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How Effective are Automatic Stabilizers in Reducing Aggregate Volatility in Korea?*

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We quantified the contribution of automatic stabilizers on business cycle volatility using a heterogeneous agent New Keynesian model, which is calibrated to match important features of the Korean economy. We find that reducing unemployment benefit expenditures by 0.2% of the GDP increases its volatility by 0.24%. Reducing social transfers by the same amount increases the volatility by 1.49%. Lowering the tax rates of income tax, corporate tax, and VAT have little effect on aggregate volatility. A flat income tax increases the volatility of GDP by 3.49%. Simultaneously reducing unemployment benefit expenditures, social transfer expenditures, income tax revenue, corporate tax revenue, and VAT revenue each by 0.2% of the GDP increases the business cycle volatility by 1.56%. In the case of Korea, the stabilization effect of automatic stabilizers seems to be small.

JEL Classification: E6, H3
Key words: Automatic Stabilizers, Aggregate Volatility, Fiscal Policy

I. Introduction

The Great Recession of 2008 and the European Debt Crisis have raised interest in the workings of automatic stabilizers and their effects. The hope among policymakers is that automatic stabilizers can provide stabilization when monetary policy is inhibited by the effective-lower-bound, without the political and economic pressures of discretionary spending that may often lead to sovereign debt crises. This interest is especially strong in Korea, where government spending rates have

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increased steadily from 22% of the GDP in 2010 to 25% of in 2019.

In this paper, we utilized a heterogeneous agent New Keynesian model, to study the effect of automatic stabilizers on business cycle volatility in Korea. Our model features incomplete markets, thus allowing for a cross-sectional distribution of income and wealth across agents and includes various New Keynesian frictions, such as price stickiness and capital adjustment cost. The model also includes varying (un)employment states across workers. Furthermore, we incorporated tax and transfer policies that constitute the automatic stabilization mechanism in Korea; the progressive income tax, the corporate tax, the VAT, unemployment benefits, and government transfers.

We calibrated this model to match important moments of the Korean economy and conducted policy experiments where we reduced the size of each component of the automatic stabilizer by 0.2% of the steady state of the GDP. We studied the case in which we replaced the progressive income tax with a revenue neutral flat income tax. We compared the volatility of the economy with a weakened stabilizer with the baseline economy, in which all stabilizers operated at full strength. We determined that the effectiveness of automatic stabilizers in reducing volatility in Korea is somewhat limited.

The most effective stabilization mechanisms we found are social transfers (transfers to the long-term unemployed) and the progressivity of the income tax. However, even for these mechanisms, a decrease in social transfers will increase the output volatility by 1.49% and moving from a progressive tax to a flat tax increases the output volatility by 3.49%. This translates to a change in the standard deviation of the GDP of approximately 0.015 and 0.035 percentage points, as the standard deviation of GDP is approximately 1% at quarterly frequency in Korea. A reduction in the composite automatic stabilizer, which comprises all mechanisms, with the exception of the progressivity of the income tax, will increase GDP volatility by 1.56%. These effects are small, relative to the comparable changes in monetary policy.

Social transfers are the most effective mechanism due to their effect on precautionary savings motives. A reduction in social transfers may increase the precautionary savings motives of households. This reduces the consumption volatility due to increased asset holdings, but increases the volatility of investment and labor supply, which may lead to an increase in the volatility of output. Unemployment benefits work via a similar mechanism, but its effects are much smaller. Adjustments in the level of tax rates are ineffective in reducing volatility, as across-the-board changes in the tax rates do not affect the intertemporal substitution incentives of consumption or investment. Furthermore, their effect on stabilizing disposable income is dominated by monetary policy effects and does not play an important role in reducing output volatility.

These results are similar to those of McKay and Reis (2016), who find that

automatic stabilizers are mostly ineffective in reducing business-cycle volatility in the U.S. However, they find that the composite mix of automatic stabilizers in the U.S. actually increases output volatility, whereas we found that automatic stabilizers may reduce volatility in Korea.[1]

However, we determine that the progressive income tax is relatively effective in reducing volatility, as it introduces considerable intertemporal substitution. This result is in contrast to McKay and Reis' (2016) result, in which the progressivity of the income tax has a negligible effect on the business cycle in the United States. The difference is due to the fact that the slope of the marginal income tax rate for the top quantile households differs between the U.S. and Korea. In Korea, the marginal tax rates continued to increase, even for households near the top of the income distribution, as opposed to the U.S. where the marginal income tax rates are relatively flat above median.

Our results contributed to the understanding of the workings of automatic stabilizers. Along with McKay and Reis (2016), we are one of only a few papers to study the effect of automatic stabilizers using heterogeneous agent general equilibrium models. Because the particulars of the Korean economy and policy are different from those of the U.S., we determined that the effects of automatic stabilizers may sometimes differ in our model, compared to those in McKay and Reis. Our findings indicate that the income and wealth distributions and their interactions with the fiscal system is an important determinant of the effect of automatic stabilizers on economic volatility.

To our best knowledge, we are the first paper to study the effect of automatic stabilizers on business cycle volatility in Korea. There are few studies on automatic stabilizers in Korea, and the few studies that exist, such as Park and Park (2002) and Park and Lee (2011), focused on measuring the degree of automatic stabilization inherent in the Korean fiscal system by measuring the elasticities of fiscal mechanisms to changes in output. Therefore, our results are crucial in understanding the effect of automatic stabilizers on economic volatility in Korea.

Nevertheless, some recent works have examined the effect of fiscal policies using heterogeneous agent frameworks. Kang and Woo (2019) utilized a heterogeneous agent New Keynesian model, to study the multiplier effects of government transfers. Others, such as Chee and Han (2016) and Jung and Heo (2018), have used models that include hand-to-mouth households to study the policy effects in Korea.

Other works on automatic stabilizers using general equilibrium models include Janiak and Monteiro (2016) who found a positive relationship between government

[1] We find that reducing the size of automatic stabilizers increases aggregate volatility, and because our model is symmetric near the equilibrium, we can conclude that automatic stabilizers reduce volatility. In addition, we note that the exact policy experiment conducted with composite automatic stabilizers is somewhat different in this paper from that of McKay and Reis (2016). We maintain the progressivity in the income tax whereas McKay and Reis consider a flat income tax.

size and stabilization. They argued that high tax rates needed to support large governments may squeeze out young and old workers who, on average, have greater labor supply elasticities and therefore contribute to increased volatility. McKay and Reis (forthcoming) studied optimal automatic stabilizers and determined that the optimal generosity of the social insurance system depends on a macroeconomic stabilization term. They found that in the U.S., optimal unemployment benefit payments are counter-cyclical and the optimal progressivity of the income tax is independent of the business cycle.

This paper is also related to the recent studies that apply a general equilibrium framework to investigate the business cycle properties of the Korean economy. Kim and Lee (2020) used a representative multi-sector New Keynesian model to explore the implications of sectoral heterogeneity in Korea for monetary policy. Woo (2020) used a Neo-classical heterogeneous firm model to investigate state-dependent effects of investment subsidy policies. Kim and Lee (2016) utilized a New Keynesian model with labor market frictions to study the business cycle properties of the Korean labor market. This study differs from the aforementioned papers, in which we developed our paper using a heterogeneous agent New Keynesian model.

The rest of this paper is organized as follows. Section 2 describes the heterogeneous agent New Keynesian model, which we utilized to study the effect of automatic stabilizers. In Section 3, we discussed the properties of the model under the baseline calibration and studied the economy's response to various shocks. The policy experiments in which we studied the effects of automatic stabilizers are presented in Section 4. Section 5 exhibits the conclusion.

II. The Model

In this section, we introduced the model used to study the effect of automatic stabilizers in Korea. The model is a heterogeneous agent New Keynesian model, similar to the one used in McKay and Reis (2016). Heterogeneity in income, employment status, and asset holdings allowed us to incorporate the distribution of income and wealth. New Keynesian frictions, such as price rigidity and capital adjustment costs, are necessary to capture the propagation of government spending and taxes. Furthermore, we included the progressive income tax, flat corporate tax, VAT tax, unemployment insurance, and social transfers as parts of the automatic stabilization mechanism.

2.1. Households

There are two types of households in the economy, patient and impatient households. As in McKay and Reis (2016), we assumed that a representative patient

household exists that holds stock of all the capital in the economy. The assumption of a representative patient household is equivalent to assuming that these households have access to complete asset markets. We believe this to be reasonable, as these are high-income households with corresponding wealth that should have the ability to insure themselves from idiosyncratic risks. The patient household solves the following optimization problem:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\log c_t - \psi_1 \frac{n_t^{1+\psi_2}}{1+\psi_2} \right] \tag{1}$$

$$\text{s.t.} \quad (1-\tau_c) p_t c_t + b_{t+1} - b_t = p_t [x_t - \overline{\tau}^x(x_t) + T_t^p] \tag{2}$$

where c_t is consumption, n_t is labor hours, τ_c is the consumption tax rate, p_t is the price level, b_t denotes risk-free bond holdings, x_t denotes real pre-tax income, $\overline{\tau}^x(x_t)$ is the tax on income, and T_t^p is the lump-sum tax(transfer) on patient households.

The real pre-tax income of the patient household is

$$x_t = \left(\frac{I_{t-1}}{p_t} \right) b_t + d_t + w_t \overline{s} n_t \tag{3}$$

where I_t is the nominal return on bonds and d_t is the dividend from firms. Together, w_t, the average wage rate of the economy, and $\overline{s}$, the patient household's labor productivity, determine the wage of the patient household. The personal income tax is determined as follows:

$$\overline{\tau}^x(x) = \int_0^x \tau^x(x') dx'$$

where $\tau^x(x')$ denotes the marginal income tax at income x'.

There is a measure ν of impatient households indexed by $i \in [0, \nu]$. The impatient households save using debt and do not own any capital. As the name suggests, the impatient households' time discount rate $\hat{\beta}$ is lower than that of the patient household ($\hat{\beta} < \beta$). The impatient household can be either employed, unemployed, or long-term unemployed. They transition from one employment status to another according to some exogenous transition probabilities. In addition, impatient households are subject to idiosyncratic shocks to their labor productivity.

The impatient households maximized a discount sum of their flow utility subject to the budget constraint and a borrowing constraint as follows:

$$E_0 \sum_{t=0}^{\infty} \hat{\beta}^t \left[\log c_t(i) - \psi_1 \frac{n_t(i)^{1+\psi_2}}{1+\psi_2} \right] \tag{4}$$

subject to

$$\begin{aligned} &(1-\tau) p_t c_t(i) + b_{t+1}(i) - b_t(i) = \\ &p_t [x_t(i) - \overline{\tau}^x(x_t(i)) + \overline{T}^s \cdot \mathbf{1}\{\text{long-term unemployed}\}] \end{aligned} \tag{5}$$

and $b_{t+1}(i) \geq 0$. Social transfers $\overline{T}^s$ are given only to the long-term unemployed. The impatient household's pre-tax income is as follows:

$$x_t(i) = \begin{cases} \frac{I_{t-1} b_t(i)}{p_t} + w_t s_t(i) n_t(i) & \text{if employed;} \\ \frac{I_{t-1} b_t(i)}{p_t} + \overline{T}^u \cdot \min\{s_t(i), \overline{s}\} & \text{if unemployed;} \\ \frac{I_{t-1} b_t(i)}{p_t} & \text{if long-term unemployed.} \end{cases} \tag{6}$$

where $s_t(i)$ is the labor productivity of household i and $\overline{T}^u \cdot \min\{s_t(i), \overline{s}\}$ is the unemployment benefit payout. The unemployment benefit payment is determined as a function of worker productivity to capture its dependence on previous earnings.

The impatient household's labor productivity $s_t(i)$ can either be high, medium, or low (s_l, s_m, s_h). The idiosyncratic productivity of the households evolve according to the following transition matrix:

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$$\begin{array}{c} \\ \text{low} \\ \text{medium} \\ \text{high} \end{array} \begin{bmatrix} 1-p & p & 0 \\ p & 1-2p & p \\ 0 & p & 1-p \end{bmatrix}. \tag{7}$$

Each row of the matrix (7) represents the low (s_l), medium (s_m), and high (s_h) productivities at time t in that order, as does each column for the following period. Each element of the matrix (7) represents the transition probability from one productivity to another. For example, the element in the second row of the first column would represent the probability of transitioning from s_m to s_l in the following period. We assume that workers cannot directly transition from low to high states and vice versa. A worker's transition probability from high to medium or medium to low productivity (and vice versa) is assumed to equal a constant probability p.

The transition of the employment status for the impatient household is also determined by an exogenous transition matrix Φ_t. The transition matrix at time t

is determined as

$$\Phi_t = \bar{\Phi} + \begin{bmatrix} p_1 & -p_1 & 0 \\ 0 & 0 & 0 \\ p_2 & 0 & -p_2 \end{bmatrix} [\omega_1 \log \varepsilon_t^{TFP} - \omega_2 \log \varepsilon_t^{m} - (1-\omega_1-\omega_2) \log \varepsilon_t^{markup}]. \quad (8)$$

$\bar{\Phi}$ is a 3×3 steady state transition matrix, where each row represents the employed (E), unemployed (U), and long-term unemployed (L) states at time t in that order, as does each column for the following period. Each element represents the transition probability from one employment state to another. For example, Φ_{21}, the element of the second row of the first column of Φ would represent the probability of transitioning from unemployment currently to employment in the following period.

The business cycle shocks may affect the transition probabilities across employment states, as shown in the second term of (8). The shocks ε_t^{TFP}, ε_t^{m}, and ε_t^{markup} each denoted shocks to TFP, monetary policy, and markups, respectively. (We described these shocks in more detail below.) Parameters p_1, p_2, ω_1, and ω_2 governed the degree to which each shock influences the transition probabilities. A positive TFP shock generally improves employment conditions. A shock to monetary policy ε_t^{m} increases the nominal interest rate and has a negative effect on employment. The markup shock ε_t^{markup} lowers the markups of firms, which worsens the labor market conditions.

2.2. The Final Goods Producer

The final goods producer aggregates the intermediate goods using a constant elasticity of substitution aggregator.

$$y_t = \left(\int y_t(j)^{1/\mu_t} (dj)^{\mu_t} \right)$$

where $y_t(j)$ is the product of the intermediate goods producer j. Given the price of the intermediate good $p_t(j)$, the cost minimization indicates the following:

$$y_t(j) = \left(\frac{p_t(j)}{p_t} \right)^{\mu_t/(1-\mu_t)} y_t. \quad (9)$$

Equation (9) acts as the demand schedule for the intermediate goods producers. The aggregate price index can be calculated as follows:

$$p_t = \left(\int p_t(j)^{1/(1-\mu_t)} dj \right)^{1-\mu_t}. \tag{10}$$

The final goods producers are subject to shocks to their markups in the form of shocks to the elasticity of substitution. The elasticity of substitution μ_t follows the process.

$$\log(\mu_t) = \log(\bar{\mu}) + \sigma_\mu \varepsilon_t^{markup} \tag{11}$$

where $\varepsilon_t^{markup} \sim N(0,1)$.

2.3. Intermediate Goods Producers

There is a measure one of the intermediate goods-producing firms facing monopolistic competition. They produce according to the following production function:

$$y_t(j) = a_t k_t(j)^\alpha l_t(j)^{1-\alpha} \tag{12}$$

where a_t is the aggregate productivity, $k_t(j)$ is the capital, and $l_t(j)$ is the effective labor of firm j. Aggregate productivity follows a AR(1) process,

$$\log(a_t) = \rho_a \log(a_{t-1}) + \sigma_a \varepsilon_t^{TFP}$$

where $\varepsilon_t^{TFP} \sim N(0,1)$.

The after-tax profit of the firm is

$$d_t(j) = (1-\tau_k)\left(\frac{p_t(j)}{p} y_t(j) - w_t l_t(j) - (r_t + \delta) k_t(j) - \xi \right) \tag{13}$$

where τ_k is the corporate tax rate, r_t is the rental rate of the capital, δ is the depreciation rate, and ξ is the fixed cost of operation. Given price $p_t(j)$, firms choose inputs to maximize (13) subject to the demand schedule (9).

The intermediate goods producers face price stickiness of the Calvo type. They are only able to change their price each period with probability θ. With probability $1-\theta$, they maintain their price from the previous period. When given the opportunity, the intermediate goods producers choose the price that maximizes.

$$\max_{p_t^*(j)} E_t \sum_{s=0}^{\infty} (1-\theta)^s \lambda_{t,t+s} d_{t+s}(j) \tag{14}$$

s.t. $p_{t+s}(j) = p_t^*(j) \quad \forall s \geq 0$

where $\lambda_{t,t+s}$ is the stochastic discount factor of the patient household that owns the firm.

2.4. The Capital Goods Producer

A representative capital goods producer produces capital, which it loans to the intermediate goods producers at the rate r_t. The capital goods producer is subject to an adjustment cost $\frac{\zeta}{2}(\frac{\Delta k_{t+1}}{k_t})^2$ in the production of capital, where $\Delta k_{t+1} = k_{t+1} - k_t$. Their profits are as follows:

$$d_t^k = r_t k_t - \Delta k_{t+1} - \frac{\zeta}{2}\left(\frac{\Delta k_{t+1}}{k_t}\right)^2 k_t . \tag{15}$$

Solving the capital goods producer's profit maximization problem results in a firm value equal to v_t, where

$$v_t = q_t k_t \tag{16}$$

$$\text{and} \quad q_t = 1 + \zeta\left(\frac{\Delta_{t+1}}{k_t}\right). \tag{17}$$

Note that the dividends received by the patient household is the sum of dividends from the intermediate goods producers and the capital goods producer.

$$d_t = \int_0^1 d_t(j)dj + d_t^k . \tag{18}$$

2.5. Government and Market Clearing

We assumed that the monetary authority conducts monetary policy in accordance with the Taylor rule,

$$I_t = \bar{I} + \phi_p \Delta \log(p_t) + \varepsilon_t . \tag{19}$$

We assumed that monetary policy only reacts to the price level to facilitate the effectiveness of the automatic stabilizers we consider. Efficient monetary policy reduces the ability of automatic stabilizers to influence the intertemporal substitution incentives of households. The innovation to monetary policy ε_t

follows an AR(1) process,

$$\varepsilon_t = \rho_m \varepsilon_{t-1} + \sigma_m \varepsilon_t^m \tag{20}$$

where $\varepsilon_t^m \sim N(0,1)$.

We specified the government spending rule as depending on the deviation from the steady state debt level $(\frac{B_t / p_t}{\bar{B}})$ as follows:

$$\log(g_t) = \log(\bar{g}) + \gamma_b^G \log\left(\frac{B_t / p_t}{\bar{B}}\right). \tag{21}$$

Lump-sum taxes (transfers) adjust in a way to reduce deficits over time.

$$\log(T_t^p) = \log(\bar{T}^p) + \gamma^T \log\left(\frac{B_t / p_t}{\bar{B}}\right) \tag{22}$$

The parameter γ^G determines the effect of debt on government spending and γ^T governs the speed with which deficits are repaid.

The government budget constraint is determined wherein the difference between the total tax revenue and government spending and transfer expenditures is equal to the interest payments on existing debt, plus new debt issuances.

$$p_t\left[\tau_c\left(\int_0^1 c_t(i)di + c_t\right) + \int_0^\nu \bar{\tau}_x(x_t(i))di + \bar{\tau}_x(x_t) + \tau_k\left[\int_0^1 d(j)dj\right]\right.$$
$$\left. + T_t^p - g_t - \int_0^\nu [T_t^u(i) + T_t^s(i)di\right] = I_{t-1}B_t - (B_{t+1} - B_t) \tag{23}$$

Finally, the market clearing conditions for labor, capital, and government bonds are as follows:

$$\int_0^1 l_t(j)dj = \int_0^\nu s_t(i)n_t(i)di + \bar{s}n_t \tag{24}$$

$$k_t = \int_0^1 k_t(j)dj \tag{25}$$

$$B_t = \int_0^\nu b_t(i)di + b_t\,. \tag{26}$$

2.6. Equilibrium

The equilibrium of this economy is the collection of aggregate quantities $(y_t, k_t, d_t, v_t, c_t, n_t, b_{t+1}, x_t, d_t^k)$; aggregate prices (p_t, w_t, q_t); impatient households

policy functions for consumption and labor supply; the distribution of households over assets, labor productivity, and employment statuses; individual firm variables $(y_t(j), p_t(j), k_t(j), l_t(j), d_t(j))$; and government policy variables (I_t, B_t, g_t) such that:

1. Patient households maximized (1), subject to the budget constraint (2) and (3),
2. The impatient household decision rules maximized (4), subject to (5) and (6)
3. The distribution of households over assets, productivity, and employment levels evolved in a manner consistent with the decision rules and the exogenous idiosyncratic shocks,
4. Final-goods firms behaved optimally according to equations (9) and (10),
5. Intermediate-goods firms maximized (14) subject to (9), (12), (13),
6. Capital-goods firms maximized expression (15), wherein their value is given by (16) and (17),
7. Monetary policy followed (19) and fiscal policy followed (21), (22), and (23),
8. Markets clear for dividends in equation (18), for labor in Equation (24), for capital in Equation (25), and for bonds in Equation (26).

2.7. Calibration

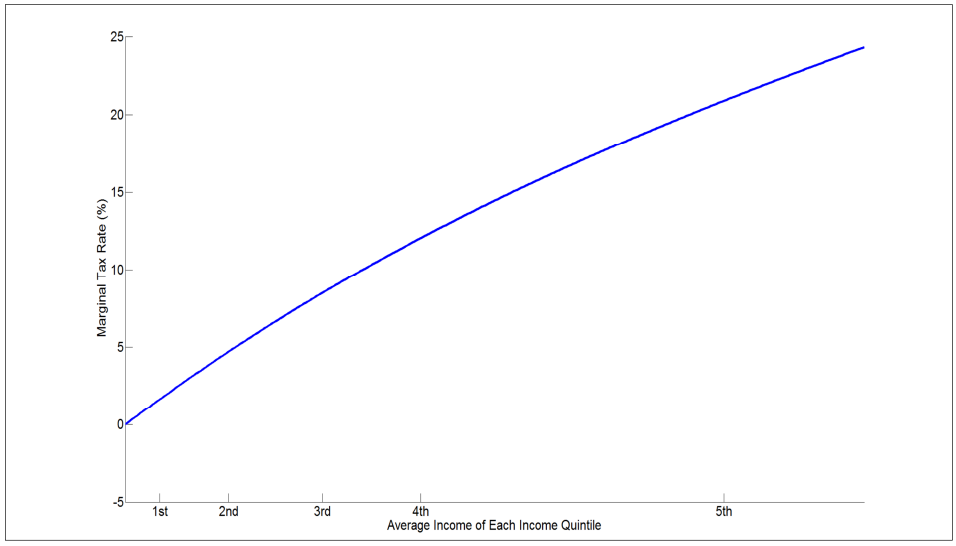
2.7.1. Steady State Parameters

The model is calibrated to the quarterly frequency. We calibrated the measurement of impatient households ν to 4, in which the patient household represents households in the top 20 percentile of income. The capital share α is calibrated to 0.36, the Frisch elasticity of labor supply $1/\psi_2$ to 0.5, and the depreciation rate to 1.5%, wherein all values are frequently used in the literature. The probability of price adjustment is equal to 0.25, following Park and Song (2013), who determined that the median duration of prices is one year in Korea. The steady state elasticity of substitution ε is calibrated to be 4.5, which consistent with Bae's (2014) estimate of 5.97.

We calibrated the remaining steady state parameters to target the following moments. We calibrated the labor disutility parameter ψ_1, in which workers spend one-third of their time working in a steady state. The time discount factor for patient households β^e is calibrated to match the capital stock to GDP ratio, which is measured as the ratio between productive capital less residential structures and GDP reported by the Bank of Korea and the Bureau of Statistics' "Korean National Balance Sheets for 2017." The discount factor for impatient households β^h is calibrated to match the share of total assets held by the patient households, which is equal to 43.5%, according to the Bureau of Statistics' "Assets, liabilities, and income by income quintile" report based on the "Survey of Household Finances and Living Conditions."

The progressivity of the income tax rate is captured using a 3rd order polynomial. The four necessary parameters are calibrated to match the average tax rate in each of the income brackets of 10 to 20 million won, 20 to 40 million won, 40 to 60 million won, as well as to target the average tax rate for the top 20 percentile income households in 2017. Figure 1 illustrates the marginal income tax rate in our model. The corporate tax rate and the VAT rates are calibrated to match their ratio of revenue-to-GDP of 3.4% and 3.9% in 2017, respectively. The fixed cost of operation is targeted to match the ratio of firm profits-to-GDP of 18.5% in 2017.[2]

[Figure 1] Marginal income tax rates



The average unemployment benefit payment during the month of January 2017 as reported in the "Employment Insurance Statistics Table for January 2017" of the Korea Employment Information Service is 999 thousand won. This is equivalent to 24% of the average monthly earnings. Thus, we targeted this ratio to be 24% in determining the unemployment benefits parameter $\overline{T}^u$. The average social transfer payment during the same period is 420,000 won, according to "The First comprehensive Plan for Basic Livelihood Security Program (2018-2020)," a report from the Ministry of Health and Welfare. This accounts for 7.5% of average earnings, which we targeted to calibrate $\overline{T}^s$. The steady state government consumption expenditure g is calibrated to target the ratio of total government spending less transfers[3] to GDP in 2017. The ratio amounts to 5.85%. Steady state

[2] The data for the corporate tax and VAT tax revenues are from the 2019 Statistical Yearbook of National Tax. The GDP data is obtained from the National Accounts data. Firm profits are computed as the sum of operating profits of non-financial and financial firms of the National Accounts data.

[3] We include goods and services, corporate special accounting, and capital expenditure as total

debt B is calibrated to match the ratio of debt-to-GDP of 36.3% in 2017.[4]

In addition, we need to calibrate the parameters governing the impatient household's labor productivity, along with the productivity of the patient household ($\bar{s}, s_l, s_m, s_h, p$). We utilized the data from the report "Living Conditions, assets, liabilities, and income by income quintile" from the Survey of Household Finances. We targeted the following moments: the ratio between the average income of households in the 20% to 40% income bracket to the average income for the economy, the ratio for the 40% to 60% income bracket, the ratio for the 60% to 80% income bracket, the ratio for the 80% to 100% income bracket, and a normalized average income of 1. The parameter values are shown in Table 1 and the data and model target moments are shown in Table 2.

Finally, the steady state transition probabilities governing the employment status of the worker is determined as follows:

$$\Phi = \begin{matrix} E \\ U \\ L \end{matrix} \begin{bmatrix} 0.988 & 0.012 & 0 \\ 0.199 & 0.678 & 0.122 \\ 0.062 & 0 & 0.938 \end{bmatrix}.$$

Each row and column of matrix Φ represents the employed (E), unemployed (U), and long-term unemployed (L) states.

First, note that it is impossible to transition from an employed state directly to the long-term unemployed state. Likewise, one cannot transition directly from being long-term unemployed to unemployed. We calibrated the probability that an employed worker becomes unemployed to 0.012. This targets the average value of the ratio of the number of new unemployment benefit claims to the number of workers with unemployment insurance between the first quarter of 2015 and the second quarter of 2019 of 1.5% ($= \frac{0.012}{1-0.199}$).

The probability that a long-term unemployed worker finds work is 0.062, and is calibrated to target the number of households (with the ability to work) receiving social transfers that graduated out of the program of 22.7%, according to the report "The First comprehensive Plan for Basic Livelihood Security Program (2018-2020)." The transition probabilities out of unemployment into either employment or long-term unemployment are calibrated to match the average ratio of the number of workers with unemployment insurance, the number of workers receiving unemployment benefits, and the number of workers between the age of 15 to 64 receiving social transfers of 92%, 2.7%, and 5.3% between 2008 and 2018.

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government spending less transfers.

[4] We use only central government debt in our computation of the debt-to-GDP ratio.

[Table 1] Steady state parameters

Parameter	Model	Description
ν	4	measure of impatient households
ψ_1	18.3	disutility of labor
$1/\psi_2$	0.5	Frisch elasticity of labor
β^e	0.997	discount factor (patient household)
β^h	0.992	discount factor (impatient household)
α	0.36	capital share
δ	0.015	depreciation rate
θ	0.25	probability of price adjustment
$\mu/(\mu-1)$	4.5	elasticity of substitution
τ_3^x	0.0017	3rd order polynomial (income tax)
τ_2^x	-0.018	2nd order polynomial (income tax)
τ_1^x	0.12	1st order polynomial (income tax)
τ_0^x	0	constant (income tax)
τ_k	18.8%	corporate tax rate
τ_c	5.0%	consumption tax rate
$\overline{T}^u$	16.4%	unemployment benefit
$\overline{T}^s$	7.5%	social insurance payment
ξ / GDP	0.004%	fixed cost of operation
$\overline{B} / GDP$	36.3%	government debt
$g/(GDP+\xi)$	5.99%	government spending less transfers
s_l	0.37	low labor productivity
s_m	1.47	medium labor productivity
s_h	1.66	high labor productivity
$\overline{s}$	2.83	patient household labor productivity
p	1.8%	productivity transition probability

2.7.2. Business Cycle Parameters

In addition to the steady state parameters, we must calibrate additional parameters to match the business cycle properties of the model to the data. We calibrated 13 parameters governing the shock processes, the labor market transition probabilities, and government policies to match 13 target moments in the data. We targeted the persistence and volatility of GDP, the persistence and volatility of inflation, the volatility of government consumption, investment and the debt-to-GDP ratio, the volatility of ratio of the number of workers receiving unemployment benefits to the number of workers with unemployment insurance, the volatility of the ratio of the number of workers receiving social transfers to the number of workers with unemployment insurance plus the number of workers receiving unemployment

benefits, the share of output variance and unemployment rate variance attributable to monetary shocks, and the share of output variance and unemployment benefit variance attributable to markup shocks.

[Table 2] Steady state moments

Target Moment	Data	Model
K/GDP	9.9	9.62
share of assets held by top 20% in income	43.5	42.94
labor supply	1/3	1/3
average tax rate (10-20 mil)	1.28	1.34
average tax rate (20-40 mil)	3.54	3.86
average tax rate (40-60 mil)	6.57	6.27
average tax rate (top 20%)	12.5	11.52
total corporate tax / GDP	3.42	3.45
total value added tax / GDP	3.88	3.95
firm profit / GDP	18.53	18.36
unemployment benefit / average income	24	24.6
social insurance payments / average income	7.5	7.6
government spending / GDP	5.85	5.99
government debt / GDP	36.3%	36.3%
average income of households in the 20-40 / average income	49.06	41.59
average income of households in the 40-60 / average income	81.24	79.93
average income of households in the 60-80 / average income	121.18	120.33
average income of households in the 80-100 / average income	230.12	243.10
normalized average income	-	1

[Table 3] Business cycle parameters

Parameter	Model	Description
ϕ	1.476	Taylor rule coefficient
ρ_m	0.507	monetary shock persistence
σ_m	0.006	monetary shock standard deviation
ρ_a	0.877	TFP shock persistence
σ_a	0.004	TFP shock standard deviation
σ_ε	0.097	markup shock standard deviation
γ_G	-2.155	government spending response to debt
γ^T	3.254	lump-sum tax response to debt
ζ	13.678	capital adjustment cost
ω_1	0.476	TFP contribution to employment status transition
ω_2	0.506	monetary contribution to employment status transition
p_1	0.136	business cycle transition probability adjustment (E)
p_2	0.640	business cycle transition probability adjustment (L)

[Table 4] Business cycle moments

Target Moment	Data	Model
real GDP persistence	0.6960	0.6238
real GDP volatility	0.0105	0.0100
inflation persistence	0.5654	0.5738
inflation volatility	0.0055	0.0053
government consumption volatility	0.0100	0.0101
investment volatility	0.0340	0.0344
debt/GDP volatility	0.0071	0.0076
$\frac{\#\text{ of workers receiving unemployment benefits}}{\#\text{ of workers with unemployment insurance}}$ volatility	0.0016	0.0016
$\frac{\#\text{ of workers receiving social transfers}}{\#\text{ with unemployment insurance} + \#\text{ receiving unemployment benefits}}$ volatility	0.0037	0.0036
monetary shock share of output variance	0.25	0.2571
markup shock share of output variance	0.25	0.2557
monetary shock share of unemployment rate variance	0.25	0.2448
markup shock share of unemployment rate variance	0.25	0.2450

We used the data from 2008 to 2018 for the number of workers receiving unemployment benefits, the number of workers with unemployment insurance, and the number of workers receiving social transfers. We used HP-filtered data from 2000 to 2017 to calculate the persistence and volatility of GDP, inflation, government consumption expenditure, and government debt. We targeted the share of output variance and unemployment rate variance of monetary shocks and markup shocks, respectively, to be 25% each, following McKay and Reis (2016). This indicates that the share of output variance and unemployment rate variance of the productivity shock is equal to 50%. The parameter values are shown in Table 3 and the data and model target business cycle moments are shown in Table 4.

The parameters determining the transition matrix at time t is determined as

$$\Phi_t = \begin{matrix} E \\ U \\ L \end{matrix}\begin{bmatrix} 0.988 & 0.012 & 0 \\ 0.199 & 0.678 & 0.122 \\ 0.063 & 0 & 0.938 \end{bmatrix} + \begin{bmatrix} 0.136 & -0.136 & 0 \\ 0 & 0 & 0 \\ 0.640 & 0 & -0.640 \end{bmatrix} [0.476 \log \varepsilon_t^{TFP} - 0.506 \log \varepsilon_t^{m} - 0.018 \log \varepsilon_t^{markup}] \quad (27)$$

where each row of matrix Φ represents the employed (E), unemployed (U), and long-term unemployed (L) states and ε_t^{TFP}, ε_t^{m}, and ε_t^{markup} are shocks to TFP, monetary policy, and markup, respectively.

III. Properties of the Model

In this section, we examined the properties of the baseline model. The model economy includes TFP shocks, monetary policy shocks, and markup shocks that generate aggregate volatility. Each shock has a different effect on the economy, which indicates that each automatic stabilizer will have a different effect on the economy, depending on the type of shock. We examined the dynamic properties of the economy in response to each shock and presented the business cycle properties of the baseline model, in which all three shocks hit the economy. Lastly, we examined the households' marginal propensity to consume in our model by their employment status, labor productivity, and wealth levels.

3.1. TFP Shocks

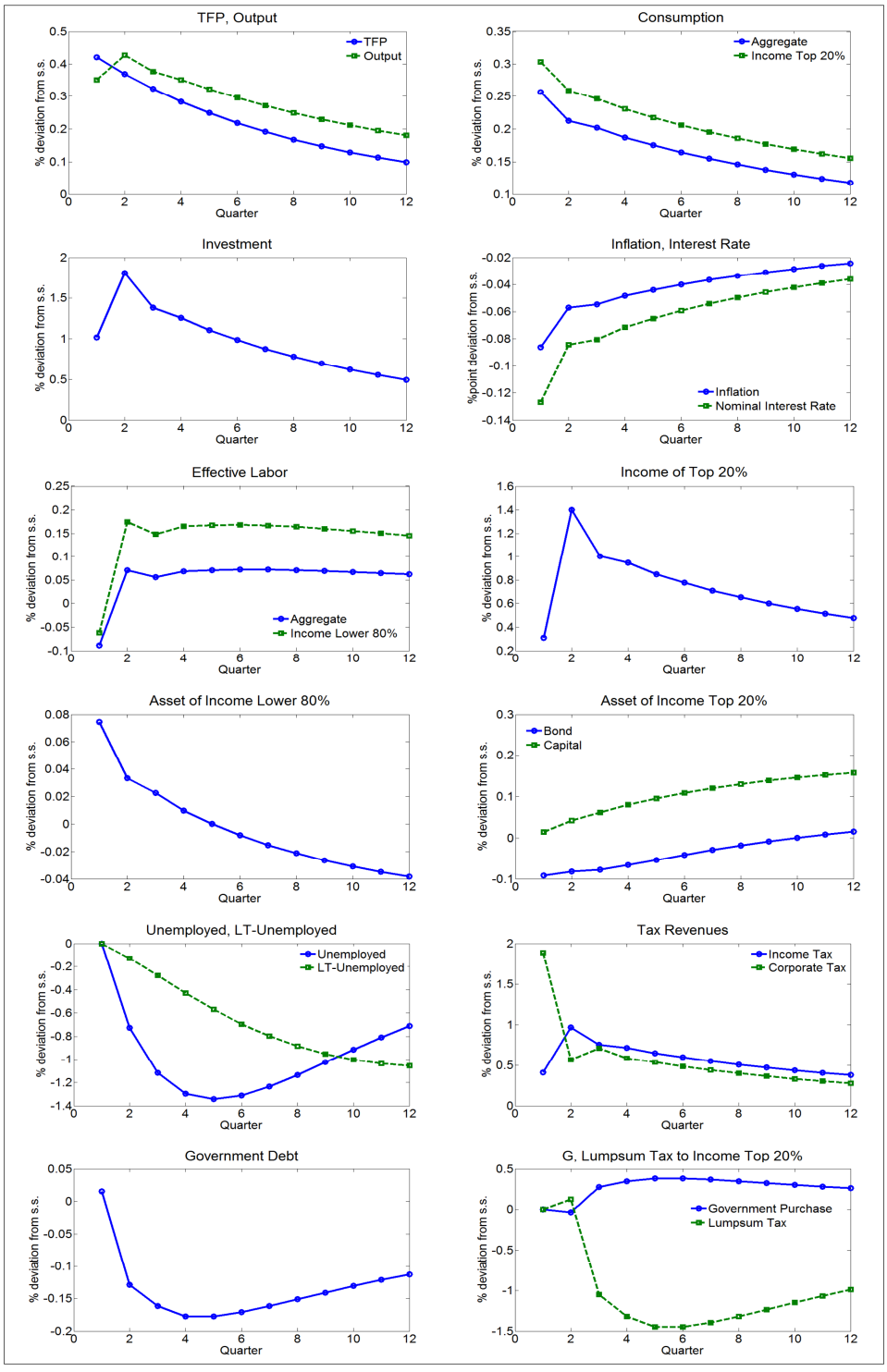
The impulse response functions of the baseline economy to a TFP shock are shown in Figure 2. Aggregate output, consumption, investment, and effective labor all increased in response to a TFP shock. Aggregate output increases as productivity spikes not only raise output given a level of inputs, but also because it increases labor demand, as the per unit cost of the intermediate good falls. Consumption rises for both patient and impatient households, but the increase is greater for the patient household, as TFP shocks increased the firm profits, which are then transferred over as dividends. The inflation rate falls as the cost decreases, which may lead to decreases in the price of the intermediate good. This leads to a fall in the nominal interest rate per the monetary policy rule.

A positive shock to TFP decreases unemployment and long-term unemployment as the transition probability from employment to unemployment decreases while the transition probability from long-term unemployment to employment increases. Income tax revenues increased along with household income and corporate tax revenues increase due to increases in intermediate firm profits. In addition, as unemployment benefits and social transfers decrease, the government debt falls, leading to an increase in government spending and a decrease in lump-sum taxation.

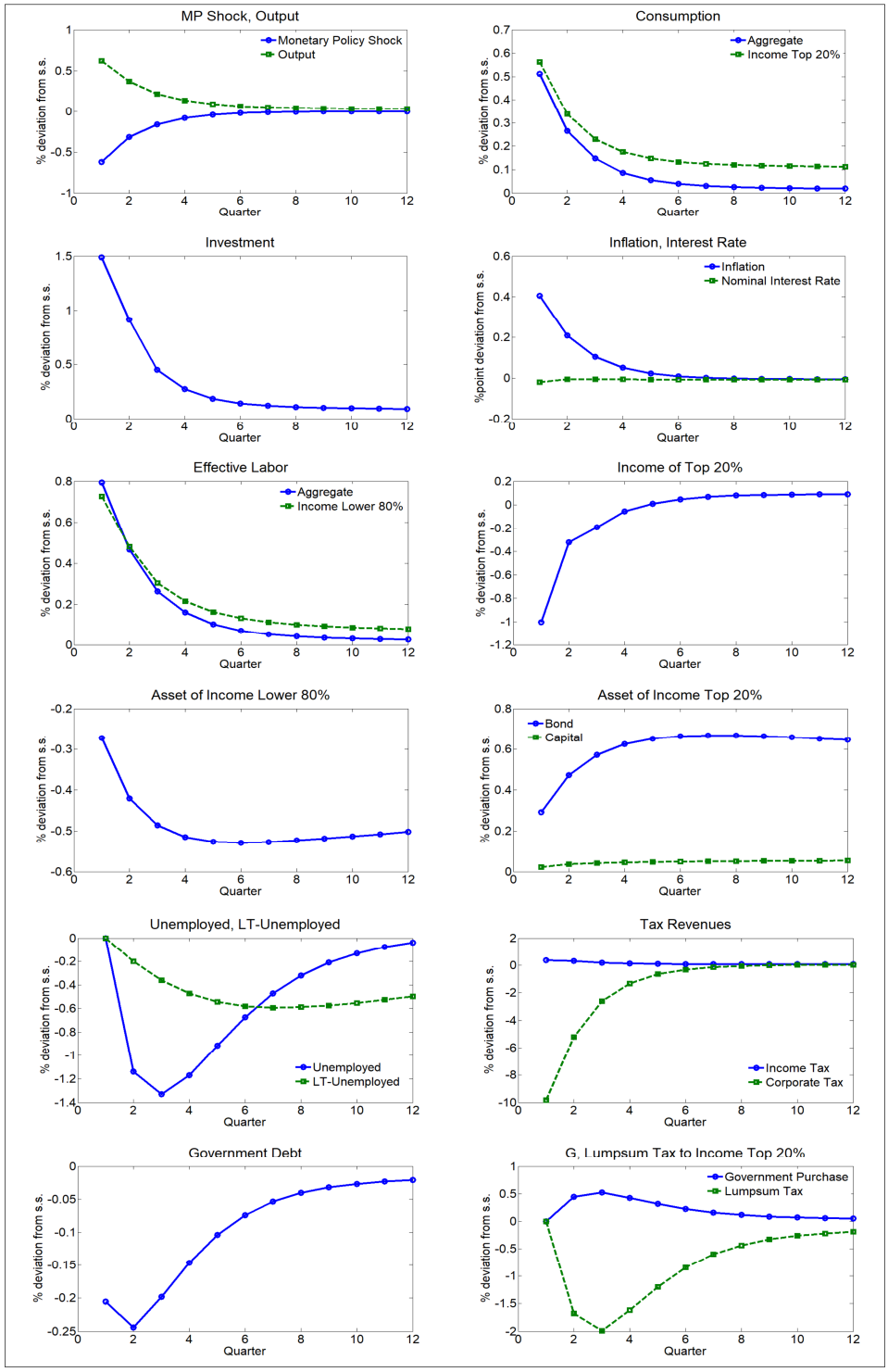
3.2. Monetary Policy Shocks

Figure 3 shows the impulse response functions to a monetary policy shock. Output, consumption, and investment would all increase in response to a negative monetary policy shock. This occurs as the inflation response fails to fully offset the decrease in the nominal interest rate, and the real interest rate falls, thus increasing aggregate demand. This leads to an increase in labor demand and increasing effective labor. The income of the patient household decreases as the markups of the

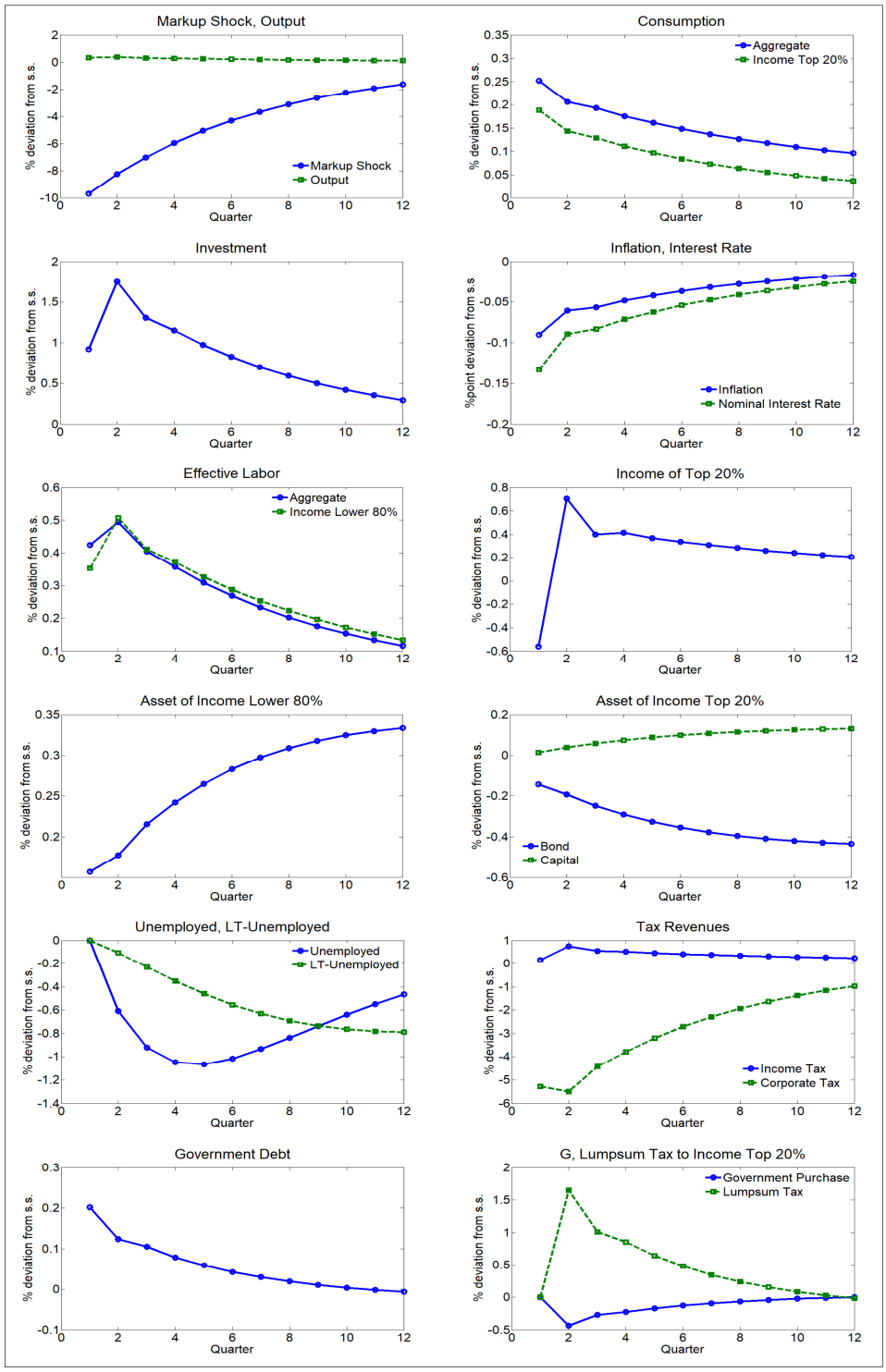
[Figure 2] Impulse response functions to TFP shocks



[Figure 3] Impulse response functions to monetary policy shocks



[Figure 4] Impulse response functions to markup shocks



intermediate firms decrease. Nevertheless, the consumption of the patient household increases as the substitution effect from a fall in the real interest rate dominates.

Unemployment and long-term unemployment rates decrease. Income tax revenues remain mostly unchanged, whereas corporate tax revenues may fall due to decreased firm profits. Government debt falls because unemployment benefits and social transfers decrease and the interest payment burden on outstanding debt is lessened.

3.3. Price Markup Shocks

Figure 4 shows the impulse response functions to a markup shock. A shock to the markup of intermediate goods producers lowers the reset price of firms, thus decreasing inflation. A fall in inflation leads to a lowering nominal interest rate and the monetary policy rule indicates that the real rates may fall as well. Output increases due to low real interest rates, as well as from increased demand buoyed by lower markups. Effective labor supply increases as well. The fall in the real rate induces consumption increases via the intertemporal substitution effect. The consumption increase is greater for impatient households, as the income of the patient household initially falls due to falling firm profits.

In contrast to the response to TFP or monetary shocks, markup shocks may result in increased government debt, as the drop in corporate tax revenues overwhelms the slight increase in income tax revenue and reduced transfer spending. Therefore, government consumption expenditures may decrease, while lump-sum taxes may increase.

3.4. Business Cycle Statistics

We studied the business cycle properties of the baseline model, which we utilized to analyze the effect of automatic stabilizers in the following section. We compared the relative volatility and GDP correlation of various variables of the baseline economy with those found in the data between 2000 and 2017 with the exception of unemployment benefits and social transfers, for which we utilized the data from 2010 to 2018. Whenever we can, we used the quarterly frequency in calculating the statistics in the data. However, due to lack of quarterly data, we calculate the statistics based on annual data for the number of individuals receiving social transfers, corporate tax revenue, income tax revenue, VAT revenue, total tax revenue, and government debt. We simulated our model for 10,000 periods.

Table 5 reports the standard deviation of various macroeconomic and fiscal variables relative to the standard deviation GDP and their correlation with GDP.[5]

[5] We used the data from the National Accounts for GDP, consumption, investment, and government consumption. We used CPI inflation and nominal interest rates from the Bank of Korea

Our model does a reasonable job of matching the data, along with some dimensions, but shows some differences among others. For example, the volatility of consumption in our model is smaller than the volatility of GDP, whereas the volatility in the data is larger than GDP. This relates to the "excess consumption volatility puzzle" of emerging market economies. Han and Kim (2020) argued that trend shocks are important to account for this fact in Korea. Because our model is focused on the business cycle, we cannot account for this feature in our analysis.

The nominal interest rates are positively correlated with GDP in the data, whereas it is negatively correlated in our model. This indicates that the monetary policy is more accommodating in the data compared to our model. This could potentially lead to an understatement of the effect of automatic stabilizers in our model. In addition, the volatility of unemployment benefits and social transfers are extremely large in the data. However, this is due to the fact that both programs experienced structural change during this period, as social welfare programs were expanded in Korea in the 2010s. Moreover, the data reflects the demographic changes that may affect welfare programs that are not necessarily related to the business cycle phenomenon.

The correlation of the corporate tax revenue to GDP is negative in our model, whereas it is positive in the data. This issue arises in part because, as in many business cycle models with nominal rigidities, markups are counter-cyclical in our model. However, as over half of corporate taxes are paid in the

year after incidence in the real economy, the GDP correlation in the data also does not reflect the "true" economic relationship between GDP and corporate tax revenue. In the model, taxes are paid in the period of incidence, which may be an accurate representation of the economic relationship between corporate taxation and GDP.

The relative volatility of the income tax and VAT tax are larger in the data compared to the model. However, we believe that this is due in large part to policy changes and anomalous events, rather than reflecting true business cycle effects. The Korean government exerted continuous efforts to reduce income tax exemptions during this period, and made several changes to the income tax rates as well, which may have amplified volatility in the data. However, the variance of the VAT tax revenue is greatly amplified in the data due to large outliers in 2002-2003 and 2015. Removing these three years from the sample lowers the relative volatility of the VAT tax to 192.8, which is close to the results for consumption volatility. One would expect that the volatility of the VAT tax would be similar to the volatility of consumption, as the VAT tax is a flat tax charged on consumption expenditures.

Statistical Database. Data regarding tax revenues are also obtained from the Bank of Korea Statistical Database. Information on total wage (effective labor), government debt and social transfers were obtained from the Korean Statistical Information Service. Unemployment benefit records are provided by the Korea Employment Information Service.

[Table 5] Relative Volatility and Correlation with GDP

	Volatility		Correlation	
	Data	Model	Data	Model
consumption	159.6 [2]	69.3	0.70	0.97
investment	308.6	318.1	0.66	0.95
total effective labor	325.6 (197.0)	88.5	0.25 [1]	0.81
inflation	52.4	31.8	0.26	0.02
nominal interest rates	29.2	21.4	0.30	-0.89
unemployment benefit payments	1482.9	320.3	-0.17	-0.79
individuals receiving social transfers	2879.4	371.3	-0.17	-0.62
corporate tax revenue	950.6	1018.9	0.35	-0.60
income tax revenue	681.4	182.7	0.55	0.92
VAT tax revenue	363.5 (192.8)	69.3	0.26	0.97
total tax revenue	396.9	226.9	0.62	0.12

Note: We used the data from between 2000 and 2017 to compute the volatility and correlation of variables with the exception of unemployment benefits and social transfers, for which we utilized the data from 2010 to 2018. We used the annual values for the following variables: the number of individuals receiving social transfers, corporate tax revenue, income tax revenue, VAT tax revenue, total tax revenue, and government debt. We used the quarterly values for all other variables.

As discussed, the model does a good job of matching the relationships found in the data in some aspects and not so well on others. However, along with many of the dimensions in which the model and the data disagree, it is not always clear whether the data or the model is more accurately reflecting the underlying true relationships. In many cases, we believe that there is reason to believe that the data cannot reflect the true relationships between the variables, and the model is actually a better reflection of the economic mechanisms. Therefore, we believe that our model is a reasonable vehicle to study the effect of automatic stabilizers on the Korean economy.

3.5. Marginal Propensity to Consume

Lastly, the model we studied includes heterogeneous households with various income and wealth levels. This heterogeneity results in a large variance in the marginal propensity to consume (MPC) across households. Understanding the MPCs of different households is important because one of the main channels through which automatic stabilizers may affect the economy is through redistribution, where the transfer of resources from households with low MPCs to those with high MPCs can increase aggregate demand.

Table 6 shows the marginal propensity to consume of households in the baseline economy introduced in Section 2. The marginal propensity to consume can differ widely, depending on the employment status, productivity, and wealth of the

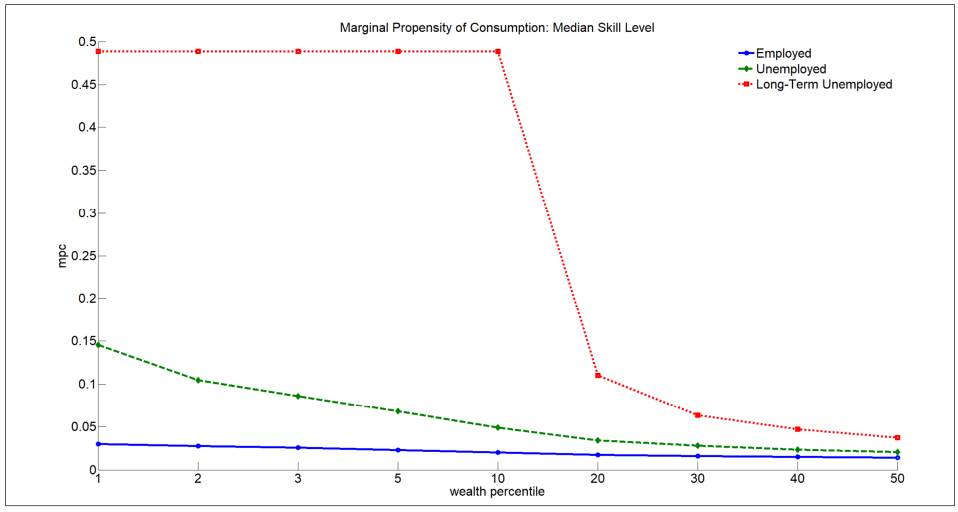
household. Figure 5 shows the relationship between household MPC and wealth by employment status. Figure 6 shows the relationship between MPC and wealth by household productivity. It is evident from these figures and Table 6 that while the MPC of unemployed households with low productivity and low wealth levels can be as high as 0.49, the MPC of households decreased dramatically as employment, income, and wealth levels improved.

Using credit card expenditure changes around the first round of COVID-19 emergency disaster relief transfers, Kim and Oh (2020) determined that the average MPC of households in Korea is approximately between 0.26 and 0.36. In addition, the MPC of households who have failed to make payments on their credit card balances between February and April of 2020 is 30.8% higher than households who

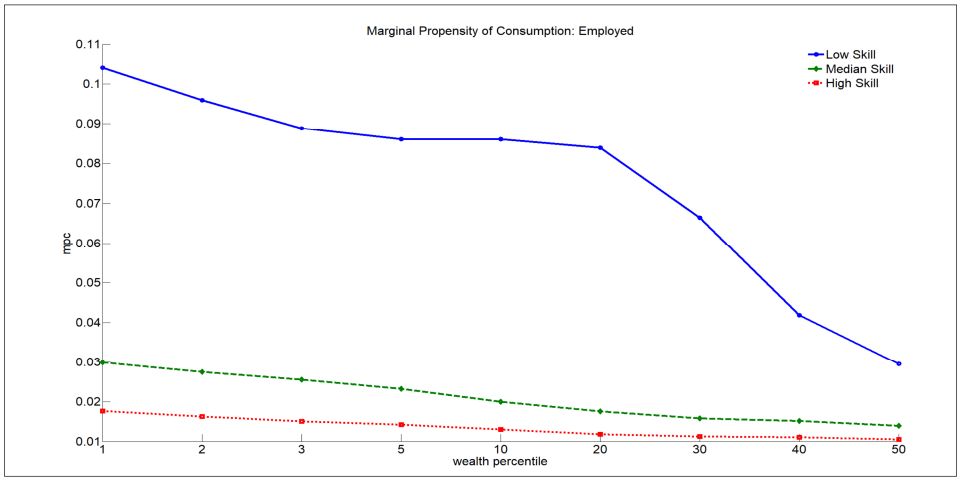
[Table 6] Marginal Propensity to Consume

		Wealth Percentile				
Employment	Productivity	10th	20th	30th	40th	50th
Employed	s_l	0.09	0.08	0.07	0.04	0.03
	s_m	0.02	0.02	0.02	0.02	0.01
	s_h	0.01	0.01	0.01	0.01	0.01
Unemployed	s_l	0.49	0.43	0.23	0.09	0.05
	s_m	0.05	0.03	0.03	0.02	0.02
	s_h	0.03	0.02	0.02	0.02	0.02
Long-term unemployed	s_l	0.48	0.48	0.48	0.17	0.07
	s_m	0.49	0.11	0.06	0.05	0.04
	s_h	0.14	0.06	0.05	0.04	0.03

[Figure 5] MPC by employment status and wealth of households



[Figure 6] MPC by productivity and wealth of households



have not. Thus, the MPC of constrained households in the model is similar to those found in the data. However, the MPC of households with median wealth levels are below 0.1 in our model. While this is lower than the findings of Kim and Oh (2020), their results were estimated during a period in which many households experienced large negative income shocks, which may have increased the average MPCs. Furthermore, because assets are fully liquidity in our model, the model may underrepresent the MPC of households with illiquid assets.

IV. Automatic Stabilizers and Business Cycle Volatility

In this section, we studied the effect of each automatic stabilizer by dampening each mechanism and simulating the model to compare the volatility of output in the economy with a weakened stabilizer with the volatility of output in the baseline economy. Our model features six automatic stabilizers: unemployment benefits, social transfers, the level of each of income, corpo-rate, and VAT and the progressivity of income tax.

For all but the progressivity of the income tax, we decreased the total expenditure of each mechanism by 0.2% of steady state GDP. This indicates that we decreased the unemployment benefit payments by 5.96%, social transfer payments by 4.5%, the income tax rates by 0.25% for all income levels, the corporate tax rate by 1.09% and the VAT rate by 0.26%. To study the effect of the progressivity of the income tax, we replaced the income tax with a revenue neutral flat tax of 7.9%. Lastly, we studied the effect of a composite stabilizer by simultaneously weakening all automatic stabilizers, with the exception of the progressivity of the income tax.

We compared the business cycle volatility of the economy with weakened

stabilizers to the baseline economy as follows:

$$S = \frac{V}{V'} - 1$$

where V is the standard deviation of the variable of interest in the baseline economy and V' is the standard deviation of the variable in the economy with a dampened stabilizer. We reported S. A negative value of S indicates that the automatic stabilizer in question is effective and reduces the volatility of the economy. A positive value indicates that the automatic stabilizer increases the volatility of the economy.

4.1. Unemployment Benefits and Social Transfers

We studied the stabilization effect of unemployment benefits and social transfers. As previously stated, we reduced the unemployment benefit payments by 5.96% and social transfer payments by 4.5%, reducing the total expenditure of each mechanism by 0.2% of the GDP.

Reducing unemployment benefits raises the precautionary savings motives of employed workers and increases their labor supply. This has the effect of increasing the overall wealth of the population. Figure 7 depicts the wealth distribution of employed, unemployed, and long-term unemployed impatient households. It shows that the wealth distribution of employed and unemployed impatient households actually improved with lower unemployment benefits. The density of households near the borrowing constraint of zero decreases by a large amount.

As wealth levels increased, the consumption volatility of impatient households fell. However, with increased wealth, the effect of income on the labor supply is reduced leading to an increase in the volatility of labor supply. The increase in labor supply volatility indicates that the marginal productivity of capital becomes more volatile, leading to investment volatility growth.

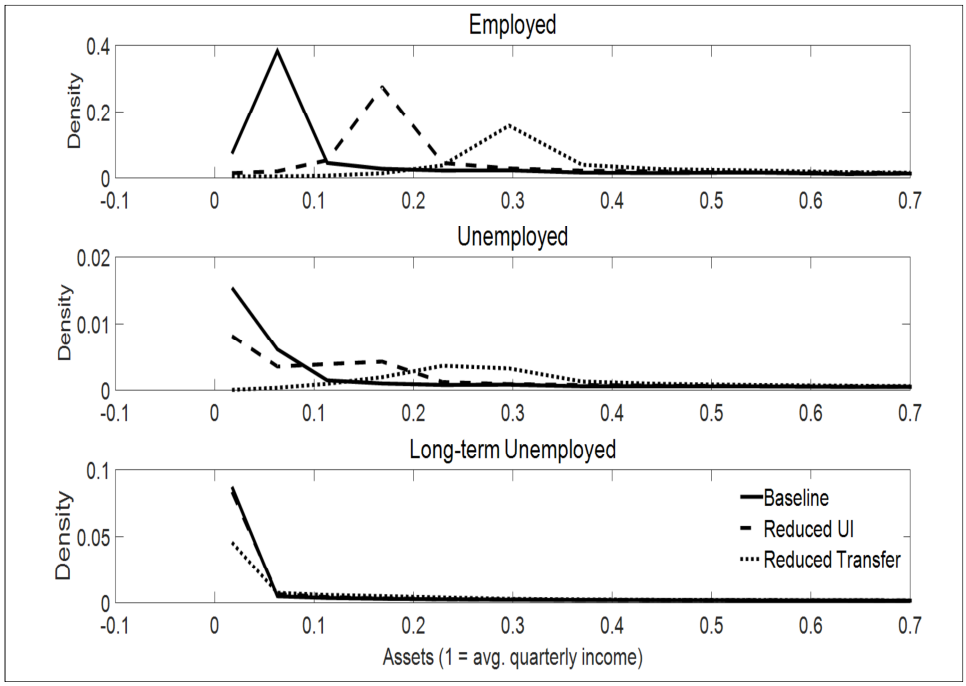
Table 7 shows the stabilization effect of each automatic stabilization mechanism on various macroeconomic and fiscal variables. Reducing unemployment benefits by 0.2% of GDP increases aggregate output volatility by 0.24%, as shown in Column (1) of Table 7. Because the effect of automatic stabilizers on the economy is symmetric around the equilibrium in our model, this indicates that unemployment benefits work to reduce the volatility of GDP. The destabilizing effect of unemployment benefits on total consumption is offset by the reductions in investment and labor supply volatility. An increase in unemployment benefits of 0.2% of the GDP would result in an increase in consumption volatility of 0.12%, but investment volatility would fall by 0.89% and total effective labor supply volatility would drop by 0.16%.

[Table 7] Effect of automatic stabilizers on aggregate volatility

	(1) unemp.	(2) soc.tr	(3) inc.tax	(4) corp.tax	(5) VAT.tax	(6) prog.tax	(7) composite	(8) alternative mp
GDP	-0.24	-1.49	0.03	0.08	0.03	-3.49	-1.56	-3.06
consumption	0.12	1.14	-0.09	0.06	0.03	-7.84	1.15	1.80
consumption (top 20%)	-1.03	-8.14	-0.05	-0.07	-0.10	-1.81	-9.21	-14.24
investment	-0.89	-5.06	0.17	0.36	0.01	0.98	-5.21	-18.74
total effective labor	-0.16	-1.09	0.01	0.12	0.04	-7.18	-1.06	-8.32
effective labor of impatient households	-0.69	-4.80	0.11	0.10	0.00	-3.77	-5.13	-1.62
(effective) labor of patient households	0.08	-0.25	0.01	-0.01	0.01	1.65	-0.38	-8.95
total labor hours	-0.86	-4.15	0.03	0.13	0.03	-5.12	-4.45	-4.33
income (top 20%)	-2.14	-12.43	0.75	-0.10	0.05	8.92	-13.29	-6.33
inflation	0.13	0.45	0.18	0.05	-0.01	-2.17	0.70	-0.37
nominal interest rates	-0.07	0.26	1.07	-0.37	-0.04	18.10	0.93	-1.00
unemployment benefit payments	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
social transfers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
income tax revenue	-2.48	-11.98	-2.14	0.75	-0.02	11.56	-15.24	-21.28
corporate tax revenue	0.03	-0.02	-0.02	0.27	0.03	-3.90	0.23	0.45
VAT tax revenue	0.12	1.14	-0.09	0.06	0.03	-7.84	1.15	1.80
total tax revenue	-2.04	-1.85	-0.19	2.06	-0.10	1.93	-2.23	-2.09
government debt	0.65	-1.24	0.45	-0.49	0.19	16.68	-0.45	-6.25

Note: The values in this table indicated the reduction in the standard deviation of each variable as a percent of its total volatility. A negative value indicates that the mechanism reduces aggregate volatility. Column (1) shows the results from the reduction in unemployment benefit payments. Column (2) shows the results from the reduction in social transfer payments. Column (3) shows the results from a proportional reduction in the income tax rate. Column (4) shows the results from the reduction in the corporate tax rate. Column (5) shows the results from the reduction in the VAT rate. Column (6) shows the results for when we replaced the progressive income tax with a revenue-neutral flat income tax. Column (7) shows the results for the composite automatic stabilizer. Column (8) shows the results for the composite automatic stabilizer, in an economy with an alternative monetary policy rule that is less responsive to changes in the aggregate price.

[Figure 7] Impatient household wealth distribution



Social transfers may affect volatility through the same channels as unemployment benefits. However, as shown in Figure 7, the effect of social transfers on precautionary savings motives and the wealth distribution is much greater than that of unemployment benefits. With reduced social transfers, the savings of unemployed households increased, thus increasing wealth and reducing the number of unemployed and long-term unemployed households near the borrowing constraint.

The effect of social transfers on aggregate volatility is also much greater. Column (2) of Table 7 shows that reducing social transfers increases the GDP volatility. Because the effect of automatic stabilizers on the economy is symmetric, an *increase* in social transfers of 0.2% of GDP would reduce GDP volatility by 1.49%. Consumption volatility will increase by 1.14%, but investment volatility will fall by 5.06% and the volatility of total effective labor supply will decrease by 1.09%. The effect of social transfers on GDP, consumption, investment, and labor supply volatility is 6.2, 9.5, 5.7, and 6.8 times greater than the effect of unemployment benefits identical in total expenditure levels, respectively. Thus, from the stand point of economic stabilization, social transfers are much more efficient than unemployment benefits.

Nevertheless, the magnitude of the stabilization provided is quite small, even for social transfers. Note that our unit of measurement is percent and not percentage

points. A one percent decrease in GDP volatility would reduce the standard deviation of GDP by approximately 0.01 percentage points, as the standard deviation of GDP is approximately 1% in Korea at the quarterly frequency. Thus, a reduction in GDP volatility of 1.49% from social transfers indicates that the standard deviation of GDP is reduced by only 0.015 percentage points. As we shall discuss in Section 4.5, this is considerably smaller than the stabilization effect of a comparable change to the monetary policy.

4.2. Proportional Taxes

To reduce the revenue of income, corporate and VAT by 0.2% of steady state GDP, we lowered the tax rates of each by 0.25 percentage points, 1.09 percentage points, and 0.26 percentage points. For the income tax, the reduction is uniform across all income levels. We determined that proportional taxes do little to alter the volatility of variables regardless of the type of tax, or the type of shock hitting the economy.

Columns (3) through (5) of Table 7 show our results. All three mechanisms changed the GDP volatility by less than 0.1%, while the effect on other variables such as consumption, investment, and labor supply is also negligible. Proportional taxes can potentially lower the business cycle volatility by stabilizing the disposal income of households. However, monetary policy plays a direct role in stabilizing aggregate demand. Therefore, the effect of automatic stabilizers through the disposable income channel is largely mitigated by monetary policy.

4.3. Progressivity of the Income Tax

We studied the effect of the progressivity of the income tax rate by replacing the progressive income tax with a revenue neutral flat tax of 7.9%. The progressivity of the income tax has a large effect on the patient households who are subject to higher marginal tax rates and account for a disproportionate fraction of income tax revenue. Furthermore, its effect differs widely by the type of shock.

Recall from Figures 2, 3, and 4 that in response to a TFP shock, the income of the patient household increases as firm profits increases. For monetary policy shocks, markups, and profits decrease and income decreases. After markup shocks, the income of the patient household initially falls, but immediately rebounds the next period to 0.7 standard deviations above the steady state level, as the markup shocks in our model have no persistence. After the second period, the patient household's income steadily declines to the steady state level.

The income path of the patient household is important in determining the effect of the progressivity of the income tax on economic volatility. The real interest rates fell, following each shock and intertemporal substitution effects dictate the behavior

of household consumption and savings. Marginal tax rates mitigate or amplify these effects, and the degree of intertemporal substitution depends on the path of household income in response to each shock.

Figure 8 compares the impulse response functions of income, marginal income tax rates, consumption, and investment of the patient household in an economy with a flat income tax with those from the baseline economy. It shows the income and marginal tax rates increasing after TFP and markup shocks and income and marginal tax rates decreasing after monetary policy shocks. In response to a TFP shock, the response of consumption is much smaller with progressive taxation, as marginal rates increased, while a similar effect is present in the response to markup shocks, although to a lesser degree. However, one can see that the consumption response is slightly larger with progressive taxes after a monetary policy shock. Consequently, the volatility of consumption is reduced due to progressive taxation in response to TFP and markup shocks, but was amplified in response to monetary policy shocks.

The response of investment depends heavily on the dynamic path of the marginal tax rate, as it determines the patient household's incentive to substitute investment intertemporally. As marginal tax rates decreased dynamically after TFP and markup shocks, the investment response is larger in the baseline economy, as shown in Figure 8. The opposite effect takes place after a monetary policy shock. Hence, progressive taxation increases the investment volatility following TFP and markup shocks and reduces volatility post monetary shocks. Together, this leads to an increased output volatility in response to TFP shocks, and lower output volatility in response to monetary and markup shocks.

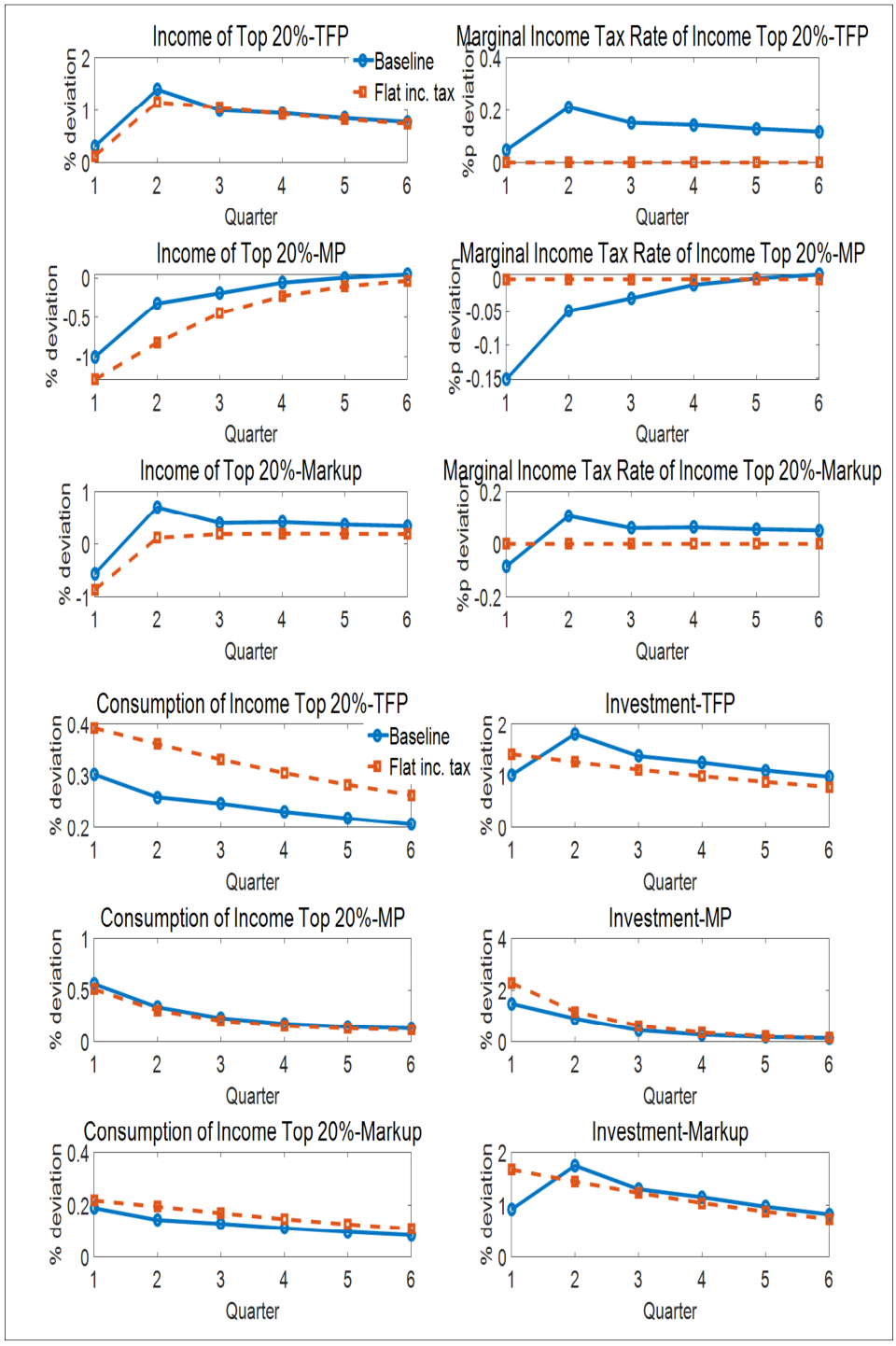
In the economy with all three shocks, consumption volatility is reduced and investment volatility is amplified from progressive income tax rates. Progressive income tax rates decreased the aggregate output volatility by 3.49%.

Our results on the effect of progressive taxation may differ from the findings of McKay and Reis (2016), who determined the modest effects of progressive taxes on output volatility. The difference stems from the fact that households in the top 20% of the income distribution in Korea still face relatively steep marginal tax rates, whereas in the U.S., marginal tax rates are relatively flat above the median. This difference results in the considerable gap in the relevance of intertemporal substitution effects between the two countries.

4.4. The Composite Automatic Stabilizer

We studied the effect of a composite of an automatic stabilizer to document the effect on volatility when various stabilization mechanisms interact. We compared the baseline case with the case in which unemployment benefits, social transfers, income tax rates, corporate tax rates, and VAT rates are all simultaneously reduced.

[Figure 8] Impulse response functions of patient households to various shocks depending on income tax scheme



The progressivity of the income tax, however, is left unchanged. As before, unemployment benefit payments are reduced by 5.96%, social transfer payments are reduced by 4.5%, income tax rates are reduced by 0.25 percentage points, corporate tax rates are reduced by 1.09 percentage points, and VAT rates are reduced by 0.26 percentage points.

Column (7) of Table 7 shows our results. The composite reduction of the automatic stabilizers increases the GDP volatility by 1.56%. Thus, an equivalent increase in the automatic stabilizer will decrease the GDP volatility by 1.56%, increase consumption volatility by 1.15%, and lower investment volatility by 5.21%. These results closely resemble the results from social transfers (shown in column (2)) in sign and magnitude, indicating that social transfers dominate the effect of the composite automatic stabilizer.

Throughout our analysis, we have assumed that government consumption expenditures can adjust in response to changes in government debt. Alternatively, we may want to exclude the contributions of government spending changes, if one were to believe that government spending is mostly determined arbitrarily from the standpoint of the business cycle. In Appendix A, we provided the results regarding the effect of the composite automatic stabilizer when keeping government consumption expenditures fixed at the steady state level. We determined that the volatility differences in variables such as GDP, consumption, and investment remain largely unchanged.

4.5. Less Responsive Monetary Policy

As shown, the effectiveness of automatic stabilizers in Korea is quite limited and works to reduce aggregate volatility by only a modest 1.56% for the composite automatic stabilizer. One possibility for the limited effectiveness of automatic stabilizers is due to the effective monetary policy. Because monetary policy also works to reduce business cycle volatility, effective monetary policy can mitigate the necessity of automatic stabilizers for business cycle purposes. Therefore, we explored the effects of monetary policy on the effectiveness of automatic stabilizers by studying the effect of the composite automatic stabilizer in an economy where the effectiveness of monetary policy is reduced.

As a small open economy, the base rate of the Bank of Korea has never reached the zero-lower-bound and the rate of 0.5% reached during the COVID-19 pandemic is the lowest rate in history. Therefore, instead of imposing the zero-lower-bound on the model, we studied an economy in which the responsiveness of the monetary policy to economic conditions is reduced to explore the potential effectiveness of automatic stabilizers when the monetary policy is constrained in Korea.

We can reduce the responsiveness of the monetary policy by adjusting the

parameter ϕ_p of the monetary policy rule shown in Equation (19). We lowered the value of ϕ_p from 1.48 of the main calibration to 1.35, which is the lowest value of ϕ_p that we can impose without violating the determinacy of the model. We studied the effect of the composite automatic stabilizer on the volatility of aggregate and fiscal variables by redoing the policy exercise in Section 4.4 in the economy with the less responsive monetary policy rule.

Column (8) of Table 7 shows the results. We determined that the effect of the composite automatic stabilizer on aggregate volatility is amplified in the economy with a less responsive monetary policy rule. The composite reduction of the automatic stabilizers in the economy with the alternative monetary policy rule increases the volatility of the GDP by 3.06%, indicating that the composite stabilizer lowers the volatility of the GDP by the same amount. The effect is almost double the size of that in Column (7). The composite stabilizer also reduces the volatility of investment and total effective labor by 8.32% and 1.62%, respectively, which is about 1.6 times the size of reduction in the baseline economy.

Monetary policy works by changing the real rate, which affects the aggregate demand through the intertemporal Euler equation. Automatic stabilizers work mostly by influencing the precautionary savings motive of households, which affects the wealth distribution and labor supply. Although each policy affects the economy through different channels, with effective monetary policy, the stabilization effect of automatic stabilizers is reduced due to complementarities between the volatility of investment in physical capital and the volatility of aggregate effective labor supply.

For comparison purposes, we also studied the direct effect of monetary policy responsiveness on aggregate volatility. We determined that the effect of monetary policy on aggregate volatility is large in comparison with the effect of automatic stabilizers. An adjustment in the responsiveness of monetary policy to the aggregate price level of 10% (by adjusting ϕ_p in Equation (19) from 1.48 to 1.35) results in the volatility of the GDP increasing by 3.4%. In comparison, we reduced the unemployment benefits parameter $\overline{T}^u$ from 16.4% to 10.4% and social transfers parameter $\overline{T}^s$ from 7.5% to 3%, which is a decrease of 37% and 60%, respectively. The progressivity of the income tax rate is assumed to be zero. Because we utilized the Reiter method, which uses linear approximation with respect to aggregate state variables for our computation, the effects of aggregate parameters on aggregate variables are likely to be proportional to the change in the aggregate parameter. Assuming that the effects scale linearly, this would indicate that a reduction in the parameters by similar proportions would imply that the effect of unemployment benefits on aggregate volatility is about 5.2% of the magnitude of the effect of monetary policy. The effect of social transfers and the progressivity of the income tax would be 19.6% and 27.4% in magnitude, respectively.

4.6. Welfare Effects

In this section, we studied the welfare effects of automatic stabilizers. Automatic stabilizers also take on the role of social insurance policies, in which their effect on social welfare is also of great interest. As unemployment benefits and social transfers are an important part of the composite automatic stabilization mechanism, the welfare effects of automatic stabilizers are likely to vary widely by household.

To analyze the effect of automatic stabilizers on household welfare, we compared the welfare of households before and after reducing the composite automatic stabilizer for the policy experiment in Section 4.4. We compared the households of the same employment status, productivity level, and wealth percentile in the two economies. We measured the effect of the composite automatic stabilizer on the welfare of households using consumption equivalence variation.

Table 8 shows our results. Negative values indicate that household welfare decreases as the composite automatic stabilizer is reduced, while positive values indicate that the household welfare increases. For example, long-term unemployed households with low s_l productivity levels in the 10th percentile of the wealth distribution experienced a decline in welfare, which is equivalent to a decrease in consumption of 12.35% from their consumption in the baseline economy, if the composite automatic stabilizer is reduced as in the policy experiment in Section 4.4.

Unemployed and long-term unemployed households with low wealth levels are heavily dependent on unemployment benefits or social transfers. Thus, a reduction in these payments may lower their welfare by a large amount. However, employed households with high wealth levels may actually find their welfare increase with reduced automatic stabilizers, as reduced tax rates increase their disposable income.

Because the welfare effect of automatic stabilizers is different across households, we must assume a social welfare function to calculate the effect of automatic stabilizers on total welfare. Assuming a utilitarian social welfare function (with equal Pareto weights for all households), we determined that the total welfare decreases by 0.2% when the composite automatic stabilizer is reduced. This indicates that the composite automatic stabilizer is currently working to improve total social welfare.

V. Conclusion

Using a New Keynesian model calibrated to simulate the Korean economy, we studied the effect of automatic stabilizers on reducing business cycle volatility. We found that reducing unemployment benefit payments by 5.96% would decrease the total expenditure by 0.2%, while the GDP increases output volatility by 0.24%. Because the standard deviation of GDP in Korea is approximately 1% at the

[Table 8] Welfare Cost of Impatient Households

		Wealth Percentile				
Employment	Productivity	10th	25th	50th	75th	90th
Employed	s_l	-1.92	-1.47	0.20	0.86	1.21
	s_m	-0.52	0.05	0.42	0.72	0.86
	s_h	0.11	0.27	0.49	0.84	0.70
Unemployed	s_l	-5.26	-4.33	-1.36	-0.09	0.12
	s_m	-2.49	-1.40	-0.60	-0.06	-0.22
	s_h	-1.41	0.79	-0.68	-0.25	0.03
Long-term unemployed	s_l	-12.35	-10.65	-4.87	-2.06	-0.88
	s_m	-10.73	-4.73	-2.19	-1.16	-0.72
	s_h	-6.07	-2.95	-1.53	-0.81	-0.57

Note: The values in this table indicated the change in welfare from a reduction in the composite automatic stabilizer measured in units of consumption. A negative value indicates that a reduction in the composite automatic stabilizer lowers the welfare of the household.

quarterly frequency, this indicated that the standard deviation of the GDP decreases by 0.002 percentage points due to unemployment benefits. Reducing social transfers by 4.5%, to the effect of lowering total expenditure by 0.2% of the GDP, increases the output volatility by 1.49%. Reducing income tax rates, corporate tax rates, and VAT rates may lower the volatility by 0.03%, 0.08%, and 0.03%, respectively.

The progressivity of the income tax has a relatively large effect on aggregate volatility. When we replaced the progressive tax with a revenue-neutral flat income tax, the volatility of GDP increases by 3.49%. This result depends heavily on the progressivity of the income tax faced by high income households. Our results differed from those from the U.S., wherein replacing the current income tax scheme with a flat tax has a negligible effect on business cycle volatility. In the U.S., marginal tax rates are relatively flat above the median household income, whereas in Korea, marginal rates increased, even for households in the top income quantile. Finally, a composite automatic stabilizer, in which we reduced the unemployment benefits, social transfers, and proportional tax rates, wherein the expenditure (or revenue) from each decreases by 0.2% of the GDP and increases the business cycle volatility of aggregate output by 1.56%.

Compared to comparable changes to monetary policy, the effects of automatic stabilizers on aggregate volatility are an order of magnitude smaller. Therefore, our results seem to indicate that the stabilization effect of automatic stabilizers seem to be small in Korea in both relative and absolute terms.

A Appendix

[Table 9] Composite automatic stabilizer with fixed government consumption

	Stabilization Effect
GDP	-1.57
consumption	0.88
consumption (top 20%)	-9.21
investment	-5.42
total effective labor	-0.99
effective labor of impatient households	-5.28
(effective) labor of patient households	-0.76
total labor hours	-4.46
income (top 20%)	-13.66
inflation	0.58
nominal interest rates	0.38
unemployment benefit payments	0.00
social transfers	0.00
income tax revenue	-15.60
corporate tax revenue	0.23
VAT tax revenue	0.88
total tax revenue	-2.46
government debt	-0.85

Note: The values in this table indicate the reduction in the standard deviation of each variable as a percent of its total volatility. A negative value implies that the mechanism reduces aggregate volatility.

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자동안정화장치는 한국의 경기변동성을 낮추는데 얼마나 효과적인가?

강 동 익* · 우 진 희**

초 록

본 연구는 한국 경제의 특성을 반영한 이질적 주체 뉴케인지언 모형을 활용하여 자동안정화장치가 경기안정화에 미치는 효과를 살펴보았다. 분석 결과, 실업급여 지출을 GDP 대비 0.2% 줄일 경우 GDP 변동성이 0.24% 증가하는 것으로 나타났다. 생계급여 지출을 같은 비중만큼 줄일 경우 GDP 변동성은 1.49% 증가하였으며, 소득세, 법인세, 그리고 부가가치세 세율을 각각의 세수가 GDP 대비 0.2% 감소하도록 낮춘 경우에는 GDP 변동성에 큰 변화가 없었다. 소득세율을 누진구조에서 단일세율로 대체할 경우 GDP 변동성은 3.49% 증가하였다. 마지막으로 실업급여 지출, 생계급여 지출, 소득세, 법인세, 부가가치세를 모두 동시에 감소시킨 결과 GDP 변동성은 1.56% 증가하였다. 이를 종합하여 볼 때, 한국 자동안정화장치의 경기안정화 효과는 크지 않은 것으로 보인다.

핵심 주제어: 자동안정화장치, 경기변동성, 재정정책

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