



Optimal monetary policy in an economy with vertical production and trade: An analysis based on the perspective of local currency pricing



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ARTICLE INFO

Article history:

Received 19 August 2013
Received in revised form 26 July 2014
Accepted 26 March 2015
Available online 27 April 2015

JEL classification:

F41
F42

Keywords:

Local currency pricing
Vertical production and trade
Monetary coordination

ABSTRACT

By incorporating the factor of firms' asymmetric price setting behavior into a two-country model with vertical production and trade, we analyze the issues of optimal monetary policies in non-cooperative and cooperative equilibriums. The three main results to be stressed are as follows. First, we show that if the home and foreign countries have identical ratios with respect to intermediate goods firms that set their export prices in the local currency, the optimal monetary stance in a non-cooperative equilibrium is eased in response to an increase in the ratios. Second, under such an optimal monetary stance, we show that welfare is maximized in both the home and foreign countries if all home and foreign intermediate goods firms set their export prices in the local currency. Third, in a scenario where not all home and foreign intermediate goods firms adopt this pricing strategy, we show that there is always a welfare gain from cooperation.

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1. Introduction

Over the past several decades, interdependence among nations has grown with the deepening of vertical structures of production and trade. This can easily be observed from the current structure of world trade. For example, intermediate goods produced in Japan are exported to China and ASEAN, where they are assembled into final goods that are exported to Japan and the United States. In an empirical study of such a trade structure, using data from 10 OECD and four emerging economies, [Hummels et al. \(2001\)](#) show that vertical trade accounts for 21 percent of these countries' total exports and grew 28 percent between 1970 and 1990. They also show that growth in vertical trade accounts for 30 percent of the growth in these countries' exports.¹ There exist several studies that try to find the optimal monetary policy by focusing on an environment where all the trade in goods between countries occurs in one stage, but there are very few studies that focus on economies with vertical structures of production and trade. The purpose of this paper, therefore, is to examine the issues of optimal monetary policies and international policy coordination analytically, using a two-country model with vertical production and trade, taking

into account intermediate goods firms' asymmetric price setting behavior.²

To achieve the above purpose, using the two-country model proposed by [Corsetti and Pesenti \(2001\)](#),³ we construct a new open economy macroeconomics (hereinafter referred to as "NOEM") model including the two factors of trade in intermediate goods, and intermediate goods firms' asymmetric price setting behavior.⁴ Note that the volume of literature on NOEM that analyzes optimal monetary policies and international policy coordination using one or both of the aforementioned factors is relatively small. [Devereux and Engel \(2007\)](#) use a model limited to only intermediate goods trade to develop a view of the exchange rate policy as a trade-off between the desire to smooth fluctuations in real exchange rates and the

² This paper incorporates the factor of firms' price setting behavior, which is a major feature in the context of the recent open macroeconomic models, into the model. [Knetter \(1993\)](#), which is a representative research paper in this field, finds that approximately half of all Japanese firms set their export prices in the local currency, while almost all U.S. firms set their export prices in their own currency. Other studies besides [Knetter \(1993\)](#) also find that many firms in major developed countries aside from the U.S. set their export prices in the local currency; examples include [Marston \(1990\)](#), [Parsley \(1993\)](#), [Athukoralal and Menon \(1994\)](#), [ECU Institute \(1995\)](#) and [Gagnon and Knetter \(1995\)](#).

³ [Corsetti and Pesenti \(2001\)](#) is a paper representative of NOEM literature.

⁴ Our current paper has constructed a new model of NOEM mainly for examining the issues of optimal monetary policies. This model, however, is similar to the model for examining the welfare effects of home monetary expansion used in [Dohwa \(2014\)](#), which is our previous paper.

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¹ [Hummels et al. \(2001\)](#) argue, based on empirical analysis, that the vertical structure of production and trade is an important feature of today's global production and trade. [Feenstra \(1998\)](#) and [Yi \(2003\)](#) also emphasize this point in their papers.

need to allow flexibility in the nominal exchange rate. Huang and Liu (2006) mainly examine the effects of home monetary expansion on the welfare of both countries using the two-country model with multiple stages of production and trade, taking into account firms' pricing behavior. However, none of the above studies analyzes the optimal monetary policy in the two-country model with vertical production and trade.

On the other hand, as mentioned before, there are numerous studies on the optimal monetary policy in an environment where all the trade in goods between countries occurs in one stage. For example, by incorporating firms' asymmetric price setting behavior into the two-country model, Corsetti and Pesenti (2005) and Michaelis (2006) compare optimal monetary policies in non-cooperative and cooperative equilibriums. By incorporating firms' price setting behavior into the two-country model, Devereux and Engel (2003) also do the same thing. However, Devereux and Engel (2003) cannot consider the issues of optimal monetary policy under a condition of asymmetric price setting behavior among home and foreign firms, since they assume that all home and foreign firms set their export prices in either their own currency or the local currency. Betts and Devereux (2000b) also have the same problem as Devereux and Engel (2003), since they assume that the fraction of exporters who set prices in the local currency of sale is symmetric across countries. Benigno (2002), Clarida et al. (2002), Obstfeld and Rogoff (2002), and Benigno and Benigno (2003) perform their analysis without regard to firms' price setting behavior.

As a further comparison, Shi and Xu (2007) examine the issue of non-cooperative optimal monetary policy in a world with vertical production and trade by incorporating two stages of production and trade into the two-country model. However, they do not tackle the issue of cooperative optimal monetary policy and moreover perform their analysis focusing on an environment where all home and foreign intermediate goods firms set their export prices in either their own currency or the local currency.

Our contribution to the literature is to present a simple formal analysis incorporating a vertical structure of production and trade, and asymmetric price setting behavior among home and foreign firms engaged in intermediate goods trade, and to show how it can be used to shed light on issues such as the above, which cannot be handled by models that are more conventional. These issues include the comparison of non-cooperative and cooperative optimal monetary policies, and the role played by the asymmetric price setting behavior of home and foreign intermediate goods firms, which affects non-cooperative optimal monetary policies in various ways.

The main results of this paper are as follows. First, when the home and foreign countries have identical ratios of intermediate goods firms that set their export prices in the local currency, the optimal monetary stance in a non-cooperative equilibrium is eased in response to the increase in their ratios. Second, under such an optimal monetary stance, when all home and foreign intermediate goods firms set their export prices in the local currency, the levels of home and foreign welfare are maximized. Third, when the home intermediate goods firms set their export prices in their own currency and the foreign intermediate goods firms set their export prices in the local currency, the non-cooperative optimal monetary stance in the foreign country is tightened in response to the easing of the same in the home country. Fourth, under such a circumstance, home welfare falls below foreign welfare. Finally, in a scenario where not all home and foreign intermediate goods firms set their export prices in the local currency, there is always a welfare gain from cooperation.

The remainder of this paper is structured as follows. Section 2 presents the model. Section 3 presents the solution of the model. Section 4 considers the optimal monetary policies in non-cooperative and cooperative equilibriums. Section 5 concludes.

2. The model

2.1. Various price indexes

The world consists of two countries of the same size, one denoted as the home country and the other as the foreign country. We denote the foreign variables with an asterisk. We assume that each country has two types of firms: final goods firms and intermediate goods firms, and both kinds of goods are tradable. Firms of the first type produce final goods using a composite of domestically produced intermediate inputs and a composite of imported intermediate inputs, while those of the second type produce differentiated products using labor. Final goods firms are competitive producers, and intermediate goods firms are monopolistically competitive producers. We assume that the home final goods firms continuously exist in the interval $[0,1]$ and the foreign final goods firms continuously exist in the interval $[1,2]$, i.e., the numbers of final goods firms of both countries are normalized to unity. On the other hand, although we also assume that the numbers of intermediate goods firms of both countries are normalized to unity, we assume that a fraction s of intermediate goods firms located in the home country and a fraction s^* of intermediate goods firms located in the foreign country set their export prices in the local currency, i.e., they employ local-currency-pricing (hereinafter referred to as "LCP"). The remaining intermediate goods firms located in both countries set their export prices in their own currency, i.e., they employ producer-currency-pricing (hereinafter referred to as "PCP"). This paper adopts a consumption index of the Cobb-Douglas type as the aggregate consumption index, in which case the consumption-based price indexes (CPIs) are defined as follows:

$$P_t = P_t^H \frac{1}{2} P_t^F \frac{1}{2}, \quad (1)$$

$$P_t^* = P_t^{H*} \frac{1}{2} P_t^{F*} \frac{1}{2}, \quad (2)$$

where P_t (P_t^*) is the CPI of the home (foreign) country, P_t^H (P_t^F) is the home-currency price of the home (foreign) final good, and P_t^{H*} (P_t^{F*}) is the foreign-currency price of the home (foreign) final good. This paper assumes that the law of one price holds for final goods in all the periods. Then, the following relationships are derived:

$$P_t^H = e_t P_t^{H*}, \quad (3)$$

$$P_t^F = e_t P_t^{F*}, \quad (4)$$

where e_t is the nominal exchange rate, defined as the home-currency price of the foreign currency. From Eqs. (1)–(4), purchasing power parity holds true:

$$P_t = e_t P_t^*. \quad (5)$$

In addition, Eq. (5) implies that the CPI-based real exchange rate is unity:

$$\frac{e_t P_t^*}{P_t} = 1. \quad (6)$$

Here, P_t^H and P_t^{F*} are defined as follows:

$$P_t^H = P_{H,t}^{\frac{1}{2}} P_{F,t}^{\frac{1}{2}}, \quad (7)$$

$$P_t^{F*} = P_{H,t}^{*\frac{1}{2}} P_{F,t}^{*\frac{1}{2}}, \quad (8)$$

where

$$P_{F,t} = \left(s^* (P_{F,t}^{LCP})^{1-\varepsilon} + (1-s^*) (P_{F,t}^{PCP})^{1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}}, \quad (9)$$

$$P_{H,t}^* = \left(s (P_{H,t}^{*LCP})^{1-\varepsilon} + (1-s) (P_{H,t}^{*PCP})^{1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}}, \quad (10)$$

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