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Supply shocks and the divine coincidence

Bae-Geun Kim

Chung-Ang University, 84 Heukseok-ro, Dongjak-gu, Seoul 156-756, Republic of Korea

HIGHLIGHTS

- Central banks face a trade-off between inflation and output variability.
- The conventional view is that supply shocks can create the trade-off.
- Yet no theory justifies the conventional view.
- This paper resolves the issue by focusing on low substitutability between inputs.

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ABSTRACT

Unlike the conventional view, Blanchard and Gali (2007) point out that supply shocks alone do not create a policy trade-off between stabilizing inflation and stabilizing the output gap. This paper shows that supply shocks can be a natural source of the trade-off by assuming that non-produced inputs are used in fixed proportions with output in the production process. The results can also be generalized to the case when the elasticity of substitution between non-produced inputs and labor is less than unity.

1. Introduction

Stabilizing inflation and stabilizing output variability are the two distinct goals of many central banks around the world. However, the standard new Keynesian Phillips curve (NKPC) implies that stabilizing inflation is equivalent to stabilizing the output gap. This property is called the divine coincidence by Blanchard and Gali (2007). The implication of the standard NKPC is at odds with the common perception that there is a trade-off between the two goals.

It has long been believed that supply shocks such as oil price hikes generate the trade-off. The stagflation observed in the 1970s is a historical event that supports this conventional view. Some researchers introduce an ad hoc cost-push shock in the NKPC reflecting the conventional view (see, for example, Clarida et al., 1999 among others). However, theoretically it is not clear how supply shocks add to the NKPC. Blanchard and Gali (2007) argue that supply shocks themselves do not make the divine coincidence disappear, and so mechanisms like real wage rigidities are necessary.

There are other approaches to addressing this issue. A number of researchers introduce inefficient shocks such as time-varying taxes and changes in desired price and wage markups. Steinsson (2003), Woodford (2003), Benigno and Woodford (2005), and Smets and Wouters (2007) are such examples. As in Erceg et al. (2000), nominal wage rigidities rather than real wage rigidities can also act to remove the divine coincidence. Additionally, recent paper by Alves (2014) shows that, if the steady-state inflation rate is not zero, the divine coincidence no longer holds.

In view of the recent global economic conditions, oil price changes appear to have a big effect on inflation, and to pose a dilemma for most central bankers. Under this circumstance, it may seem that supply shocks are a more natural source of policy trade-offs. Yet no theory justifies this perception.

This paper provides a theoretical justification for this perception. It points out that Blanchard and Gali's (2007) conclusions stem from the assumption that the elasticity of substitution between non-produced inputs and labor is unity (that is, Cobb–Douglas production function). As Basu (1996) argues, however, substitutability between materials and primary inputs is very

E-mail address: kimbg@cau.ac.kr.

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low. This study shows that, even without real wage rigidities, supply shocks do create a trade-off between stabilizing inflation and stabilizing the output gap if the elasticity of substitution between non-produced inputs and labor is less than unity.

2. The model

2.1. General setup

Supply shocks are modeled as exogenous changes in the real price of non-produced input. To begin with, I describe an economy in which firms use labor and non-produced input to produce output. Non-produced input is not substitutable with labor, and used in fixed proportions with output. The case of some substitutability between the two inputs is discussed later. Other features of the model are the same as in Blanchard and Gali (2007) to facilitate comparisons.

A representative household chooses a stream of consumption (C_t), hours worked (H_t) and bond holdings (B_t) to maximize the lifetime expected utility.

$$\text{Max. } E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log C_t - \frac{\xi_t}{1+\gamma} H_t^{1+\gamma} \right\} \tag{1}$$

where β is the subjective discount factor, γ is the inverse of the Frisch elasticity, and ξ_t is the time-varying parameter that represents the preference for labor. The budget constraint of this household is

$$P_t C_t + B_t = W_t H_t + DIV_t + R_{t-1} B_{t-1}$$

where DIV_t is dividend income received from firms, P_t the price level, W_t the nominal wage, and R_{t-1} the gross nominal interest rate on bonds held in the previous period. Aggregate consumption is a composite good expressed with a CES aggregator $C_t = \left[\int_0^1 C_t(i)^{(\varepsilon-1)/\varepsilon} di\right]^{\varepsilon/(\varepsilon-1)}$ where ε is the elasticity of substitution among differentiated goods and $C_t(i)$ is the household's consumption demand for the ith firm's good.

The first-order conditions of this problem are

$$\xi_t C_t H_t^{\gamma} = \frac{W_t}{P_t}, \tag{2}$$

$$\frac{1}{C_t} = \beta E_t \frac{1}{C_{t+1}} \frac{R_t}{\Pi_{t+1}} \tag{3}$$

where $\Pi_{t+1} = P_{t+1}/P_t$ is the gross inflation rate between periods t and $t+1$.

There is a continuum of firms indexed on [0, 1], each firm producing a differentiated good. An individual firm has Leontief production technology as follows. I suppress the firm-specific index to simplify notation.

$$Y_t = \min\left[\frac{M_t}{\phi}, \frac{A_t L_t}{1-\phi}\right] \tag{4}$$

where Y_t, M_t and L_t are output, non-produced input and labor input, respectively. A_t is the technology level common to all firms. ϕ is the parameter that implies the amount of non-produced input necessary to produce one unit of output. Cost minimization implies the following combination of inputs:

$$M_t = \phi Y_t, \tag{5}$$

$$L_t = (1-\phi)\frac{Y_t}{A_t}. \tag{6}$$

Thus total production cost of each firm is

$$TC_t = P_t^m M_t + W_t L_t = \phi P_t^m Y_t + (1-\phi) W_t \frac{Y_t}{A_t} \tag{7}$$

where P_t^m is the price of non-produced input. So it follows that real marginal cost is given by

$$mc_t = \phi \frac{P_t^m}{P_t} + (1-\phi)\frac{W_t}{P_t}\frac{1}{A_t}. \tag{8}$$

Real marginal cost is the same across all firms.

2.2. First-best allocation

As in Blanchard and Gali (2007), the first-best (or efficient) allocation is the one that obtains when there is perfect competition in product and labor markets, and at the same time all prices and wages are flexible. Since prices are flexible and marginal cost is the same across all firms, we can consider a symmetric equilibrium where all prices and quantities of output are the same across all firms. Under the first-best allocation, real marginal cost (the inverse of the markup) is equal to one:

$$\phi \frac{P_t^m}{P_t} + (1-\phi)\frac{W_t}{P_t}\frac{1}{A_t} = 1.$$

Let us define $w_t = W_t/P_t$ and $v_t = P_t^m/P_t$ as the real wage and the real price of non-produced input, respectively. The above equation implies that, in equilibrium, the real wage is determined by both the technology level and the real price of non-produced input:

$$w_t = \frac{A_t}{1-\phi}(1-\phi v_t). \tag{9}$$

In equilibrium, market clearing conditions hold as well:

$$Y_t = C_t, \tag{10}$$

$$H_t = L_t. \tag{11}$$

Eq. (6) implies that $Y_t = A_t L_t/(1-\phi)$. Using this relation and Eqs. (2), (9), (10) and (11), we have

$$\xi_t \frac{A_t L_t}{1-\phi} L_t^{\gamma} = \frac{A_t}{1-\phi}(1-\phi v_t).$$

Solving this equation for L_t gives us the first-best employment level (henceforth I use superscript * to denote variables under the first-best).

$$L_t^* = (\xi_t)^{-\frac{1}{1+\gamma}} (1-\phi v_t)^{\frac{1}{1+\gamma}}, \tag{12}$$

which in turn implies that the efficient output level is given by

$$Y_t^* = \frac{A_t}{1-\phi}(\xi_t)^{-\frac{1}{1+\gamma}} (1-\phi v_t)^{\frac{1}{1+\gamma}}. \tag{13}$$

2.3. Second-best equilibrium

The second-best (or natural) equilibrium is defined to be the resource allocation that prevails under the presence of imperfect competition in the product market. But it is still assumed that prices and wages are flexible. Under the CES structure, the desired markup is $\overline{\mu} = \varepsilon/(\varepsilon-1)$. So real marginal cost becomes equal to the inverse of the desired markup:

$$\phi v_t + (1-\phi)\frac{w_t}{A_t} = \frac{1}{\overline{\mu}}.$$

Now the real wage is given by

$$w_t = \frac{A_t}{1-\phi}\left(\frac{1}{\overline{\mu}} - \phi v_t\right). \tag{14}$$