Causes of Global Imbalances: A NOEM perspective

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Abstract: From the perspective of New Open Economy Macroeconomics, we develop a two-country general equilibrium model to explore the main causes of global imbalances. We show that, given dynamics of the current account, an overall improvement in productivity leads to current account deficits, and by incorporating non-tradable sectors and separating consumption of tradable from that of non-tradable goods, productivity differentials between non-tradable sectors of two countries play a critical role in causing global imbalances. We predict that countries experiencing higher growth in the tradable sector while running surplus, which conflicts with the productivity theory, must suffer lower growth in the non-tradable sector. The monetary policies stabilizing the shocks drive differentials in the nominal expenditure and then lead to imbalances. We consider the pair of countries has a fixed exchange rate regime and suggest that adjustment should majorly come from improving the structure of the economic growth of both countries.

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1. Introduction

In major regions of the world, many economies in the recent decades have experienced structural imbalances in their external accounts, which is known as the global imbalances. At the fore-front of these imbalances is the United States that, in 2008, the country's ratio of current account deficits to GDP reached 4.72%, which is alarmingly high. In a mirror image of the obstinate trade deficit in the US, there are persistent current account surpluses in Asia and oil producing countries. Possible dire consequences of the global imbalance have become a major concern of the world economy and debates are raging on its resolution.

Adjustment of the global imbalances requires an apt understanding of the causes behind the phenomenon. The growing literature on the global imbalances has produced six major strands on the causes (Mendoza, Quadrini and Ríos-Rull 2009). One prominent school believes that the imbalances result from economic policy misalignments in the US and other countries (Blanchard, Giavazzi and Sa 2005; Obstfeld and Rogoff 2005; Roubini and Setser 2005). Other approaches argue that the imbalances are caused by events such as differentials in productivity growth (Backus, Henriksen, Lambert and Telmer 2005; Caballero, Farhi and Gourinchas 2008; Engel and Rogers 2006; McGrattan and Prescott 2008), or business cycle volatility (Croke, Kamin and Leduc 2005; Fogli and Perri 2006), demographic dynamics (Attanasio, Kitao and Violante 2006; Henriksen 2005), a "global savings glut" (Bernanke 2005), and the valuation effects (Cavallo and Tille 2006; Ghironi, Lee and Rebucci 2007; Gourinchas and Rey 2007; Hausmann and Sturzenegger 2006).

Depending on their perceptions of the source of imbalances, three main positions have emerged in the literature on the adjustment (Little and Lafrance 2006). The optimistic view regards the global imbalances as an "equilibrium" phenomenon resulting from responses of households and firms to a world of economic and financial integration that links nations ever closer. To them, the situation is not very alarming as the imbalances will self-correct themselves over time through interaction between technological, political, and market forces.

The pessimistic view claims that the imbalances are the manifestation of Americans on the comfortable path to destruction. Unwillingness or inability of surplus countries to stimulate domestic demand and deficit country to curb overspending increases the probability of a hard landing with catastrophic impacts.

A third group takes the middle-ground in believing that, if proper measures are taken, orderly resolution of the imbalances is achievable, but governments needs to remove distortions that thwart the market forces, which is hard to come by and so in an area for concern. According to (Little and Lafrance 2006), most international organizations, such as the IMF, the Bank for International Settlements (BIS), and the Organisation for Economic Co-operation and Development (OECD) take this view. While key players notably the United States and China are less concerned, some governments like the Canadian government may also fall into this group.

In the recent literature on international imbalances, there is a trend of using general equilibrium models to explain the dynamics of current account. Bergin (2006) empirically tests a NOEM model using the US and G7 data and finds that the model performs reasonably well for fitting the dynamics of the exchange rates and the current accounts. This is a direct support for using NOEM model as an approach to explain imbalances. In a general equilibrium approach with three trading regions, Obstfeld and Rogoff (2005) attribute a prominent role to the terms of trade effect in the adjustment of the international Imbalances. They assume that each of the three trading blocs (countries), namely the US, Europe and Asia, does not have identical preferences, but has a home bias in tradables consumption, such that each country has a relative preference for tradables that it produces and exports. Ferrero, Gertler, and Svensson (2008) examine current account dynamics with a variant of the Obstfeld and Rogoff's model. They develop a simple two-country DSGE model which nests Obstfeld and Rogoff's (2005) static model with an essential extension that endogenizes the dynamic adjustment path and incorporates production and nominal price rigidities. Recently, the International Monetary Fund has launched a series of research into the causes of the global imbalances that is in the general spirit of the NOEM approach. The work by Cova, Pisani, Batini, and Rebucci (2009) marks a beginning example of this development. Their research uses a flexible-price version of the dynamic general equilibrium model of the world economy developed at the Bank of Italy. In many aspects, this model shares many features with the IMF's Global Economy Model (GEM) which is built with the NOEM as its theoretical foundation.

In this paper, we follow the NOEM approach to develop a two-country dynamic general equilibrium model to examine the main causes of the imbalances. Much work in the NOEM literature adopt settings such as complete asset markets and some special type of consumption index that shuts down current account dynamics, in order to derive a closed form solution or for the ease of analysis. We construct a more general framework that does not rely exclusively on such specific preference settings. Though for the ease of analysis, we show a simpler derivation in the paper, a model with weaker assumptions is provided in the appendix. The model assumes incomplete international financial markets and incorporates non-tradable sectors of both home and foreign economies, which show productivity differentials. After linearization of the model, we derive the first-order effects of productivity shocks to the short-run and long-run current accounts.

Traditionally, in analysis of trade balance the role of the non-tradable sector is largely absent. We however in this research highlight the particular importance of productivity differentials between non-tradable sectors across countries.

By focusing on the role of productivity shocks to the global imbalances, we argue that it is the differential improvement in productivity across countries that leads to the global imbalance. A richer set of elements then is unveiled causing the global imbalances when the role of non-tradable sector is taken into consideration. We assume endogenous monetary supply that optimizes the economy under productivity shocks. The responding stabilizing monetary policy to the shocks causes differentials in demands for imports compared to the growth of exports, thereby leads to current account deficits.

Especially, by setting unit elasticity of substitution between different goods, we are able to eliminate the substitution effect on the imbalances and focus on the role of monetary policy differentials. Given the fact that many countries that are now experiencing high growth by international trading run surplus to those developed economies, which conflicts with the productivity theory, we predict that deficit countries must have higher growth in the non-tradable sectors which is not achieved by the developing ones. Since imbalances under this synthesis are the results of the spillover effects of stabilizing monetary policy, we find that different pricing regimes of trade between the two countries do not account in this model, and we argue that even if we weaken this assumption of unit elasticity, the imbalances attributed to the substitution effect might be small.

Considering that exchange rate adjustments are not easily available between countries under fixed regime, or within a monetary union, we develop our model under the context of fixed exchange rate. Then we suggest that adjustments come from two streams, thorough improving the structure of economic growth and a monetary policy coordination under limited and acceptable level.

This paper is structured as follow. In section 2 we develop the model and find the solutions to the model through linearization. Section 3 presents analysis of the effect of productivity differentials on global imbalances and proposes adjustment method. Section 4 concludes the paper.

2. A New Open Economy Macroeconomics Model with Non-tradable Sector

In this section, we develop a two-country dynamic general equilibrium model, incorporating monopolistic competition and price rigidities, in the spirit of New Open Economy Macroeconomics. Apart from the widely used setting that all goods are internationally traded, we consider in each country a non-tradable sector. Both traded and non-tradable productions are subject to productivity shocks, which are not assumed to be necessarily symmetric. This feature, together with an incomplete international financial market, generates non-constant share of world income distribution, and then drives international borrowing and allows the model to reflect current account dynamics. In the Appendix, we give the derivation of a model in the general case, but in this section, we specify a case with a few stronger assumptions on the parameters for analysis purpose.

The representative household for each of the two counties maximizes its utility. The utility function U_t is defined as:

$$U_t = E_t \left\{ \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[\ln C_\tau + \alpha_M \ln \left(\frac{M_\tau}{P_\tau} \right) - \alpha_L L_\tau \right] \right\} \tag{1}$$

where C_t is consumption, M_t is money holding, P_t is the consumer price index and Z_t the working effort. The budget constraint for the home household is:

$$P_t C_t + M_t + P_t T_t + B_t = W_t L_t + \Pi_t + (1 + i_{t-1}) B_{t-1} + M_{t-1} \tag{2}$$

where T_t is the tax paid (transfer received if negative), B_t the bond of the home country, W_t the wage, and Π_t all profits received from the firms.

Households choose consumption, money holding, leisure and bond to maximize utility. The intertemporal choice of consumption largely depends on money holding and bond. The Euler equation for the home household is:

$$\frac{1}{P_t C_t} = \beta(1+i_t)E_t\left\{\frac{1}{P_{t+1}C_{t+1}}\right\} \tag{3}$$

We assume that the foreign household can only access the internationally traded bond issued by the home country. The budget for the foreign household is similar as the home one, except for the bond, which is denominated in the home currency:

$$P_t^* C_t^* + M_t^* + P_t^* T_t^* + \frac{B_t}{\mathcal{E}_t} = W_t^* L_t^* + \Pi_t^* + \frac{(1+i_{t-1})B_{t-1}}{\mathcal{E}_t} + M_{t-1}^* \tag{4}$$

where $\mathcal{E}_t$ is the exchange rate between the two countries. The foreign household adopts a similar consumption path, but the exchange rate enters the equation:

$$\frac{1}{P_t^* C_t^*} = \beta(1+i_t)E_t\left\{\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\frac{1}{P_{t+1}^* C_{t+1}^*}\right\} \tag{5}$$

For analytical purpose, we linearize our model to derive all the first-order effects, while eliminating the ones of second and higher orders. Linearization, or approximation if necessary, is made around initial steady state to get both short-run equilibrium and long-run steady state. We denote deviation of a variable in the short-run to its initial steady state by a hat and its deviation in the long-run by a bar; e.g. $\hat{C}$ is $d\ln C$ in the short-run and $\bar{C}$ for long-run respectively. Prices in the short-run are assumed to be fully fixed, while in the long-run firms can adjust prices according to their optimizing solution. For tractability, we express all equations in terms of differentials between home and foreign variables. These can be obtained by subtracting the linearized equations of the home country by their foreign counterparts.

Linearization of the Euler equations holds exactly. The differential between the home and foreign consumption path is expressed as:

$$-(\hat{C}_t - \hat{C}_t^*) - (\hat{P}_t - \hat{P}_t^*) + \hat{E}_t = -(\hat{C}_{t+1} - \hat{C}_{t+1}^*) - (\hat{P}_{t+1} - \hat{P}_{t+1}^*) + \hat{E}_{t+1} \quad (6)$$

This equation interprets the smooth path of consumption similarly as Obstfeld and Rogoff (1995). Consumption jumps to the long-run level immediately. As we define bond in the nominal terms, together with the assumption of foreign's access only to the home bond, we have a consumption path that is subject to the change of the effective exchange rate:

$$-(\hat{C} - \hat{C}^*) - (\hat{P} - \hat{P}^*) + \hat{E} = -(\bar{C} - \bar{C}^*) - (\bar{P} - \bar{P}^*) + \bar{E} \quad (7)$$

Demand for money of the households can be derived using first-order conditions of the optimization. Money demand of the home country is:

$$\alpha_M \left(\frac{M_t}{P_t}\right)^{-1} = \frac{i_t}{1+i_t} C_t^{-1} \quad (8)$$

Money demand for the foreign household is:

$$\alpha_M \left(\frac{M_t^*}{P_t^*}\right)^{-1} = \frac{i_t^* + d_t^*}{1 + i_t^* + d_t^*} (C_t^*)^{-1} \quad (9)$$

where i_t^* is the interest rate in the foreign economy and d_t^* represents the deviation from UIP between the two countries. The interest rates of the two countries are assumed to satisfy:

$$1 + i_t = \frac{E_t\{\mathcal{E}_{t+1}\}}{\mathcal{E}_t}(1 + i_t^* + d_t^*) \tag{10}$$

The differential between the growths of money demands of the two countries in the short-run satisfies:

$$-(\hat{M} - \hat{M}^*) + (\hat{P} - \hat{P}^*) = -(\hat{C} - \hat{C}^*) + \beta(\hat{i} - \hat{i}^*) - \beta\hat{d}^* \tag{11}$$

This linearized equation holds exactly if at initial steady state the foreign economy satisfies $d_0^* = 0$. $\hat{d}_t^*$ is the ratio of movement of UIP deviation to the initial foreign interest rate $\hat{d}_t^* = d_t^*/i_0^*$.

By incorporating the non-tradable sector, our model contains richer elements than the standard NOEM literature. The consumption of the home country follows Cobb-Douglas aggregation of tradable and non-tradable:

$$C_t = \frac{C_{T,t}^{\omega_1} C_{N,t}^{1-\omega_1}}{\omega_1^{\omega_1}(1-\omega_1)^{1-\omega_1}} \tag{12}$$

where ω_1 is the weight of tradable in the total consumption. The model in the appendix does not assume unitary elasticity of substitution between tradable and non-tradable.

In the supply side, firms set prices to maximize profits. We assume nominal rigidities such that prices cannot be changed in the short-run, but they are fully flexible in the long-run. We assume that all firms in both countries set their prices using Producer Currency Pricing (PCP). That is to say, firms maximize profits by choosing the prices according to the currency of their own country. Foreign importers undertake full exchange rate pass-through in this case. Home prices of home goods and foreign prices of foreign goods remain constant in the short-run. Their counter parts are affected by exchange rate movements. The short-run differentials between prices are:

$$\hat{P}_H - \hat{P}_F^* = 0 \tag{13}$$

$$\hat{P}_F - \hat{P}_H^* = 2\hat{\mathcal{E}} \tag{14}$$

where P_H and P_F represent home prices of home and foreign tradable respectively. We discuss later in the next section the robustness of this setting. Since all prices are flexible in the long-run, firms set prices according to the movements of marginal cost:

$$\bar{P}_H - \bar{P}_F^* = (\bar{W} - \bar{W}^*) - (\bar{Z}_T - \bar{Z}_T^*) \tag{15}$$

$$\bar{P}_F - \bar{P}_H^* = -(\bar{P}_H - \bar{P}_F^*) + 2\bar{\mathcal{E}} \tag{16}$$

Here Z_T is the productivity in the production $Y_{T,t}$:

$$Y_{T,t} = Z_{T,t} L_{T,t} \tag{17}$$

where $L_{T,t}$ is the demand for labour in the tradable sector. Production in the non-tradable sector is similar, except for a productivity $Z_{N,t}$ that is independent with the tradable productivity.

By assuming zero initial bond holding, the level of the bond reflects the change of the current account from the initial state. We define the current account deviation as the ratio of the change of the current account to the initial nominal GDP of the home country. The short-run current account deviation can be expressed as:

$$\hat{CA} = \hat{B} = \omega_1(1 - \omega_2)\left(\hat{\mathcal{E}} + \hat{P}_H^* + \hat{C}_H^* - \hat{P}_F - \hat{C}_F\right) \tag{18}$$

The current account in the long-run is the deviation of the long-run bond holding from that of the short-run:

$$\bar{C}A = \bar{B} - \hat{B} \tag{19}$$

3. Productivity and Current Account Dynamics

To explore productivity differentials between countries as the main cause of persistent current account deficit or surplus, in this section, we derive the functions of the current account in terms of productivity shocks in traded and non-tradable sectors. We specify the monetary policies of the two countries as those maximize their utility individually. Each country adopts a monetary supply that is fully competitive to the productivity shocks. We assume a fixed exchange rate regime for the foreign country. Based on these, we then analyze the effects on the current account of shocks in both sectors. The shocks in tradable and non-tradable sectors are not necessarily symmetric in our analysis.

3.1. The Current Account Dynamics

To close the model, we need to define the monetary policies. We consider the monetary supplies are to stabilize the economy from the shocks. Corsetti and Pesenti (2005) concludes that the optimal monetary supply should fully stabilize the shocks in the economy. The mechanism is such that marginal costs changes with productivity. Nominal rigidities, however, forbid the firms from adjusting prices and then distort the economy from its maximum. The optimal monetary policy should be fully competitive to the productivity shocks and runs the economy as if prices were flexible. Also, the economies adopt this policy in a closed economy synthesis. That is to say, there is no consideration of foreign policy or coordination when adopting optimal monetary supply. The differential between the monetary supplies of the two countries is:

$$\hat{M} - \hat{M}^* = \bar{M} - \bar{M}^* = \omega_1(\hat{Z}_T - \hat{Z}_T^*) + (1 - \omega_1)(\hat{Z}_N - \hat{Z}_N^*) \tag{20}$$

We consider the context where adjustments through the exchange rate are not achievable. The exchange rate is fixed in both short-run and long-run:

$$\hat{\mathcal{E}} = \bar{\mathcal{E}} = 0 \tag{21}$$

One contribution of our model is that, we consider the different process of development between the tradable and non-tradable sectors of an economy. This is reflected as the different productivity growths of the sectors within a country. We assume that the ratio of the differentials of non-tradable to tradable productivity growth between the two countries is δ:

$$\hat{Z}_N - \hat{Z}_N^* = \delta(\hat{Z}_T - \hat{Z}_T^*) \tag{22}$$

All shocks are assumed to be permanent.

Until now, we closed the model and then are able to express the short-run and long-run current accounts in terms of productivity shocks:

$$\hat{CA} = -\omega_1[\delta + (1 - \delta)\omega_1](1 - \omega_2)(\hat{Z}_T - \hat{Z}_T^*) \tag{23}$$

$$\bar{CA} = 0 \tag{24}$$

where ω_1 is the share of tradable in total consumption and ω_2 is the share of home goods in the tradable sector. The short-run current account steps away from balance, but then back to balance in the long-run. If the home economy experiences slower productivity growth in the tradable sector as compared to the foreign, it runs deficit in the short-run under the condition that:

$$\delta < -\frac{\omega_1}{1-\omega_1} < 0 \tag{25}$$

which predicts a higher growth of non-tradable sector in the home country. A simple calibration will find that the ratio of tradable to non-tradable is not trivial even if the share of tradable is not much less that 50%. Productivity theory explains the deficit as a result of higher growth, which is hard to explain the fact between the US and many developing countries. Our results suggest that the large deficit of the US may come from the higher development of its non-tradable sector, even if many developing economies take off by pursuing incomes from international trading. In the next part, we justify the rational behind such results.

3.2. Productivity Shocks and Global Imbalances

To see how productivity shocks enter current account imbalances, we start from the interest rates between the two countries. We don't assume an uncovered interest rate parity, but under fixed exchange rate, the short-run deviation of UIP equals the differential of interest rates between the two countries:

$$\hat{d}^* = \hat{i} - \hat{i}^* \tag{26}$$

Combining with the money demand equation (11), the nominal expenditure of the representative household is affected by the monetary supply:

$$(\hat{P}-\hat{P}^{*})+(\hat{C}-\hat{C}^{*})=\hat{M}-\hat{M}^{*} \tag{27}$$

As we have specified the monetary policies of the two countries as to stabilize shocks, productivity differentials enter the nominal expenditures through the monetary policies:

$$\hat{M}-\hat{M}^{*}=\hat{Z}-\hat{Z}^{*}=\omega_1(\hat{Z}_T-\hat{Z}_T^{*})+(1-\omega_1)(\hat{Z}_N-\hat{Z}_N^{*}) \tag{28}$$

Differential in the nominal expenditures drives the differential of demands for tradable goods:

$$\hat{C}_T-\hat{C}_T^{*}=-(\hat{P}_T-\hat{P}_T^{*})+(\hat{P}-\hat{P}^{*})+(\hat{C}-\hat{C}^{*}) \tag{29}$$

And then that differential changes exports and imports through the demand function:

$$\hat{C}_F-\hat{C}_H^{*}=-(\hat{P}_F-\hat{P}_H^{*})+(\hat{P}_T-\hat{P}_T^{*})+(\hat{C}_T-\hat{C}_T^{*}) \tag{30}$$

In this function, if home requires relatively more tradable goods than the foreign, import $\hat{C}_F$ shall grow faster than export $\hat{C}_H^{*}$ for the home country, finally leading to a current account deficit.

In this process, the non-tradable sector plays an essential role, in the sense that if productivity happens in both sectors, a stabilizing policy may save the economy from distortions overall. This policy, which depends on the magnitude of change of the non-tradable sector however, cannot avoid affecting the demand of the tradable sector. Even if the home improvement in non-tradable sector relative to the foreign is of the same level as the relative growth of the foreign to the home in the tradable sector, imbalances may also happen given that the tradable and non-tradable have different shares in the total consumption. This can be shown by assuming $\delta = -1$, which leads to the short-run current account:

$$\hat{CA} = -\omega_1(1-\omega_2)(2\omega_1 - 1)(\hat{Z}_T - \hat{Z}_T^*) \tag{31}$$

If the home runs a slower growth in tradable sector, still it is in deficit in the short-run if non-tradable goods have a larger share in the total consumption $\omega_1 < 1/2$.

Here we must clarify that rather than attributing global imbalances solely to the productivity shocks, it is more precise to say that the optimal monetary policies to stabilize shocks cause the imbalances. If we write the current account deviation using shocks in both sectors explicitly, we can find this point.

$$\begin{aligned} \hat{CA} =& -\omega_1(1-\omega_2)[\omega_1(\hat{Z}_T - \hat{Z}_T^*) + (1-\omega_1)(\hat{Z}_N - \hat{Z}_N^*)] \\ =& -\omega_1(1-\omega_2)(\hat{M} - \hat{M}^*) \end{aligned} \tag{32}$$

The current account dynamics are indifferent to the choice of the currency in the pricing of production. Short-run currency account deficit is of the same level no matter we choose PCP, LCP or asymmetric pricing. The reason is that the cause of current account deficit in our model is the monetary policy that responds to the productivity shocks. This policy raises nominal expenditure and thus raises spending on exports relative to income on imports. By our setting of unitary elasticities of substitution between tradable and non-tradable, and between home and foreign tradable, the pairwise relation of price and demand for a certain type of goods does not change the nominal expenditure on it. Thereby substitution effect between different types of goods on net exports does not enter the deficit in this case and only monetary policy differential between the two countries accounts. In a more general case as in the appendix, non-unit rates of substitution shall at least bring some imbalances. However, we shall emphasize that the setting of unit substitution between tradable and non-tradable, and between home and foreign goods is not far from facts, and therefore the role of substitution between different goods shall not account much in the imbalances in reality, at least in the short-run.

3.3. International Adjustment

Given the fact that exchange rate adjustments are not available in many cases, such as within a monetary union, or between countries that seem cannot easily moving the distortion of fixed exchange rate, it is important to discuss international adjustment under this regime.

The first point is that monetary policy coordination is not able to remove all imbalances. In the context of our model, zero short-run current account can be achieved only if the differential between the monetary policies of the two countries is zero. This kind of coordination drives both economies experiencing shocks to productivity from optimum and thereby intuitions of adjustment are not seemingly strong. However, the short-run deficit of the home country in our model may be very large, if the share of tradable sector is less than half of the total production. Also the long-run balance does not tell actually how long the rebalancing movements take.

They could be very persistent though we cannot figure out the details in our model. Given these points, monetary policy coordination only to some limited extent should be executed.

Further, as imbalances in our model are caused by the different structures of productivity growth in the two countries, a direct way to adjust is to remove this kind of structural differential between countries. In the case that both countries have similar productivity improvements and in the meanwhile they all pursue the similar development of both tradable and non-tradable sectors, the short-run imbalances may not be large, and thus tolerable. Countries with lower development in non-tradable sector shall not only enjoy the benefits from importing tradable from countries taking off by developing tradable sectors, but also should endeavour to improve the tradable sector of themselves. On the other hand, those countries initiate developing from international trading should put efforts on achieving development of better structure of their economic growth. Though these methods might be difficult and not seemingly come into effect in the very short time, they assure the short-run imbalances not to be too severe and then a limited monetary policy coordination is acceptable and enough.

4. Conclusions

In this paper, we develop a two-country dynamic general equilibrium model based on the NOEM framework. After linearization of the model, we derive the first-order effects of productivity shocks to the short-run and long-run current accounts. Non-tradable sectors of both home and foreign economies are incorporated in the analysis. The sectors are subjected to productivity differentials and shown to have a critical effect on the formation of global imbalances.

The model demonstrates that differential improvement in productivity across countries is a main cause leading to current account imbalances in the world economy. Incorporating of the non-tradable sector in the modelling process enables to uncover a richer set of influences that also contribute to the global imbalances. Productivity shocks originated from the non-tradable sector prove to be an important source of imbalances by way of affecting the endogenous stabilizing monetary policies which cause the differential between monetary policies and finally lead to the imbalances.

We predict that countries experiencing higher growth in the tradable sector while in the meantime running surplus must have a lower growth in the non-tradable sector. The role of pricing currency in the international trade is not important and we argue that the substitution between different goods is not a major cause of imbalances at least in the short-run. In our model, we consider a context when exchange rate adjustment cannot be easily achieved between countries that adopting fixed regime or within a monetary union. We suggest that when the exchange rate cannot present, adjustments shall come from improving the structure of growth of different countries. Countries take off by increasing income from international trade should invest more to the non-tradable sector, while the counterparts should improving their tradable sector as well. Also, an appropriate level of monetary coordination can also narrow the gap of imbalances.

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Appendix. Algebra of the Model

There are two symmetric countries in the world, namely home and foreign. Each economy is consisted of a continuum of households. Home and foreign households have the same form of utility functions, U_t and U_t^*. Consumption of goods C_t and money holding M_t generate positive welfare, while households enjoy leisure, thereby work efforts L_t generates disutility. The utility function for a home household j is defined as:

$$U_t(j) = E_t \left\{ \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[\frac{C_\tau(j)^{1-\eta_1}}{1-\eta_1} + \frac{\alpha_M}{1-\eta_2} \left(\frac{M_\tau(j)}{P_\tau} \right)^{1-\eta_2} - \frac{\alpha_L}{1+\eta_3} L_\tau(j)^{1+\eta_3} \right] \right\}$$

$$0 < \beta < 1,\ \eta_1,\ \eta_2,\ \eta_3,\ \alpha_M \text{ and } \alpha_L > 0$$

Households receive wages W_t from their supply of work efforts $L_t(j)$ and receive government transfers or pay taxes T_t. The budget constraint of a household in the home country is:

$$\begin{aligned} P_t C_t(j) + M_t(j) + P_t T_t(j) + B_t(j) =& W_t L_t(j) + \Pi_t(j) + (1+i_{t-1}) B_{t-1}(j) \\ &+ M_{t-1}(j) \end{aligned}$$

P_t is the consumption price index of the home country. Since we assume that households hold portfolios of domestic firms assets, they receive profits in terms of dividends $\Pi_t(j)$. Households also make decision on the number of nominal bonds $B_t(j)$ to hold and i_t is the nominal interest rate of the bond. We assume that government's finance comes from tax received:

$$\int_0^1 M_{t-1}(j)dj = \int_0^1 M_t(j)dj + P_t \int_0^1 T_t(j)dj$$

Households optimize their utility by choosing the consumption, money holding, labour supply and bonds, subject to the budget constraint. The optimization problem is described as:

$$\max_{C_t(j),M_t(j),L_t(j),B_t(j)} U_t(j)$$

The first-order condition on consumption leads to the Euler equation:

$$\frac{C_t(j)^{-\eta_1}}{P_t} = \beta(1+i_t)E_t\left\{\frac{C_{t+1}(j)^{-\eta_1}}{P_{t+1}}\right\}$$

from which we can find that households choice of consumption is symmetric across a country. Further, this rule applies to other first-order conditions and therefore we assume a representative household for each economy, instead of the previous assumptions. First-order conditions for the representative home household are:

$$\frac{C_t^{-\eta_1}}{P_t} = \beta(1+i_t)E_t\left\{\frac{C_{t+1}^{-\eta_1}}{P_{t+1}}\right\}$$
$$W_t = \frac{\alpha_L L_t^{\eta_3} P_t}{C_t^{-\eta_1}}$$
$$\alpha_M\left(\frac{M_t}{P_t}\right)^{-\eta_2} = \frac{i_t}{1+i_t}C_t^{-\eta_1}$$

Together with the government's budget, the constraint of the representative household collapses to:

$$P_tC_t + B_t = W_tL_t + \Pi_t + (1+i_{t-1})B_{t-1}$$

The foreign representative has similar utility function as the home one, except that it choose the optimal holding of bond issued by the home country due to our assumption of incomplete financial market. The Euler equation for the foreign household is:

$$\frac{(C_t^*)^{-\eta_1}}{P_t^*} = \beta(1+i_t)E_t\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\frac{(C_{t+1}^*)^{-\eta_1}}{P_{t+1}^*}$$

Also, the first-order condition of monetary holding for the foreign household is:

$$\alpha_M \left(\frac{M_t^*}{P_t^*}\right)^{-\eta_2} \frac{1}{P_t^*} = \frac{(C_t^*)^{-\eta_1}}{P_t^*} \left(\frac{i_t^* + d_t^*}{1 + i_t^* + d_t^*}\right)$$

The consumption basket is consisted of both traded goods $C_{T,t}$ and non-tradable goods $C_{N,t}$ and assumed to have constant elasticity of substitution (CES):

$$C_t = \left[\bar{\omega}_1^{\frac{1}{\phi_1}} C_{T,t}^{\frac{\phi_1 - 1}{\phi_1}} + (1 - \bar{\omega}_1)^{\frac{1}{\phi_1}} C_{N,t}^{\frac{\phi_1 - 1}{\phi_1}}\right]^{\frac{\phi_1}{\phi_1 - 1}}$$

ϕ_1 is the elasticity of substitution between tradable and non-tradable. $\bar{\omega}_1$ is the share of tradable in the basket. The composite of traded goods is assumed to contain goods from home firms $C_{H,t}$ and imports $C_{F,t}$:

$$C_{T,t} = \left[\bar{\omega}_2^{\frac{1}{\phi_2}} C_{H,t}^{\frac{\phi_2 - 1}{\phi_2}} + (1 - \bar{\omega}_2)^{\frac{1}{\phi_2}} C_{F,t}^{\frac{\phi_2 - 1}{\phi_2}}\right]^{\frac{\phi_2}{\phi_2 - 1}}$$

Within each group of non-tradable, home tradable and foreign tradable, a continuum of firms produce differentiated goods. We assume they all have a CES production function in each group:

$$C_{N,t} = \left(\int_0^1 C_{N,t}(n)^{\frac{\phi_3 - 1}{\phi_3}} dn\right)^{\frac{\phi_3}{\phi_3 - 1}}$$

$$C_{H,t} = \left(\int_0^1 C_{H,t}(h)^{\frac{\phi_3 - 1}{\phi_3}} dh\right)^{\frac{\phi_3}{\phi_3 - 1}}$$

$$C_{F,t} = \left(\int_0^1 C_{F,t}(f)^{\frac{\phi_3 - 1}{\phi_3}} df\right)^{\frac{\phi_3}{\phi_3 - 1}}$$

Following Dixit-Stiglitz's geometry, we derive the corresponding price index. Home consumption price index (CPI) is:

$$P_t = \left[\bar{\omega}_1 P_{T,t}^{1-\phi_1} + (1 - \bar{\omega}_1) P_{N,t}^{1-\phi_1}\right]^{\frac{1}{1-\phi_1}}$$

$P_{T,t}$ and $P_{N,t}$ are indices of traded and non-tradable goods respectively:

$$P_{T,t} = \left[\bar{\omega}_2 P_{H,t}^{1-\phi_2} + (1-\bar{\omega}_2) P_{F,t}^{1-\phi_2}\right]^{\frac{1}{1-\phi_2}}$$

Prices of non-tradable goods, home produced tradable $P_{H,t}$ and foreign sourced tradable $P_{F,t}$ are defined as:

$$P_{N,t} = \left(\int_0^1 P_{N,t}(n)^{1-\phi_3} dn\right)^{\frac{1}{1-\phi_3}}$$

$$P_{H,t} = \left(\int_0^1 P_{H,t}(h)^{1-\phi_3} dh\right)^{\frac{1}{1-\phi_3}}$$

$$P_{F,t} = \left(\int_0^1 P_{F,t}(f)^{1-\phi_3} df\right)^{\frac{1}{1-\phi_3}}$$

The demand functions for each type of goods are assumed to be:

$$C_{T,t} = \omega_1 \left(\frac{P_{T,t}}{P_t}\right)^{-\phi_1} C_t$$

$$C_{N,t}(n) = \left(\frac{P_{N,t}(n)}{P_{N,t}}\right)^{-\phi_3} C_{N,t} = \left(\frac{P_{N,t}(n)}{P_{N,t}}\right)^{-\phi_3} (1-\omega_1) \left(\frac{P_{N,t}}{P_t}\right)^{-\phi_1} C_t$$

$$C_{H,t}(h) = \left(\frac{P_{H,t}(h)}{P_{H,t}}\right)^{-\phi_3} C_{H,t} = \left(\frac{P_{H,t}(h)}{P_{H,t}}\right)^{-\phi_3} \omega_2 \left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\phi_2} C_{T,t}$$

$$C_{F,t}(f) = \left(\frac{P_{F,t}(f)}{P_{F,t}}\right)^{-\phi_3} C_{F,t} = \left(\frac{P_{F,t}(f)}{P_{F,t}}\right)^{-\phi_3} (1-\omega_2) \left(\frac{P_{F,t}}{P_{T,t}}\right)^{-\phi_2} C_{T,t}$$

The foreign economy is symmetric with home economy in preferences and has the same coefficients. For example, the share of foreign consumption of foreign produced traded goods is also $\bar{\omega}_2$. For the sake of space economy, we do not provide equations for foreign variables.

Producers of each group of goods are a continuum of firms. Firms hire labour which paying wages and receive revenue from sales of products. The product functions are assumed to be:

$$Y_{T,t}(h) = Z_{T,t}L_{T,t}(h)$$

$$Y_{N,t}(n) = Z_{N,t}L_{N,t}(n)$$

where $Y_{T,t}$ is the supply of home produced tradable and $Y_{N,t}$ is the supply of non-tradable. $L_{T,t}$ and $L_{N,t}$ are labour demanded in both tradable and non-tradable sectors. $Z_{T,t}$ and $Z_{N,t}$ are productivities.

When both goods market and labour market clear we have:

$$Y_{T,t}(h) = C_{H,t}(h) + C^*_{H,t}(h)$$

$$Y_{N,t}(n) = C_{N,t}(n)$$

$$L_t = \int_0^1 L_{T,t}(h)dh + \int_0^1 L_{N,t}(n)dn$$

Firms pay all their profits to the shareholders, which are the households in the home economy.

$$\Pi_t = \int_0^1 \Pi_{T,t}(h)dh + \int_0^1 \Pi_{N,t}(n)dn$$

Profits from selling each type of goods are defined as:

$$\Pi_{T,t}(h) = P_{H,t}(h)Y_{T,t}(h) - W_tL_{T,t}(h)$$

$$\Pi_{N,t}(n) = P_{N,t}(n)Y_{N,t}(n) - W_tL_{N,t}(n)$$

Firms maximize profits by setting the price of their products. In a flexible price case, firms can change prices and do not consider any current or future price rigidities. The flexible prices can be derived by solving the optimization problems:

$$\max_{P_{H,t}(h)} \Pi_{T,t}(h)$$

$$\max_{P_{N,t}(n)} \Pi_{N,t}(n)$$

By solving the flexible prices, we can find that price settings are symmetric for firms in each sector:

$$P_{N,t} = P_{N,t}(n) = \frac{\phi_3}{\phi_3 - 1}\frac{W_t}{Z_{N,t}}$$
$$P_{H,t} = P_{H,t}(h) = \frac{\phi_3}{\phi_3 - 1}\frac{W_t}{Z_{T,t}}$$

This further leads to the symmetric demand for each type of goods and symmetric demand for labour across different firms. Thereby the firms can also be described by a representative firm in each sector:

$$Y_{T,t} = Z_{T,t}L_{T,t}$$

$$Y_{N,t} = Z_{N,t}L_{N,t}$$

$$Y_{T,t} = C_{H,t} + C^*_{H,t}$$

$$Y_{N,t} = C_{N,t}$$

$$\Pi_{T,t} = P_{H,t}Y_{T,t} - W_tL_{T,t}$$

$$\Pi_{N,t} = P_{N,t}Y_{N,t} - W_tL_{N,t}$$

Foreign prices of home produced tradables are assumed to follow the law of one price. That is to say, firms set prices according to the Producer Currency Pricing (PCP):

$$P^*_{H,t} = \frac{P_{H,t}}{\mathcal{E}_t}$$

where $\mathcal{E}_t$ is the exchange rate between the two countries.

Linearization, and approximation if necessary, is made around either short-run equilibrium or long-run steady state. We denote deviation of a variable in the short-run to its initial steady state by a hat and its deviation in the long-run by a bar; e.g. $\hat{C}$ is $d\log C$ in the short-run and $\bar{C}$ for long-run respectively. The difference between the short-run and long-run deviations is that prices in the short-run are assumed to be fully fixed, while in the long-run firms can adjust prices according to their optimizing solution.

We display equations necessary for closing the model below. For simplicity, we do not list all foreign counterparts if they are similar.

$$-\eta_1\hat{C}_t - \hat{P}_t = (1-\beta)\hat{i}_t - \eta_1 E_t\{\hat{C}_{t+1}\} - E_t\{\hat{P}_{t+1}\}$$

$$-\eta_1\hat{C}_t^* - \hat{P}_t^* = (1-\beta)\hat{i}_t + \hat{\mathcal{E}}_t - E_t\{\hat{\mathcal{E}}_{t+1}\} - \eta_1 E_t\{\hat{C}_{t+1}^*\} - E_t\{\hat{P}_{t+1}^*\}$$

$$\hat{W}_t = \eta_3\hat{L}_t + \hat{P}_t + \eta_1\hat{C}_t$$

$$-\eta_2\hat{M}_t + \eta_2\hat{P}_t = \beta\hat{i}_t - \eta_1\hat{C}_t$$

$$-\eta_2\hat{M}_t^* + \eta_2\hat{P}_t^* = \beta(\hat{i}_t^* + \hat{d}_t^*) - \eta_1\hat{C}_t^*$$

$$\hat{C}_{T,t} = -\phi_1\hat{P}_{T,t} + \phi_1\hat{P}_t + \hat{C}_t$$

$$\hat{C}_{N,t} = -\phi_1\hat{P}_{N,t} + \phi_1\hat{P}_t + \hat{C}_t$$

$$\hat{C}_{H,t} = -\phi_2\hat{P}_{H,t} + \phi_2\hat{P}_{T,t} + \hat{C}_{T,t}$$

$$\hat{C}_{F,t} = -\phi_2\hat{P}_{F,t} + \phi_2\hat{P}_{T,t} + \hat{C}_{T,t}$$

$$\hat{P}_t = \omega_1\hat{P}_{T,t} + (1-\omega_1)\hat{P}_{N,t}$$

$$\hat{P}_{T,t} = \omega_2\hat{P}_{H,t} + (1-\omega_2)\hat{P}_{F,t}$$

$$\hat{Y}_{T,t} = \hat{Z}_{T,t} + \hat{L}_{T,t}$$

$$\hat{Y}_{N,t} = \hat{Z}_{N,t} + \hat{L}_{N,t}$$

$$\hat{Y}_{T,t} = \omega_2 \hat{C}_{H,t} + (1 - \omega_2)\hat{C}^*_{H,t}$$

$$\hat{Y}_{N,t} = \hat{C}_{N,t}$$

$$\hat{L}_t = \omega_1 \hat{L}_{T,t} + (1 - \omega_1)\hat{L}_{N,t}$$

$$\hat{P}_{N,t} = 0$$

$$\hat{P}_{H,t} = 0$$

$$\hat{P}^*_{F,t} = 0$$

$$\hat{P}_{F,t} = \hat{\mathcal{E}}_t$$

$$\hat{P}^*_{H,t} = -\hat{\mathcal{E}}_t$$

$$\hat{B}_t = \omega_1(1 - \omega_2)\left(\hat{\mathcal{E}}_t + \hat{P}^*_{H,t} + \hat{C}^*_{H,t} - \hat{P}_{F,t} - \hat{C}_{F,t}\right)$$

$$\hat{CA}_t = \hat{B}_t$$

Conditions used for the linearizing of the model are:

$$\omega_1 = \bar{\omega}_1^{\frac{1}{\phi_1}} \left(\frac{C_{T,0}}{C_0}\right)^{\frac{\phi_1 - 1}{\phi_1}}$$

$$\omega_2 = \bar{\omega}_2^{\frac{1}{\phi_2}} \left(\frac{C_{H,0}}{C_{T,0}}\right)^{\frac{\phi_2 - 1}{\phi_2}}$$

Also some equations are approximated by imposing conditions on the initial state of the economy:

$$\omega_1 = \bar{\omega}_1$$

$$\omega_2 = \bar{\omega}_2$$

$$C_{T,0} = Y_{T,0}$$

$$C_0 = C_{T,0} + C_{N,0}$$

$\hat{B}_t$ is defined as the ratio of bond holdings to initial nominal GDP of the home economy:

$$\hat{B}_t = \frac{B_t}{P_{H,0} Y_{T,0}}$$

Long-run linearized equations are similar as the short-run ones, except for the following. The Euler equation collapses in the long-run steady state:

$$\bar{i} = 0$$

In the long-run, we assume that firms fully adjust prices hence long-run prices of goods are flexible ones:

$$\bar{P}_N = \bar{W} - \bar{Z}_N$$

$$\bar{P}_H = \bar{W} - \bar{Z}_T$$

The current account in the long-run is defined as:

$$\bar{CA} = \bar{B} - \hat{B}$$

Finally, we close the model by specifying optimal monetary policies of the two countries. We assume that each country chooses their monetary policy as if in a closed economy synthesis (Corsetti and Pesenti 2005). Thereby monetary policy is to stabilize the economy from shocks to productivity. Assuming that at the initial, productivity of both sectors are symmetric:

$$Z_{T,0} = Z_{N,0}$$

Optimal monetary policy is derived as the weighted average of productivity shocks in both sectors:

$$\hat{M} = \omega_1 \hat{Z}_T + (1-\omega_1)\hat{Z}_N$$

This monetary response can be viewed as a stability policy that targets the output gap. In the short-run, fixed prices induce the output from its natural level under productivity shocks. Such a policy increases the output as if the prices are fully flexible.

The current account dynamics under the setting when $\eta_1 = 1$, $\eta_2 = 1$, and $\eta_3 = 0$ are shown below. The results for a general case can be provided on demand.

$$\hat{CA} = -\omega_1[\delta + (1-\delta)\omega_1](1-\omega_2)(\hat{Z}_T - \hat{Z}_T^*)$$

$$\bar{CA} = -\omega_1(1-\omega_1)(1-\omega_2)(1 - 2\omega_1 + 2\omega_1\omega_2 + \phi_1 - 2\omega_2\phi_2)(1-\delta)(\hat{Z}_T - \hat{Z}_T^*)$$