Changes in the Number of Varieties, Consumption Home Bias and Long-Run Macroeconomic Fluctuations

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Abstract

This paper is based on New Open Economy Macroeconomics as the theoretical foundation thereby applying the principle of comparative advantage of the international trade theory to open economics for finding out the effect of the change in the number of varieties on a set of macroeconomic variables in a country, such as consumption, price, output, terms of trade, and exchange rate, as well as the role of computation home bias. This paper finds that under the long−run, an increase in the number of varieties will have positive effects on consumption and terms of trade, but negative effects on output, price index, as well as exchange rate. The effect of changes in the number of varieties on world consumption is ambiguous. It depends upon the degree of home bias in consumption. If home consumption is biased towards home (foreign) goods, then an increase in the number of varieties can cause an increase (decrease) in world consumption.

Keywords: number of varieties, consumption home bias, new open economy macroeconomics

1. Introduction

In 1817, David Ricardo proposed the theory of "Comparative Advantage" in his book, "The Principles of Political Economy and Taxation". He suggested that the variation in number of varieties quantity is inherent to different countries by nature. If one country can specialized production with comparative advantage (such as the product of high productivity, high production efficiency, and abundance of resources) and engage in trading, these countries can make profit. This proposition unleashed a new mindset for the development of economics and launched a new wave of international trade. Yet, the effect of the change in number of varieties in open economics has not been discussed in detail. As such, we attempt in this paper to combine the model of international trade proposed by Ricardo and open economics with the use of New Open Economy Macroeconomics (hereinafter referred to as NOEM) to find out the effect of the change in the number of varieties on a set of macroeconomic variables in a country, such as consumption, price, output, terms of trade, and exchange rate so as to extend the contribution of Ricardo (1817), Hicks (1953), Gomory and Baumol (2000), and Samuelson (2004) to open economics.

The theoretical foundation of the open economics is principally based on the works of the Keynesian-based Mundell-Fleming model (Mundell, 1963; Fleming, 1962) and the Dornbusch model (Dornbusch, 1976). However, the principal issue of open economics is the lack of micro-foundations. Not until the proposition of NOEM by Obstfeld and Roggof (1995, 1996) could a complete model of open economics with micro-foundations to be established. As such, this paper is an attempt to extend the works of Obstfeld and Roggof (1995) by combining with the theory of comparative advantage, and the merger with the topic of consumption home bias in the model, a topic that has attracted increasing attention.

Consumption home bias refers to consumers of the home countries are inclined to the consumption of domestic products. Ever since Obstfeld and Rogoff (2000) have classified home bias in consumption puzzle as one of their proposed six puzzles, (Note 1) subsequent studies on macroeconomics could be divided into two main streams, namely, the study on the causes and the effect of home bias in consumption, and the study on the effect of home bias in consumption on the establishment of the optimal economic policy. Literatures in the past showed that cost of transportation (Obstfeld and Rogoff, 2000; Ried, 2009), the size of the economic, the degree of openness (Sutherland, 2005; De Paoli, 2009), non-traded goods (Stockman and Dellas, 1989; Pesenti and Wincoop, 2002; Collard et al., 2007) and intermediate input factors (Hillberry and Hummels, 2002) have been extensively recognized as the main

causes for home bias in consumption. In the studies of the effect of consumption home bias, Pierdzioch (2004) presented an analysis of the impact of monetary shock on different degree of consumption home bias and capital mobility, Hau (2002), Pitterle and Steffen (2004), Kollmann (2004), Sutherland (2005), Leith and Lewis (2006), and Cooke (2010) studies on the influence of consumption home bias on the exchange rate; De Paoli (2009) discussed the extent of consumption home bias and the welfare effect of monetary policy. Nonetheless, the study on consumption home bias and the optimal monetary policymaking is also a popular topic. Related works have been done by Faia and Monacelli (2008), Jondeau and Sahuc (2008), Galí and Monacelli (2008), and Wang (2010). In this paper, we investigate the role of home bias in consumption in the process of the influence of number of varieties change on the macroeconomic variables.

In conclusion, it is clear that existing literature lacks a complete theoretical basis and the research of the effects of changes in the number of varieties and consumption home bias on open economy. To remedy such regrets, this paper connected the theory of comparative advantage and consumption home bias on an open economy in NOEM framework. From theoretical deviation, we found that the change in the number of varieties are positively correlated with consumption and terms of trade but negatively correlated with the output, price index, and exchange rate, the degree of home bias in consumption determines the effect of changes in the number of varieties on world consumption.

The structure of this paper: Section 1 presents the motive and purpose of this paper. Section 2 describes the model. Section 3 derives the equilibrium solution; Section 4 gives an analysis of the impact of number of varieties change in international trade on consumption, exchange rate, terms of trade, output and price. Section 5 sums up the findings with a conclusion.

2. The Model

This paper is based on the NOEM model proposed by Obstfeld and Rogoff (1995) as the theoretical foundation with the following assumptions:

(1) There are only two countries in the whole world, namely, the home country and the foreign country. For differentiating the variables of the home country and the foreign country, the symbol "*" is used for economic variables of the foreign country.

(2) The quantity of individuals of the world are distributed in the interval of [0, 1] in continuum, where the quantity of individuals in the home country are distributed in the interval of $[0,1/2)$ while the quantity of individual in the foreign country are distributed in the interval of $[1/2, 1]$.

(3) Each individual is a consumer and a producer at the same time. Individuals input their own labor (L) for producing heterogeneous products (y). The production function is $y = L$. Of all the number of varieties available for consumption [0,1], the consumption of the individuals in the home country is $[0, n)$ and in the foreign country is $[n, 1]$. Of all the number of varieties in the world [0,1], the number of varieties produced in the home country is $[0, V)$ and in the foreign country is $[V, 1]$.

(4) The representative individuals are chasing for the maximization of expected lifetime utility.

(5) Individuals exhibit consumption home bias. Following the setting proposed by Cooke (2009), using the consumption home bias parameter to determine the extent of consumption home bias.

(6) The change in the production quantity of heterogeneous products is an exogenous variable. This setting entails the meaning in theory and practice. Theoretically speaking, the principle of comparative advantage of Ricardo (1817) suggested that there is variation inherent to the number of varieties production in a country mainly due to the difference in conditions (such as production technology, production efficiency, and abundance of resources), which prompts the country to produce products with comparative advantage. Under this notion, production technology or product quantity change is taken as the theory of exogenous variables. In practice, the control of product quantity in prevailing in all governments, such as the exercise of production subsidy (control), import and export subsidy (control), and incentives for research and development.

2.1 Representative Individuals

Assuming all individuals have the same preference, and the expected lifetime utility of the representative individuals is positively proportional to consumption and the real money balance, but negatively proportion to labor input, (Note 2) the utility function as follows:

$$U_t = E_t\left\{\sum_{s=t}^{\infty}\beta^{s-t}\left[\log C_s + \frac{\chi}{1-\varepsilon}\left(\frac{M_s}{P_s}\right)^{1-\varepsilon} - \frac{\kappa}{2}L_s(z)^2\right]\right\},\ \varepsilon > 0 \tag{1}$$

Where C is the consumption index, M represents the holding nominal money of the home country, P represents the domestic price level, M/P is the real money balance of the home country, L represents the labor input, β is the discount factor ($0 < \beta < 1$), ε is the elasticity marginal utility of the real money demand, (Note 3) χ and κ are the importance of the money balance and labor input in the utility function, respectively, and z represents specific product z.

In Eq. (1), consumption index is defined as:

$$C_t = \frac{C_{H,t}^{1-\lambda}C_{F,t}^{\lambda}}{(1-\lambda)^{1-\lambda}\lambda^{\lambda}},\ 0 < \lambda < 1 \tag{2}$$

Where C_H is the consumption of domestic products by the home representative individual, C_F is the consumption of foreign products by the home representative individual, λ is the share of the consumption of domestic products in the consumption index. In the literatures, λ is consumption home bias which is consisted of two parameters, size of the country and degree of openness. In this paper, the two countries are identical in size and the consumption home bias coefficient reflects the degree of openness of a country.

In Eq. (2), the expressions of C_H and C_F is:

$$C_{H,t} = \left[\int_0^{1/2} C_{H,t}(z)^{\frac{\theta-1}{\theta}}\,di\right]^{\frac{\theta}{\theta-1}} \tag{3}$$

$$C_{F,t} = \left[\int_{1/2}^{1} C_{F,t}(z)^{\frac{\theta-1}{\theta}}\,di\right]^{\frac{\theta}{\theta-1}} \tag{4}$$

In Eqs. (3) and (4), $C_H(z)$ is the consumption of specific domestic product z by the home individuals, $C_F(z)$ is the consumption of specific foreign product z by the home individuals. θ is the elasticity of substitution of products (θ>1).

Given the definition of total consumption index (Eq. (2)), we could derive the price index as: (Note 4)

$$P_t = P_{H,t}^{1-\lambda}P_{F,t}^{\lambda} \tag{5}$$

Where, P_H and P_F are the domestic prices of domestic products and foreign products, respectively, and the form are as follows:

$$P_{H,t} = \left[\int_0^{V} P_{H,t}(z)^{1-\theta}\,dz\right]^{\frac{1}{1-\theta}} \tag{6}$$

$$P_{F,t} = \left[\int_{V}^{1} P_{F,t}(z)^{1-\theta}\,dz\right]^{\frac{1}{1-\theta}} \tag{7}$$

In Eqs. (6) and (7), $P_H(z)$ is the domestic price of specific domestic product z, $P_F(z)$ is the domestic price of specific foreign product z, V is the number of varieties produced in the home country and $1-V$ is the number of varieties produced in the foreign country. In this paper, the number of varieties is taken as an exogenous variable.

From Eq. (2) to (7), we could deduce the consumption level of domestic and foreign products by the home representative consumers as:

$$C_{H,t} = (1-\lambda)\left[\frac{P_{H,t}}{P_t}\right]^{-1} C_t \tag{8}$$

$$C_{F,t} = \lambda\left[\frac{P_{F,t}}{P_t}\right]^{-1} C_t \tag{9}$$

$$C_{H,t}(z) = \left[\frac{P_{H,t}(z)}{P_{H,t}}\right]^{-\theta} C_{H,t} \tag{10}$$

$$C_{F,t}(z) = \left[\frac{P_{F,t}(z)}{P_{F,t}}\right]^{-\theta} C_{F,t} \tag{11}$$

For the foreign country, the symmetrical analysis gives:

$$C^*_{H,t} = (1-\lambda)\left[\frac{P^*_{H,t}}{P^*_t}\right]^{-1} C^*_t \tag{12}$$

$$C^*_{F,t} = \lambda\left[\frac{P^*_{F,t}}{P^*_t}\right]^{-1} C^*_t \tag{13}$$

$$C^*_{H,t}(z) = \left[\frac{P^*_{H,t}(z)}{P^*_{H,t}}\right]^{-\theta} C^*_{H,t} \tag{14}$$

$$C^*_{F,t}(z) = \left[\frac{P^*_{F,t}(z)}{P^*_{F,t}}\right]^{-\theta} C^*_{F,t} \tag{15}$$

2.2 Asset Market

Assuming there is an international capital market and each individual can trade real bonds (B) in the international capital market. The Fisher Equation offers bond yield at the rate of (r_t) at maturity and the nominal interest rate of the home country (i_t), the relation between the two is:

$$1 + i_t = \frac{P_{t+1}}{P_t}(1 + r_t) \tag{16}$$

The relation between the nominal interest rate of the home country (i_t) and of the foreign country (i^*_t) is given by the uncovered interest parity:

$$1 + i_t = \frac{E_{t+1}}{E_t}(1 + i^*_t) \tag{17}$$

The above equation is the equilibrium equation of the asset market. (Note 5)

The holding of bonds reflect the financing relation between the agents of the two countries, which satisfy $(B_t / 2) + (B^*_t / 2) = 0$,(Note 6) that is:

$$B_t^* = -B_t \tag{18}$$

Where B_t is the quantity of bonds held by the home country while B_t^* is the quantity of bonds held by the foreign country. (Note 7)

2.3 Government

For simplicity in the analysis, we assume that the government has not expenditure and the seignorage revenue of the government will be transferred to the agents in lump-sum fashion with government budget constraint set as:

$$\frac{M_t - M_{t-1}}{P_t} = T_t \tag{19}$$

Where $M_t - M_{t-1}$ is the seignorage revenue and T_t is the real lump-sum transfer.

2.4 Budget Constraints

The budget constraint of the individuals is:

$$P_t B_t + P_t C_t + M_t = P_t(1+r_{t-1})B_{t-1} + M_{t-1} + w_t(z)L_t(z) + \pi_t(z) + P_t T_t \tag{20}$$

Where the right side of Eq. (20) mark specified the sources of incomes in current period (period t), including the bond yield ($P_t(1+r_{t-1})B_{t-1}$) in the previous period (period $t-1$), the money balance of the previous period (M_{t-1}), labor income in current period ($w_t(z)L_t(z)$), share of profit in current period ($\pi_t(z)$) and income from lump-sum transfer ($P_t T_t$). The left side of Eq. (20) mark, implying that consumers may use the incomes in current period for buying bonds ($P_t B_t$), for consumption ($P_t C_t$) and holding currency (M_t).

2.5 Production Sector

The pricing strategy mapped out by the firms in the home country aims at maximization of profit and the function of profit for the firms of the home country ($\pi(z)$) is:

$$\pi_t(z) = P_{H,t}(z)C_{H,t}(z) + E_t P_{H,t}^*(z)C_{H,t}^*(z) - w_t(z)(C_{H,t}(z) + C_{H,t}^*(z)), \quad z \in [0,\upsilon) \tag{21}$$

Where E represents the nominal exchange rate.

To impute Eqs. (10) and (14) into the above equation, and to derive first-order condition with $P_H(z)$ and $P_H^*(z)$, we could get that the pricing level of the firms in the domestic market and the foreign market is:

$$P_{H,t}(z) = E_t P_{H,t}^*(z) = \frac{\theta}{\theta - 1} w_t(z), \quad z \in [0,V) \tag{22}$$

The equation explains that after the determination of wage and exchange rate level, the optimal pricing strategy will be mapped out whereby the pricing method of the firms in monopolistic competition is the mark-up on cost. (Note 8)

Likewise, the firms in foreign country can get:

$$P_{F,t}(z) = E_t P_{F,t}^*(z) = \frac{\theta}{\theta - 1} w_t(z), \quad z \in [V,1] \tag{23}$$

From the equation of the consumption of specific domestic product z by home representative individuals (Eqs. (8) and (10)) and the equation of the consumption of specific domestic product z by foreign representative individuals (Eqs. (12) and (14)), and with the use of Eqs. (6) and (22), we could get the firms in the home country face the demand for product z as shown below:

$$y_t(z) = \frac{1}{2}C_{H,t}(z) + \frac{1}{2}C_{H,t}^*(z) = V^{\theta-1}(1-\lambda)\left[\frac{P_{H,t}(z)}{P_t}\right]^{-1} C_t^W \tag{24}$$

Where C^W is defined as the world consumption, $C^W \equiv nC + (1-n)C^*$.

Likewise, we could get the firms in the foreign country face the demand for product z as shown below:

$$y_t^*(z) = \frac{1}{2}C_{F,t}(z) + \frac{1}{2}C_{F,t}^*(z) = (1-V)^{\theta-1}\lambda\left[\frac{P_{F,t}^*(z)}{P_t^*}\right]^{-1} C_t^W \tag{25}$$

Also, from Eqs. (5), (6), and (7), the domestic price index could be rewritten as follow:

$$P_t = VP_{H,t}(z)^{1-\lambda}(1-V)P_{F,t}(z)^{\lambda} \tag{26}$$

Likewise, we get the foreign price index as:

$$P_t^* = VP_{H,t}^*(z)^{1-\lambda}(1-V)P_{F,t}^*(z)^{\lambda} \tag{27}$$

To compare Eqs. (26) and (27), with the use of Eqs. (22) and (23), we could see that the purchasing power parity (PPP) could be validated:

$$P_t = EP_t^* \tag{28}$$

2.6 First-Order Conditions

Under budget constraint (Eq. (20)), the first-order condition of the maximization of utility (Eq. (1)) is:

$$C_{t+1} = \beta(1+r_t)C_t \tag{29}$$

$$\frac{M_t}{P_t} = \left(\frac{(1+i_t)\chi}{i_t}C_t\right)^{\frac{1}{\varepsilon}} \tag{30}$$

$$\kappa L_t = \frac{w_t}{P_t C_t} \tag{31}$$

Where Eq. (29) is the Euler Equation of consumption specifying intertemporal consumption behavior. Eq. (30) is the equation of money demand, which explains the substitution between the demand in real money and consumption. Eq. (31) is the equation of labor supply specifying the relation between labor supply and consumption.

3. Solutions for Equilibrium

In order to find out the effect of the changes in the number of varieties on the macroeconomic variables. We have to deduce the steady state of the economic system and use the initial steady state (0-steady state) as the basis for comparison. The following symbols without lower case indication are defined as variable in the long run. The symbol "$_0$" at the lower case represents the variable of the initial steady state. For example, C and C_0 represents the consumption level in the long run and initial steady state.

3.1 Equilibrium in the Steady State

Steady state refers to the economic system is in the state of convergence after exogenous impact in the long run. Under steady state, all variables tend to be constant.

1. The real interest rate level in the steady state

In the steady state, $C_{t+1} = C_t$. As such, the Euler Equation (Eq. (29)) shows $\beta(1+r) = 1$, which is:

$$r = \frac{1-\beta}{\beta} \tag{32}$$

The above equation explains that the real interest rate is determined by the discount factor.

2. The private budget constraints in the steady state

To combine Eqs. (19) and (20), and use the profit function ($\pi_t(z)=P_{H,t}(z)y_t(z)-w_t(z)L_t(z)$), we get:

$$C_t = (1+r_{t-1})B_{t-1} - B_t + \frac{P_{H,t}(z)y_t(z)}{P_t} \tag{33}$$

Likewise, in the foreign country, we have:

$$C_t^* = (1+r_{t-1}^*)B_{t-1}^* - B_t^* + \frac{P_{F,t}^*(z)y_t^*(z)}{P_t^*}$$

To impute Eq. (18) into the above equation, we get:

$$C_t^* = -(1+r_{t-1}^*)\frac{n}{1-n}B_{t-1} + \frac{n}{1-n}B_t + \frac{P_{F,t}^*(z)y_t^*(z)}{P_t^*} \tag{34}$$

In the steady state, $B_{t+1} = B_t$. As such, Eq. (33) and Eq. (34) could be rewritten as:

$$C = rB + \frac{P_H(z)y(z)}{P} \tag{35}$$

$$C^* = -r\frac{n}{1-n}B + \frac{P_F^*(z)y^*(z^*)}{P^*} \tag{36}$$

Eqs. (35) and (36) are the equations of private budget constraints in the home country and in the foreign country in the steady state.

3.2 Initial Steady State

The initial steady state refers to the initial state of the economic system with the assumption that under the initial steady state, all foreign assets held by the individuals is 0 ($B_0 = B_0^* = 0$) and the number of varieties in the home country is equal to the number of products ($V = 1/2$).

1. The private budget constraints in initial steady state

In the initial steady state, $B_0 = B_0^* = 0$, and Eq. (35) could be rewritten as:

$$C_0 = \frac{P_{H,0}(z)y_0(z)}{P_0} \tag{37}$$

Assuming the economic system can achieve balance of trade in the initial steady state, which is:

$$C_0 = y_0(z) \tag{38}$$

To impute Eq. (38) into Eq. (37), we have:

$$P_0 = P_{H,0}(z) \tag{39}$$

Likewise, the symmetric foreign country has:

$$C_0^* = y_0^*(z)\,;\;\; P_0^* = P_{H,0}^*(z) \tag{40}$$

2. The aw of one price and PPP in initial steady state

The law of one price and PPP in initial steady state is shown below:

$$P_{H.0}(z) = E_0 P^*_{H,0}(z);\ \ P_0 = E_0 P^*_0 \tag{41}$$

3. World consumption in initial steady state

From Eqs. (38) and (40), we could see that the world consumption in initial steady state is:

$$C^W_0 = \frac{1}{2}C_0 + \frac{1}{2}C^*_0 = \frac{1}{2}y_0(z) + \frac{1}{2}y^*_0(z) \tag{42}$$

4. The output and consumption level in initial steady state

To combine Eqs. (22), (38), and (39) with (31), we get:

$$y_0(z) = \left(\frac{\theta - 1}{k\theta}\right)\left[\frac{1}{2}y_0(z) + \frac{1}{2}y^*_0(z)\right] \tag{43}$$

Likewise, in the foreign country, we have:

$$y^*_0(z) = \left(\frac{\theta - 1}{k\theta}\right)\left[\frac{1}{2}y_0(z) + \frac{1}{2}y^*_0(z)\right] \tag{44}$$

To compare the above two equations, and get:

$$y_0(z) = y^*_0(z)$$

To impute the above equation to Eq. (43), we get the output level of the firms of the home country in initial steady state as:

$$y_0(z) = \left(\frac{\theta - 1}{k\theta}\right)^{\frac{1}{2}}$$

Likewise, we can deduce that the output level of the firms in the foreign country in initial steady state as:

$$y^*_0(z) = \left(\frac{\theta - 1}{k\theta}\right)^{\frac{1}{2}}$$

In summing up the above results, we could see that the output and consumption level in initial steady state is:

$$y_0(z) = y^*_0(z) = \left(\frac{\theta - 1}{k\theta}\right)^{\frac{1}{2}} = C_0 = C^*_0 = C^W_0 \tag{45}$$

Eq. (45) explains that the output and the consumption level in initial steady state in identical.

5. The nominal and real interest rate in initial steady state

In initial steady state, the nominal interest rate (i) is equal to the real interest rate (r). From Eq. (32), we could get the level of nominal interest rate and real interest rate as:

$$i_0 = r_0 = \frac{1 - \beta}{\beta} \tag{46}$$

6. Money demand in the initial steady state

From the Eqs. (30) and (38), we could see that the conditions for the equilibrium of the money market in the home country are: (Note 9)

$$\frac{M_0}{P_0} = \left[\frac{\chi}{1-\beta} y_0(z)\right]^{\frac{1}{\varepsilon}} \tag{47}$$

Likewise, in the foreign country, we have:

$$\frac{M_0^*}{P_0^*} = \left[\frac{\chi}{1-\beta} y_0^*(z)\right]^{\frac{1}{\varepsilon}} \tag{48}$$

To combine Eqs. (47) and (48) and use Eq. (45), we get the function of money demand in initial steady state as:

$$\frac{M_0}{P_0} = \frac{M_0^*}{P_0^*} = \left[\frac{\chi}{1-\beta} y_0(z)\right]^{\frac{1}{\varepsilon}} \tag{49}$$

7. The nominal exchange rate in initial steady state

To impute the PPP conditions (Eq. (41)) into the above equation, and get the nominal exchange rate in initial steady state as:

$$E_0 = \frac{M_0}{M_0^*} \tag{50}$$

3.3 Log-linearization

The purpose of log-linearization is to get the closed-form solution of the model for the analysis of the effect of number of varieties change on the macroeconomic variables. We refer the following variables to log-linearization in initial steady state in order, and get the volatility of the variables around the initial steady state. (Note 10)In this paper, the symbol in upper case, specified as "^", represents the value of the variable after log-linearization. For example, if $\hat{X}_t$ is the result of log-linearization of X_t around X_o, then:

$$\hat{X}_t = \frac{X_t - X_0}{X_0} = \frac{dX_t}{X_0} = \ln\left(\frac{X_t}{X_0}\right)$$

1. Log-linearization of price index

To impute Eqs. (22) and (23) into Eqs. (26) and (27), and refer to log-linearization, we have:

$$\hat{P}_t = (1-\lambda)\hat{P}_{H,t}(z) + \lambda(\hat{E}_t + \hat{P}_{F,t}^*(z)) \tag{51}$$

$$\hat{P}_t^* = (1-\lambda)(\hat{P}_{H,t}(z) - \hat{E}_t) + \lambda P_{F,t}^*(z) \tag{52}$$

To subtract Eq. (52) from Eq. (51), and get:

$$\hat{P}_t - \hat{\hat{P}}_t^* = \hat{E}_t \tag{53}$$

Where Eq. (53) is relative PPP.

2. Log-linearization of world consumption

From Eqs. (35) and (36), we can get the equation for world consumption as:

$$C_t^W = \frac{1}{2}C_t + \frac{1}{2}C_t^* = \frac{P_{H,t}(z)y_t(z)}{2P_t} + (1-n)\frac{P_{F,t}^*(z)y_t^*(z^*)}{2P_t^*} \tag{54}$$

Take log-linearization with Eq. (54), and get:

$$2\hat{C}_t^W = [P_{H,t}(z) + \hat{y}_t(z) - \hat{P}_t] + [P_{F,t}^*(z) + \hat{y}_t^*(z) - \hat{P}_t^*] \tag{55}$$

3. Log-linearization of the demand function

Take log-linearization with Eqs. (24) and (25)), we have:

$$\hat{y}_t(z) = (1-\lambda)[\hat{P}_t - \hat{P}_{H,t}(z)] + \hat{C}_t^W + (\theta-1)\hat{V}_t \tag{56}$$

$$\hat{y}_t^*(z) = \lambda[\hat{P}_t^* - \hat{P}_{F,t}^*(z)] + \hat{C}_t^W - (\theta-1)\hat{V}_t \tag{57}$$

4. Log-linearization of the labor supply function

To combine Eqs. (22) and (31) and use the production function ($y_t(z) = L_t(z)$), then proceed to log-linearization, we get:

$$\hat{y}_t(z) = (\theta-1)[\hat{P}_{H,t}(z) - \hat{P}_t] - \theta\hat{C}_t \tag{58}$$

Likewise, in the foreign country, we have:

$$\hat{y}_t^*(z) = (\theta-1)[\hat{P}_{F,t}^*(z) - \hat{P}_t^*] - \theta\hat{C}_t^* \tag{59}$$

5. Log-linearization of the Euler Equation

To refer Eq. (29) to log-linearization, we get:

$$\hat{C}_{t+1} = \hat{C}_t + (1-\beta)\hat{r}_t \tag{60}$$

Likewise, for the foreign country:

$$\hat{C}_{t+1}^* = \hat{C}_t^* + (1-\beta)\hat{r}_t \tag{61}$$

6. Log-linearization of money demand

To refer Eq. (30) to log-linearization, and get:

$$\hat{M}_t - \hat{P}_t = \frac{1}{\varepsilon}\left[\hat{C}_t - \beta\left(\hat{r}_t + \frac{\hat{P}_{t+1} - \hat{P}_t}{1-\beta}\right)\right] \tag{62}$$

Likewise, for the foreign country:

$$\hat{M}_t^* - \hat{P}_t^* = \frac{1}{\varepsilon}\left[\hat{C}_t^* - \beta\left(\hat{r}_t + \frac{\hat{P}_{t+1}^* - \hat{P}_t^*}{1-\beta}\right)\right] \tag{63}$$

3.4 Solutions in the Long Run

Take log-linearization with Eqs. (35) and (36), and get:

$$\hat{C}_t = r\hat{B}_t + P_{H,t}(z) + \hat{y}_t(z) - \hat{P}_t \tag{64}$$

$$\hat{C}_t^* = -r\frac{n}{1-n}\hat{B}_t + P_{F,t}^*(z) + \hat{y}_t^*(z) - \hat{P}_t^* \tag{65}$$

Where $\hat{B} = dB / C_o^W$.

There are 4 markets in the model proposed in this paper. They are the product market, labor market, money market, and asset market. The same applies to the foreign country. In the product market, the equation for the steady state satisfies the demand equal to supply, which is shown in Eqs. (56) and (57). In the labor market, the free adjustment of nominal wages allows for labor supply equal to labor demand, which is shown in Eqs. (58) and (59). In the money

market, Eqs. (62) and (63) guarantee money supply is equal to money demand. According to the Walras' Law, if there are n markets in the economic system, and the $n-1$ th market is in equilibrium then the n th market will also be in equilibrium. As such, when the product market, labor market, and money market are in steady state of equilibrium, the asset market will also be in steady state of equilibrium.

If we move further that there are 7 endogenous variables suggested in this paper, namely, domestic consumption ($\hat{C}$), foreign consumption ($\hat{C}^*$), world total consumption ($\hat{C}^W$), domestic output ($\hat{y}$), foreign output ($\hat{y}^*$), the difference between the price of specific domestic product and price index ($\hat{P}_H(z)-\hat{P}$), and the difference between the price of specific foreign product and price index ($\hat{P}_F^*(z)-\hat{P}^*$). These 7 endogenous variables can be obtained jointly by the solutions from the 7 equations of the world consumption (Eq. (55)), the function of domestic and foreign demand (Eqs. (56) and (57)), the function of domestic and foreign labor supply (Eqs. (58) and (59)), the equations of private budget constraints in home country and foreign country (Eqs. (64) and (65)).

The Mathematica 10.0 software is used in this paper for solutions as shown below:

$$\hat{C}=\frac{[\theta+2(1-\lambda)(\theta^2-\lambda(1+\theta))]r\hat{B}-[2\theta(1-\lambda)(1-\theta^2)]\hat{V}}{(1+\theta)[\theta-2\lambda(1-\lambda)(1+\theta)]} \tag{66}$$

$$\hat{C}^*=\frac{-[\theta+2\theta^2\lambda-2\lambda(1-\lambda)(1+\theta)]r\hat{B}+[2\theta\lambda(1-\theta^2)]\hat{V}}{(1+\theta)[\theta-2\lambda(1-\lambda)(1+\theta)]} \tag{67}$$

$$\hat{C}^W=\frac{[\theta^2(1-2\lambda)]r\hat{B}+\theta[(1+2\lambda)+\theta^2(1-2\lambda)]\hat{V}}{(1+\theta)[\theta-2\lambda(1-\lambda)(1+\theta)]} \tag{68}$$

$$\hat{y}(z)=\frac{-\theta[2(1-\lambda)^2+\theta(1-2\lambda(1-\lambda))]r\hat{B}-2(\theta^2-1)(1-\lambda)\hat{V}}{(1+\theta)[\theta-2\lambda(1-\lambda)(1+\theta)]} \tag{69}$$

$$\hat{y}^*(z)=\frac{\theta[\theta-2\lambda((1+\theta)(1-\lambda)-1)]r\hat{B}+2(\theta^2-1)\lambda\hat{V}}{(1+\theta)[\theta-2\lambda(1-\lambda)(1+\theta)]} \tag{70}$$

$$\hat{P}_H(z)-\hat{P}=\frac{2\theta(1-\lambda)r\hat{B}-2(1-\theta^2)(1-\lambda)\hat{V}}{\theta-2\lambda(1-\lambda)(1+\theta)} \tag{71}$$

$$\hat{P}_F^*(z)-\hat{P}^*=\frac{-2\theta\lambda r\hat{B}+2(1-\theta^2)\lambda\hat{V}}{\theta-2\lambda(1-\lambda)(1+\theta)} \tag{72}$$

Where Eqs. (66), (67), and (68) explain the effect of the exogenous changes in the number of varieties on domestic, foreign, and world consumption in the long run. Eqs. (69) and (70) show the effect of exogenous changes in the number of varieties on domestic output and foreign output in the long run. Eq. (71) describes the effect of exogenous changes in the number of varieties on the difference between the price of specific domestic product and domestic price index. Eq. (72) explains the effect of the exogenous changes in the number of varieties on the difference between the price of specific foreign product and foreign price index in the long run.

4. Analysis of the Effect of Number of Varieties Change in the Long Run

In the analysis of the effect of number of varieties change in the long run, we assume the holding of bonds in steady state is 0 ($\hat{B}=0$) for the closed-form solution.

4.1 The Effect of Exchange Rate

In the long run, the function of money demand in the home country and in the foreign country (Eqs. (62) and (63))

could be rewritten as:

$$\hat{P} = \hat{M} - \frac{1}{\varepsilon}\hat{C} \tag{73}$$

$$\hat{P}^* = \hat{M}^* - \frac{1}{\varepsilon}\hat{C}^* \tag{74}$$

To subtract Eq. (74) from Eq. (73) and make use of Eq. (53), we get:

$$\hat{E} = \hat{M} - \hat{M}^* - \frac{1}{\varepsilon}(\hat{C} - \hat{C}^*) \tag{75}$$

To subtract the Eq. (66) and Eq. (67), then have:

$$\hat{C} - \hat{C}^* = \frac{[2\theta^2(1-2\lambda)]r\hat{B} - [2\theta(1-\theta^2)]\hat{V}}{(1+\theta)[\theta - 2\lambda(1-\lambda)(1+\theta)]} \tag{76}$$

To impute Eq. (76) into Eq. (75), we get the response of exchange rate as:

$$\hat{E} = \hat{M} - \hat{M}^* - \frac{[2\theta^2(1-2\lambda)]r\hat{B} - [2\theta(1-\theta^2)]\hat{V}}{\varepsilon(1+\theta)[\theta - 2\lambda(1-\lambda)(1+\theta)]} \tag{77}$$

In Eq. (77), since $\hat{B} = 0$ in the long run, θ>1 and $0 < \lambda < 1$, hence the denominator is in negative value and the numerator is in positive value. As such, we could deduce that the increase in the number of domestic varieties will cause the decline of the exchange rate with the appreciation of the home currency. Accordingly, the higher the consumption home bias (which means the gap between λ and $1-\lambda$ is wider), and the lesser the range of exchange rate decline.

4.2 The Effect of Consumption

From Eqs. (66) and (67), we could see that an increase of the number of domestic varieties will push up the consumption level of the home country and press down the consumption level in the foreign country in the long run. For the world consumption, it will be determined by the extent of the consumption home bias parameter (λ). When $\lambda \leq 0.5$, world consumption level will rise. When $\lambda > 0.5$, world consumption level will fall.

4.3 The Effect of Output

From Eq. (69) and Eq. (70), we could see that an increase of the number of domestic varieties, the output level in the home country will fall while the output level of the foreign country will rise in the long run.

4.4 The Effect of Terms of Trade

To subtract Eqs. (72) from and (71)), and make use of Eq. (53), we get:

$$T\hat{O}T = \hat{P}_H(z) - \hat{P}_F^*(z) - \hat{E} = \frac{2\theta r\hat{B} + 2(\theta^2 - 1)\hat{\upsilon}}{\theta - 2\lambda(1-\lambda)(1+\theta)} \tag{78}$$

From Eq. (78), we could see that an increase of the number of domestic varieties will improve the terms of trade in the long run.

4.5 The Effect of Price

To impute Eqs. (66) and (67) into Eqs. (73) and (74) respectively, we have:

$$\hat{P} = \hat{M} - \frac{[\theta + 2(1-\lambda)(\theta^2 - \lambda(1+\theta))]r\hat{B} - [2\theta(1-\lambda)(1-\theta^2)]\hat{V}}{\varepsilon(1+\theta)[\theta - 2\lambda(1-\lambda)(1+\theta)]} \tag{79}$$

$$\hat{P}^* = \hat{M}^* - \frac{-[\theta + 2\theta^2\lambda - 2\lambda(1-\lambda)(1+\theta)]r\hat{B} + [2\theta\lambda(1-\theta^2)]\hat{V}}{\varepsilon(1+\theta)[\theta - 2\lambda(1-\lambda)(1+\theta)]} \tag{80}$$

From Eqs. (79) and (80), we could see that an increase of the number of domestic varieties will cause a fall of the domestic commodity price level and a rise in the foreign commodity price level in the long run.

The above analysis leads us to the following conclusion. In the long run, the increase in the number of domestic varieties pushes up the domestic consumption level and presses down the domestic output. Accordingly, domestic price will fall with downward adjustment of the exchange rate. Terms of trade will be improved. The parameter of the degree of the consumption home bias (λ) will determine the world consumption. When $\lambda \leq 0.5$, world consumption will rise. When $\lambda > 0.5$, world consumption will fall.

This is because the increase in the number of domestic varieties with comparative advantage implies the dropping of the production cost and hence the product price, which pushes up consumption level. The upward movement of consumption level will stimulate the demand for money and hence trigger the appreciation of home currency (downward adjustment of exchange rate) and the terms of trade improved. However, the parameter of extent of the consumption home bias will determine the world consumption level. If the agents of the home country exhibit consumption home bias, world consumption level will rise.

5. Conclusion

In this paper, the principle of comparative advantage in the theory of international trade and NOEM are combined for exploring the effect of the changes in the number of varieties on the macroeconomic variables, such as consumption, commodity price, output, terms of trade, and exchange rate of a country. The role of home bias in consumption is also explored to complement the inadequacy of the literatures on hand.

This paper finds that an increase in the number of varieties will have positive effects on consumption and terms of trade, but negative effects on output, price index, as well as exchange rate. The effect of changes in the number of varieties on world consumption is ambiguous. It depends upon the degree of home bias in consumption. If home consumption is biased towards home (foreign) goods, then an increase in the number of varieties can cause an increase (decrease) in world consumption.

In this paper, a topic of microeconomics for application to the models of open economics has been proposed for analysis. Yet, there are far too many issues that require further studies, such as, the inclusion of technology level, trade dispute, and pricing methods into the framework of analysis in this paper for subsequent studies. Analysis in the short run and empirical study could also be included for enriching the content of study.

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Notes

Note 1. Obstfeld and Rogoff (2000) have singled out six puzzle, which are “consumption home bias puzzle”, “home bias in equity portfolios puzzle”, “purchasing power parity puzzle”, “exchange rate disconnect puzzle”, “the high investment-saving correlation puzzle”, and the “the low international consumption correlation puzzle”. Consumption home bias refers to the situation in the consumers preferred consumption with domestic products. Yet, the existence of this universal phenomenon cannot be explained by the scholars in this field.

Note 2. The increase in labor input implies the decrease of leisure for the individuals and hence the decline of

individual utility.

Note 3. The elasticity of marginal utility of real money demand is defined as the degree of response in marginal utility of real money demand with the change of real money demand by 1%.

Note 4. This price is the price index level at minimum spending and could be obtained from the following optimal solutions.

$$\min_{c(z)} Z = \int_0^1 p(z)c(z)dz \quad \text{subject to} \quad \left[\int_0^1 c(z)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} = 1$$

Note 5. The validation of Eqs. (12) and (13) imply the validation of the theory of purchasing power parity.

Note 6. Bonds as referred to in this paper are international bonds. The bonds held by the home (foreign) country nationals are issued by the home (foreign) country nationals. No additional issue of bonds per se, and Mark (2001) called this equation as bonds with zero-net-supply constraint.

Note 7. Obstfeld and Rogoff (1995) suggested the holding of bonds as investment income so as to explain the changes in the current accounts.

Note 8. In the model, the assumption of $\theta > 1$ implies no negativity of the pricing for the firms.

Note 9. Where $\frac{1+i_0}{i_0} = \frac{1+r}{r} = \frac{1+\frac{1-\beta}{\beta}}{\frac{1-\beta}{\beta}} = \frac{1}{1-\beta}$.

Note 10. Due to the complexity of setting the model, literatures tended to adopt two methods for the closed-form solutions for the exogenous and the endogenous variables. They are: 1. log-linearization, and 2. numerical simulations. (See Obstfeld and Rogoff (1996), ch10, p. 667). In this paper, the log-linearization model was adopted.