How the Financial Market Can Dampen the Effects of Commodity Price Shocks

Myunghyun Kim*

The views expressed herein are those of the author, and do not necessarily reflect the official views of the Bank of Korea. When reporting or citing this paper, the author's name should always be explicitly stated.

* Economist, Economic Research Institute, The Bank of Korea, Tel: +82-2-759-5430, E-mail: mhkim7812@bok.or.kr

I am very grateful to Andrea Ferrero and David Vines for their guidance and advice. I also thank Guido Ascari, Kook Ka, Junsang Lee, Paul Luk, John Muellbauer, Gulcin Ozkan, Segye Shin, Rick van der Ploeg and seminar participants at the University of Oxford, the Korea Energy Economics Institute and the Bank of Korea for helpful comments. Any errors remaining are my own.

Contents

How the Financial Market Can Dampen the Effects of Commodity Price Shocks

Commodities have begun to function as an asset class during the past decade, as trading in commodity derivatives has increased massively since the 2000s. This paper studies the role of commodities as an asset class in accounting for the recently lessened impacts of commodity price shocks on the economy, by constructing a model with financial frictions and with financial intermediaries that own two assets – tied to commodities as well as to capital. Simulation results of the model show that financial intermediaries' holdings of commodities as assets have contributed to the recent reduction in the effects of commodity price shocks.

Keywords: Commodity price shocks, Commodity derivatives

JEL Classification: E30, E44, Q43

Ⅰ. Introduction

It is generally accepted that there is an inverse relationship between the prices of commodities such as oil, wheat, basic metals, etc. and the economy: when commodity prices fall, the economic effects of this are positive. This is because a fall in commodity prices leads to a decrease in living costs and an increase in real income. Moreover, when commodity prices fall, firms using commodities as inputs benefit from the low input prices.

Many studies have confirmed this inverse relationship between commodity prices (especially oil prices) and the economy. Hamilton (1983) presents evidence supporting the proposition that oil price shocks contributed to almost every U.S. recession over the 1948-72 period. Burbidge and Harrison (1984), Rotemberg and Woodford (1996), Cuñado and de Gracia (2003) and Leduc and Sill (2004) also show that an increase in oil prices brings about declines in industrial production or in output.

However, there is other literature providing evidence that energy price shocks have little effect on the economy. For example, Kim and Loungani (1992) include energy in a real business cycle (RBC) model with exogenous energy prices and find that the inclusion of energy price shocks increases output volatility only modestly.[1] Dhawan and Jeske (2008) obtain similar results by extending the model of Kim and Loungani (1992). Krugman (2016) also argues that the assumed relationship does not hold, since for example spending for investment falls quickly when oil prices plunge, as a lot of it is tied to oil prices.

More importantly, according to some literature, when more recent data is used the relationship between commodity prices and macroeconomic variables is found to be insignificant or attenuated.

1) This result supports views such as that of Tobin (1980) that the effects of energy price shocks on the economy are not important, since the share of energy in GNP is too small for large aggregate effects to be generated from energy price shocks.

Using vector autoregressions (VARs) over the 1970-83 and 1984-2006 periods, Blanchard and Galí (2007) conclude that oil prices had a much lower impact on inflation and output in the second period than they did in the first. According to them, this was due to the lack of concurrent adverse shocks, the smaller share of oil in the economy, more flexible labor markets and improvements in monetary policy during the second period. Segal (2011) also finds that the rises in oil prices during the last few years have had little influence on the economy.[2)]

Something that is not discussed in the above literatures is the fact that, as trading in commodity derivatives tied to commodity prices has increased massively since the 2000s[3)] (see Figure 1), commodities have in recent years begun to function as an asset class, which may have contributed to the weakened relationship noted as well.[4)]

Specifically, suppose that firms produce goods by using commodities, capital and labor as inputs, and financial intermediaries (FIs) own two assets - one tied to the capital of firms and the other to commodities. The net worths of FIs will then be affected by the returns on capital and commodities, both of which depend on changes in commodity prices. For instance, a fall in commodity prices will reduce firms'

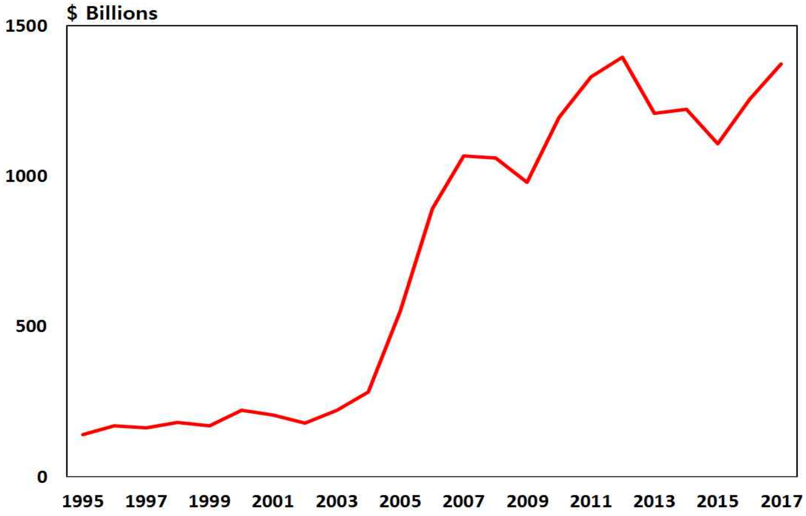
2) Differently from this literature, Kilian (2009) concludes that the reason why the recent increases in oil prices have not been followed by a U.S. recession is that they were due to strong demand for oil thanks to the booming world economy rather than to oil supply disruptions. Considering the reasons for the changes in commodity prices would be interesting, but is not the purpose of this paper which focuses on why the impacts of commodity price shocks on the economy have declined since the 2000s, irrespective of the shocks' sources.

3) Basu and Gavin (2011) explain well why many financial intermediaries have added commodity derivatives as an asset class to their portfolios. The first reason is the search for higher yields; when the returns on safe assets are low, intermediaries tend to choose riskier assets. Second, they use commodity derivatives to hedge against equity risks, in line with the negative correlation between equity and commodity returns.

4) Separately, many empirical studies have investigated whether the sharp increase in trading in commodity derivatives played a role in the high commodity prices (mainly oil prices) during the 2005-2008 period, i.e. whether speculative trading of commodities affected commodity prices. Most of them have confirmed that speculation has no significant effects on commodity prices (for details see Kilian and Murphy, 2014; Kilian and Lee, 2014; Knittel and Pindyck, 2016; etc.).

input costs and their outputs will hence rise, which will lead to an increased return on capital. In contrast, the commodity price decline will lead directly to a decreased return on commodities as well. Under this environment, if commodity prices decrease the net worths of FIs will rise by less than in a case in which they hold only capital. This will lead to a smaller increase in FIs' demand for investment, which will partly offset the positive impact of the fall in commodity prices on the economy.

Figure 1. Commodity Derivative Contracts



Note: The values are the year-end notional amounts of commodity derivative contracts for commercial banks, savings associations and trust companies holding derivatives in the U.S.
Source: Quarterly Report on Bank Trading and Derivatives Activities, Office of the Comptroller of the Currency, U.S. Department of the Treasury

However, it is impossible to capture the linkage between commodity prices and the net worths of FIs with the existing models in which financial markets are modeled, since these models omit the role of commodities as an asset class. For example, Bernanke, Gertler and Gilchrist (1999, hereafter BGG) assume that entrepreneurs borrow money from FIs to purchase capital and are leveraged. In their model, owing to the existence of the countercyclical external finance premium, when an adverse productivity shock hits the economy, the price of capital falls more initially, which amplifies and propagates the shock to the economy compared to the frictionless models (the financial accelerator). Similarly, other studies also do not consider commodities as an asset class, and in their models FIs or entrepreneurs hold only assets tied to capital (see Gertler and Karadi, 2011; Christiano, Motto and Rostagno, 2014; etc.). There are also models that do contain two assets for FIs or entrepreneurs, but they mainly extend the framework of BGG to two-country models and the two assets are thus capital at home and capital in foreign countries (see Ueda, 2012; and Dedola and Lombardo, 2012). In any case, the existing models consider FIs or entrepreneurs to hold only assets tied to capital.

In this paper, I extend the model with financial frictions and the costly state verification (CSV) approach developed by BGG, by adding to it FIs that invest in assets tied to both commodities and capital. I use this model to show that if FIs can hold two assets, tied to commodities as well as to the capital of firms, then the effects of a negative commodity price shock on the economy will be attenuated. To be specific, I simulate the responses of macroeconomic variables to a negative commodity price shock in situations of varying proportions of FI investment in commodities relative to that in capital, and compare them to those in a model with FIs' investment in commodities omitted to see whether commodities as an asset class play a role in the reduced impacts of commodity price shocks.

The remainder of the paper is organized as follows. Section 2 describes the model, in which FIs invest in two assets – tied both to capital and to commodities. Section 3 presents the simulation results of the model, and explains why its inclusion of commodities as an asset class is important and relevant. Section 4 concludes.

Ⅱ. The Model

In this section I describe the model[5] with financial frictions and FIs investing in two assets – tied to capital and to commodities. The model is very close to that of BGG. The main differences between them are that in this model firms use commodities as well as labor and capital as inputs to produce goods, and that FIs invest not only in the shares in capital issued by firms but also in commodities. Commodities are imported from abroad at an exogenous world price. Considering that nominal rigidities do not have an intrinsic role in BGG's financial accelerator, I also assume for simplicity that prices are flexible. Finally, I do not consider monetary policy in the model, since it is of no interest in this paper.

1. Financial Market

The framework of the financial market is closely related to that of Gertler and Karadi (2011). Specifically, firms issue shares to acquire funds that are necessary for purchasing capital for production, and there is no friction in the process of firms obtaining funding from FIs. Only FIs face credit constraints in obtaining funds from investors.

There are two kinds of contracts in the financial market: loan contracts between FIs and investors, and share contracts between firms and FIs.[6] FIs have their own net worth, N, which is not sufficient for investing in commodities and in shares in capital issued by firms. FIs thus enter into loan contracts with investors in order to borrow money.

As in BGG, FIs face idiosyncratic shocks, ω, to their returns. Therefore, the ex post gross return to investment of FI $i \in \{1, 2, \cdots, \infty\}$

5) See Appendix for the details of the model.

6) Since there are no frictions in the share contracts between FIs and firms, the contracts are not described.

is equal to $\omega_i R^F_{t+1}$, where R^F_{t+1} is the ex post aggregate return to investment of FIs. $\ln\omega$ follows a normal distribution with mean $-\frac{1}{2}\sigma^2$ and variance σ^2, and under this assumption, $E[\omega]=1$. The CDF of ω is $F(\cdot)$ and the PDF is $f(\cdot)$. ω is *i.i.d.* across time and across FIs.[7)]

As in BGG, CSV is assumed. Since the return on FIs' investment is subject to the idiosyncratic shock ω, if investors wish to observe the shock for a specific FI they have to pay a monitoring cost, which is a fixed fraction, μ, of the entire wealth of the FI.

In each period, FI i wishes to invest $Q_t S_{i,t}$ in shares in capital issued by firms, and $p_t x^F_{i,t}$ in commodities. S_i is the quantity of the shares in capital issued by the firms, Q is the price of each share, which is equal to the price of each unit of capital, x^F is the units of the composite commodity used noncommercially, and p is the price of one unit of the composite commodity. Therefore, FI i needs to borrow $Q_t S_{i,t} + p_t x^F_{i,t} - N_{i,t+1}$ from investors. Accordingly, the FI's balance sheet is as given in Figure 2:

Figure 2. FIís Balance Sheet

· **Assets**	· **Liabilities**
- Shares: QS	- Borrowing: $QS + px^F - N$
- Commodity: px^F	
	· **Equities**
	- Net worth: N

If it does not default, FI i has to repay to investors the principal and interest, $Z_{i,t+1}(Q_t S_{i,t} + p_t x^F_{i,t} - N_{i,t+1})$, where $Z_{i,t+1}$ is the gross non-default loan rate. If it defaults, investors that lend money to FI i

7) See Appendix for details.

pay the monitoring cost and take the entire wealth of FI i.

By assuming that in each period FIs expend a fixed ratio, $\tau \in [0,1]$, relative to their expenditures on investment in shares in capital issued by firms, $Q_t S_{i,t}$, for investment in commodities,[8] I relax the assumption in BGG that FIs invest all available funds in shares in capital issued by firms,[9] and this implies that

$$p_t x_{i,t}^F = \tau Q_t S_{i,t}. \tag{1}$$

Thus, the ex post aggregate return to investment of FIs is

$$R_{t+1}^F = \frac{1}{1+\tau}\left(R_{t+1}^K + \tau R_{t+1}^x\right), \tag{2}$$

where R_{t+1}^K is the return to FIs' investment in the shares in capital issued by firms, and R_{t+1}^x is the return to FI's investment in commodities. Since in period t FIs buy x_t^F units of the composite commodity at p_t, and sell them at p_{t+1} in period $t+1$, R_{t+1}^x is

$$R_{t+1}^x = p_{t+1}/p_t + \Delta, \tag{3}$$

where $\Delta > 0$ makes the steady state return to commodity investment, R^x, equal to the steady state return to investment in shares in capital, R^K.[10] This can be thought of as the risk spread.

Since this is the standard debt contract, there exists a threshold value of the shocks, $\overline{\omega}_i$, for FI i (see Townsend, 1979). If $\omega_i \geq \overline{\omega}_i$, then FI i makes enough profit to repay the investors, while if $\omega_i < \overline{\omega}_i$, it

8) Since the aim of this paper is to show that, as long as FIs invest some amount in commodities, the impacts of commodity price shocks on the economy become weaker, rather than to analyze how FIs allocate their available funds to the two asset classes, this assumption is not critical.
9) If $\tau = 0$, FIs invest all available funds in the shares in capital issued by firms, as in BGG.
10) The variables without the time subscript 't' denote their steady state values.

defaults. Then, $\overline{\omega}_{i,t+1}$ is such that

$$\overline{\omega}_{i,t+1} R^F_{t+1}\left(Q_t S_{i,t} + p_t x^F_{i,t}\right) = Z_{i,t+1}\left(Q_t S_{i,t} + p_t x^F_{i,t} - N_{i,t+1}\right). \quad (4)$$

Denote $\Gamma(\overline{\omega}_i) \in (0,1)$ the share of the returns on FI i's investment that goes to the investors. Then, $\Gamma(\overline{\omega}_i) R^F(QS_i + px^F_i) = G(\overline{\omega}_i) R^F(QS_i + px^F_i) + (1 - F(\overline{\omega}_i)) Z_i (QS_i + px^F_i - N_i)$ holds, where $G(\overline{\omega}_i) = \int_0^{\overline{\omega}_i} \omega f(\omega) d\omega$. Using equation (4), this becomes $\Gamma(\overline{\omega}_i) = G(\overline{\omega}_i) + (1 - F(\overline{\omega}_i))\overline{\omega}_i$. Finally, considering the monitoring cost, the net share of the returns to FI i going to investors is

$$\Psi(\overline{\omega}_i) = \Gamma(\overline{\omega}_i) - \mu G(\overline{\omega}_i). \quad (5)$$

Unless the expected profit of the contract is higher than the risk free rate, R, investors do not participate in the contract. Therefore, the expected participation constraint is

$$E_t\left[\Psi(\overline{\omega}_{i,t+1}) R^F_{t+1}\left(Q_t S_{i,t} + p_t x^F_{i,t}\right)\right] = R_{t+1}\left(Q_t S_{i,t} + p_t x^F_{i,t} - N_{i,t+1}\right), \quad (6)$$

where E_t is the expectations operation conditional on the information at t.

Risk averse FIs choose the expenditure on investment, $Q_t S_{i,t} + p_t x^F_{i,t}$, and the threshold values of the idiosyncratic shocks, $\overline{\omega}_{i,t+1}$, so as to maximize the expected logarithm of their profits, $E_t\left[\ln\left[(1 - \Gamma(\overline{\omega}_{i,t+1})) R^F_{t+1}\left(Q_t S_{i,t} + p_t x^F_{i,t}\right)\right]\right]$. The first order condition is

$$\frac{E_t\left[R^F_{t+1}\right]}{R_{t+1}} = E_t\left[\frac{\Gamma_\omega(\overline{\omega}_{i,t+1})}{(1 - \Gamma(\overline{\omega}_{i,t+1}))\Psi_\omega(\overline{\omega}_{i,t+1}) + \Gamma_\omega(\overline{\omega}_{i,t+1})\Psi(\overline{\omega}_{i,t+1})}\right], \quad (7)$$

where $\Gamma_{\omega}(\cdot)=\frac{\partial}{\partial\omega}\Gamma(\cdot)$, $\Psi_{\omega}(\cdot)=\frac{\partial}{\partial\omega}\Psi(\cdot)$, and $\frac{E_t\left[R^F_{t+1}\right]}{R_{t+1}}$ is called the external finance premium.[11)]

Since the left-hand side of equation (7) is determined exogenously to the financial market, every FI's choice for $E_t\left[\overline{\omega}_{i,t+1}\right]$ is the same. Thus, equation (7) can be aggregated:

$$\frac{E_t\left[R^F_{t+1}\right]}{R_{t+1}}=E_t\left[\frac{\Gamma_{\omega}\left(\overline{\omega}_{t+1}\right)}{\left(1-\Gamma\left(\overline{\omega}_{t+1}\right)\right)\Psi_{\omega}\left(\overline{\omega}_{t+1}\right)+\Gamma_{\omega}\left(\overline{\omega}_{t+1}\right)\Psi\left(\overline{\omega}_{t+1}\right)}\right]. \tag{8}$$

Aggregating the expected participation constraints, equation (6), yields

$$E_t\left[\Psi\left(\overline{\omega}_{t+1}\right)R^F_{t+1}\left(Q_tS_t+p_tx^F_t\right)\right]=R_{t+1}\left(Q_tS_t+p_tx^F_t-N_{t+1}\right), \tag{9}$$

where $S_t=\sum_i S_{i,t}$, $x^F_t=\sum_i x^F_{i,t}$ and $N_{t+1}=\sum_i N_{i,t+1}$. Using equations (8) and (9), the relationship between FIs' leverage, $\left(Q_tS_t+p_tx^F_t\right)/N_{t+1}$, and the external finance premium can be obtained:

$$\frac{Q_tS_t+p_tx^F_t}{N_{t+1}}=\aleph\frac{E_t\left[R^F_{t+1}\right]}{R_{t+1}}, \tag{10}$$

where $\aleph=E_t\left[\frac{\left\{\left(1-\Gamma\left(\overline{\omega}_{t+1}\right)\right)\Psi_{\omega}\left(\overline{\omega}_{t+1}\right)+\Gamma_{\omega}\left(\overline{\omega}_{t+1}\right)\Psi\left(\overline{\omega}_{t+1}\right)\right\}^2}{\left(1-\Gamma\left(\overline{\omega}_{t+1}\right)\right)\Psi_{\omega}\left(\overline{\omega}_{t+1}\right)\Gamma_{\omega}\left(\overline{\omega}_{t+1}\right)}\right]$. Since the numerator of $\aleph$ is positive, $1-\Gamma\left(\overline{\omega}_{t+1}\right)>0$, $\Psi_{\omega}\left(\overline{\omega}_{t+1}\right)>0$ and $\Gamma_{\omega}\left(\overline{\omega}_{t+1}\right)>0$, $\aleph>0$.[12)] Therefore, leverage is increasing in the external finance premium.

The aggregate net worth of FIs depends on their aggregate earnings from the above contracts, and from their labor incomes since it is

11) See Appendix for details.
12) See Appendix for details.

assumed that FIs inelastically supply one unit of labor to operating firms. Let V_t be the aggregate earnings of FIs from the above contract. Then, the aggregate net worth of FIs evolves according to

$$N_{t+1} = \gamma^F V_t + W_{F,t}, \tag{11}$$

where $V_t = (1 - \Gamma(\overline{\omega}_t))R_t^F(Q_{t-1}S_{t-1} + p_{t-1}x_{t-1}^F)$ and $W_{F,t}$ is the labor incomes of FIs. Let γ^F be the survival probability for FIs. When an FI quits its business, it consumes all of its net worth, and the consumption of quitting FIs is thus

$$C_t^F = (1 - \gamma^F)\, V_t. \tag{12}$$

2. The Rest of the Economy

2.1. Households

A representative household chooses its consumption, labor supply and real lending so as to maximize its utility. For simplicity, log utility function of consumption and separability between consumption and labor are assumed. The utility function is

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left(\ln C_t - \frac{L_{C,t}^{1+\chi}}{1+\chi} \right), \tag{13}$$

where C_t is consumption, $L_{C,t}$ is the labor supply by households, β is the discount factor, and χ is the inverse of Frisch elasticity of labor supply.[13)]

13) Some papers such as Bodenstein, Erceg and Guerrieri (2011) assume that households consume commodities. However, for simplicity, I do not consider commodity consumption in the model, since it does not play a notable role in generating the results of this paper.

The budget constraint is

$$C_t + B_{t+1} = W_t L_{C,t} + R_t B_t + \Pi_t, \tag{14}$$

where B_t is the real lending, W_t is the real wage, R_t is the real return from lending, and Π_t is the profits remitted by firms.

The first order conditions of a representative household's utility maximization problem are

$$1 = \beta E_t \left[\frac{C_t}{C_{t+1}} R_{t+1} \right], \tag{15}$$

$$W_t = C_t L_{C,t}^{\chi}. \tag{16}$$

Equation (15) is the Euler equation, and equation (16) is the condition of intratemporal substitution between consumption and labor.

2.2. Firms

A representative firm produces goods using capital, labor and commodities. The production function is a nested CES with constant returns to scale, following Kim and Loungani (1992) and Dhawan and Jeske (2008):

$$Y_t = A_t \left\{ (1-a) K_t^{-\nu} + a x_t^{-\nu} \right\}^{-\frac{\alpha}{\nu}} L_t^{1-\alpha}, \tag{17}$$

where x is the units of the composite commodity used in production, K is the capital inputs, and $1-\alpha$ is the labor share of income. The parameter a determines the importance of the commodities. The parameter ν is equal to $\frac{1-\varsigma}{\varsigma}$, where ς is the elasticity of substitution between capital and commodities. A is the productivity, and follows an AR(1) process as usual:

$$\ln A_t = \rho_A \ln A_{t-1} + \varepsilon_t, \tag{18}$$

where ε_t is the productivity shock. As in BGG, L_t is a composite of the labor that is supplied by households $(L_{C,t})$ and FIs $(L_{F,t})$. L_t is expressed by

$$L_t = L_{C,t}^{1-\Omega_F} L_{F,t}^{\Omega_F}. \tag{19}$$

In each period, firms issue shares in order to purchase capital for production, which means that

$$Q_t K_{t+1} = Q_t S_t. \tag{20}$$

Firms purchase capital at the end of period $t-1$ to produce goods in period t, and sell the non-depreciated capital back to the capital goods producers at the end of period t. Hence, the profit maximization problem is

$$\max_{K_t, x_t, L_{C,t}, L_{F,t}} \left[Y_t + (1-\delta) Q_t K_t - R_t^K Q_{t-1} K_t - p_t x_t - W_t L_{C,t} - W_{F,t} L_{F,t} \right], \tag{21}$$

where δ is the depreciation rate, and x is the commodity input. The corresponding first order conditions with respect to $L_{C,t}$ and $L_{F,t}$ are

$$W_t = (1-\alpha)(1-\Omega_F)\frac{Y_t}{L_{C,t}}, \tag{22}$$

$$W_{F,t} = (1-\alpha)\Omega_F \frac{Y_t}{L_{F,t}}. \tag{23}$$

The realized return on capital is obtained by the first order condition with respect to K_t:

$$R_t^K = \frac{1}{Q_{t-1}} \left\{ (1-\delta) Q_t + \alpha (1-a) K_t^{-\nu-1} \frac{Y_t}{(1-a) K_t^{-\nu} + a x_t^{-\nu}} \right\}. \tag{24}$$

The first order condition with respect to x_t is

$$p_t = a \alpha x_t^{-\nu-1} \frac{Y_t}{(1-a) K_t^{-\nu} + a x_t^{-\nu}}. \tag{25}$$

Commodity prices are determined exogenously, and follow AR(1)[14] as in Wei (2003):

$$\ln p_t = \rho \ln p_{t-1} + \eta_t, \tag{26}$$

where η_t is the commodity price shocks.

2.3. Capital Goods Producers

The capital goods producers use their technology to convert final goods to capital goods. In each period they buy I_t of final goods and $(1-\delta)K_t$ of used capital from firms. They then produce new capital goods, K_{t+1}. Thus, the capital goods producer's problem is the following:

$$\max_{K_{t+1}} Q_t K_{t+1} - (1-\delta) Q_t K_t - I_t,$$

subject to the law of motion for capital

$$K_{t+1} = (1-\delta) K_t + I_t - \frac{\xi}{2} \frac{(K_{t+1} - K_t)^2}{K_t}, \tag{27}$$

14) Although this is different from Kim and Loungani (1992) and Dhawan and Jeske (2008), in which energy prices follow ARMA(1,1), this difference does not affect the results of the model simulation.

where ξ is the parameter associated with the adjustment costs. The first order condition gives the price of capital:

$$Q_t = 1 - \xi + \xi \frac{K_{t+1}}{K_t}. \tag{28}$$

2.4. Resource Constraint

In each period, all produced goods are used for either consumption, investment, purchases of commodities by firms for production, commodity investment by FIs, or the monitoring costs of investors. Thus, the resource constraint is given by

$$Y_t = C_t + C_t^F + I_t + p_t x_t + p_t x_t^F + \mu G(\overline{\omega}_t) R_t^F (Q_{t-1} K_t + p_{t-1} x_{t-1}^F). \tag{29}$$

The last term is the monitoring cost of investors.[15)]

15) Note that, according to BGG, $C_{F,t}$ and the monitoring cost have relatively low weights under any reasonable parameterization of the model, and thus have no recognizable effects on the dynamics.

Ⅲ. Model Analysis

1. Calibration

The parameter values are given in Table 1. They mainly follow BGG and Kim and Loungani (1992), and the calibration is based on quarterly U.S. data.

First of all, the U.S. Treasury Department data shows that during the 1998 to 2015 period the average ratio of the value of FIs' commodity derivative contracts, relative to the value of their total assets minus the value of their commodity derivative contracts, was around 0.08. τ is therefore set to 0.08, which means that FIs invest 8% of the amount that they invest in the shares in capital issued by firms, in commodities. In order to show how the responses of the macroeconomic variables to a negative commodity price shock change as FIs' investment in commodities increases, I also consider two more cases for the values of τ: $\tau = 0$, in which FIs invest only in the shares in capital issued by firms, and $\tau = 0.04$, in which FIs invest 4% of their expenditure on investment in the shares in commodities.

In keeping with much of the literature, the discount factor, β, is 0.99, the inverse of Frisch elasticity of labor supply, χ, is set to 3, the depreciation rate, δ, is assumed to be 0.025, the parameter associated with capital adjustment costs, ξ, is 10, and the labor share of income, $1-\alpha$, is equal to 0.64.

Following BGG, the share of FIs' labor inputs, Ω_F, is 0.01, the rate of failure of FIs, $F(\overline{\omega})$, is 0.03/4, and the steady state risk spread, $R^K - R$, is assumed to be 0.005, which implies that $R^K = 1.0151$. Since $R^x = R^K$, $\Delta = 0.0151$. I assume that the steady state ratio of capital to the FIs' net worth, K/N, is 4 (the same as in Gertler and Karadi, 2011), which implies that the steady state ratio of commodity investment to net worth, x^F/N, is equal to 4τ by equation (1).

As in Kim and Loungani (1992), I assume that the parameter related to the elasticity of substitution between capital and commodity inputs in production, ν, is 0.7. The steady state capital/commodity ratio, K/x, is assumed to be 126.2.[16] Accordingly, the parameter related to the importance of commodities in production, a, is 0.007, which is determined by the values of K/x, R^K, δ and ν from equations (24) and (25) in the steady state.

Table 1. Parameter Values

Parameter	Value	Definition	Parameter	Value	Value
β	0.99	Discount factor	ν	0.7	Parameter related to the elasticity of substitution between commodities and capital in production
χ	3	Inverse of Frisch elasticity of labor supply	a	0.007	Parameter related to the weight of commodities in production
δ	0.025	Depreciation rate	σ	0.1171	Standard deviation of $\ln\omega$
ξ	10	Parameter associated with capital adjustment costs	μ	0.0975	Monitoring cost
$1-\alpha$	0.64	Labor share of income	γ^F	0.970	Survival probability for FIs
Ω_F	0.01	Share of FIs' labor inputs	ρ	0.95	Autoregressive parameter for commodity prices

Note: The values of σ, μ and γ^F are for when $\tau=0$.

Using the definition of the log-normal distribution, the steady state expected participation constraint and the first order condition of the FI's problem, the steady state threshold value of the idiosyncratic shocks, $\overline{\omega}$, and the variance of $\ln\omega$, σ^2, can be obtained. Therefore, the monitoring cost, μ, and the probability of survival for FIs, γ^F, can be

16) This is different from Kim and Loungani (1992), who assume that steady state capital/energy ratio is 200. However, in this model firms use all commodities, rather than only energy. Considering that the weight of energy in the IMF's commodity price index is 0.631, $200 \times 0.631 = 126.2$ as the steady state capital/commodity ratio seems appropriate.

calculated. σ is 0.1171, μ is 0.0975, and γ^F is 0.970 when $\tau = 0$.[17)]

Finally, I assume that the autoregressive parameter for commodity prices, ρ, is 0.95 as in Wei (2003).

2. Effects of a Negative Commodity Price Shock

This section shows how the model responds to a negative commodity price shock. By conducting this analysis, the way in which the existence of commodities as an asset class can dampen the effects of commodity price shocks on the economy can be shown. Figure 3 presents the responses of the model, with various values of τ, to a negative 1% deviation shock to commodity prices.

First, consider the case of $\tau = 0$, in which FIs invest only in the shares in capital issued by firms. Since a negative commodity price shock leads to a fall in firms' input costs, their demands for both commodities and capital increase. Thus, the price of capital, Q, jumps, which leads to a rise in FIs' returns on investment in the shares in capital issued by firms, R_t^K. Since from equation (2) the FIs' aggregate return on investment, R_t^F, is equal to R_t^K when $\tau = 0$, R_t^F increases. Due to the realized participation constraint, equation (9), a rise in R^F brings about a fall in the threshold value of the idiosyncratic shocks, $\overline{\omega}$, since $\Psi_\omega > 0$. That is, as FIs' aggregate return on investment increases, their default probability falls. Because R^F and the share of the profits going to FIs in the loan contract, $1 - \Gamma(\overline{\omega})$, increase ($\Gamma_\omega > 0$), the net worth of FIs, N, rises in accordance with equation (11). More intuitively, a rise in FIs' aggregate return on investment leads to an increase in their net worth. Therefore, owing to the increases in N and in the demand for capital, the investment goes up and output thus expands.

However, since when $\tau \in \{0.04, 0.08\}$ the shock brings about a fall in

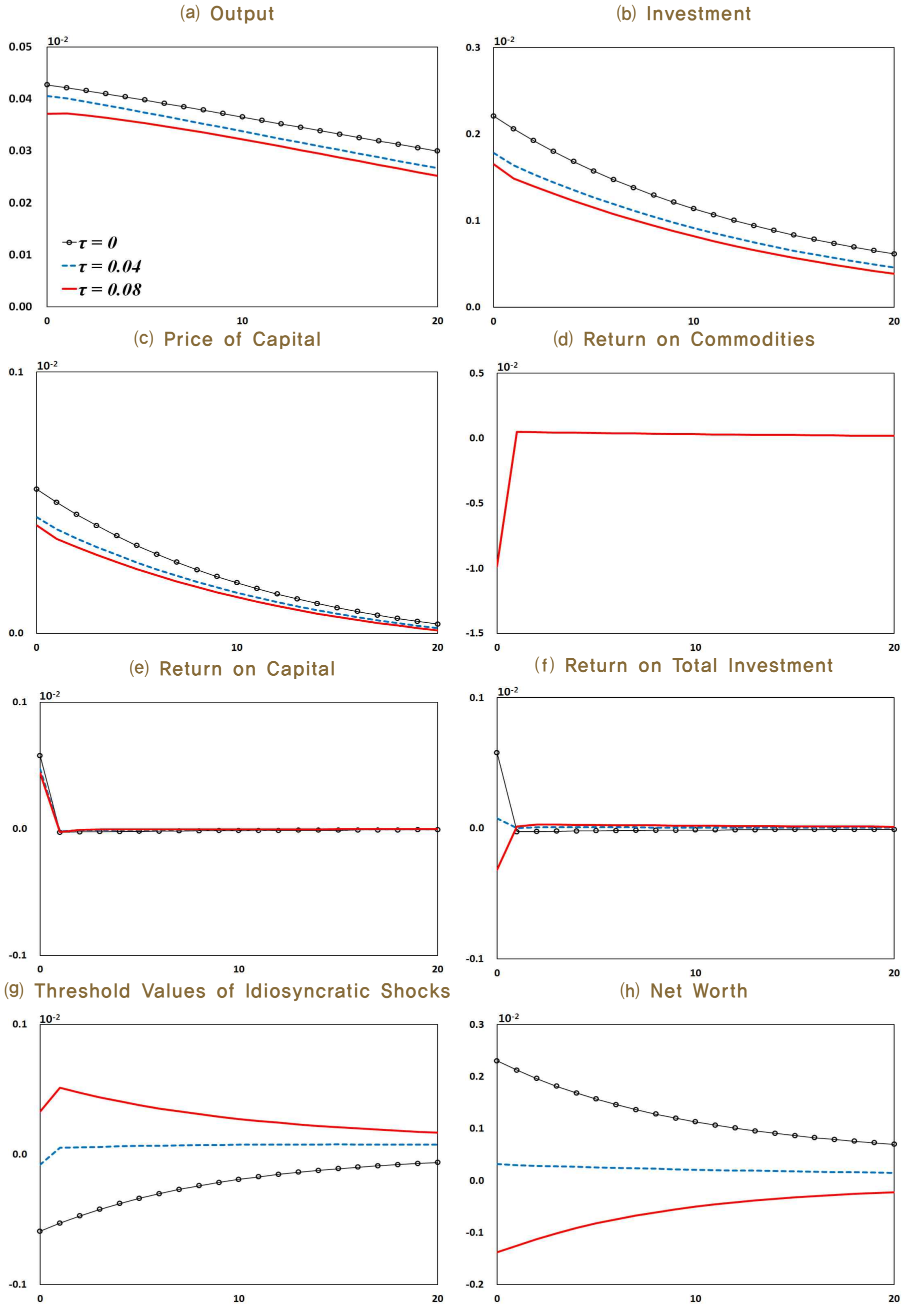
---

17) $\sigma = 0.1121$, $\mu = 0.0969$ and $\gamma^F = 0.969$ when $\tau = 0.04$, and $\sigma = 0.1075$, $\mu = 0.0964$ and $\gamma^F = 0.968$ when $\tau = 0.08$.

the FIs' returns on investment in commodities, R^x, R^F rises by less or decreases even despite a rise in R^K. The smaller rise or fall in R^F leads to a lesser amount of decrease or to an increase in $\overline{\omega}$, and $1-\Gamma(\overline{\omega})$ thus rises by less or goes down. Given the smaller increases or the decreases in R^F and $1-\Gamma(\overline{\omega})$, N also rises by less or falls. FIs' investment in the shares in capital issued by firms thus increases by less. Although demand for capital grows due to a fall in commodity prices, investment rises by less than when $\tau = 0$ owing to the smaller increase or the decrease in N. Output therefore increases by less than in the case of $\tau = 0$. In other words, the more the assets tied to commodities that FIs hold, the less N increases, and thus the less investment and output rise.

To summarize, if FIs own assets tied to commodities, investment and output will increase to a lesser extent following a negative commodity price shock. This is mainly because a fall in commodity prices causes not only an increase in the returns to FIs' investments in assets tied to capital, but also a fall in their returns on investment in commodities. As a result, FIs' returns on total investment go up by less than in the models in which FIs hold only assets associated with capital, or even decrease, and their net worth hence falls or rises by less. Thus, considering that commodities have begun to function as an asset class since the 2000s, and that according to the literature such as Blanchard and Galí (2007) the impacts of commodity price shocks have weakened since the 2000s, these results are consistent with the hypothesis that commodities as an asset class have played an important role in the recently reduced impacts of commodity price shocks on the economy.

Figure 3. Responses of the Model to a Negative Commodity Price Shock



3. Importance and Relevance of Commodities as an Asset Class

The importance and relevance of commodities as an asset class in this model result from the fact that, by investing in commodities, FIs can hedge against the risks to their investments in the shares in capital issued by firms stemming from commodity price shocks.

To be specific, the demand for commodities in production, x, is decreasing in commodity prices, and the return to capital, R^K, is increasing in x. Hence, R^K is decreasing in commodity prices. However, the return on commodity investment, R^x, is increasing in commodity prices. Therefore, R^K and R^x react in the opposite directions to changes in commodity prices, which enables FIs to hedge against the risks from commodity price shocks to their investments in the shares in capital issued by firms by investing in commodities. For instance, a rise in commodity prices will lead to an increase in R^x by equation (3), but to a fall in R^K by equations (24) and (25). If FIs do not invest in commodities, their returns on investment, R^F, will fall. In this model, however, since FIs hold commodities as an asset R^F declines due to a rise in R^x by less than when they do not hold them, i.e. when FIs invest in commodities their returns on investment fluctuate by less in response to commodity price shocks.

The existence of commodities as an asset class in this model is very consistent with the fact that FIs use commodity derivatives to hedge against equity risks, which is noted in the literature such as Basu and Gavin (2011). In models in which FIs invest only in capital, their returns on investment depend solely on the returns to capital, and there are no instruments with which FIs can diversify the risk of investment associated with capital. In this model FIs do have such instruments, however, and this model is thus more relevant than others in considering the existence of commodities as an instrument for hedging by FIs.

Ⅳ. Conclusion

This paper has developed a model with financial frictions and FIs investing in two assets − tied to capital and to commodities − by extending the model of BGG to explain the role of commodities as an asset class in the recently declined effects of commodity price shocks on the economy. The simulation results of the model show that FIs' investment in commodities has been an important factor explaining these recent reduced impacts of commodity price shocks.

A negative commodity price shock causes both a rise in the return on FIs' investments in assets tied to capital and a fall in the return on their investments in commodities. In models such as BGG, in which there is no asset tied to commodities, there is only the former effect and the net worth of FIs thus increases. In this model, however, in which FIs invest in commodities as assets also, both effects exist, and the net worth of FIs therefore either falls or rises by less. As a consequence, FIs' investment in the shares in capital issued by firms increases by less, which results in smaller responses of the economy to commodity price shocks; i.e. the presence of commodities as an asset class makes the economy less volatile in response to commodity price shocks.

The existence of commodities as an asset class in this model is moreover consistent with the fact that FIs use commodity derivatives to hedge against equity risk. Specifically, since the returns to capital and to commodities react in the opposite directions when commodity prices changes, FIs can hedge against the risk of investment in the shares in capital issued by firms to commodity price shocks by investing in commodities.

It should finally be noted that monetary and fiscal policies are omitted in this paper. However, these policies can be included in the model, and it would be interesting future research to study how the policy effects change and to analyze the optimal policies to commodity price shocks when commodities as an asset class are present in the model. This paper also does not consider the reasons for changes in commodity prices, such as rises in commodity prices due to strong demand or supply disruptions. Although considering them in the framework of the model in this paper would be interesting, I leave that to future research.

References

Basu, P. and W. T. Gavin (2011), "What Explains the Growth in Commodity Derivatives?" *Federal Reserve Bank of St. Louis Review*, Vol. 93, pp. 37-48.

Bernanke, B. S., M. Gertler, and S. Gilchrist (1999), "The Financial Accelerator in a Quantitative Business Cycle Framework," *Handbook of Macroeconomics*, Vol. 1, pp. 1341-1393.

Blanchard, O. J. and J. Galí (2007), "The Macroeconomic Effects of Oil Price Shocks: Why Are the 2000s So Different from the 1970s?" NBER Working Paper No. 13368.

Bodenstein, M., C. J. Erceg, and L. Guerrieri (2011), "Oil Shocks and External Adjustment," *Journal of International Economics*, Vol. 83, pp. 168-184.

Burbidge, J. and A. Harrison (1984), "Testing for the Effects of Oil-price Rises Using Vector Autoregressions," *International Economic Review*, Vol. 25, pp. 459-484.

Christiano, L. J., R. Motto, and M. Rostagno (2014), "Risk Shocks," *American Economic Review*, Vol. 104, pp. 27-65.

Cuñado, J. and F. P. de Gracia (2003), "Do Oil Price Shocks Matter? Evidence for Some European Countries," *Energy Economics*, Vol. 25, pp. 137-154.

Dedola, L. and G. Lombardo (2012), "Financial Frictions, Financial Integration and the International Propagation of Shocks," *Economic Policy*, Vol. 27, pp. 319-359.

Dhawan, R. and K. Jeske (2008), "Energy Price Shocks and the Macroeconomy: The Role of Consumer Durables," *Journal of Money,* *Credit and Banking*, Vol. 40, pp. 1357-1377.

Gertler, M. and P. Karadi (2011), "A Model of Unconventional Monetary Policy," *Journal of Monetary Economics*, Vol. 58, pp. 17-34.

Hamilton, J. D. (1983), "Oil and the Macroeconomy since World War II," *Journal of Political Economy*, Vol. 91, pp. 228-248.

Kilian, L. (2009), "Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market," *American Economic Review*, Vol. 9, pp. 1053-1069.

Kilian, L. and T. K. Lee (2014), "Quantifying the Speculative Component in the Real Price of Oil: The Role of Global Oil Inventories," *Journal of International Money and Finance*, Vol. 41, pp. 71-87.

Kilian, L. and D. P. Murphy (2014), "The Role of Inventories and Speculative Trading in the Global Market for Crude Oil," *Journal of Applied Econometrics*, Vol. 29, pp. 454-478.

Kim, I. and P. Loungani (1992), "The Role of Energy in Real Business Cycle Models," *Journal of Monetary Economics*, Vol. 29, pp. 173-189.

Knittel, C. R. and R. S. Pindyck (2016), "The Simple Economics of Commodity Price Speculation," *American Economic Journal: Macroeconomics*, Vol. 8, pp. 85-110.

Krugman, P. (2016), "Oil Goes Nonlinear," The New York Times, January 16.

Leduc, S. and K. Sill (2004), "A Quantitative Analysis of Oil-price Shocks, Systematic Monetary Policy, and Economic Downturns," *Journal of Monetary Economics*, Vol. 51, pp. 781-808.

Rotemberg, J. J. and M. Woodford (1996), "Imperfect Competition and the Effects of Energy Price Increases on Economic Activity," *Journal of Money, Credit and Banking*, Vol. 28, pp. 549-577.

Segal, P. (2011), “Oil Price Shocks and the Macroeconomy,” *Oxford Review of Economic Policy*, Vol. 27, pp. 169-185.

Tobin, J. (1980), “Stabilization Policy Ten Years After,” *Brookings Papers on Economic Activity*, Vol. 11, pp. 19-90.

Townsend, R. (1979), “Optimal Contracts and Competitive Markets with Costly State Verification,” *Journal of Economic Theory*, Vol. 21, pp. 265-293.

Ueda, K. (2012), “Banking Globalization and International Business Cycles: Cross-border Chained Credit Contracts and Financial Accelerators,” *Journal of International Economics*, Vol. 86, pp. 1-16.

Wei, C. (2003), “Energy, the Stock Market, and the Putty-clay Investment Model,” *American Economic Review*, Vol. 93, pp. 311-323.

Appendix

Analytical expressions of $\Gamma(\bar{\omega})$, $G(\bar{\omega})$ and $\Psi(\bar{\omega})$, and their derivatives

By the definition of a log-normal distribution, if $\ln y \sim N(c, d^2)$, $E[y] = \exp\left[c + \frac{1}{2}d^2\right]$. Since $\ln\omega \sim N\left(-\frac{1}{2}\sigma^2, \sigma^2\right)$, $E[\omega] = 1$.

From the definition of a cumulative log-normal distribution, $F(\bar{\omega}) = \Phi\left(\frac{\ln\bar{\omega} + \frac{1}{2}\sigma^2}{\sigma}\right)$, where $\Phi(\cdot)$ is the CDF of the standard normal distribution. $G(\bar{\omega}) = \int_0^{\bar{\omega}} \omega f(\omega) d\omega = E[\omega | \omega \leq \bar{\omega}] \Pr(\omega \leq \bar{\omega}) = \exp\left[-\frac{1}{2}\sigma^2 + \frac{1}{2}\sigma^2\right] \Phi\left(\frac{\ln\bar{\omega} + \frac{1}{2}\sigma^2 - \sigma^2}{\sigma}\right) = \Phi\left(\frac{\ln\bar{\omega} - \frac{1}{2}\sigma^2}{\sigma}\right)$.

Therefore, the first derivatives with respect to ω of $F(\bar{\omega})$, $\Gamma(\bar{\omega})$, $G(\bar{\omega})$ and $\Psi(\bar{\omega})$ can be obtained:

$$F_\omega(\bar{\omega}) = \frac{\partial F(\bar{\omega})}{\partial \omega} = \frac{1}{\bar{\omega}\sigma}\phi\left(\frac{\ln\bar{\omega} + \frac{1}{2}\sigma^2}{\sigma}\right) > 0, \quad \text{(A.1)}$$

$$G_\omega(\bar{\omega}) = \frac{\partial G(\bar{\omega})}{\partial \omega} = \frac{1}{\bar{\omega}\sigma}\phi\left(\frac{\ln\bar{\omega} - \frac{1}{2}\sigma^2}{\sigma}\right) > 0, \quad \text{(A.2)}$$

$$\Gamma_\omega(\bar{\omega}) = \frac{\partial\left(G(\bar{\omega}) + (1 - F(\bar{\omega}))\bar{\omega}\right)}{\partial \omega} = 1 - F(\bar{\omega}) > 0, \quad \text{(A.3)}$$

$$\Psi_\omega(\bar{\omega}) = \frac{\partial\left(\Gamma(\bar{\omega}) - \mu G(\bar{\omega})\right)}{\partial \omega} = \Gamma_\omega(\bar{\omega}) - \mu G_\omega(\bar{\omega}), \quad \text{(A.4)}$$

where $\phi(\cdot)$ is the PDF of the standard normal distribution.

The sign of $\frac{\partial \Psi(\overline{\omega})}{\partial \omega} = \Psi_{\omega}(\overline{\omega})$, however, is ambiguous. $\Psi_{\omega}(\overline{\omega}) = 1 - F(\overline{\omega}) - \mu\overline{\omega} f(\overline{\omega}) = (1 - F(\overline{\omega}))(1 - \mu\overline{\omega} h(\overline{\omega}))$, where $h(\overline{\omega}) = \frac{f(\overline{\omega})}{1 - F(\overline{\omega})}$ is the hazard rate. Since $\frac{\partial \{\overline{\omega} h(\overline{\omega})\}}{\partial \overline{\omega}} > 0$ as in BGG, there exists $\overline{\omega}^*$ such that $\Psi_{\omega}(\overline{\omega}^*) = 0$. Then, $\Psi(\overline{\omega}^*)$ is the global maximum. Therefore, $\overline{\omega}^* > \overline{\omega}$, and thus $\Psi_{\omega}(\overline{\omega}) > 0$.

FI i' s profit maximization problem

Since maximizing the expected profit and maximizing the expected logarithm of profit are identical, FI i's profit maximization problem can be expressed by

$$\max_{\overline{\omega}_{i,t+1}, (Q_t S_{i,t} + p_t x_{i,t}^F)} E_t \left[\left(1 - \Gamma\left(\overline{\omega}_{i,t+1}\right)\right) R_{t+1}^F \left(Q_t S_{i,t} + p_t x_{i,t}^F\right) \right],$$

subject to the expected participation constraint. The corresponding Lagrangian is

$$\mathcal{L} = E_t [\left(1 - \Gamma\left(\overline{\omega}_{i,t+1}\right)\right) R_{t+1}^F \left(Q_t S_{i,t} + p_t x_{i,t}^F\right) +$$
$$\lambda_{i,t+1} \left\{ \Psi\left(\overline{\omega}_{i,t+1}\right) R_{t+1}^F \left(Q_t S_{i,t} + p_t x_{i,t}^F\right) - R_{t+1} \left(Q_t S_{i,t} + p_t x_{i,t}^F - N_{i,t+1}\right) \right\}],$$

where λ is the Lagrange multiplier. The first order conditions are

$$\frac{\partial \mathcal{L}}{\partial \overline{\omega}_{i,t+1}} = E_t \left[-\Gamma_{\omega}\left(\overline{\omega}_{i,t+1}\right) + \lambda_{i,t+1} \Psi_{\omega}\left(\overline{\omega}_{i,t+1}\right) \right] = 0,$$

$$\frac{\partial \mathcal{L}}{\partial \left(Q_t S_{i,t} + p_t x_{i,t}^F\right)} = E_t [\left(1 - \Gamma\left(\overline{\omega}_{i,t+1}\right)\right) R_{t+1}^F +$$
$$\lambda_{i,t+1} \left\{ \Psi\left(\overline{\omega}_{i,t+1}\right) R_{t+1}^F - R_{t+1} \right\}] = 0.$$

Simplifying these two equations yields

$$\lambda_{i,t+1} = E_t\left[\frac{\Gamma_\omega(\bar{\omega}_{i,t+1})}{\Psi_\omega(\bar{\omega}_{i,t+1})}\right], \tag{A.5}$$

$$\frac{E_t\left[R^F_{t+1}\right]}{R_{t+1}} = E_t\left[\frac{\lambda_{i,t+1}}{(1-\Gamma(\bar{\omega}_{i,t+1}))+\lambda_{i,t+1}\Psi(\bar{\omega}_{i,t+1})}\right]. \tag{A.6}$$

Relationship between the external finance premium and leverage

From equations (8) and (9),

$$E_t\left[\frac{\Gamma_\omega(\bar{\omega}_{t+1})}{(1-\Gamma(\bar{\omega}_{t+1}))\Psi_\omega(\bar{\omega}_{t+1})+\Gamma_\omega(\bar{\omega}_{t+1})\Psi(\bar{\omega}_{t+1})}\right]= E_t\left[\frac{Q_tS_t+p_tx^F_t-N_{t+1}}{\Psi(\bar{\omega}_{t+1})(Q_tS_t+p_tx^F_t)}\right]. \tag{A.7}$$

From equation (A.7),

$$\frac{Q_tS_t+p_tx^F_t}{N_{t+1}} = E_t\left[\frac{(1-\Gamma(\bar{\omega}_{t+1}))\Psi_\omega(\bar{\omega}_{t+1})+\Gamma_\omega(\bar{\omega}_{t+1})\Psi(\bar{\omega}_{t+1})}{(1-\Gamma(\bar{\omega}_{t+1}))\Psi_\omega(\bar{\omega}_{t+1})}\right]. \tag{A.8}$$

By equations (8) and (A.8),

$$\frac{Q_tS_t+p_tx^F_t}{N_{t+1}} = E_t\left[\frac{\left\{(1-\Gamma(\bar{\omega}_{t+1}))\Psi_\omega(\bar{\omega}_{t+1})+\Gamma_\omega(\bar{\omega}_{t+1})\Psi(\bar{\omega}_{t+1})\right\}^2}{(1-\Gamma(\bar{\omega}_{t+1}))\Psi_\omega(\bar{\omega}_{t+1})\Gamma_\omega(\bar{\omega}_{t+1})}\right] \times \frac{E_t\left[R^F_{t+1}\right]}{R_{t+1}}. \tag{A.9}$$

Summary of the model

$$p_t x_t^F = \tau Q_t K_{t+1}, \tag{A.10}$$

$$R_t^F = \frac{1}{1+\tau}\left(R_t^K + \tau R_t^x\right), \tag{A.11}$$

$$R_t^x = p_t / p_{t-1} + \Delta, \tag{A.12}$$

$$\frac{E_t\left[R_{t+1}^F\right]}{R_{t+1}} = E_t\left[\frac{\Gamma_\omega\left(\overline{\omega}_{t+1}\right)}{\left(1-\Gamma\left(\overline{\omega}_{t+1}\right)\right)\Psi_\omega\left(\overline{\omega}_{t+1}\right) + \Gamma_\omega\left(\overline{\omega}_{t+1}\right)\Psi\left(\overline{\omega}_{t+1}\right)}\right], \tag{A.13}$$

$$\Psi\left(\overline{\omega}_t\right) R_t^F\left(Q_{t-1}K_t + p_{t-1}x_{t-1}^F\right) = R_t\left(Q_{t-1}K_t + p_{t-1}x_{t-1}^F - N_t\right), \tag{A.14}$$

$$N_{t+1} = \gamma^F\left(1-\Gamma\left(\overline{\omega}_t\right)\right) R_t^F\left(Q_{t-1}K_t + p_{t-1}x_{t-1}^F\right) + W_{F,t}, \tag{A.15}$$

$$C_t^F = \left(1-\gamma^F\right)\left(1-\Gamma\left(\overline{\omega}_t\right)\right) R_t^F\left(Q_{t-1}K_t + p_{t-1}x_{t-1}^F\right), \tag{A.16}$$

$$1 = \beta E_t\left[\frac{C_t}{C_{t+1}} R_{t+1}\right], \tag{A.17}$$

$$W_t = C_t L_{C,t}^{\chi}, \tag{A.18}$$

$$Y_t = A_t\left\{(1-a)K_t^{-\nu} + a x_t^{-\nu}\right\}^{-\frac{\alpha}{\nu}} L_{C,t}^{(1-\alpha)(1-\Omega_F)}, \tag{A.19}$$

$$\ln A_t = \rho_A \ln A_{t-1} + \varepsilon_t, \tag{A.20}$$

$$W_t = (1-\alpha)(1-\Omega_F)\frac{Y_t}{L_{C,t}}, \tag{A.21}$$

$$W_{F,t} = (1-\alpha)\Omega_F Y_t, \tag{A.22}$$

$$R_t^K = \frac{1}{Q_{t-1}}\left\{(1-\delta)Q_t + \alpha(1-a)K_t^{-\nu-1}\frac{Y_t}{(1-a)K_t^{-\nu} + a x_t^{-\nu}}\right\}, \tag{A.23}$$

$$p_t = a\alpha x_t^{-\nu-1}\frac{Y_t}{(1-a)K_t^{-\nu} + a x_t^{-\nu}}, \tag{A.24}$$

$$\ln p_t = \rho \ln p_{t-1} + \eta_t, \tag{A.25}$$

$$K_{t+1} = (1-\delta)K_t + I_t - \frac{\xi}{2}\frac{\left(K_{t+1} - K_t\right)^2}{K_t}, \tag{A.26}$$

$$Q_t = 1 - \xi + \xi\frac{K_{t+1}}{K_t}, \tag{A.27}$$

$$Y_t = C_t + C_t^F + I_t + p_t x_t + p_t x_t^F + \mu G\left(\overline{\omega}_t\right)R_t^F\left(Q_{t-1}K_t + p_{t-1}x_{t-1}^F\right). \tag{A.28}$$

‹Abstract in Korean›

금융시장과 국제원자재가격 충격의 영향

김명현*

2000년대 들어 원유, 곡물 등 원자재 관련 파생상품 거래가 급증하면서 원자재가 하나의 자산(commodities as an asset class)으로서 역할을 수행하기 시작하였다. 한편, 기존연구에 따르면 국제원자재가격 충격의 경제에 대한 영향 또한 2000년대 들어 줄어든 것으로 분석되고 있다. 이에 따라 본고는 자산으로서의 원자재가 최근 들어 약화된 국제원자재가격 충격의 영향력에 어떠한 역할을 하였는지를 분석하기 위해 금융기관(financial intermediaries)이 자본(capital)뿐만 아니라 원자재에도 투자하는 모형을 설정하였다. 모형의 시뮬레이션 결과에 따르면 자산으로서의 원자재가 국제원자재가격 충격의 경제에 대한 영향력 감소에 일부 기여한 것으로 나타났다.

핵심 주제어: 국제원자재가격, 원자재관련 파생상품 거래

JEL Classification: E30, E44, Q43

* 한국은행 경제연구원 국제경제연구실 부연구위원(전화: 02-759-5430, E-mail: mhkim7812@bok.or.kr)

이 연구내용은 집필자의 개인의견이며 한국은행의 공식견해와는 무관합니다. 따라서 본 논문의 내용을 보도하거나 인용할 경우에는 집필자명을 반드시 명시하여주시기 바랍니다.

BOK 경제연구 발간목록

한국은행 경제연구원에서는 Working Paper인 『BOK 경제연구』를 수시로 발간하고 있습니다. 『BOK 경제연구』는 주요 경제 현상 및 정책 효과에 대한 직관적 설명 뿐 아니라 깊이 있는 이론 또는 실증 분석을 제공함으로써 엄밀한 논증에 초점을 두는 학술논문 형태의 연구이며 한국은행 직원 및 한국은행 연구용역사업의 연구 결과물이 수록되고 있습니다.
『BOK 경제연구』는 한국은행 경제연구원 홈페이지(http://imer.bok.or.kr)에서 다운로드하여 보실 수 있습니다.

제2015 -1	글로벌 금융위기 이후 주요국 통화정책 운영체계의 변화	김병기 · 김인수
2	미국 장기시장금리 변동이 우리나라 금리기간구조에 미치는 영향 분석 및 정책적 시사점	강규호 · 오형석
3	직간접 무역연계성을 통한 해외충격의 우리나라 수출입 파급효과 분석	최문정 · 김근영
4	통화정책 효과의 지역적 차이	김기호
5	수입중간재의 비용효과를 고려한 환율변동과 수출가격 간의 관계	김경민
6	중앙은행의 정책금리 발표가 주식시장 유동성에 미치는 영향	이지은
7	은행 건전성지표의 변동요인과 거시건전성 규제의 영향	강종구
8	Price Discovery and Foreign Participation in The Republic of Korea's Government Bond Futures and Cash Markets	Jaehun Choi · Hosung Lim · Rogelio Jr. Mercado · Cyn-Young Park
9	규제가 노동생산성에 미치는 영향: 한국의 산업패널 자료를 이용한 실증분석	이동렬 · 최종일 · 이종한
10	인구 고령화와 정년연장 연구 (세대 간 중첩모형(OLG)을 이용한 정량 분석)	홍재화 · 강태수
11	예측조합 및 밀도함수에 의한 소비자물가 상승률 전망	김현학
12	인플레이션 동학과 통화정책	우준명
13	Failure Risk and the Cross-Section of Hedge Fund Returns	Jung-Min Kim
14	Global Liquidity and Commodity Prices	Hyunju Kang · Bok-Keun Yu · Jongmin Yu

제2015 -15	Foreign Ownership, Legal System and Stock Market Liquidity	Jieun Lee · Kee H. Chung
16	바젤Ⅲ 은행 경기대응완충자본 규제의 기준지표에 대한 연구	서현덕 · 이정연
17	우리나라 대출 수요와 공급의 변동요인 분석	강종구 · 임호성
18	북한 인구구조의 변화 추이와 시사점	최지영
19	Entry of Non-financial Firms and Competition in the Retail Payments Market	Jooyong Jun
20	Monetary Policy Regime Change and Regional Inflation Dynamics: Looking through the Lens of Sector-Level Data for Korea	Chi-Young Choi · Joo Yong Lee · Roisin O'Sullivan
21	Costs of Foreign Capital Flows in Emerging Market Economies: Unexpected Economic Growth and Increased Financial Market Volatility	Kyoungsoo Yoon · Jayoung Kim
22	글로벌 금리 정상화와 통화정책 과제: 2015년 한국은행 국제컨퍼런스 결과보고서	한국은행 경제연구원
23	The Effects of Global Liquidity on Global Imbalances	Marie-Louise DJIGBENOU-KRE · Hail Park
24	실물경기를 고려한 내재 유동성 측정	우준명 · 이지은
25	Deflation and Monetary Policy	Barry Eichengreen
26	Macroeconomic Shocks and Dynamics of Labor Markets in Korea	Tae Bong Kim · Hangyu Lee
27	Reference Rates and Monetary Policy Effectiveness in Korea	Heung Soon Jung · Dong Jin Lee · Tae Hyo Gwon · Se Jin Yun
28	Energy Efficiency and Firm Growth	Bongseok Choi · Wooyoung Park · Bok-Keun Yu
29	An Analysis of Trade Patterns in East Asia and the Effects of the Real Exchange Rate Movements	Moon Jung Choi · Geun-Young Kim · Joo Yong Lee
30	Forecasting Financial Stress Indices in Korea: A Factor Model Approach	Hyeongwoo Kim · Hyun Hak Kim · Wen Shi

제2016 -1	The Spillover Effects of U.S. Monetary Policy on Emerging Market Economies: Breaks, Asymmetries and Fundamentals	Geun-Young Kim · Hail Park · Peter Tillmann
2	Pass-Through of Imported Input Prices to Domestic Producer Prices: Evidence from Sector-Level Data	JaeBin Ahn · Chang-Gui Park · Chanho Park
3	Spillovers from U.S. Unconventional Monetary Policy and Its Normalization to Emerging Markets: A Capital Flow Perspective	Sangwon Suh · Byung-Soo Koo
4	Stock Returns and Mutual Fund Flows in the Korean Financial Market: A System Approach	Jaebeom Kim · Jung-Min Kim
5	정책금리 변동이 성별·세대별 고용률에 미치는 영향	정성엽
6	From Firm-level Imports to Aggregate Productivity: Evidence from Korean Manufacturing Firms Data	JaeBin Ahn · Moon Jung Choi
7	자유무역협정(FTA)이 한국 기업의 기업내 무역에 미친 효과	전봉걸 · 김은숙 · 이주용
8	The Relation Between Monetary and Macroprudential Policy	Jong Ku Kang
9	조세피난처 투자자가 투자 기업 및 주식 시장에 미치는 영향	정호성 · 김순호
10	주택실거래 자료를 이용한 주택부문 거시 건전성 정책 효과 분석	정호성 · 이지은
11	Does Intra-Regional Trade Matter in Regional Stock Markets?: New Evidence from Asia-Pacific Region	Sei-Wan Kim · Moon Jung Choi
12	Liability, Information, and Anti-fraud Investment in a Layered Retail Payment Structure	Kyoung-Soo Yoon · Jooyong Jun
13	Testing the Labor Market Dualism in Korea	Sungyup Chung · Sunyoung Jung
14	북한 이중경제 사회계정행렬 추정을 통한 비공식부문 분석	최지영

제2016 –15	Divergent EME Responses to Global and Domestic Monetary Policy Shocks	Woon Gyu Choi · Byongju Lee · Taesu Kang · Geun-Young Kim
16	Loan Rate Differences across Financial Sectors: A Mechanism Design Approach	Byoung-Ki Kim · Jun Gyu Min
17	근로자의 고용형태가 임금 및 소득 분포에 미치는 영향	최충 · 정성엽
18	Endogeneity of Inflation Target	Soyoung Kim · Geunhyung Yim
19	Who Are the First Users of a Newly-Emerging International Currency? A Demand-Side Study of Chinese Renminbi Internationalization	Hyoung-kyu Chey · Geun-Young Kim · Dong Hyun Lee
20	기업 취약성 지수 개발 및 기업 부실화에 대한 영향 분석	최영준
21	US Interest Rate Policy Spillover and International Capital Flow: Evidence from Korea	Jieun Lee · Jung-Min Kim · Jong Kook Shin
제**2017** –1	가계부채가 소비와 경제성장에 미치는 영향 – 유량효과와 저량효과 분석 –	강종구
2	Which Monetary Shocks Matter in Small Open Economies? Evidence from SVARs	Jongrim Ha · Inhwan So
3	FTA의 물가 안정화 효과 분석	곽노선 · 임호성
4	The Effect of Labor Market Polarization on the College Students' Employment	Sungyup Chung
5	국내 자영업의 폐업률 결정요인 분석	남윤미
6	차주별 패널자료를 이용한 주택담보대출의 연체요인에 대한 연구	정호성
7	국면전환 확산과정모형을 이용한 콜금리 행태 분석	최승문 · 김병국

제2017-8	Behavioral Aspects of Household Portfolio Choice: Effects of Loss Aversion on Life Insurance Uptake and Savings	In Do Hwang
9	신용공급 충격이 재화별 소비에 미치는 영향	김광환 · 최석기
10	유가가 손익분기인플레이션에 미치는 영향	김진용 · 김준철 · 임형준
11	인구구조변화가 인플레이션의 장기 추세에 미치는 영향	강환구
12	종합적 상환여건을 반영한 과다부채 가계의 리스크 요인 분석	이동진 · 한진현
13	Crowding out in a Dual Currency Regime? Digital versus Fiat Currency	KiHoon Hong · Kyounghoon Park · Jongmin Yu
14	Improving Forecast Accuracy of Financial Vulnerability: Partial Least Squares Factor Model Approach	Hyeongwoo Kim · Kyunghwan Ko
15	Which Type of Trust Matters?: Interpersonal vs. Institutional vs. Political Trust	In Do Hwang
16	기업특성에 따른 연령별 고용행태 분석	이상욱 · 권철우 · 남윤미
17	Equity Market Globalization and Portfolio Rebalancing	Kyungkeun Kim · Dongwon Lee
18	The Effect of Market Volatility on Liquidity and Stock Returns in the Korean Stock Market	Jieun Lee · KeeH.Chung
19	Using Cheap Talk to Polarize or Unify a Group of Decision Makers	Daeyoung Jeong
20	패스트트랙 기업회생절차가 법정관리 기업의 이자보상비율에 미친 영향	최영준
21	인구고령화가 경제성장에 미치는 영향	안병권 · 김기호 · 육승환
22	고령화에 대응한 인구대책: OECD사례를 중심으로	김진일 · 박경훈

제2018-4	Establishment Size and Wage Inequality: The Roles of Performance Pay and Rent Sharing	Sang-yoon Song
5	가계대출 부도요인 및 금융업권별 금융취약성: 자영업 차주를 중심으로	정호성
6	직업훈련이 청년취업률 제고에 미치는 영향	최충 · 김남주 · 최광성
7	재고투자와 경기변동에 대한 동학적 분석	서병선 · 장근호
8	Rare Disasters and Exchange Rates: An Empirical Investigation of South Korean Exchange Rates under Tension between the Two Koreas	Cheolbeom Park · Suyeon Park
9	통화정책과 기업 설비투자 – 자산가격경로와 대차대조표경로 분석 –	박상준 · 육승환
10	Upgrading Product Quality: The Impact of Tariffs and Standards	Jihyun Eum
11	북한이탈주민의 신용행태에 관한 연구	정승호 · 민병기 · 김주원
12	Uncertainty Shocks and Asymmetric Dynamics in Korea: A Nonlinear Approach	Kevin Larcher · Jaebeom Kim · Youngju Kim
13	북한경제의 대외개방에 따른 경제적 후생 변화 분석	정혁 · 최창용 · 최지영
14	Central Bank Reputation and Inflation-Unemployment Performance: Empirical Evidence from an Executive Survey of 62 Countries	In Do Hwang
15	Reserve Accumulation and Bank Lending: Evidence from Korea	Youngjin Yun
16	The Banks' Swansong: Banking and the Financial Markets under Asymmetric Information	Jungu Yang

제2018 –17	E–money: Legal Restrictions Theory and Monetary Policy	Ohik Kwon · Jaevin Park
18	글로벌 금융위기 전·후 외국인의 채권투자 결정요인 변화 분석: 한국의 사례	유복근
19	설비자본재 기술진보가 근로유형별 임금 및 고용에 미치는 영향	김남주
20	Fixed–Rate Loans and the Effectiveness of Monetary Policy	Sung Ho Park
21	Leverage, Hand–to–Mouth Households, and MPC Heterogeneity	Sang–yoon Song
22	선진국 수입수요가 우리나라 수출에 미치는 영향	최문정 · 김경근
23	Cross–Border Bank Flows through Foreign Branches: Evidence from Korea	Youngjin Yun
24	Accounting for the Sources of the Recent Decline in Korea's Exports to China	Moon Jung Choi · Kei–Mu Yi
25	The Effects of Export Diversification on Macroeconomic Stabilization: Evidence from Korea	Jinsoo Lee · Bok–Keun Yu
26	Identifying Uncertainty Shocks due to Geopolitical Swings in Korea	Seohyun Lee · Inhwan So · Jongrim Ha
27	Monetary Policy and Income Inequality in Korea	Jongwook Park
28	How the Financial Market Can Dampen the Effects of Commodity Price Shocks	Myunghyun Kim