Choice of Policy Instrument and Optimal Monetary Policy in Open Economies*

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Abstract

This paper examines the choice of policy instrument for implementing optimal monetary policy under noncooperative games in a two-country dynamic stochastic general equilibrium model under local currency pricing. It examines four options of policy instruments, obtains impulse responses of key macro variables to technology shocks and computes welfare costs from noncooperation under each noncooperative game. It shows that choosing different policy instruments generally leads to different equilibria and, in particular, choosing the nominal interest rate results in equilibrium indeterminancy. In addition, the welfare ranking of these policy instruments depends on the degree of openness of a country, measured by the weight consumers put in utility on imported goods. When countries are less open, choosing the producer price index inflation rate as policy instrument induces larger welfare cost from noncooperation than choosing the consumer price index inflation rate does, which in turns induces larger welfare cost than choosing the import price inflation rate; Conversely, the reverse is true when countries are more open. These results shed light on the important role that a country's openness plays in affecting the choice of noncooperative policy regimes, while the former could be affected by the process of the country's economic integration and deserves special attention from national policy makers.

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1 Introduction

In the context of open economies, the interaction between policy makers when implementing optimal monetary policy, that is whether they should conduct their monetary policy in a cooperative or noncooperative way, is one of the key issues in monetary policy analysis. While the definition of cooperation between two policy makers in the literature is straightforward, researchers differ on the specification of monetary policy under noncooperation, which takes form of a choice of policy instrument.[1]

Policy instrument choice for noncooperative games is a small but important part of the monetary policy literature, and yet to be examined extensively. The question at stake is whether the strategic interaction specified by the choice of instrument matters for the outcome of implementing optimal monetary policy under noncooperation. And if so, to what extent it matters?

This question was first discussed in an early literature starting with Poole (1970). The literature is based on the Hicksian IS-LM models and compares two classical monetary policy instruments that monetary authorities operate through–interest rate changes or money stock changes–in closed economies and, as international extensions, in small open economies. It does not consider the impact of domestic monetary policy on the rest of the world. It typically argues that the choice of instrument could have a significant effect on the volatility of macro variables and that the welfare ranking of instruments depends on the particular values of parameters. Later studies by Canzoneri and Henderson (1989), Henderson and Zhu (1990), and Turnovsky and d'Orey (1989), among others, start to examine monetary policy instrument choice with two-country models. They still work with the two classical monetary policy instruments but have strategic game considerations, inspired by the work of Hamada (1976). The conclusion drawn from these works is that the noncooperative equilibrium that emerges from the strategic game played by central banks depends crucially on the instrument chosen by the two players. Since the mid-1990s, the so-called New Open Economy Macroeconomics (hereafter, NOEM) has become the workhorse for monetary policy analysis.[2] Under the NOEM framework, Obstfeld and Rogoff (1998, 2002), Devereux and Engel (2003), and Sutherland (2004) consider the traditional choice of the money supply as policy instrument, Clarida, Galí, and Gertler (2002) and Corsetti and Pesenti (2005) specify monetary policy in terms of the nominal interest rate, while Benigno and Benigno (2006) choose the inflation rate of the producer goods for their noncooperative strategic space. Yet none of these studies has explicitly addressed the issue of whether choosing a different policy instrument would change the equilibrium outcome of their respective noncooperative monetary policy.

This paper contributes to the NOEM literature on policy instrument choice by examining four options of policy instruments and their impact on equilibrium and welfare

[1] The cooperative policy is defined as that policy makes jointly maximize the weighted sum of the aggregate welfare of both countries and the weight is equal to the country size.

[2] The literature was initiated by Obstfeld and Rogoff (1995) and Svensson and van Wijnbergen (1989). Fujiwara and Wang (2016) provides a detailed taxonomy of this literature. The NOEM literature assumes explicit microfoundation of private sector, providing a natural criterion for evaluating welfare implications of alternative noncooperative monetary policies.

from implementing noncooperative optimal monetary policy in a microfounded, sticky-price, two-country general equilibrium stochastic equilibrium (hereafter, DSGE) model under local currency pricing (hereafter, LCP). The four policy instrument options are the nominal interest rate, the producer price index (hereafter, PPI) inflation rate, the consumer price index (hereafter, CPI) inflation rate, and the inflation rate of price for imported goods.[3] The noncooperative game in the paper is defined as that each policy maker maximizes the aggregate welfare function of its own country, taking as given the entire path of the foreign policy makers' instrument, as in Blake and Westaway (1995), i.e. an open-loop Nash equilibrium.[4] Lombardo and Sutherland (2006) and Coenen et al. (2010) also explicitly evaluate the impact of different policy instruments on the equilibria and welfare under the NOEM framework, although they only consider the money supply and the nominal interest rate as policy instruments and adopt the closed-loop equilibrium which makes their results not directly comparable to this paper.

Two key findings are obtained. First, the choice of policy instrument does matter for the equilibrium under noncooperative games. Choosing different policy instruments leads to different equilibria. In particular, choosing the nominal interest rate as policy instrument leads to equilibrium indeterminacy. This repeats the findings in Blake (2012) and de Fiore and Liu (2002), although they use different models from the one in this paper.[5] Second, the welfare ranking of the policy instruments, excluding the nominal interest rate, depends on the degree of openness of the economy, which is measured by the weight that consumers put in utility from consuming the imported goods. When the economy is less open, that is, the domestically produced goods carry a larger weight in the consumption basket than the imported goods, choosing the inflation rate of the domestically produced goods (the PPI inflation rate) as policy instruments generates larger welfare cost from noncooperation than choosing the CPI inflation rate or the inflation rate of price for the imported goods does. Conversely, when the economy is more open and the producer goods carry a smaller weight, selecting the PPI inflation rate for the noncooperative game then induces smaller deviation of the welfare from its cooperative level.

In the paper, there are special cases in which the choice of policy instrument is irrelevant to the equilibrium outcome. They are (1) consumers put equal weight on both types of goods, or (2) the disutility function is linear in labor. Under LCP, these are also

[3]Under producer currency pricing (hereafter, PCP), the law of one price holds and the only appropriate option for policy makers is the PPI inflation rate, because fluctuations of import price inflation rates fully reflect fluctuations of the nominal exchange rate, and the CPI inflation rate moves in proportion to the PPI inflation rate.

[4]The alternative Nash equilibrium would be a closed-loop equilibrium for which the sequence of foreign instruments is known to be dependent on some of the other system variables. See, for example, Coenen et al. (2010) for a discussion on the distinction between the open- and closed-loop Nash game and a list of relevant studies adopting the closed-loop Nash equilibrium into different models.

[5]Blake (2012) uses several canonical New Keynesian models to examine the indeterminacy of fixed nominal interest rate rules in finite horizons. de Fiore and Liu (2002) examine the conditions on equilibrium determinacy with a feedback interest rate rule in a small open economy model under PCP. They find that a passive interest rate always ensures equilibrium determinacy while an active interest rate can lead to determinacy only if the degree of openness exceeds a certain threshold and a certain critical level, both of which are determined by fundamental parameters in preferences and in technologies.

the special cases in which gains from cooperation become zero.

The rest of the paper is organized as follows. Section 2 sets up the model and derives equilibrium conditions. Section 3 specifies cooperative policy and the noncooperative policy under each of the four strategic games. Section 4 compares impulse responses under cooperation and each of the four noncooperative games and computes welfare costs from noncooperation given each of the games. Section 5 concludes.

2 The Model

The model is nearly identical to the one in Fujiwara and Wang (2016). There are two countries of equal size, Home and Foreign, each populated with a continuum of households with population size normalized to unity. Agents in the two countries consume both home goods and foreign goods but put different weights on the two categories of goods for utility. This is a popular assumption in the open-economy macroeconomics literature, and can be regarded as a short-cut way of modeling the openness of a country. A less open economy puts less weight on consumption of imported goods.[6] Households supply labor services to firms within their own country via a competitive labor market. Households are also the owner of domestic firms. Firms maximize profits in a monopolistically competitive market using labor as the only input according to aggregate technology. Firms choose domestic prices and export prices separately under LCP. The law of one price does not hold. Governments levy a lump-sum tax on households and subsidize firms so that the deterministic steady-state output level becomes efficient. Central banks as policy makers are benevolent and aim to maximize social welfare through either cooperation or noncooperation. In the cooperative equilibrium, both central banks conduct the optimal monetary policies that maximize the joint welfare which is a population-weighted sum of the utility of the representative households in both economies; In the noncooperative equilibrium, each central bank maximizes the welfare of its own country, taking as given the entire path of the other central bank's instrument. The candidates for policy instruments include the PPI inflation rate, the CPI inflation rate, the inflation rate of price for imported goods, and the nominal interest rate. Correspondingly, I define the Nash game given each of the four policy specifications as Game 1, 2, 3 and 4, respectively.

The structure of the home country is briefly described below. The foreign country has an identical structure. Where appropriate, foreign variables are denoted with an asterisk.

2.1 Households

A representative household in the home country maximizes welfare

$$W_{H,t_0} \equiv \mathbb{E}_{t_0} \sum_{t=t_0}^{\infty} \beta^{t-t_0} \left[u\left(C_t\right) - v\left(h_t\right) \right] \tag{2.1}$$

[6]In other words, consumers exhibit home bias.

subject to the budget constraint:

$$\mathbb{E}_t \left[m_{t,t+1}A_{t+1}\right] + B_{t+1} + P_t C_t \leq A_t + \left(1+i_{t-1}\right) B_t + W_t h_t + \Pi_t + T_t,$$

for $t \geq t_0$, where the consumption aggregator C_t, the aggregate consumption of locally produced goods $C_{H,t}$, and the aggregate consumption of imported goods $C_{F,t}$ is given by

$$C_t = C_{H,t}^{\frac{\nu}{2}} C_{F,t}^{1-\frac{\nu}{2}}, \tag{2.2}$$

$$C_{H,t} = \left[\int_0^1 C_{H,t}\left(j\right)^{1-\frac{1}{\varepsilon}} \mathrm{d}j\right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{2.3}$$

$$C_{F,t} = \left[\int_0^1 C_{F,t}\left(j^*\right)^{1-\frac{1}{\varepsilon}} \mathrm{d}j^*\right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{2.4}$$

respectively. $u\left(.\right)$ is the period utility function, increasing and concave in consumption. $v\left(.\right)$ is the period disutility function, increasing and convex in labor h_t (measured by working hours). W_t denotes the nominal wage. A_{t+1} denotes the holdings of the state contingent (Arrow) securities at the end of period t denominated in the domestic currency, which equates the marginal rates of substitutions of two countries even *ex post*. $m_{t,t+1}$ denotes the price of the Arrow securities in period t which gives an unitary return in period $t+1$. B_t is the amount of one-period risk-free nominal bonds held at the beginning of period t with net rate of return i_{t-1}. Π_t represents the dividend from the ownership of firms. T_t represents the lump-sum tax levied by the government. β is the discount factor. ϵ denotes the elasticity of substitution among differentiated varieties within each country. $\nu \in [0,2]$ determines the (symmetric) home bias. When ν is larger (smaller) than unity, consumer preference exhibits home (foreign) bias. There is no home bias when ν equals unity. $C_{H,t}\left(j\right)$ and $C_{F,t}\left(j^*\right)$ denote the home representative household's consumption of the goods produced by the home firm j and the foreign firm j^*, respectively. Note that Lagrange multipliers on the constraints in equations (2.2) to (2.4) represent CPI P_t, PPI $P_{H,t}$, and the import price index $P_{F,t}$.

2.2 Firms

Firm j in the home country sets prices in a monopolistically competitive market to maximize the present discounted value of profits:

$$\mathbb{E}_{t_0} \sum_{t=t_0}^{\infty} \theta^{t-t_0} m_{t_0,t} \Pi_t\left(j\right),$$

where

$$\Pi_t\left(j\right) = \left(1+\tau\right) P_{H,t}(j) C_{H,t}(j) + \left(1+\tau\right) S_t P_{H,t}^*(j) C_{H,t}^*(j) - W_t h_t\left(j\right)$$

subject to the production function:

$$Y_t(j) = \exp(z_t) h_t(j), \tag{2.5}$$

and the resource constraint:

$$Y_t(j) = C_{H,t}(j) + C^*_{H,t}(j). \tag{2.6}$$

$m_{t_0,t}$ is the stochastic discount factor by which firms value profits for their owner, S_t denotes the nominal exchange rate of the foreign currency in units of the home currency. τ represents the government subsidy rate. Firm j produces $Y_t(j)$ of the product by hiring $h_t(j)$ of labor service from the domestic households according to aggregate production technology $\exp(z_t)$, where z_t follows an AR(1) exogenous process. Firms set their optimal prices, $P_{H,t}(j)$ and $P^*_{H,t}(j)$, in a staggered manner à la Calvo (1983) rule. Each time, only with probability $1-\theta$, can they re-optimize their prices. Note that the Lagrange multiplier on a constraint where the production function in equation (2.5) and the resource constraint in equation (2.6) are combined represents nominal marginal costs:

$$NMC_t = \frac{W_t}{\exp(z_t)}.$$

There is no firm specificity in marginal costs.

2.3 Governments and Central Banks

The government in the home country collects a lump sum tax from households and subsidizes firms to eliminate steady state distortions stemming from monopolistic competition.[7] Thus, the subsidy rate is given by

$$\tau = \frac{1}{\epsilon - 1}.$$

The government always achieves a balanced budget constraint:

$$T_t = \tau \int_0^1 \left[P_{H,t}(j) C_{H,t}(j) + S_t P^*_{H,t}(j) C^*_{H,t}(j) \right] \mathrm{d}j.$$

Benevolent central banks aim to maximize social welfare as Ramsey planners. I consider two cases: both central banks cooperate to maximize global welfare; each maximizes social welfare of its own country in an open-loop Nash (noncooperative) game. Details of such optimal policies will be discussed later.

[7] There is no strategic interaction between the government and the central bank.

2.4 Aggregate Conditions

Taking the integral of equation (2.5) over j gives the aggregate production function of the home country

$$Y_t = \exp(z_t) h_t.$$

Taking the integral of the resource constraint equation (2.6) over j and making use of the Hicksian demand functions for good j by consumers in both countries gives the aggregate resource constraint of the home country

$$Y_t = C_{H,t}\Delta_{H,t} + C^*_{H,t}\Delta^*_{H,t},$$

where $\Delta_{H,t} \equiv \int_0^1 \left[\frac{P_{H,t}(j)}{P_{H,t}}\right]^{-\epsilon} \mathrm{d}j$ and $\Delta^*_{H,t} \equiv \int_0^1 \left[\frac{P^*_{H,t}(j)}{P^*_{H,t}}\right]^{-\epsilon} \mathrm{d}j$ are the price dispersion terms.[8]

The global assets market is assumed complete, and thus trades in the Arrow securities equate the marginal rates of substitution between two countries even *ex post*. With the assumption of the symmetric initial conditions of wealth, the standard risk sharing condition is obtained as follows:

$$u'(C^*_t) = e_t u'(C_t),$$

where the real exchange rate is defined as

$$e_t \equiv \frac{S_t P^*_t}{P_t}.$$

2.5 Equilibrium Conditions

The home representative household's period utility is specified as

$$\begin{aligned} u(C_t) &\equiv \frac{C_t^{1-\sigma} - 1}{1-\sigma}, \\ v(h_t) &\equiv \chi \frac{h_t^{1+\omega}}{1+\omega}. \end{aligned}$$

The system of equations consists of the first-order necessary conditions from solving households' as well as firms' optimization problem together with market clearing conditions. All nominal variables are detrended by the aggregate price indexes, P_t and P^*_t, and inflation rates are defined as follows: $\pi_t = P_t/P_{t-1}$, $\pi^*_t = P^*_t/P^*_{t-1}$, $\pi_{H,t} = P_{H,t}/P_{H,t-1}$, $\pi^*_{H,t} = P^*_{H,t}/P^*_{H,t-1}$, $\pi_{F,t} = P_{F,t}/P_{F,t-1}$, and $\pi^*_{F,t} = P^*_{F,t}/P^*_{F,t-1}$. The detailed system of equilibrium conditions is summarized in Table 2 in Fujiwara and Wang (2016). These equations together with monetary policy rules solve the rational expectations equilibrium.

[8] See Fujiwara and Wang (2016) for details in derivation of the Hicksian demand functions.

3 Optimal Monetary Policies

In this section, I first set up the Ramsey problem under both cooperative and noncooperative games.

- **Cooperative Policy**

Central banks under cooperation maximize global welfare:

$$W_{W,t_0} = W_{H,t_0} + W_{F,t_0},$$

where

$$W_{H,t_0} \equiv \mathbb{E}_{t_0} \sum_{t=t_0}^{\infty} \beta^{t-t_0} \left[u\left(C_t\right) - v\left(h_t\right) \right]$$

as in equation (2.1) and

$$W_{F,t_0} \equiv \mathbb{E}_{t_0} \sum_{t=t_0}^{\infty} \beta^{t-t_0} \left[u\left(C_t^*\right) - v\left(h_t^*\right) \right], \tag{3.1}$$

subject to the nonlinear equilibrium conditions summarized in Table 2 in Fujiwara and Wang (2016).

- **Noncooperative Policy**
  - *Game 1*

    In this noncooperative case, the domestic central bank maximizes equation (2.1) given $\{\pi_{F,t}^*\}_{t=t_0}^{\infty}$ while the foreign central bank maximizes equation (3.1) given $\{\pi_{H,t}\}_{t=t_0}^{\infty}$, both central banks are subject to the same nonlinear equilibrium conditions summarized in Table 2 Fujiwara and Wang (2016).
  - *Game 2*

    In this noncooperative case, the domestic central bank maximizes equation (2.1) given $\{\pi_t^*\}_{t=t_0}^{\infty}$ while the foreign central bank maximizes equation (3.1) given $\{\pi_t\}_{t=t_0}^{\infty}$, both central banks are subject to the same nonlinear equilibrium conditions as above.
  - *Game 3*

    In this noncooperative case, the domestic central bank maximizes equation (2.1) given $\{\pi_{H,t}^*\}_{t=t_0}^{\infty}$ while the foreign central bank maximizes equation (3.1) given $\{\pi_{F,t}\}_{t=t_0}^{\infty}$, both central banks are subject to the same nonlinear equilibrium conditions as above.
  - *Game 4*

    In this noncooperative case, the domestic central bank maximizes equation (2.1) given $\{i_t^*\}$ while the foreign central bank maximizes equation (3.1) given $\{i_t\}_{t=t_0}^{\infty}$, both central banks are subject to the same nonlinear equilibrium conditions as above.

I apply the perturbation method to solve the above Ramsey problems. Deterministic steady states around which the system is locally approximated are obtained and reported in Appendix A in Fujiwara and Wang (2016).[9] Results are presented and discussed in the next section.[10]

4 Results

In this section, I first depict the impulse responses of the two countries in response to a technology shock to the home country under both cooperative policy and noncooperative policies defined in Section 3. I then compute welfare costs from noncooperation specified by each of the games above. Note that under Game 4 where a central bank chooses the optimal allocation taking as given the foreign interest rate, a locally indeterminate (explosive) equilibrium emerges. The rationale behind the indeterminacy is that the domestic central bank would choose a best response to the exogenously given foreign interest rate such that a saddle-path equilibrium is reestablished, and when two such strategies are combined together, they would produce too many unstable roots, as Coenen et al. (2010) argue. Below I report dynamics and welfare costs from noncooperation under cooperation and Games 1-3.

4.1 Impulse Responses Results

The baseline calibration for parameter values is shown in Table 1. β, χ and the probability of not being able to reset prices θ are set at the conventional values. ν is set at 1.5 which means consumers put 3/4 of the weight on domestic goods in utility, that is, consumption preference exhibits home bias or equivalently, countries are less open. The inverse of intertemporal elasticity of substitution in consumption,σ, is set it to 1 and the elasticity of substitution among different varieties within goods category, ϵ, is set at 7.66. The inverse of the Frisch elasticity ω is at 4.71. And finally the log-technology follows an AR(1) stochastic process with serial correlation ρ set at 0.856 and standard deviation at 0.0064.[11]

[9] As discussed in Fujiwara and Wang (2016), the deterministic steady state turns out to be irrespective of cooperation or noncooperation. It is that under the flexible price equilibrium thanks to the appropriate fiscal subsidy rate that eliminates the monopolistic distortion in output at the steady state. This allows me to make meaningful comparison of the welfare under alternative policies.

[10] I develop the code in Dynare and execute it in MATLAB. Code is available upon request.

[11] For the range of σ, see Benigno and Benigno (2006), for the range of ω, see Erceg, Gust, and Lopez-Salido (2007), and for technology calibration, see Schmitt-Grohé and Uribe (2007).

Table 1: Parameter values (Baseline)

Parameter	Value	Description
β	0.99	Subjective discount factor
θ	0.75	Probability of a firm not being chosen to reset its prices at each period
ϵ	7.66	Elasticity of substitution among different products within goods category
ν	1.5	Weight that households put on consumption of domestic goods in utility ($\nu/2$)
σ	1	Inverse of the intertemporal elasticity of substitution of consumption
χ	1	Coefficient associated with disutility of labor
ω	4.71	Inverse of the Frisch elasticity

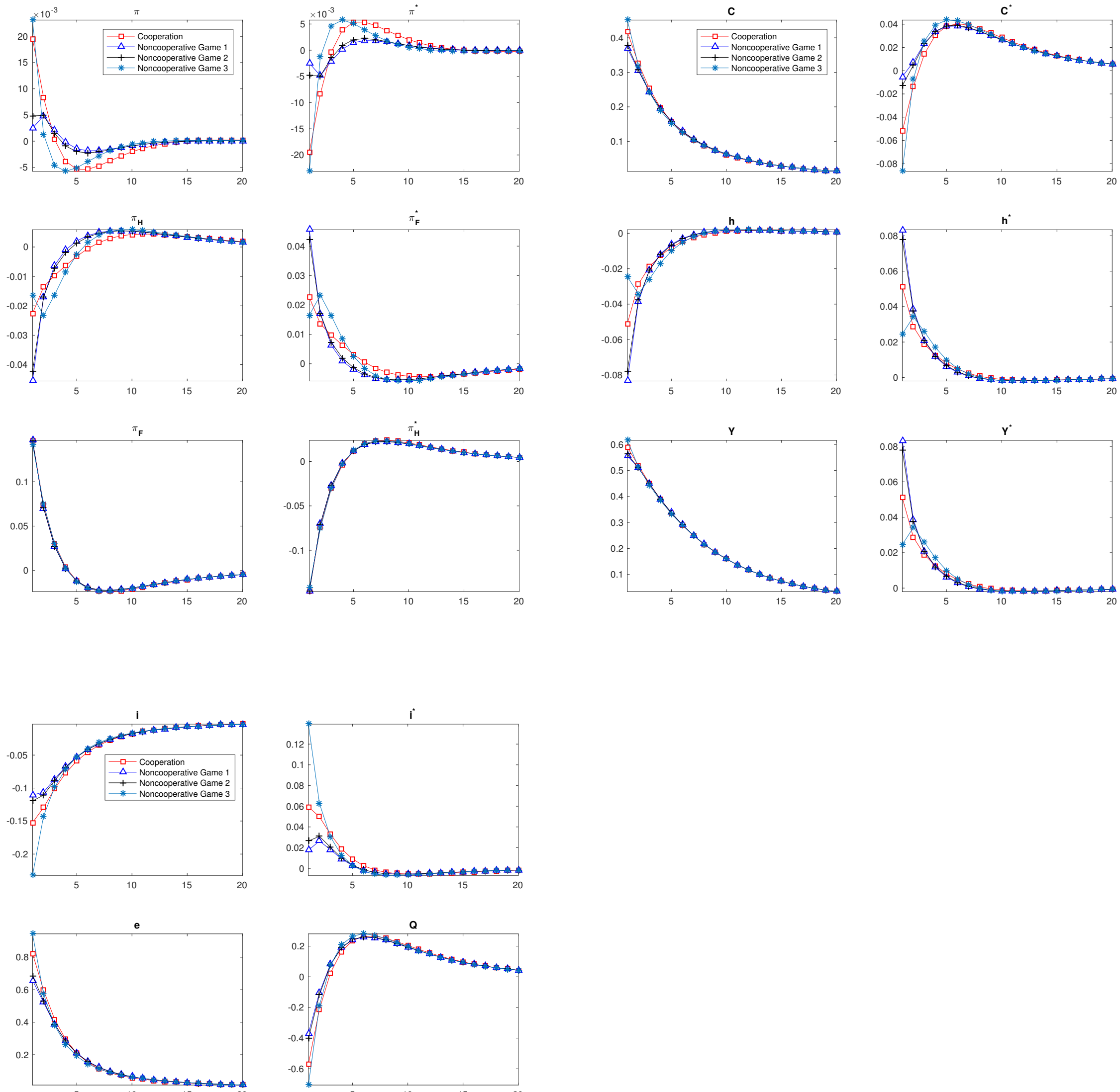
Figure 1 depicts the impulse responses of the key macro variables under both cooperation and noncooperative games specified by Game 1-3 in response to one standard deviation of a positive technology shock to the home country (I scale up the impulse responses by 100 so the dynamics in Figure 1 are measured in per cent). Figure 1 shows that optimal monetary policies under different noncooperative games lead to different equilibria under LCP in response to the same technology shock. Specifically, choosing the PPI inflation rate as policy instrument for implementing the optimal policy (Game 1) gives rise to the largest deviation of the real variables from their respective cooperative allocations while taking the import price inflation rate in the counterpart country as given (Game 3) generates the smallest deviation. Game 2 with the CPI inflation rate as policy instrument sees a deviation that lies in between the first two.

To understand the dynamics under these noncooperative regimes, it is important to first recognize that under LCP, optimal policy under noncooperation seeks to stabilize inflation rates that are relevant to its own country and de-stabilize those relevant to the foreign country more so than it does under cooperation, as demonstrated by the additional terms in the quadratic loss functions under noncooperation in Fujiwara and Wang (2016). With $\nu > 1$, the two countries are less open and the producer goods weigh more than the imported goods in the consumption basket for utility. The stabilizing/destabilizing incentive then becomes the largest under Game 1 where the PPI inflation rate of the foreign country is taken as given. As a result, the CPI inflation rate of the two countries is stabilized to the largest extent under Game 1, to a lesser extent under Game 2 while Game 3 sees the smallest deviation of the CPI inflation rate from its allocation under cooperation.

Bearing this in mind, under LCP with $\nu > 1$, optimal policy also trades off output responses with stabilization of the CPI inflation rate. As a trade-off, home output increases the least under Game 1, which translates into a farthest fall in home PPI inflation rate and corresponds to a biggest cut back in home working hours. In response to a technology improvement shock, the home (foreign) monetary policy thus becomes the least expansionary (contractionary) under Game 1, evidenced by the movements in nominal interest rates in both countries. The resultant (nominal and) real exchange rate depreciation and terms-of-trade improvement of the home country is of the smallest degree again under Game 1.[12] This means the real purchasing power of the home consumers is raised by the smallest amount at any given price level, thus the home aggregation consumption (demand for both goods) rises the least under Game 1. Foreign output rises the largest under Game 1 because the smallest improvement of the home terms of trade mirrors the smallest deterioration of the foreign terms of trade, giving foreign consumers stronger purchasing power under Game 1, relative to that under Game 2 or 3, which raises foreign demand for the foreign goods given any price level. Foreign aggregation consumption is compensated and working hours are extended the most under Game 1 accordingly.

[12] Recall that under LCP a depreciation of the home currency leads to an improvement of the home terms of trade as households receive more revenues from export sales denominated in the home currency, leading to a stronger real purchasing power of the home consumers.

Figure 1: Impulse responses of both countries to one SD home technology improvement shock.



4.2 Welfare Cost from Noncooperation

Table 2 reports welfare costs from noncooperation under each of the three strategic games. The welfare cost is measured in consumption units by Lucas (1992).[13] The first two rows report the welfare costs from noncooperation for the home and foreign households, respectively, in the baseline parameterization as in Section 4.1. It shows that when $\nu > 1$ in the baseline model, welfare cost from the inability to cooperate is the largest under Game 1 where the PPI inflation rate is selected as policy instrument, amounted to 0.0297% in consumption units for each country, meaning that households in each country have to give up about 0.03 per cent of their aggregate consumption to be as well off under cooperation as under noncooperative Game 1. Welfare cost from noncooperation reduces to $\lambda_H = \lambda_F^* = 0.0219\%$ under Game 2 and $\lambda_H = \lambda_F^* = 0.0114\%$ under Game 3 for both countries. Note that the gain from cooperation is relatively small in absolute values with only technology shocks (Fujiwara and Wang (2016) computes the welfare gain from cooperation over the reasonable range of parameter calibration and in general the size of the gain with only technology shocks is small).

The rows in $\nu = 0.5$ in Table 1 show that the ranking of the welfare costs is reversed when the two countries become more open with $\nu < 1$. Welfare cost from noncooperation is computed to be the smallest under Game 1 while the largest under Game 3. As a robustness check, the rows in $\sigma = 2$ report welfare costs from noncooperation when the intertemporal elasticity of substitution of consumption is not unitary. They show that given the degree of openness in the baseline calibration, the welfare ranking of the strategic games stays unchanged.

There are two special cases in which choice of policy instrument is irrelevant to the equilibrium outcome under LCP, as shown in rows of $\nu = 1$ and $\omega = 0$ in Table 1. They are the exact special cases in which welfare costs from noncooperation are zero found in Fujiwara and Wang (2016).

Table 2: Welfare costs from noncooperation under different games.
Baseline parameter values: $\nu = 1.5$, $\omega = 4.71$, $\sigma = 1$.

		Game 1	Game 2	Game 3
baseline	λ_H	.0297	.0219	.0114
	λ_F^*	.0297	.0219	.0114
$\nu = 0.5$	λ_H	.0114	.0219	.0297
	λ_F^*	.0114	.0219	.0297
$\sigma = 2$	λ_H	.0048	.0037	.0007
	λ_F^*	.0053	.0041	.0008
$\nu = 1$	λ_H	0	0	0
	λ_F^*	0	0	0
$\omega = 0$	λ_H	0	0	0
	λ_F^*	0	0	0

[13]See Fujiwara and Wang (2016) for details in derivation of expressions for consumption units.

5 Conclusions

This paper adds to the discussion on policy instrument choice in the NOEM literature by explicitly considering four options of policy instruments–the nominal interest rate, the PPI inflation rate, the CPI inflation rate and the import price inflation rate–for implementing noncooperative optimal monetary policy. It examines the impact of selecting different policy instruments on the equilibrium and welfare of the noncooperative policy in a two-country DSGE model under LCP. It shows that in general the choice of policy instrument does matter for the equilibrium outcome and affects the size of welfare cost from noncooperation. Excluding the choice of taking the nominal interest rate of the foreign country as given, which leads to equilibrium indeterminacy, the welfare ranking of the rest three policy instruments depends crucially on the degree of openness of the country. As consistence with the previous chapter, this paper assumes only technology shocks. As an extension of the current paper, it would be interesting to re-examine the equilibrium and welfare implication of the noncooperative regimes considered in this paper if other exogenous shocks, such as markup shocks, hit the economy.

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