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The Effect of Heterogeneous Wage Contracts on Macroeconomic Volatility in a Financially Fragile Economy*

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I build a small open economy (SOE) dynamic stochastic general equilibrium (DSGE) model to investigate the effect of a heterogeneous wage contract between regular and temporary workers on a macroeconomic volatility in a financially fragile economy. The imperfect financial market condition is captured by a quadratic financial adjustment cost for borrowing foreign assets, and the labor market friction is captured by a Nash bargaining process which is only available to the regular workers when they negotiate their wages with the firms while the temporary workers are given their wage which simply equals the marginal cost. As a result of impulse responses to a domestic productivity shock, the higher elasticity of substitution between two types of workers and the lower weight on the regular workers in the firm's production process induce the higher volatilities in most variables. This is reasoned that the higher substitutability creates more volatile wage determination process while the lower share of the regular workers weakens their Nash bargaining power in the contract process.

Keywords: DSGE, Nash Bargaining Wage Contract, Labor Market Friction, Open Economy Macroeconomics, Financial Market Fragility
JEL classification: C68, E52, F41, G10

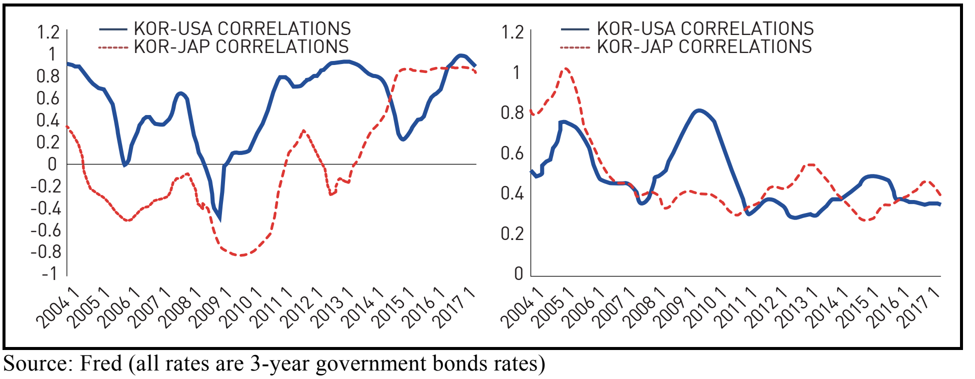
I. INTRODUCTION

During the last decade, while the imperfect financial integration condition for some developing countries has been relaxed, a relatively high level of economic volatility affected by foreign interest rates has been consistently suspected. Figure

* This paper is the developed version of the first chapter of my doctoral thesis, "Labor Market Friction, Imperfect Financial Market Integration and Optimal Monetary Policy for Developing Economies." Therefore, some sentences are exactly matched with the chapter. I appreciate for helpful comments from three anonymous referees. All errors are mine.

1 shows an example of Korean government bonds market, which connectedness to the markets of primary counterpart countries has been grown recently but the volatility of spreads between Korea and the others have been fluctuated at relatively high level compared to those of the countries within Eurozone, which volatilities converged to a very low level, as shown in ECB (2006). As a financial openness does not fully explain the effect of foreign interest rates on domestic fluctuations, an investigation on the other possible factors that affect the volatility in a country with this type of financial fragility should be studied.

Figure 1. Price-Based Indicators for Financial Integration of Korean Government Bonds Market

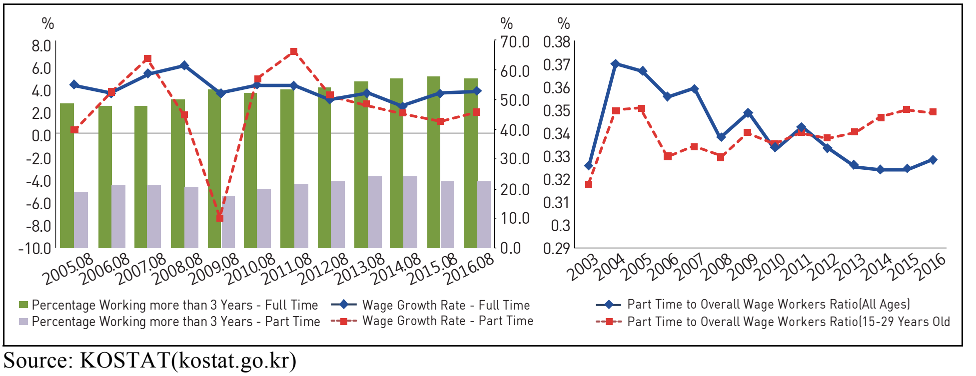


Source: Fred (all rates are 3-year government bonds rates)

In this paper, I build a dynamic stochastic general equilibrium (DSGE) model to investigate this issue. To do so, based on benchmark open economy New Keynesian assumptions such as monopolistic competition, price rigidity, and financial and commodity markets openness, which are based on the seminal benchmark models such as Gali and Monacelli (2005) or Gali (2008), a quadratic financial adjustment cost is additionally assumed as a default friction to capture the financial fragility. A linear quadratic form of the financial adjustment cost is widely used in the related literature because not only it easily guarantees a steady state condition but also a model with it generally fits the data well, especially recent trends in some developing economies with specific economic conditions. Here I adopt the form of Demirel (2009) and Demirel (2010) in which the form creates interest rate differentials between home and foreign countries.

To capture the main volatility driver in the model, a polarized labor market condition is assumed. During the last decade, the labor market inequality between full-time and part-time workers in Korea in terms of duration of work and wage level has been widened. The left-side of Figure 2 shows that wage fluctuations of part-time workers have been more volatile than full-time workers', and the gap between possibilities of working for longer term for the two types of workers has never been narrowed. Moreover, the right side of Figure 2 represents that the portion of part-time workers has been increased in the younger group while the portion in the overall ages has been decreased. These simple statistics implies that as growing portion of young part-time workers suffers uncertainty on their job security, wage level, or expectation of future incomes, and experiences less wage bargaining power. This phenomenon can also possibly affect the macroeconomic fluctuations by increasing overall uncertainty for longer terms and thus distracting the present level of consumptions of some households. In order to investigate the effect of this type of labor friction on economic volatility, I adopt a heterogeneous wage contracts assumption developed by Mattesini and Rossi (2009) and Matsui and Yoshimi (2015). In these papers, one type of workers is given totally flexible wage where the marginal utility of labor equals marginal disutility of it, while the other group of workers has a Nash-bargaining power which makes different wage dynamics between those two groups.

Figure 2. Korean Labor Market Conditions: Full-time vs. Part-time



Source: KOSTAT(kostat.go.kr)

The main results of this paper are twofold. First, the higher elasticity of substitution between two types of workers induces the higher volatilities in most macroeconomic variables in the impulse responses to the domestic productivity shock. This is because the substitutability plays an important role in wage dynamics in the model, especially by increasing a labor elasticity of Nash bargaining power for the regular workers and thus making a wage determination process of both workers more volatile. Second, the lower weight on the regular workers in the firm's production process also increases the macroeconomic fluctuations. This is because the lower share of regular workers has the same effect with the lower Nash bargaining power for that type of workers, hence the contract position of the workers is weaken, which ultimately induces the more unstable economic condition.

The main contribution of this paper is that it introduces a friction to the labor market in the DSGE model by inviting an inequality between regular and temporary workers to explain the recent trend in the business cycles of specific type of economy. Many economists view developing economies as financially fragile. However, these regions also have a high level of misallocation of labor demand or, at least, have a relatively weak wage bargaining power of high portion of workers, namely a temporary worker. As low level of macroeconomic growth has been globally sustained for a decade after 2008 financial crisis, quality of labor market in some developing economies has been worsened. This paper captures a part of this trend by introducing part-time workers' different wage bargaining power which affects dynamic equilibrium conditions and overall economic sensitivities to exogenous shocks. By doing this, despite some technical limitations, the paper explains that this type of labor market friction can partially explain the sustained volatility in a financially fragile economy.

The remainder of the paper is organized as follows. The second section explains the theoretical DSGE model in detail. This section also qualitatively analyzes the effect of the assumed frictions on the business cycle of the economy. The third section explains the parameter values used in the quantitative analysis and notes the impulse responses of the system of equilibrium equations to various types of exogenous shocks. Finally, the fourth section concludes the paper.

II. MODEL

The theoretical analysis of the combined effect of labor market friction and financial market fragility on the business cycles and monetary policy decisions begins by building a small open economy DSGE model. Here, I follow Gali and Monacelli (2005) and Gali (2008) as benchmark frameworks for the New Keynesian open economy model. Based on these baseline models, I adopt a quadratic financial adjustment cost to create imperfect financial market accessibility for a domestic country. In addition I use interest rate differentials between the home and world economies to replicate the foreign bond holdings in the small open economy, following the works of Schmitt-Grohe and Uribe (2003) and Demirel (2010). In this setting, while a foreign country has no additional cost to access the foreign currency denominated bonds, the home country pays an additional cost to hold a certain amount of foreign assets. Additionally, I add two more assumptions for an asymmetric small open economy case. First, home and foreign countries have different size economies. The economic impact of the home country is assumed to be negligible compared to that of the world economy. Therefore, the home country is given the foreign output, consumption, and prices. This assumption makes it possible to observe the response of a domestic business cycle to exogenous foreign demand and monetary shocks. Second, domestic households can access both home and foreign currency denominated asset markets, but foreign agents can only access the foreign asset market. This is because the size of the domestic financial market is too small to be significant to the dynamics of the international financial markets. Along with these unique assumptions, I include monopolistic competition and a sticky prices framework, following Calvo (1983) and Yun (1996) to create money non-neutrality and to allow a monetary policy to stabilize economic volatility. Furthermore, the law of one price and purchasing power parity hold. Lastly, this model assumes a cashless economy, following Woodford (2003) because holding cash in a utility function does not offer any improvement to the real side of the economy and, thus, becomes a useless assumption.

1. Households

Let us consider two connected economies, Home (H) and Foreign (F) countries, which are separately populated with a continuum of agents, and the total population is normalized to one. Home and foreign consumers share the same form of utility function and maximize this utility function given a country-specific budget constraint. The utility function of a representative home agent is given by

$$U(C_t, L_t) \equiv E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{(L_{G,t} + L_{M,t})^{1+\varphi}}{1+\varphi} \right) \tag{1}$$

where C_t refers to the aggregate consumption level at time t, β is a time discounting factor, $\sigma \geq 0$ is the intertemporal elasticity of substitution in private consumption, and $\varphi \geq 0$ is the inverse of the elasticity of labor supply.[1] In their case, $1/\varphi$ can be interpreted as a Frisch labor supply elasticity, which explains the substitution effect with respect to the change of wage rate. $L_{G,t}$ is the number of hours worked by full-time, or regular workers, and $L_{M,t}$ is the number of hours worked by part-time, or temporary workers. Furthermore, the regular and temporary workers are aggregated such as

$$L_{G,t} = \int_0^1 L_{G,t}(j)dj$$
$$L_{M,t} = \int_0^1 L_{M,t}(j)dj \qquad (2)$$

where $j \in [0,1]$ denotes the variety of goods. The domestic aggregate consumption level, C_t consists of two parts, namely consumption for home and foreign final goods, and is defined by

$$C_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} (C_{H,t})^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} (C_{F,t})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \qquad (3)$$

where $\alpha \in [0,1]$ captures the degree of openness to foreign consumption by domestic households, which inversely denotes a home bias preference, and $\eta \geq 1$ is an index of <u>intratemporal</u> elasticity of substitution between home and foreign final goods. Here, $C_{H,t}$ is an index of domestic goods, using the constant elasticity of substitution functional form

[1] This elasticity is discussed in detail in Christiano et al. (2010)

$$C_{H,t} \equiv \left(\int_0^1 C_{H,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

where $\varepsilon \geq 1$ represents the elasticity of substitution among varieties. Then, $C_{F,t}$ is an index of foreign produced (imported) goods, defined by

$$C_{F,t} \equiv \left(\int_0^1 C_{F,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

Note that ε is common across the consumption of home and foreign goods. This is quite a strong assumption, but since it does not weaken any part of the main argument of this study, I accept it for the sake of simplicity. An aggregate consumption index for a foreign representative household can be similarly defined using an asterisk:

$$C_t^* \equiv \left[(\alpha^*)^{\frac{1}{\eta}} (C_{H,t}^*)^{\frac{\eta-1}{\eta}} + (1-\alpha^*)^{\frac{1}{\eta}} (C_{F,t}^*)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{4}$$

where $\alpha^* \in [0,1]$ represents the degree of openness to goods produced in the home country, satisfying $\alpha^* = \alpha$, meaning both home and foreign countries have the same degree of openness to each other. Then, $C_{H,t}^*$ and $C_{F,t}^*$ are defined as the amount of consumption by foreign households for goods produced in the home and foreign countries, respectively. Next, price indexes for the commodity markets in the home and foreign countries, based on the above preferences and aggregate consumption indexes, are given by

$$P_t \equiv \left[(1-\alpha) P_{H,t}{}^{1-\eta} + \alpha P_{F,t}{}^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{5}$$

and

$$P_t^* \equiv \left[\alpha P_{H,t}^{*\ 1-\eta} + (1-\alpha) P_{F,t}^{*\ 1-\eta}\right]^{\frac{1}{1-\eta}} \tag{6}$$

respectively. Here, P_t and P_t^* are the home and foreign consumer price indexes (CPI) and $P_{H,t}$ and $P_{F,t}$ are sub-indexes for the home and foreign produced goods consumed in the home country, respectively. Then, $P_{H,t}^*$ and $P_{F,t}^*$ are interpreted as the price indexes of home and foreign produced goods, respectively, expressed in the foreign currency. Each of the four sub-price indexes are expressed by an aggregation, as follows:

$$\begin{aligned} P_{H,t} &= \left(\int_0^1 P_{H,t}(j)^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}}, \qquad P_{F,t} = \left(\int_0^1 P_{F,t}(j)^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}}, \\ P_{H,t}^* &= \left(\int_0^1 P_{H,t}^*(j)^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}}, \qquad P_{F,t}^* = \left(\int_0^1 P_{F,t}^*(j)^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}} \end{aligned} \tag{7}$$

Using the above aggregations, we can solve for the optimal allocation of demand for varieties of goods in the home country:

$$C_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon} C_{H,t}; \qquad C_{F,t}(j) = \left(\frac{P_{F,t}(j)}{P_{F,t}}\right)^{-\varepsilon} C_{F,t} \tag{8}$$

Next, the aggregate total expenditure for the home and foreign goods follow directly from (8):

$$\int_0^1 P_{H,t}(j) C_{H,t}(j) dj = P_{H,t} C_{H,t}; \qquad \int_0^1 P_{F,t}(j) C_{F,t}(j) dj = P_{F,t} C_{F,t} \tag{9}$$

Now, the optimal allocations of expenditure for home and foreign goods are given by:

$$C_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t; \qquad C_{F,t} = \alpha\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t \tag{10}$$

Equation (10) completes the description of optimal expenditure allocations for the intra-temporal equilibrium of home households. The optimal allocation of foreign households consumption can be similarly derived, denoted using an asterisk.

Next, to explore the intertemporal equilibrium of a representative household, we need to define a budget constraint for the agent. Using equation (9) and the total aggregate consumption expenditure of the home agent, $P_{H,t}C_{H,t} + P_{F,t}C_{F,t} = P_t C_t$, the budget constraint of the households is given by

$$P_t C_t + B_{H,t} + \mathcal{E}_t B_{F,t} + \leq R_{t-1} B_{H,t-1} + \mathcal{E}_t R^*_{t-1} B_{F,t-1} + \int_0^1 W_{G,t} L_{G,t}(j)dj + \int_0^1 W_{M,t} L_{M,t}(j)dj + T_t + \mathcal{E}_t \frac{\Psi_B}{2}(B_{F,t} - B_F)^2 + \int_0^1 \Gamma_t(j)dj \tag{11}$$

where $B_{H,t}$ and $B_{F,t}$ are the home and foreign currency denominated bonds, respectively, $\mathcal{E}_t$ denotes the nominal exchange rate between the home and foreign currency (relative price of foreign currency in terms of home currency), R_t and R_t^* are the nominal interest rates in the home and foreign countries, respectively, $W_{G,t}$ and $W_{M,t}$ are nominal wages of full-time and part-time workers, B_F is the steady-state value of the foreign currency denominated bonds, T_t is a lump-sum tax or transfer governed by a fiscal authority, and $\Gamma_t(j)$ represents the profit of firm j. Then, $\frac{\Psi_B}{2}(B_{F,t} - B_F)^2$ is a quadratic financial adjustment cost for the domestic household, and the cost is assumed to be a non-zero, positive value when the current foreign bond holding is different to the steady-state value. Furthermore, Ψ_B is a constant parameter value defined by the degree of the adjustment cost for international borrowing, and captures how the domestic financial market is isolated from the world financial market. For instance, holding the same amount in foreign bonds, the higher adjustment cost associated with Ψ_B means less perfectly integrated financial markets, or that it is more difficult for the domestic households to access the international financial market. Therefore, Ψ_B functions as an inverse financial integration indicator. If Ψ_B approaches zero, or at the steady state, $B_{F,t}$ is equal to B_t, the domestic economy is assumed to have no financial friction, and the financial markets will be perfectly integrated. This quadratic intermediation cost function delivers an additional cost to domestic households buying foreign assets, and creates an interest rate differential between the home and world economies. This is a main contributor to the amount of foreign bond holdings in the home economy, as well as to changes in the marginal cost structure uniquely built in this model. Note that this type of cost is only associated with the home country agent, since the size of domestic financial market is assumed to be negligible to the foreign (world) economy, based on the small open economy assumption. The negligible size of home economy guarantees the usage of the quadratic form of the cost, and the lack of asymmetry in asset positions between creditor and debtor can be ignored without any significant harm to the logic. Therefore, the foreign representative household faces a different budget constraint:

$$P_t^* C_t^* + B_{F,t} \leq R_t^* B_{F,t-1} + W_t^* L_t^* + T_t^* + \int_0^1 \Gamma_t^*(j)dj \qquad (12)$$

While the domestic agent enjoys two different type of assets and can use international risk pooling, the foreign agent is only able to access the foreign currency denominated bonds. This is the result of the assumption that captures the reality of a small open economy, in which the size of the home financial market is negligible relative to world financial market. Thus, the world's demand for the home asset can be ignored. Furthermore, there is no division in world labor force because it is useless assumption in this analysis.

The first-order conditions necessary for equilibrium are given by

$$\frac{W_t^*}{P_t^*} = L_t^{*\varphi} C_t^{*\sigma} \qquad (13)$$

$$1 = \beta E_t \left[\frac{R_t^*}{(1+\Psi_B(B_{F,t} - B_F))} \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \right) \left(\frac{P_t}{P_{t+1}} \right) \right] \qquad (14)$$

$$1 = \beta E_t \left[R_t \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right] \qquad (15)$$

$$1 = \beta E_t \left[R_t^* \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\sigma} \left(\frac{P_t^*}{P_{t+1}^*} \right) \right] \tag{16}$$

where E_t is an expectation operator at time t. Equation (13) is interpreted as a labor supply or a real wage determination for the foreign country. Equation (14) is a home household's Euler equation for the optimal choice of foreign currency denominated bonds, corresponding to equation (16), which is a foreign agent's Euler equation for the optimal foreign bonds asset position. Equation (15) states a home household's Euler equation for the optimal level of home currency denominated bonds. Note that, from equation (14), in the limiting case in which Ψ_b approaches zero, the Euler equation replicates a frictionless benchmark version. Using the relationship between the overall price levels in the home and foreign countries, $P_t = \mathcal{E}_t P_t^*$, (16) can be rewritten in terms of the stream of the home country price level and the nominal exchange rate:

$$1 = \beta E_t \left[R_t^* \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\sigma} \left(\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \right) \left(\frac{P_t}{P_{t+1}} \right) \right] \tag{17}$$

2. Uncovered Interest Rate Parity, International Risk Sharing, and Terms of Trade

In this subsection, I derive several relations from the previously determined optimal conditions of households, as well as some international macroeconomic definitions. First, from equations (14) and (15), I find the relationship between two different nominal interest rates:

$$1 = E_t \left[\left(\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \right) \left(\frac{R_t^*}{R_t} \right) \frac{1}{1 + \Psi_B (B_{F,t} - B_F)} \right] \tag{18}$$

which is a modified version of an uncovered interest rate parity in a frictional case. According to (18), the difference between home and foreign nominal interest rates is determined by the change of the nominal exchange rate, the foreign bond holding differential, and the degree of the financial adjustment cost. This frictional parity generates a different level of international risk premium from that of the benchmark. More specifically, the difference between the home and foreign nominal interest rate ($R_t - R_t^*$) will widen if the change in the nominal exchange rate increases or the effect of the financial adjustment cost gets smaller. This means that the partial integration of the financial markets can change the gap between the two interest rates.

Next, let us define the real exchange rate between the home and foreign currencies as the ratio of the two countries' overall price levels, in which both currencies are denominated domestically,

$$\mathcal{Q}_t \equiv \mathcal{E}_t \frac{P_t^*}{P_t} \tag{19}$$

Then combining (14) and (16) gives the relation between the consumption levels of the home and foreign countries in terms of the real exchange rates and the financial adjustment cost for foreign bond holdings:

$$1 = E_t\left[\left(\frac{\mathcal{Q}_{t+1}}{\mathcal{Q}_t}\right)\left(\frac{C_t^*}{C_t}\right)^{-\sigma}\left(\frac{C_{t+1}}{C_{t+1}^*}\right)^{-\sigma}\frac{1}{1+\Psi_B(B_{F,t}-B_F)}\right] \tag{20}$$

According to (20), the adjustment cost for holding foreign assets becomes a factor that partly determines the difference between the changes in consumption of the home and foreign countries. This means that, if $B_{F,t} > B_F$ the positive effect of Ψ_B on the difference in foreign bond holdings differential widens the gap between home and foreign consumption. As one of the internationally linked markets becomes more separated, the co-movement of the consumption in both countries would weaken.

Terms of trade is defined as the ratio of the price of imported goods to that of home-produced goods,

$$\mathcal{S}_t = \frac{P_{F,t}}{P_{H,t}} \tag{21}$$

In a special case where η is close to unity, the following relation holds:

$$P_t = P_{H,t}^{(1-\alpha)} \cdot P_{F,t}^{\alpha} = P_{H,t} \cdot \mathcal{S}_t^{\alpha} \tag{22}$$

Furthermore, defining an inflation rate from term t to $t+1$ by $\Pi_t \equiv \frac{P_{t+1}}{P_t}$, the following equation holds:

$$\Pi_t = \Pi_{H,t} \cdot \Delta\mathcal{S}_t^{\alpha} \tag{23}$$

where $\Delta X_t \equiv \frac{X_t}{X_{t-1}}$, for any arbitrary variable X, Assuming the law of one price, $P_{F,t} = \mathcal{E}_t P_t^*$, holds, and combining (20) and (22), one can find the relation between the real exchange rate and the terms of trade:

$$\mathcal{Q}_t = \mathcal{S}_t^{(1-\alpha)} \tag{24}$$

Therefore, the international risk-sharing condition (21) can be reorganized in terms of the terms of trade:

$$\begin{aligned} 1 &= E_t\left[\left(\frac{\mathcal{S}_{t+1}}{\mathcal{S}_t}\right)^{(1-\alpha)}\left(\frac{C_t^*}{C_t}\right)^{-\sigma}\left(\frac{C_{t+1}}{C_{t+1}^*}\right)^{-\sigma}\frac{1}{1+\Psi_B(B_{F,t}-B_F)}\right] \\ &= E_t\left[\left(\Delta\mathcal{S}_{t+1}\right)^{(1-\alpha)}\left(\frac{\Delta C_{t+1}}{\Delta C_{t+1}^*}\right)^{-\sigma}\frac{1}{1+\Psi_B(B_{F,t}-B_F)}\right] \end{aligned} \tag{25}$$

According to (25), intertemporal consumption smoothing differences across the two countries can be determined by the change in terms of trade, the commodity market openness, and the level of home country-specific financial adjustment cost. Specifically, the gap between the current amount of foreign bond holdings and the steady-state level of the bond holdings changes the positive effect of the terms of trade on the international consumption spread differences. For instance, as the financial gap increases (increasing $(B_{F,t} - B_F)$ and the value is positive) or the degree of financial inaccessibility worsens (increasing Ψ_B), the positive effect of the increasing $\Delta\mathcal{S}_{t+1}$ on the level of gap between ΔC_{t+1} and ΔC^*_{t+1} is alleviated.

Lastly, for the convenience of later analysis, (18) can be rewritten in terms of the real exchange rate or the terms of trade:

$$\begin{aligned} 1 &= E_t\left[\left(\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}\right)\left(\frac{R_t^*}{R_t}\right)\frac{1}{1+\Psi_B(B_{F,t}-B_F)}\right] \\ &= E_t\left[\left(\frac{\mathcal{Q}_{t+1}}{\mathcal{Q}_t}\right)\left(\frac{P_t}{P_{t+1}}\right)\left(\frac{R_t^*}{R_t}\right)\frac{1}{1+\Psi_B(B_{F,t}-B_F)}\right] \\ &= E_t\left[\left(\Delta\mathcal{S}_{t+1}\right)^{(1-\alpha)}\left(\Pi_{t+1}\right)^{-1}\left(\frac{R_t^*}{R_t}\right)\frac{1}{1+\Psi_B(B_{F,t}-B_F)}\right] \end{aligned} \tag{26}$$

The second equality uses the law of one price and the additional assumption that the foreign overall price, P_t^* is normalized to 1. The third equality follows directly from (24)

3. Producers

I adopt the model of Matsui and Yoshimi (2015) that specifies joint employment of unionized and non-unionized workers in firms' production function. Suppose that each home country firm j uses two types of labor inputs to operate the identical production technology,

$$Y_t(j) = A_t L_t(j) \tag{27}$$

where $Y_t(j)$ is the output level of firm j, A_t is the exogenous total factor productivity following an AR(1) stochastic process. $L_t(j)$ is an aggregation of the two types of workers following CES fashion,

$$L_t(j)=\left[\omega\left\{L_{G,t}(j)\right\}^{\vartheta}+(1-\omega)\left\{L_{M,t}(j)\right\}^{\vartheta}\right]^{\frac{1}{\vartheta}} \tag{28}$$

where ω represents the weight on the regular workers in the firm's production, and $\frac{1}{1-\vartheta}$ means the elasticity of substitution between the regular and temporary workers. The demand function for two types of labor inputs are derived by

$$\begin{aligned} L_{G,t}(j)&=\left(\frac{1}{\omega}\frac{W_{G,t}}{W_t(j)}\right)^{\frac{1}{\vartheta-1}}L_t(j)\\ L_{M,t}(j)&=\left(\frac{1}{1-\omega}\frac{W_{M,t}}{W_t(j)}\right)^{\frac{1}{\vartheta-1}}L_t(j)\end{aligned} \tag{29}$$

where the wage index of the overall group of workers is defined by

$$W_t(j)=\left[\omega^{\frac{1}{1-\vartheta}}\left\{W_{G,t}(j)\right\}^{\frac{\vartheta}{\vartheta-1}}+(1-\omega)^{\frac{1}{1-\vartheta}}\left\{W_{M,t}(j)\right\}^{\frac{\vartheta}{\vartheta-1}}\right]^{\frac{\vartheta-1}{\vartheta}} \tag{30}$$

The marginal cost of each firm j is

$$MC_t(j)=W_t(j) \tag{31}$$

Following Mattesini and Rossi (2009) and Matusi and Yoshimi (2015), I assume there are different wage bargaining powers between two types of labor force groups. The temporary workers are given their real wages where the marginal utility of labor input and the marginal cost of the input equal,

$$\frac{W_{M,t}}{P_t} = (L_{G,t} + L_{M,t})^{\varphi} C_t^{\sigma} \tag{32}$$

Denotation j can be dropped because each firm pays an identical level of wages to the temporary workers. Contrary to the temporary workers, the regular workers have a negotiating power on their wages with the firms. The wage contract of firm j is processed following a simple Nash bargaining objective function,

$$\mathrm{N}_t(j) = [\xi(j)]^{\zeta} [\Gamma_t(j)]^{1-\zeta} \tag{33}$$

where the objective function of the regular workers is defined by,

$$\xi(j) = (W_{G,t}(j) - W_{M,t}) \cdot L_{G,t}(j) \tag{34}$$

and ζ denotes the degree of bargaining power of the regular workers. Equation (33) and (34) mean that the regular workers use their bargaining power to obtain net gains from firm j's profit, which is derived by

$$\Gamma_t(j) = [P_t(j) - MC_t(j)] \cdot Y_t(j) \tag{35}$$

The first order condition of the regular workers' maximizing problem is derived by

$$\zeta \left[\frac{\xi_t(j)}{\Gamma_t(j)} \right]^{\zeta - 1} \frac{\partial \xi_t(j)}{\partial W_{G,t}(j)} + (1-\zeta) \left[\frac{\xi_t(j)}{\Gamma_t(j)} \right]^{\zeta} \frac{\partial \Gamma_t(j)}{\partial W_{G,t}(j)} = 0 \tag{36}$$

Using (34), the relation between two different wages are derived by

$$\frac{W_{G,t}(j) - W_{M,t}}{W_{G,t}(j)} = \frac{\zeta}{\zeta V_t^{l}(j) + (1-\zeta) V_t^{\Gamma}(j)} \tag{37}$$

where

$$V_t^l(j) = \frac{\partial L_{G,t}(j)/L_{G,t}(j)}{\partial W_{G,t}(j)/W_{G,t}(j)}$$
$$V_t^\Gamma(j) = \frac{\partial \Gamma_t(j)/\Gamma_t(j)}{\partial W_{G,t}(j)/W_{G,t}(j)} \tag{38}$$

The first equation of (38) is the labor elasticity of the Nash bargaining wage and the second one is the production elasticity of the Nash bargaining wage. Following Matsui and Yoshimi (2015) it is natural to assume that both elasticities are positive values.

Next, following Calvo (1983) and Yun (1996) , the model assumes a staggered price setting. A randomly selected portion of producers, $(1-\theta)$, set a new price level at each period, while the remaining firms, θ , keep their price level as it was in the previous period. Therefore, θ captures the degree of price rigidity. Let $\overline{P_{H,t}(j)}$ be the optimal price set by firm j at time t. With the staggered price setting described above, $P_{H,t+k}(j) = \overline{P_{H,t}(j)}$. Then, the problem faced by a typical firm, j , is given by

$$Max_{\overline{P_{H,t}}} E_t \sum_{k=0}^{\infty} \theta^k E_t \left[\Lambda_{t,t+k} \{ Y_{t,t+k} \left(\overline{P_{H,t}} - \lambda_{t+k} \right) \} \right] \tag{39}$$

subject to the international demand constraints,

$$Y_{t,t+k}(j) \le \left(\frac{\overline{P_{H,t}}}{P_{H,t+k}} \right)^{-\varepsilon} \left(C_{H,t+k} + C^*_{H,t+k} \right) \equiv Y^d_{t+k}(\overline{P_{H,t}}) \tag{40}$$

where $\Lambda_{t,t+k} \equiv \beta^k \left(\frac{C_{t+k}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+l}} \right)$ and λ_{t+k} denotes the nominal marginal cost at period $t+k$ with respect to the staggered price setting, $\overline{P_{H,t}}$, and is determined by the previously derived real wage equation. Note that firm specific index j can be dropped in this problem as well, because all firms use the same price setting, subject to the same marginal cost and the same resource constraint. Furthermore, note that this problem is identical to the price setting of Gali and Monacelli (2005), with the exception of the nominal marginal cost structure. The first-order condition yields

$$\sum_{k=0}^{\infty}\theta^k E_t\left[\Lambda_{t,t+k}Y_{t,t+k}\left(\overline{P_{H,t}}-\frac{\varepsilon}{\varepsilon-1}\lambda_{t+k}\right)\right]=0 \tag{41}$$

Note that in the perfect flexible price setting, $\theta=0$, the above equation reproduces $P_{H,t}=\frac{\varepsilon}{\varepsilon-1}\lambda_t$. This can be rearranged using stationary variables, as follows:

$$\sum_{k=0}^{\infty}(\theta\beta)^k E_t\left[C_{t+k}{}^{-\sigma}Y_{t,t+k}\frac{\overline{P_{H,t}}}{P_{t+k}}\left(\frac{\overline{P_{H,t}}}{P_{H,t-1}}-\frac{\varepsilon}{\varepsilon-1}\frac{P_{H,t+k}}{P_{H,t-1}}MC_{t+k}\right)\right]=0 \tag{42}$$

where MC_{t+k} is the real marginal cost at time $t+k$, as shown above, and is equal to $\frac{\lambda_{t+k}}{P_{H,t+k}}$. One can now define the new price index of domestically produced goods under the staggered price setting,

$$P_{H,t}=\left[\theta P_{H,t-1}{}^{1-\varepsilon}+(1-\theta)(\overline{P_{H,t}})^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}\leftrightarrow\frac{P_{H,t}}{P_{H,t-1}}=\left[\theta+(1-\theta)\left(\frac{\overline{P_{H,t}}}{P_{H,t-1}}\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \tag{43}$$

4. Monetary Authority

A fiscal authority organizes a lump-sum tax or transfer. A monetary authority sets the level of the nominal interest rate, following a form of the traditional Taylor rule. The nominal interest rate rule is given by

$$R_t = \left(\frac{P_{H,t}}{P_{t-1}}\right)^{\mu_\pi} \left(\frac{Y_t}{\bar{Y}}\right)^{\mu_y} (\bar{R})(Z_t)$$
$$= \left(\Pi_{H,t}\right)^{\mu_\pi} \left(\frac{Y_t}{\bar{Y}}\right)^{\mu_y} (\bar{R})(Z_t) \tag{44}$$

where μ_π and μ_y are policy parameters, weighted by domestic inflation and output changes, respectively. Then, μ_y and $\bar{R}$ are the output and nominal interest rate steady-state values, respectively, and Z_t is an exogenous monetary policy shock, which follows an AR(1) stochastic process.

5. Aggregations, Market Clearing Conditions, and Competitive Equilibrium

The aggregate level of output in the home country is

$$Y_t = \left[\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{45}$$

And the equilibrium condition for each good and labor match-up induces

$$Y_t = A_t L_t \tag{46}$$

The market clearing condition for each differentiated home final good, j, is given by

$$Y_t(j) = C_{H,t}(j) + C^*_{H,t}(j) \tag{47}$$

The world market clearing condition is given by

$$Y^*_t = C^*_t \tag{48}$$

The world output follows an AR(1) stochastic process which information is provided in detail in the next section. Therefore, it is exogenously given to the home country agents since the demand for world output from the home economy is assumed to be negligible. The home currency denominated bond market is cleared such that

$$B_{H,t} = 0 \tag{49}$$

And the world bond market is automatically cleared by Walras' law. The home-produced goods market clearing condition (47) can be rewritten as

$$\begin{aligned} Y_t(j) &= \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon} C_{H,t} + \left(\frac{P^*_{H,t}(j)}{P^*_{H,t}}\right)^{-\varepsilon} C^*_{H,t} \\ &= \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon} (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t + \left(\frac{P^*_{H,t}(j)}{P^*_{H,t}}\right)^{-\varepsilon} (\alpha)\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\eta} C^*_t \\ &= \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\varepsilon} \left[(1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t + \alpha\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\eta} C^*_t\right] \end{aligned} \tag{50}$$

Substituting (50) into (45) gives

$$\begin{aligned} Y_t &= (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t + \alpha\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\eta} C^*_t = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t + \alpha\left(\frac{P_{H,t}}{P_t Q_t}\right)^{-\eta} C^*_t \\ &= \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} \left[(1-\alpha)C_t + \alpha\left(Q_t\right)^{\eta} C^*_t\right] \end{aligned} \tag{51}$$

The law of one price and the definition of the real exchange rate are used in the second step of the above calculation. The above national account states that the overall supply of the domestic output should be equal to the demand from both home and foreign consumers, which depend on the commodity market openness and the price levels of the home country. Furthermore, for the convenience of later discussion, (51) can be rewritten in terms of price levels, private consumption, exogenous foreign demand, and terms of trade:

$$Y_t = \left(S_t\right)^{-\eta\alpha}\left[(1-\alpha)C_t + \alpha\left(S_t\right)^{\eta(1-\alpha)} C_t^*\right] \tag{52}$$

Note that as α converges to zero, which means the home economy becomes an autarky condition, (51) and (52) converge to the benchmark commodity market clearing condition, $Y_t = C_t$.

Since all workers are assumed to move across firms freely, the Nash bargaining wages are identical across firms,

$$W_{G,t}(j) = W_{G,t} \tag{53}$$

Therefore, overall wages and marginal cost can be also identical:

$$\begin{aligned} V_t^l(j) &= V_t^l \\ V_t^\Gamma(j) &= V_t^\Gamma \\ W_t(j) &= W_t \\ MC_t(j) &= MC_t \end{aligned} \tag{54}$$

Combined with (28) and (29), labor demand functions for each group of workers are derived by

$$\begin{aligned} L_{G,t} &= \left(\frac{1}{\omega}\frac{W_{G,t}}{W_t}\right)^{\frac{1}{\vartheta-1}} Y_t \cdot \int_0^1 \left(\frac{P_t(j)}{P_t}\right)^{\varepsilon} dj \\ L_{M,t} &= \left(\frac{1}{1-\omega}\frac{W_{M,t}}{W_t}\right)^{\frac{1}{\vartheta-1}} Y_t \cdot \int_0^1 \left(\frac{P_t(j)}{P_t}\right)^{\varepsilon} dj \end{aligned} \tag{55}$$

Four exogenous variables are defined here:

$$\begin{aligned}\log A_t &= \rho_A \log A_{t-1} + \epsilon_A^2 \\ \log Z_t &= \rho_Z \log Z_{t-1} + \epsilon_Z^2 \\ \log Y_t^* &= \rho_Y \log Y_{t-1}^* + \epsilon_Y^2 \\ \log R_t^* &= \rho_A \log R_{t-1}^* + \epsilon_R^2\end{aligned} \tag{56}$$

A competitive equilibrium is defined by a stream of endogenous variables, $\{C_t, Y_t, L_t, L_{G,t}, L_{M,t}, B_{F,t}, B_t, W_t, W_{G,t}, W_{M,t}, R_t, MC_t, \Pi_t, \Pi_{H,t}, S_t, V_t^l, V_t^\Gamma, P_t\}_{t=0}^{\infty}$ with five exogenous variables, $\{A_t, Z_t, Y_t^*, R_t^*, C_t^*\}_{t=0}^{\infty}$, which solves (14), (23), (25), (26), (28), (30), (32), (37), (38), (43), (44), (46), (48), (52), (54), (55), (56), and the relation between inflation and price level, $\Pi_t = \dfrac{P_t}{P_{t-1}}$.

6. Linearized System of Equations

To make the problem feasible, the first order conditions for the optimal allocation equilibrium described in the previous subsection are log-linearized. For any arbitrary variable X_t, the log-linearized variable is denoted by x_t, such as $x_t \equiv \dfrac{X_t - X}{X}$.

$$0 = (1-\alpha)E_t\left[s_{t+1} - s_t\right] - \sigma E_t\left[c_{t+1} - c_t\right] + \sigma E_t\left[c_{t+1}^* - c_t^*\right] - B_F \Psi_B b_{F,t} \tag{57}$$

$$\pi_t = \pi_{H,t} + \alpha E_t(s_{t+1} - s_t) \tag{58}$$

$$0 = (1-\alpha)E_t\left[s_{t+1} - s_t\right] - \sigma E_t\left[c_{t+1} - c_t\right] + \sigma E_t\left[c_{t+1}^* - c_t^*\right] - B_F \Psi_B b_{F,t} \tag{59}$$

$$0 = (1-\alpha)E_t\left[s_{t+1} - s_t\right] - E_t\left[\pi_{t+1}\right] + r_t^* - r_t + B_F \Psi_B b_{F,t} \tag{60}$$

$$l_t = \frac{1}{\vartheta}\left[l_{G,t} \cdot \gamma_G + l_{M,t}\gamma_M \right] \tag{61}$$

$$w_t = \omega^{\frac{1}{1-\vartheta}} \left[\frac{W_G}{W} \right]^{\frac{\vartheta}{\vartheta-1}} w_{G,t} + (1-\omega)^{\frac{1}{1-\vartheta}} \left[\frac{W_M}{W} \right]^{\frac{\vartheta}{\vartheta-1}} w_{M,t} \tag{62}$$

$$w_{M,t} - p_t = \varphi\left(\frac{L_G}{L_G + L_M} \right) l_{G,t} + \varphi\left(\frac{L_M}{L_G + L_M} \right) l_{M,t} + \sigma c_t \tag{63}$$

$$\frac{W_G}{W_M}(w_{G,t} - w_{M,t}) = \frac{\zeta}{(\zeta V^l + (1-\zeta)V^\Gamma)^2}\left[\zeta V^l v_t^l + (1-\zeta)V^\Gamma v_t^\Gamma \right] \tag{64}$$

$$v_t^l = \frac{1}{V} \cdot \frac{\vartheta}{(1-\vartheta)^2} \cdot (1-\omega)^{\frac{1}{1-\vartheta}} \cdot \left(\frac{W_G}{W} \right)^{\frac{\vartheta}{\vartheta-1}} \cdot (w_{G,t} - w_t) \tag{65}$$

$$v_t^\Gamma = \frac{\vartheta}{\vartheta - 1} \cdot (w_{G,t} - w_t) + v_t^l \tag{66}$$

$$\pi_{H,t} = \beta E_t\left[\pi_{H,t+1} \right] + \kappa \bar{mc}_t \tag{67}$$

$$\bar{r}_t = \mu_\pi \pi_{H,t} + \mu_y \bar{y}_t + z_t \tag{68}$$

$$y_t = a_t + l_t \tag{69}$$

$$y_t^* = c_t^* \tag{70}$$

$$\pi_t = p_t - p_{t-1} \tag{71}$$

$$mc_t = w_t \tag{72}$$

$$y_t = \frac{\omega_c}{\omega_c + \omega_{c^*}} c_t + \left(\frac{(1-\alpha)\omega_{c^*}}{\omega_c + \omega_{c^*}} - \alpha \right) s_t + \frac{\omega_{c^*}}{\omega_c + \omega_{c^*}} c_t^* \tag{73}$$

$$l_{G,t} = \frac{1}{\vartheta - 1}\left(w_{G,t} - w_t \right) + y_t \tag{74}$$

$$l_{M,t} = \frac{1}{\vartheta - 1}\left(w_{M,t} - w_t \right) + y_t \tag{75}$$

where $\omega_c \equiv (1-\alpha)C$, $\omega_{c^*} \equiv \alpha\eta S^{\eta(1-\alpha)} C^*$, $\gamma_w = \frac{(\frac{W}{P})}{(\frac{W}{P}) + \Psi_N (1-L)}$, $\gamma_n = \frac{2\Psi_N(1-L)}{(\frac{W}{P}) + \Psi_N(1-L)}$,

$\gamma_G = \left[\omega L_G^{\vartheta} + (1-\omega) L_M^{\vartheta} \right] \cdot \left(\omega \vartheta L_G^{\vartheta-2} \right)$, $\gamma_M = \left[\omega L_G^{\vartheta} + (1-\omega) L_M^{\vartheta} \right] \cdot \left((1-\omega) \vartheta L_M^{\vartheta-2} \right)$,

$\kappa = \frac{(1-\theta)(1-\beta\theta)}{\theta}$, $\bar{mc}_t = mc_t - mc$, $mc = -\frac{\varepsilon}{\varepsilon - 1} \equiv -\mu$, and $\bar{r}_t$ and $\bar{y}_t$ are defined similarly. The above system of equations can be solved by using the eigenvalue-eigenvector decomposition technique developed by Sims (1999).

III. SIMULATION

In this section, I quantitatively study the dynamics of variables in the model under different labor market conditions to see the effect of the heterogeneous wage contracts on the macroeconomic volatility in an economy with a financial fragility. To do so, I firstly set the parameter values, then I observe impulse responses of the equilibrium dynamics to domestic productivity shock under different degrees of the labor market friction. The baseline model is associated with the low level of elasticity of substitution between two types of workers, $\frac{1}{1-\vartheta}$, and the low level of shares of regular workers firms' production process, ω. Then I change these two key parameters to the higher levels to observe how the changes of those values affect the dynamics of impulse responses.

1. Parameterization

To start with, I adopt appropriately established parameter values from the related literature which are not the main focus in this paper and are generally accepted in the literature. The sources of the parameters are listed in Table 1. The first set of parameters, $\Theta_1 = \{\varphi, \sigma, \eta, \beta, \varepsilon, \mu, \theta, \mu_\pi, \mu_Y\}$, is commonly adopted as constant numbers. The inverse elasticity of labor supply, φ, is set to unity, and the intertemporal elasticity of substitution between private consumption, σ, is set to two, following Demirel (2010). I adopt the international dimension of parameters from Gali and Monacelli (2005). The intra-temporal elasticity of substitution between home and foreign final goods is set to two and the degree of openness to foreign commodity markets is set to 0.4. The time discounting factor and the intertemporal elasticity of substitution among final goods are assumed to be identical across countries, and are set to 0.99 and 11, respectively. The degree of price stickiness is supposed to be 0.7 according to many recent New Keynesian works, such as Woodford (2010). The monetary policy parameters, μ_π and μ_Y, are set to be the same with Gali (2008). The second set of parameters, $\Theta_2 = \{\rho_A, \rho_Z, \rho_Y, \epsilon_A, \epsilon_Z, \epsilon_Y\}$, is used in the stochastic processes. I adopt these values such that the model replicates key macroeconomic features of the Korean economy represented in Neumeyer and Perri (2005). The standard deviation of the output and interest rate, and the ratio of these two second moments are targeted. The stochastic process parameters for the domestic productivity shock follow the values of Neumeyer and Perri (2005), the parameters for the domestic monetary policy shock are set similar to Smets and Wouters (2002), and the parameter values for the foreign demand shock is set similar to Gali and Monacelli (2005). The third set of structural parameters, $\Theta_3 = \{\vartheta, \omega, \zeta\}$, is related to the key assumption in the labor market setting. The value of elasticity of substitution between two types of labor force is set to be varied from 12.7% to 21.9%, which means that the value of ϑ is set to be changed from 0.0211 to 0.0365. This range is considered based on the Korean data that the transformation rate between temporary and regular positions from 2005 to 2011[2]. Since 12.7% was the lowest rate during 2009 to 2011 and 21.9% was the highest rate during 2005 to 2007, it is reasonable to test the effect of the job substitution under this range. Baseline level of the weight on regular workers in the production process is estimated by 0.67, which is calculated by the average percentage of the regular workers to the overall wage workers from 2003 to 2016. Wage bargaining power of the regular workers, ϑ, is originally set to be varied from 0.1 to 0.4, following the dynamic simulation result of Matsui and Yoshimi (2015), but ultimately to be fixed at 0.1 for the methodological convenience and its inability in explaining the simulation results. The financial frictional parameter, Ψ_B, are estimated by following the method suggested in Christiano et al. (2005). I build a VAR-based impulse response for exchange rates, investments, consumptions, GDP, CPI inflation rates, and domestic interest rates over the first 12 quarters to the exogenous shocks. Then I choose the value of Ψ_B to solve the problem minimizing the distance between the theoretical-based and VAR-based impulse responses.

Table 1. List of Baseline Parameter Values

Symbol	Name	Estimated Value	Source
φ	Reverse of Elasticity of Labor Supply	1	Demirel(2010)
σ	Intertemporal Elasticity of Substitution in Private Consumption	2	Demirel(2010)
η	Intra-temporal Elasticity of Substitution between Home and Foreign Final Goods	2	Gali and Monacelli(2005)
α	Degree of Openness to Foreign Commodity Market	0.4	Gali and Monacelli(2005)
ϑ	Intra-temporal Elasticity of Substitution between Regular and Temporary Workers	[0.0211, 0.0365]	-
ω	Weight on the Regular Workers in Firm's Production	0.67	-
ζ	Wage Bargaining Power of Regular Workers	[0.1, 0.4]	Matsui and Yoshimi(2015)
β	Time Discounting Factor	0.99	Woodford(2003)

2 The data was obtained from Korean Academy of Management (2013).

Table 1. Continued

Symbol	Name	Estimated Value	Source
ε	Intra-temporal Elasticity of Substitution among Final Goods	11	Woodford(2003)
μ	Markup Revenue	1.1	Woodford(2003)
θ	Degree of Price Stickiness	0.7	Woodford(2010)
Ψ_B	Degree of Financial Market Friction	42	Christiano et al.(2005)
Y	Steady State Value of Output	0.6324	-
C	Steady State Value of Home Consumption	1.5608	-
N	Steady State Value of Total Labor Force	0.6324	-
B_F	Steady State Value of Foreign Bonds	0	-
ρ_A	Autoregressive Parameter of Domestic Productivity Shock	0.7	Neumeyer and Perri(2005)
ρ_Z	Autoregressive Parameter of Domestic Monetary Policy Shock	0.9	Smets and Wouters(2002)
ρ_Y	Autoregressive Parameter of Foreign Demand Shock	0.86	Gali and Monacelli(2005)
ϵ_A	Standard Deviation of Domestic Productivity Shock	0.07	Neumeyer and Perri(2005)
ϵ_Z	Standard Deviation of Domestic Monetary Policy Shock	0.01	Smets and Wouters(2002)
ϵ_Y	Standard Deviation of Foreign Demand Shock	0.007	Gali and Monacelli(2005)
μ_π	Monetary Policy Parameter for Log of Inflation	1.5	Gali(2008)
μ_Y	Monetary Policy Parameter for Log of Output Gap	0.125	Gali(2008)
R	Policy Anchor Value of Interest Rate	1.0264	-

2. The Effect of Labor Friction on the Economic Volatility

Figure 3 shows the impulse responses of the macroeconomic variables to the negative domestic productivity shock. It represents the responses of the baseline model("baseline") along with the case of the higher level of elasticity of substitution between two types of workers("high substitutability") and the case of the higher share of the temporary workers in the production process("less weight on regular employment"). When a negative shock comes in the economy, the output and the consumption decrease. This leads to the decline in AD curve, which increases wages for both workers. Since the productivity shock is a homogeneous one across all types of workers, the direction of its effect moves in the same direction. The increasing wage level leads the increasing marginal cost which positively affects the overall rates of CPI and the domestic inflation. In the case of high substitutability between types of workers, volatilities in most macroeconomic variables are higher than ones in the baseline assumption. The reason of this is that the higher value of ϑ plays an important role in the determination process of wages, and thus it also affects the marginal cost and the other macroeconomic variables. The higher level of elasticity of substitution directly increases the wage volatility through equation (62) to (65), while there might be more efficient allocation of resource with that higher substitutability, which would be found in Ramsey type welfare measurement that is not present in this paper. As the elasticity of substitution between labors goes up, the labor elasticity of Nash bargaining also increases, which can affect overall wages and the marginal cost. The case of higher weight on temporary workers induces the similar results. The lower weight on the regular workers in the firm's production process induces the same effect with the less Nash bargaining power for regular workers in their wage contracts process. This leads the more unstable wage position for the regular workers, and also negatively affects the wage volatility of temporary workers through equation (64). Therefore, the overall macroeconomic dynamics show highly fluctuates when there are higher level of substitutability between two types of workers and higher weight on the temporary workers.

Figure 3. Impulse Responses to 1% Negative Domestic Productivity Shock

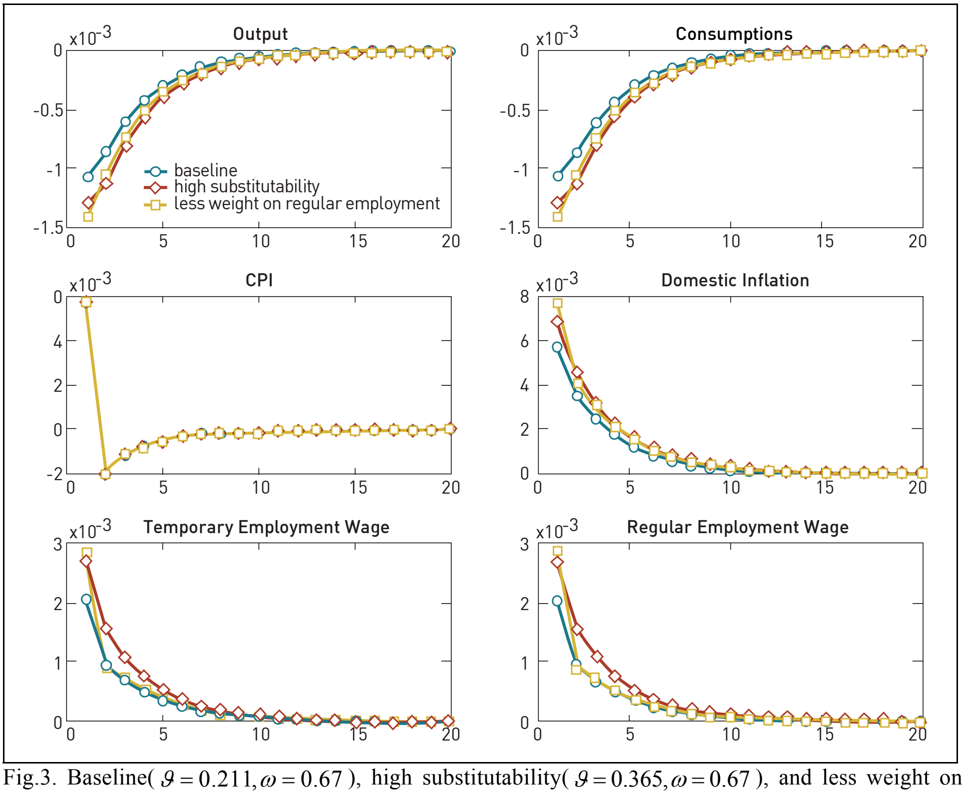


Fig.3. Baseline($\vartheta = 0.211, \omega = 0.67$), high substitutability($\vartheta = 0.365, \omega = 0.67$), and less weight on regular workers($\vartheta = 0.211, \omega = 0.3$)

IV. CONCLUSION

In this paper, I derive the equilibrium of DSGE model associated with a partially given Nash bargaining power and a financial fragility in order to study the effect of an elasticity of substitution between regular and temporary workers and a share of regular workers in a firm's production process on economic dynamics. As a result, the higher level of the substitutability and the lower share of regular workers derive the higher level of volatilities in most macroeconomic variables. This is because the higher elasticity of substitution creates more fluctuations in wage determination process while the lower share of regular workers weakens the Nash bargaining power for the regular workers in their wage contract process.

There are many limitations in this paper which should be done in further studies. First, the welfare analysis could possibly provide more detailed or improved implications. For instance, the higher elasticity of substitution would strengthen the economy in terms of an aggregate welfare because it could possibly contribute to the efficient allocation of labor resources. Second, a comparison with financially frictionless condition is also necessary, but it was not able to be done in this paper because of technical issue that the zero financial adjustment cost condition leads a non-steady state status. A parameterization on Ψ_B has been varied but there was an ongoing problem. Third, more international dimension should be discussed. For instance, this paper only assumes a perfect exchange rate pass-through condition, but it would be relaxed with more realistic assumptions such that LCP (Local Currency Pricing). Another robustness test is required.

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