^k (\hat{P}_{t+k+1} + \hat{\Phi}_{t+k+1})$)

$\Rightarrow$ $\hat{P}_t^* - \hat{P}_t = (1 - \theta\beta_s)\hat{\Phi}_t + \theta\beta_s E_t(\hat{P}_{t+1}^* - \hat{P}_{t+1} + \hat{\pi}_{t+1})$ ($\because$ $\hat{\pi}_{t+1} = \hat{P}_{t+1} - \hat{P}_t$ and Denote it as $\mathcal{F}_1$)

Also, $P_t = [\int_0^1 P_t(z)^{1-\epsilon} dz]^{\frac{1}{1-\epsilon}} = (\theta P_{t-1}^{1-\epsilon} + (1-\theta) P_t^{*1-\epsilon})^{\frac{1}{1-\epsilon}}$

$\Rightarrow$ $P_t^{1-\epsilon} = (1-\theta) P_t^{*1-\epsilon} + \theta P_{t-1}^{1-\epsilon}$

$\Rightarrow$ $P^{1-\epsilon}(1 + (1-\epsilon)\hat{P}_t) = (1-\theta) P^{1-\epsilon}(1 + (1-\epsilon)\hat{P}_t^*) + \theta P^{1-\epsilon}(1 + (1-\epsilon)\hat{P}_{t-1})$ (By log-linearization)

$\Rightarrow$ $\hat{P}_t = (1-\theta)\hat{P}_t^* + \theta\hat{P}_{t-1})$ ($\because$ $P^{1-\epsilon} = (1-\theta)P^{1-\epsilon} + \theta P^{1-\epsilon}$ in steady-state)

$\Rightarrow$ $\hat{P}_t^* - \hat{P}_t = \frac{\theta}{1-\theta}\hat{\pi}_t$ ($\because$ $\hat{\pi}_t = \hat{P}_t - \hat{P}_{t-1}$) (Denote it as $\mathcal{F}_2$)

$\therefore$ $\hat{\pi}_t = \beta_s E_t \hat{\pi}_{t+1} + \frac{(1-\theta)(1-\theta\beta_s)}{\theta} \hat{MC}_t$ (By $\mathcal{F}_1$ and $\mathcal{F}_2$)

B Steady-state of the Economy

$\pi = 1$ ($: \because P_{ss} = P_{ss+1}$)

$R = \frac{1}{\beta^s}$ (: By the Standard Taylor Rule)

$\mu = 1$ (: By Equation (7))

$r = \frac{1-\beta^s(1-\delta)}{\beta^s}$ (: By Equation (6) and $\mu = 1$)

$LTV = LTV_{ss}$ (:By the LTV Rule)

$\tau^{tc} = \tau^{tc}_{ss}$, $\tau^p = \tau^p_{ss}$ (: By equation (27) and (28))

$j = j_{ss}$ (: Since $\log(j_t) = (1-\rho_j)\log(j_{ss}) + \rho_j \log(j_{t-1}) + u^j_t$)

$A = 1$ (:Since $\log(A_t) = \rho_A \log(A_{t-1}) + u_{A,t}$)

$X = \frac{\epsilon}{\epsilon-1}$ (: By the profit maximization process of the intermediate goods producers)

Define auxiliary parameters:

$A_1 = (1 + \tau^{tc} - \beta^s(1-\tau^p))$

$A_2 = (1 + \tau^{tc} - \beta^b(1-\tau^p) - LTV(\beta^s - \beta^b))$

$B_1 = (1 + \frac{(LTV(1-\beta^s)+\lambda(\tau^{tc}+\tau^p))j}{A_2})$

$C_1 = \frac{(1-\alpha)(1-\omega)}{X}$

$C_2 = \frac{(1-\lambda)(\tau^{tc}+\tau^p)j}{A_1}$

Then,

$\frac{C_b}{Y} = \frac{C_1}{B_1} + \frac{C_2}{B_1}\frac{C_s}{Y}$ (A1: By (4), (8), (9), (10), (11), (12), (29) and (32))

$\frac{I}{Y} = \frac{\delta\omega}{Xr}$ (A2: By (2) and (33))

Thus,

$N_s = \left(\frac{(\alpha(1-\omega)/X)(1+C_2/B1)}{(1-\frac{\delta\omega}{Xr}-\frac{C_1}{B_1})}\right)^{1/\eta}$ (:By A1, A2, (3), (15) and (31))

$N_b = \left(\frac{((1-\alpha)(1-\omega)/X)(1+B_1/C_2)}{(1-\frac{\delta\omega}{Xr}+\frac{C_1}{C_2})}\right)^{1/\eta}$ (:By A1, A2, (10), (16) and (32))

$K = \left(\frac{\omega}{Xr}\right)^{1/(1-\omega)} N_s^{\alpha} N_b^{(1-\alpha)}$ (:By (14) and (33))

$Y = K^{\omega} N_s^{\alpha(1-\omega)} N_b^{(1-\alpha)(1-\omega)}$ (:By (14))

$C_s = \frac{\alpha(1-\omega)}{X} N_s^{-\eta} Y$ (: By (3) and (15))

$C_b = \frac{(1-\alpha)(1-\omega)}{X} N_b^{-\eta} Y$ (: By (10) and (16))

Define again that:

$Z_1 = \frac{\alpha(1-\omega)}{X} N_s^{-\eta}$ and $Z_2 = \frac{(1-\alpha)(1-\omega)}{X} N_b^{-\eta}$

Then,

$q = j(\frac{Z_1}{A_1} + \frac{Z_2}{A_2})Y$ (: By (4), (11), (12) and (30))

$H_s = \frac{A_2 Z_1}{A_2 Z_1 + A_1 Z_2}$ (:By q and (4))

$H_b = 1 - H_s$ (:By (30))

$TR = q(\tau^{tc} + \tau^{p})$ (:By (24) and (30))

$b = LTVqH_b\beta^s$ (:By (9))

If government purchases the final goods by using its tax revenue the steady-state will be different from the previous case.

Now define another set of auxiliary parameters:

$L_1 = LTV(1 - \beta^s) + \tau^{tc} + \tau^p$

$L_2 = \frac{1+\tau^{tc}-\beta^b(1-\tau^p)-LTV(\beta^s-\beta^b)}{j}$

$L_3 = \frac{(1+\tau^{tc})-\beta^s(1-\tau^p)}{j}$

$\frac{C_b}{Y} + \frac{qH_b}{Y} L_1 = \frac{(1-\alpha)(1-\omega)}{X}$ (A3: By (8), (9) and $TR_b = 0$)

$\frac{C_b}{Y} = \frac{qH_b}{Y} L_2$ (A4: By (11) and (12))

So, $\frac{qH_b}{Y} = \frac{1}{L_1+L_2} \frac{(1-\alpha)(1-\omega)}{X}$ and $\frac{C_b}{Y} = \frac{L_2}{L_1+L_2} \frac{(1-\alpha)(1-\omega)}{X}$ (Denote it as A5 and A6, respectively: by A3 and A4)

$\frac{C_s}{Y} = \frac{qH_s}{Y} L_3$ (A7: By (4))

$\frac{C_s}{Y} = [\frac{L_3}{L_3+\tau^{tc}+\tau^p}][1 - \frac{\delta\omega}{Xr} - \frac{L_2}{L_1+L_2} \frac{(1-\alpha)(1-\omega)}{X} - \frac{(\tau^{tc}+\tau^p)}{L_1+L_2} \frac{(1-\alpha)(1-\omega)}{X}]$ (A8: By (23), (29), A2, A5, A6 and A7)

Also, define such that:

$L_4 = [\frac{L_3}{L_3+\tau^{tc}+\tau^p}][1 - \frac{\delta\omega}{Xr} - \frac{L_2}{L_1+L_2} \frac{(1-\alpha)(1-\omega)}{X} - \frac{(\tau^{tc}+\tau^p)}{L_1+L_2} \frac{(1-\alpha)(1-\omega)}{X}]$

$L_5 = \frac{L_2}{L_1+L_2} \frac{(1-\alpha)(1-\omega)}{X}$

Then,

$N_s = (\frac{\alpha(1-\omega)}{X} \frac{1}{L_4})^{1/\eta}$ (By (3), (31) and A8)

$N_b = (\frac{(1-\alpha)(1-\omega)}{X} \frac{1}{L_5})^{1/\eta}$ (By (10), (32) and A6)

$K = \left(\frac{\omega}{Xr}\right)^{1/(1-\omega)} N_s^{\alpha} N_b^{(1-\alpha)}$ (:By (14) and (33))

$Y = K^{\omega} N_s^{\alpha(1-\omega)} N_b^{(1-\alpha)(1-\omega)}$ (:By (14))

$C_s = \frac{\alpha(1-\omega)}{X} N_s^{-\eta} Y$ (: By (3) and (15))

$C_b = \frac{(1-\alpha)(1-\omega)}{X} N_b^{-\eta} Y$ (: By (10) and (16))

$q = j(\frac{Z_1}{A_1} + \frac{Z_2}{A_2})Y$ (: By (4), (11), (12) and (30))

$H_s = \frac{A_2 Z_1}{A_2 Z_1 + A_1 Z_2}$ (:By q and (4))

$H_b = 1 - H_s$ (:By (30))

$TR = q(\tau^{tc} + \tau^{p})$ (:By (24) and (30))

$b = LTV q H_b \beta^s$ (:By (9))

C Additional Impulse Response Functions for Numerical Analysis I

Figure 12: <Transctions Tax> Impulse Response Functions after an Unanticipated Tax Shock

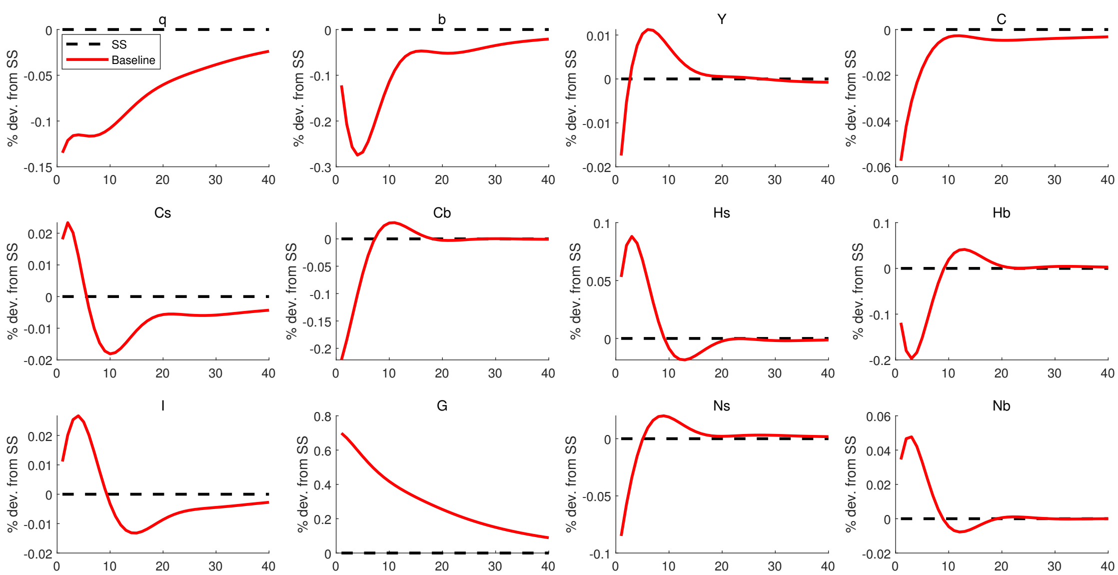


Figure 13: <Transctions Tax> Comparison of the Impulse Response Functions after an Anticipated Tax Shocks

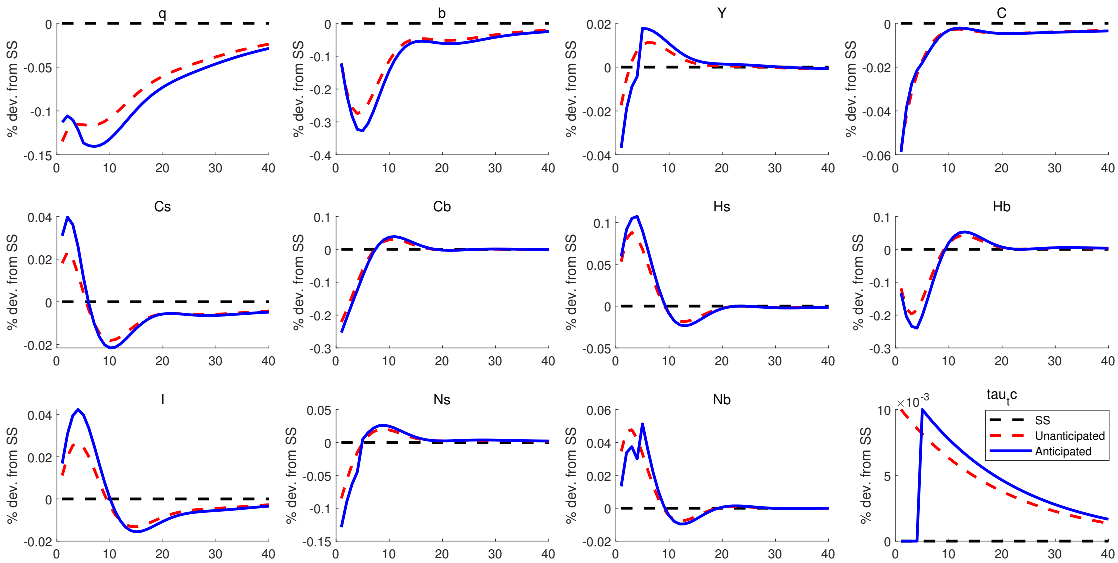


Figure 14: Comparison of Impulse Response Functions in Different Fiscal Policies

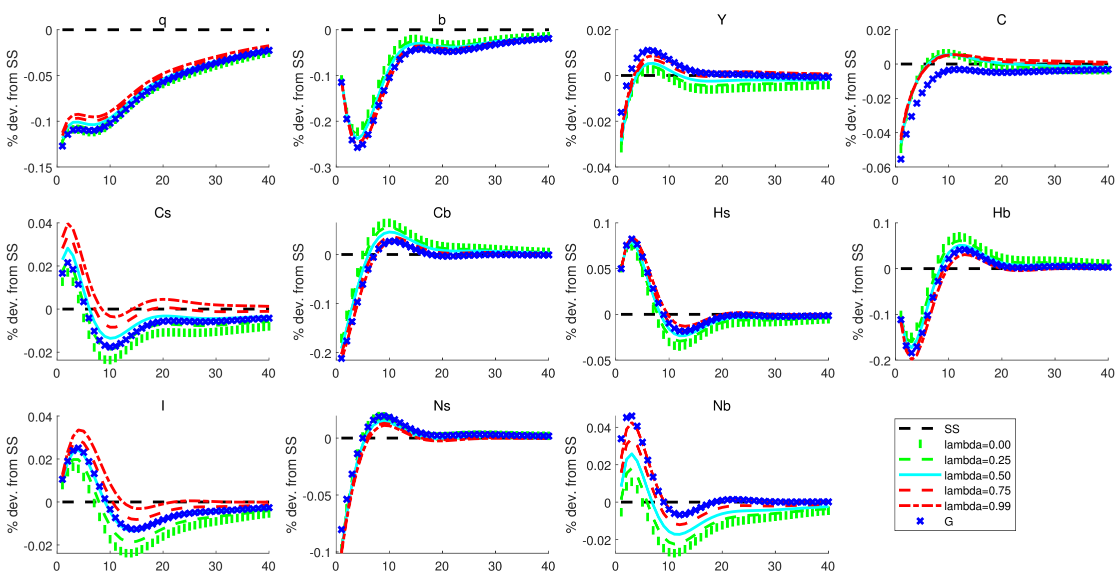
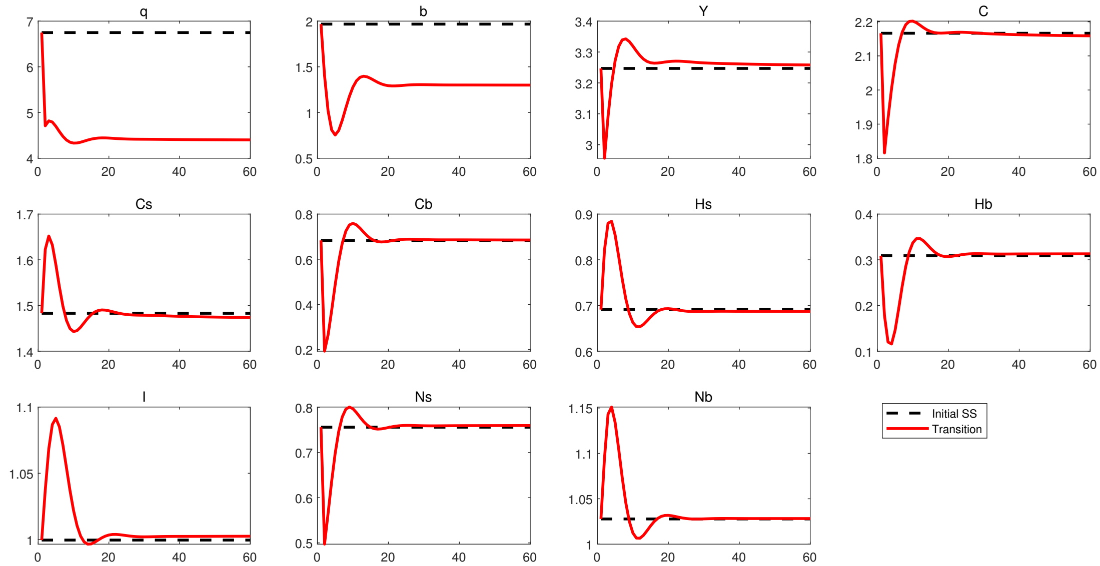


Figure 15: <Transctions Tax> Transition Dynamics of the Economy after a Permanent Tax Increase



D Steady-State Levels of the Variables under Different Tax Rates

Table 9: Steady-State Levels when $\tau^p_{ss} = 0.006$

	$G \neq 0$	$\lambda = 0.00$	$\lambda = 0.25$	$\lambda = 0.50$	$\lambda = 0.75$	$\lambda = 0.99$
N_s	0.756	0.756	0.751	0.746	0.741	0.736
N_b	1.028	0.973	0.986	0.999	1.013	1.027
K	19.991	19.486	19.534	19.587	19.644	19.703
Y	3.247	3.165	3.173	3.181	3.191	3.200
C_s	1.483	1.447	1.470	1.493	1.517	1.541
C_b	0.683	0.744	0.726	0.709	0.691	0.674
I	1.000	0.974	0.977	0.979	0.982	0.985
G	0.081	-	-	-	-	-
q	6.749	6.819	6.838	6.858	6.880	6.903
H_s	0.691	0.667	0.676	0.685	0.694	0.702
H_b	0.309	0.333	0.324	0.315	0.306	0.298
b	1.967	2.140	2.090	2.040	1.989	1.941

Table 10: Steady-State Levels when $\tau_{ss}^{p} = 0.016$

	$G \neq 0$	$\lambda = 0.00$	$\lambda = 0.25$	$\lambda = 0.50$	$\lambda = 0.75$	$\lambda = 0.99$
N_s	0.760	0.759	0.753	0.747	0.742	0.736
N_b	1.028	0.963	0.978	0.994	1.011	1.028
K	20.051	19.451	19.506	19.567	19.635	19.705
Y	3.257	3.159	3.168	3.178	3.189	3.201
C_s	1.472	1.430	1.457	1.485	1.513	1.542
C_b	0.685	0.757	0.736	0.715	0.694	0.674
I	1.003	0.973	0.975	0.978	0.982	0.985
G	0.097	-	-	-	-	-
q	4.414	4.473	4.486	4.501	4.517	4.534
H_s	0.686	0.657	0.668	0.678	0.689	0.699
H_b	0.314	0.343	0.332	0.322	0.311	0.301
b	1.308	1.447	1.406	1.366	1.326	1.287

Table 11: Percentage Changes from the economy with $\tau_{ss}^{p} = 0.006$ to the economy with $\tau_{ss}^{p} = 0.016$

	$G \neq 0$	$\lambda = 0.00$	$\lambda = 0.25$	$\lambda = 0.50$	$\lambda = 0.75$	$\lambda = 0.99$
N_s	0.52	0.52	0.38	0.24	0.10	-0.02
N_b	0.06	-0.99	-0.75	-0.50	-0.23	0.05
K	0.30	-0.18	-0.14	-0.10	-0.05	0.01
Y	0.30	-0.18	-0.14	-0.10	-0.05	0.01
C_s	-0.71	-1.21	-0.89	-0.57	-0.25	0.05
C_b	0.18	1.82	1.37	0.90	0.40	-0.09
I	0.31	-0.18	-0.14	-0.10	-0.05	0.01
G	19.91	-	-	-	-	-
q	-34.60	-34.41	-34.40	-34.38	-34.35	-34.32
H_s	-0.74	-1.51	-1.22	-0.94	-0.66	-0.40
H_b	1.66	3.04	2.55	2.04	1.50	0.95
b	-33.51	-32.42	-32.72	-33.04	-33.36	-33.69

E Additional Impulse Response Functions for Numerical Analysis II

Figures below shows the comparison of responses of the variable with different tax rules after each shock. The number of the legend in Figure 16 represents the following cases respectively. 0: No tax rule, 1: The rule in the main discussion ($\rho^{tc2} = \rho^{p2} = 3.00$, $\rho^{tc3} = \rho^{p3} = 0.00$), 2: $\rho^{tc2} = \rho^{p2} = 1.00$, $\rho^{tc3} = \rho^{p3} = 1.80$, 3: $\rho^{tc2} = \rho^{p2} = 2.00$, $\rho^{tc3} = \rho^{p3} = 2.90$, 4: $\rho^{tc2} = \rho^{p2} = 0.00$, $\rho^{tc3} = \rho^{p3} = 0.73$. Also, the number of the legend in Figure 17 represents the following cases respectively. 0: No tax rule, 1: The rule in the main discussion ($\rho^{tc2} = \rho^{p2} = 2.00$, $\rho^{tc3} = \rho^{p3} = 0.00$), 2: $\rho^{tc2} = \rho^{p2} = 1.00$, $\rho^{tc3} = \rho^{p3} = 1.80$, 3: $\rho^{tc2} = \rho^{p2} = 1.50$, $\rho^{tc3} = \rho^{p3} = 2.30$, 4: $\rho^{tc2} = \rho^{p2} = 0.00$, $\rho^{tc3} = \rho^{p3} = 0.73$. Except 0 and 1, the parameters were chosen to satisfy Blanchard-Kahn conditions.

Figure 16: Comparison of the Impulse Responses with different Tax Rules (Housing Preference Shock)

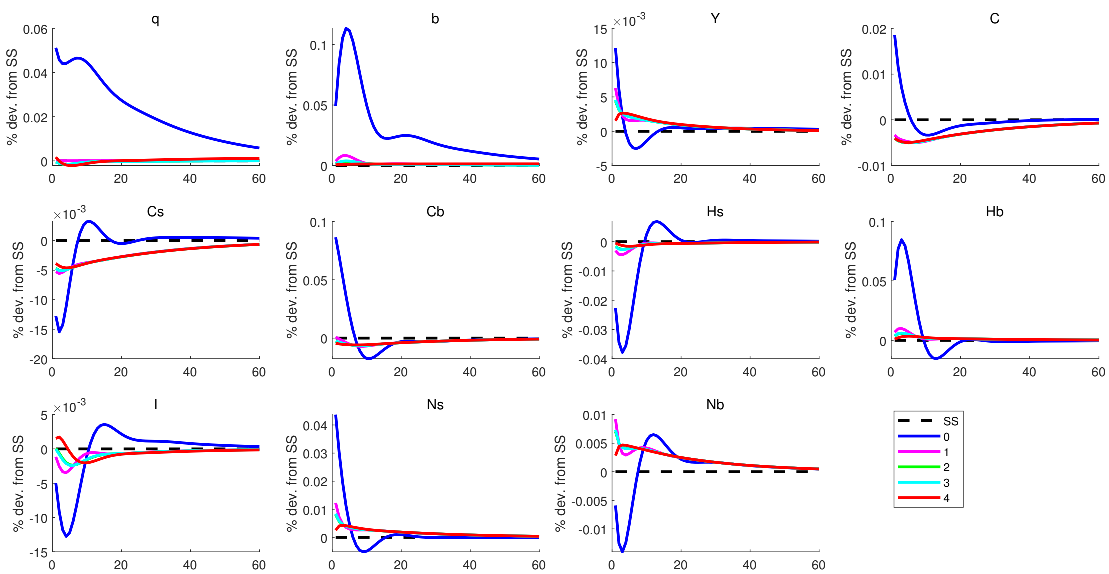
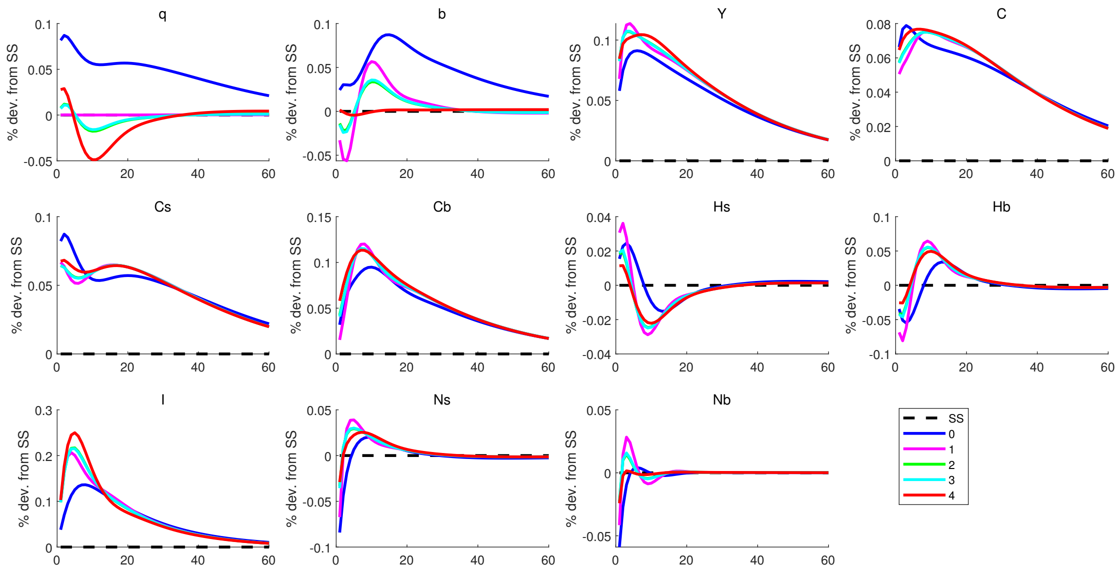


Figure 17: Comparison of the Impulse Responses with different Tax Rules (Housing Preference Shock)



F South Korean Housing Relevant Taxation Operations

F.1 Tax on Profit Margin in Sales (Table 12)

This tax is applied to the profit gain in selling a house. Not only the tax rate is changed along with the house prices trend, but it has also been applied by considering the characteristics of house owners. For instance, if a house owner sells the house within a year after purchasing it or he owns multiple houses, a higher tax rate is applied. This has the purpose of preventing speculative motives which would increase volatility in the housing market. The history of the general income tax rate change is given in table 13.

F.2 Comprehensive Real Estate Holding Tax (Table 14)

This taxation had been implemented to suppress the house price increase in Korea. This is a kind of property tax and it is imposed by considering the value of whole housing stocks. A person who owns housing stocks that values more than 0.6 Billion KRW has to pay this tax.

The tax base, which is specified as X in the table below is the total value of housing stock - 0.6 Billion KRW. For example, in 2020, a person who has a housing stock that values 8.0 Billion KRW has to pay 2.0% of 8.0 - 0.6 = 7.4 as a tax.

F.3 General Property Tax (Table 15)

The tax is applied to the holding of housing assets. There have been fewer cases of tax rate adjustment, compared to other taxes. The relevant material before 2007 is not readily available.

F.4 Registration and Acquisition Tax (Table 16)

When someone purchases a house, they should pay both acquisition and registration tax in accordance with its value and surface area. The registration tax that was needed for the purchase of a house was abolished in 2010 and it was consolidated with the acquisition tax after that time.

Table 12: History of Korean Taxation on the Profit Gain in Selling a House

Periods	Categories	Tax Rate
2002 ~ 2003	Holding Period < 1 Year	36%
	Other cases	General Income Tax Rate
2004 ~ 2005	Who owns 3 and More Houses	60%
	Holding Period < 1 Year	50%
	1 Year ≤ Holding Period < 2 Year	40%
	Other cases	General Income Tax Rate
2006 ~ 2008	Who owns 3 and More Houses	60%
	Who owns 2 Houses	50%
	Holding Period < 1 Year	50%
	1 Year ≤ Holding Period < 2 Year	40%
	Other cases	General Income Tax Rate
Jan 2009 ~ Mar 2009	Who owns 3 and More Houses	45%
	Holding Period < 1 Year	50%
	1 Year ≤ Holding Period < 2 Year	40%
	Other cases	General Income Tax Rate
Apr 2009 ~ 2013	Holding Period < 1 Year	50%
	1 Year ≤ Holding Period < 2 Year	40%
	Other cases	General Income Tax Rate
2014 ~ Mar 2018	Who owns 3 and More Houses in a 'designated' area	General Income Tax Rate + 10%p
	Holding Period < 1 Year	50%
	1 Year ≤ Holding Period < 2 Year	40%
	Other cases	General Income Tax Rate
Apr 2018 ~ Current	Who owns 3 and More Houses in a 'designated' area	General Income Tax Rate + 20%p
	Who owns 2 Houses in a 'designated' area	General Income Tax Rate + 10%p
	Holding Period < 1 Year	50%
	1 Year ≤ Holding Period < 2 Year	40%
	Other cases	General Income Tax Rate

Table 13: General Income Tax Rate

Periods	Categories	Tax Rate
2002 ~ 2008	$X \leq 10$	9%
	$10 < X \leq 40$	18%
	$40 < X \leq 80$	27%
	$80 < X$	36%
2009 ~ 2011	$X \leq 12$	6%
	$12 < X \leq 46$	15%
	$46 < X \leq 88$	24%
	$88 < X$	35%
2012 ~ 2013	$X \leq 12$	6%
	$12 < X \leq 46$	15%
	$46 < X \leq 88$	24%
	$88 < X \leq 300$	35%
	$300 < X$	38%
2014 ~ 2016	$X \leq 12$	6%
	$12 < X \leq 46$	15%
	$46 < X \leq 88$	24%
	$88 < X \leq 150$	35%
	$150 < X$	38%
2017	$X \leq 12$	6%
	$12 < X \leq 46$	15%
	$46 < X \leq 88$	24%
	$88 < X \leq 150$	35%
	$150 < X \leq 500$	38%
	$500 < X$	40%
2018 ~ 2020	$X \leq 12$	6%
	$12 < X \leq 46$	15%
	$46 < X \leq 88$	24%
	$88 < X \leq 150$	35%
	$150 < X \leq 300$	38%
	$300 < X \leq 500$	40%
	$500 < X$	42%

Table 14: History of Korean Comprehensive Real Estate Holding Tax

Period	X[18]<0.3	$0.3\leq X<0.6$	$0.6\leq X<1.2$	$1.2\leq X<5.0$	$5.0\leq X<9.4$	$9.4\leq X$
2005	1.0%	2.0%[19]	2.0%	2.0%[20]	3.0%	3.0%
2006 ~ 2008	1.0%	1.5%	1.5%	2.0%[21]	2.0%	3.0%
2009 ~ 2018	0.5%	0.5%	0.75%	1.0%	1.5%	2.0%
2019 ~ Current	0.5%	0.7%	1.0%	1.4%	2.0%	2.7%
Who owns more than 3 Houses	0.6%	0.9%	1.3%	1.8%	2.5%	2.7%

[18] X stands for the value of housing stocks minus 0.6 and the unit of account is Billion KRW

[19] 1% applied up to 0.55 Billion KRW

[20] 2% applied up to 4.55 Billion KRW

[21] 1.5% applied up to 1.4 Billion KRW

Table 15: History of Korean General Property Tax

Periods	X[22]≤40	40<X≤60	60<X≤100	100<X≤150	150<X≤300	300<X
2007 ~ 2008	0.15%	0.3%[23]	0.3%[24]	0.5%[25]	0.5%[26]	0.5%[27]
2009 ~ 2020	0.1%	0.1%	0.15%[28]	0.15%[29]	0.25%[30]	0.4%[31]

[22] X in the table stands for the value of housing stocks and the unit of account is million KRW
[23] + 60,000 KRW
[24] + 60,000 KRW
[25] + 240,000 KRW
[26] + 240,000 KRW
[27] + 240,000 KRW
[28] + 60,000 KRW
[29] + 195,000 KRW
[30] + 195,000 KRW
[31] + 570,000 KRW

Table 16: History of Korean Registration and Acquisition Tax for Housing

Periods	Acquisition								Registration	
	X [32] $<$ 0.6		$0.6 \leq$ X < 0.9		$0.9 \leq$ X < 1.2		X $>$ 1.2		-	
	M[33] $\leq 85m^2$	M $> 85m^2$	M $\leq 85m^2$	M $> 85m^2$	M $\leq 85m^2$	M $> 85m^2$	M $\leq 85m^2$	M $> 85m^2$	M $\leq 85m^2$	M $> 85m^2$
2004 and Before	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	3.0%	3.0%
2005 ~ 2006	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.5%	1.5%
2007 ~ 2008	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.2%	1.2%
2009 ~ 2010	1.0%	1.3%	1.0%	1.3%	1.0%	1.3%	1.0%	1.3%	1.2%	1.4%
2011 ~ Aug 2012	2.2%	2.7%	2.2%	2.7%	2.2%	2.7%	2.2%	2.7%		
Sep 2012 ~ Jun 2013	1.0%	1.0%	1.0%	1.0%	2.0%	2.0%	3.0%	3.0%		
Jul 2013 ~ Dec 2013	1.1%	1.75%	1.1%	1.75%	2.7%	2.7%	3.3%	3.65%	0.0%	0.0%
2014 ~ 2019	1.1%	1.3%	2.2%	2.4%	3.3%	3.5%	3.3%	3.5%		
2020 ~ Current	1.1%	1.3%	1.2~3.2%	1.4~3.4%	3.3%	3.5%	3.3%	3.5%		

[32] Xstands for the value of housing stocks and the unit of account is Billion KRW
[33] M stands for the size of surface area of the house and the unit of account is m^2