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INFLATION TARGETING, PATTERN OF TRADE, AND ECONOMIC DYNAMICS

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This paper develops an analytically tractable, two-country, two-traded-good dynamic general-equilibrium model of money to examine the long-run and short-run effects of a temporary change in the domestic inflation target on the trade pattern, the terms of trade, the foreign exchange rate, and the capital accumulation of each country and of the world economy. We find that such a *temporary* monetary innovation can generate *permanent* effects on the *world distribution of capital* and the pattern of trade, resulting in nonneutrality in an otherwise money-neutral cash-in-advance setting. This change also leads to very rich transitional dynamics that we fully characterize analytically. In particular, endogenous responses in transition can be monotone or nonmonotone and can exhibit over-shooting. Our analytic findings and quantitative results help explain some noticeable changes in the capital accumulation, output, and bilateral trade of several countries adopting inflation targeting. Since the permanent effects of a temporary change in the domestic inflation target on the pattern of international trade and the performance of the macroeconomy are driven by a new channel through the world distribution of capital, we add new insights to the literature.

Keywords: Inflation Targeting, Dynamic Pattern of Trade, World Distribution of Capital

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1. INTRODUCTION

Over the past decade or two, we have witnessed an increase in the popularity of inflation targeting (IT) policies in countries that are highly open to the international market [e.g., see Svensson (2000), De Fiore and Liu (2005)].[1] By the end of 2008, 28 countries had adopted this monetary policy regime and they accounted for almost 22% of global output.[2] Despite its growing importance, this monetary policy paradigm lacks a thorough *analytical* examination of *both the long-run and the short-run macroeconomic effects* of IT in an *open economy with domestically determined rates of interest*.[3] Think of the economic interplays between two countries adopting inflation targeting. What if one country *temporarily and unilaterally* changes the tightness of its monetary policy in the form of its inflation target while another country stays put? Would the patterns and terms of trade between the two countries be affected in the short and long run? Just how would the capital accumulation by each country and by both economies jointly respond to such unilateral monetary innovations? In this paper, we will address these important issues analytically within an integrated dynamic general equilibrium framework.

To guide our study, we could gain useful insights from empirical observations on changes in the trade patterns and capital accumulation of a given country, against a single partner or a group of them, when this country unilaterally reduces its inflation targets. Among the 28 IT countries, we select 5 advanced countries and 8 developing countries with sufficient data available both before and after the adoption of IT.[4] To draw a contrast with the treatment group of IT countries, we select a control group of 39 non-IT countries (see online Appendix A for the detailed sample selection, as well as data description and sources).[5] To control for the impact of globalization, all measures are demeaned (by the respective sample mean of all countries inclusive of IT and non-IT), which is frequently used to control for a common trend for different countries over time. Thus, among the IT countries considered, we can identify four pairs of *mutually* major trading partners: Turkey–Switzerland, Turkey–Sweden, Brazil–Switzerland, and Thailand–Australia (where we list the less developed, relatively labor-intensive countries first in each pair). These pairs are major trading partners with one *advanced with steady inflation targets*, and another *less developed with noticeable unilateral changes in inflation targets*.[6] We plot the net consumption good exports (for developing countries) and the net capital good exports (for advanced countries) over the period with 5 years prior to as well as 5 and 8 years after the adoption of IT by the developing countries (to capture the longer term effects).[7] Figure 1 shows that in response to a decrease in the developing countries' inflation rates, not only do their net consumption good exports increase, but also the advanced countries' net capital good exports go up, particularly in the longer run. This finding is robust even when we broaden our observations by reexamining the influence of a lower inflation target on the trade patterns of IT countries against the "rest of the world" within our sample. In addition to the trade patterns, we further observe that, in both groups of advanced and developing countries, inflation targeting at a lower rate tends to discourage a country's capital accumulation (see Table 1).[8]

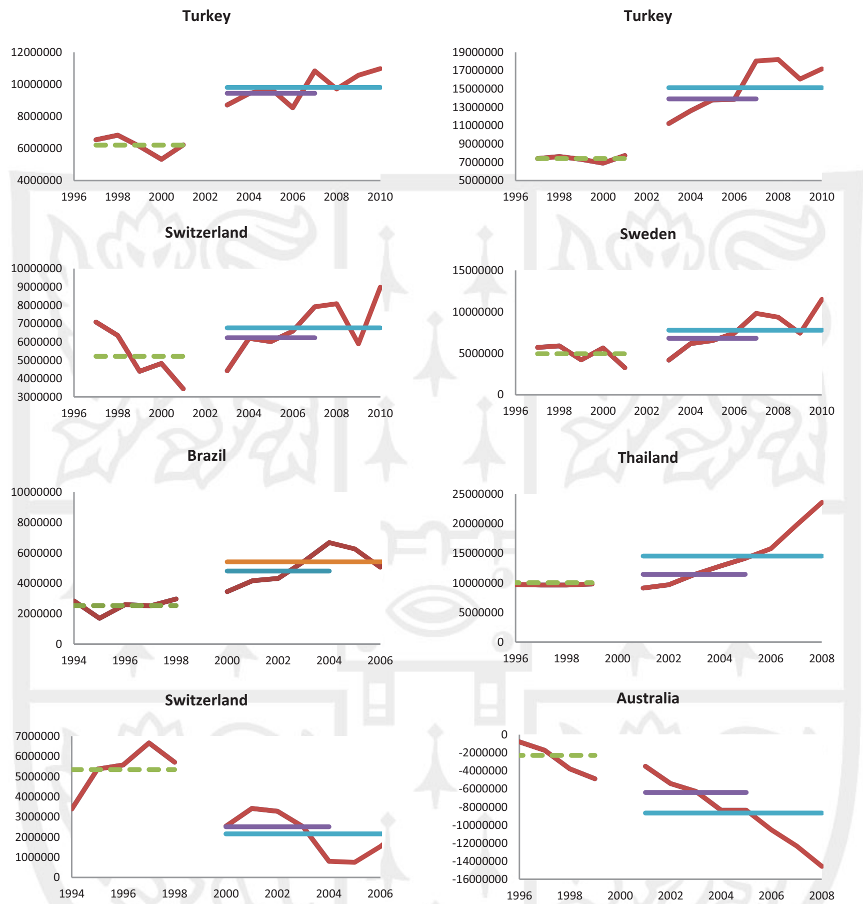

FIGURE 1. Pairs' pattern of trade and inflation targeting. Dashed lines: annual average of 5 years prior to the IT adoption by the developing country. Solid lines: annual average of 5(8) years after the IT adoption by the developing country.

The above observations point to an interesting but unexplored relationship between inflation target adjustments, capital accumulation, and the trade pattern. The chief purpose of this paper is thus to develop an *analytically tractable dynamic model* that enables a thorough examination of such a relationship in a unified framework. To do so, we construct a benchmark two-country dynamic Heckscher–Ohlin (H–O) model where the two countries only differ in their initial capital stocks and temporary inflation target changes and where money is introduced by a cash-in-advance (CIA) constraint on the purchase of consumption goods.[9] In our world economy, there are two traded goods, namely, consumption and capital investment goods, which are produced using labor and capital. The dynamic H–O framework with differential capital endowments is a good benchmark because it allows us

Table 1. Changes between the annual average of 5 years prior to and after the adoption of IT

		Difference %	Change
Advanced-country group	Net capital good exports	−1,258,047	−46.9%
	Capital stock	−239,457	−33.9%
Developing-country group	Net consumption good exports	5,010,378	96.5%
	Capital stock	−10,396	−298.2%

Note: Exports are measured in thousands of US dollars and capital is measured in millions of US dollars.

to focus primarily on the interactions between capital accumulation and trade patterns.[10] The CIA constraint setup under consideration is a useful benchmark because money would be *superneutral* if we had considered a framework that features *either a closed or an open economy with domestically determined rates of interest* [cf. Calvo (1987)].[11] Our benchmark setting is parsimonious, thereby enabling us to study not only the long run but also the dynamic effects of a temporary IT policy. To examine temporary IT policy changes, we set the same inflation target in the long run in the two countries, while allowing their inflation targets in the short run to be different. A thorough study of the effects of a temporary change in the inflation targets is particularly important because most changes in inflation targets are expected to be only temporary in reality. In particular, all the inflation-targeting central banks emphasize the flexibility of the framework: temporary deviations from the target should be allowed if the economic situation demands it.[12]

The main findings of our paper are summarized as follows. We show that the steady-state equilibrium is locally determinate, and hence the uniquely determined transition path can be fully characterized. We find that under the benchmark setup, a temporary increase in the home inflation target does not alter the world capital stock, the terms of trade or the factor prices in the steady state. *Such a temporary monetary innovation, however, has permanent effects on the world distribution of capital*: on the one hand, it favors capital accumulation in the home country and, on the other hand, harms foreign capital accumulation. This implies that an expansionary domestic inflation targeting policy creates a "beggar-thy-neighbor" effect. As a consequence, this inflation targeting policy will change the pattern of international trade: starting from a no-trade steady-state equilibrium, the home country will now export the capital-intensive good and import the labor-intensive good. Such effects on the pattern of trade in our model are permanent *even in the absence of any change in the terms of trade*. More intuitively, when the home government raises its inflation targeting unilaterally, the home inflation rate is higher, as is the opportunity cost of holding money. By "intertemporal no-arbitrage," the home country shifts from holding nominal assets (money) to holding real assets (capital). Under diminishing returns, the home marginal utility of real assets falls, whereas its capital and consumption both increase. This entails the capital redistribution effect, resembling Mundell–Tobin's asset substitution effect but via a very different channel unrelated to the terms of trade channel typically considered in the international finance literature.

Moreover, we provide a full analytic characterization of the dynamics, which is, to our knowledge, the first endeavor in this literature. In particular, we show that in response to a temporary increase in the home inflation target, the world economy exhibits very rich transitional dynamics. Although in transition the world capital stock rises in a nonmonotone fashion, the foreign capital stock may also increase in the short run despite the beggar-thy-neighbor effect in the long run. Although on impact the terms of trade (consumption in units of the investment good) falls unambiguously, it may overshoot the long-run equilibrium level if the consumption good sector is labor intensive. Finally, the nominal foreign exchange rate always increases monotonically along the transition.

Although characterizing the benchmark framework enables us to better understand the main driving forces between the inflation targeting policy, capital accumulation, output and trade patterns, it is subsequently generalized in three important dimensions for the purpose of a robustness check. In the first generalization, we account for an endogenously determined labor–leisure choice. In the second generalization, we extend the conventional H–O setup with only international flows of goods, by allowing international asset trading or international capital flows. In the third extension, we consider a generalized CIA constraint under which all consumption goods purchases as well as a fraction of investment goods purchases require cash to be paid in advance. We find that our main findings are robust to these alternations. Moreover, when the cash requirements for investment good purchases become more stringent, in response to a temporary rise in domestic inflation targeting, the home capital stock may still increase in the shorter run when the capital redistribution effect is strong, under which the home country switches from exporting the capital-intensive good in the shorter run to exporting the labor-intensive good in the longer run.

By quantifying the model with a generalized CIA constraint, we find that the long-run effects of a 1 percentage point increase in the inflation target on the home country's capital, exports, and real gross domestic product (GDP) are nonnegligible. Moreover, because all these responses over the transition are hump-shaped, their intermediate-run effects are even larger.

Three implications of particular interest follow immediately. First, when adopting tightened inflation targets, a less-developed, relatively labor-abundant country will, in the longer run, increase its exports of labor-intensive goods to and its imports of capital-intensive goods from its more-advanced, relatively capital-abundant trading partners. However, since its terms of trade (measured by the relative price of the labor-intensive consumption good) becomes less favorable on impact, the immediate or shorter run effects of such an inflation targeting policy on the trade pattern would be less conclusive. These findings lend theoretical support to the aforementioned empirical observations.

Second, although an expansionary domestic IT policy generates a positive capital redistribution effect, it also induces an adverse effect through inflation by reducing consumption purchases. Our calibration analysis suggests that the capital redistribution effect dominates the inflation effect, thereby enhancing consumption growth. Thus, even with time discounting, consumer welfare measured by lifetime utility rises monotonically along the entire transition path.

Finally, by adopting a lower inflation target, a country will experience a detrimental effect on its own capital accumulation. This may help explain the Great Canadian Slump, as dubbed by Fortin (1996). Following its adoption of a low inflation target in 1991, Canada experienced an economic downturn. From the preinflation targeting era of 1990 to the end of 1993, its slide in employment and output growth amounted to 30% of the loss suffered during the Great Depression. Brito and Bystedt (2010, p. 200) echo that "the IT regime has a significant adverse impact on the average real output growth in emerging countries. . . . If one accepts that IT has been effective in dampening inflation, the data even strongly suggest there have been costs in terms of lower output growth." Our analytical results also serve to explain such output losses in the developing countries, though via very different channels. However, quantitatively, one may inquire as to how much of the Great Canadian Slump can be explained by the IT adoption alone. We find that, relative to the preadoption regime, due to the dominating capital redistribution effect, more than one seventh of the decline in real GDP 2 years following the adoption can be explained by the IT adoption alone. Moreover, our counterfactual analysis further suggests that had Canada never adopted IT, about one sixth of the Great Canadian Slump could have been mitigated.

Related literature

This paper is related to three strands of the literature, the dynamic H–O theory of comparative advantage, inflation targeting, and open-economy monetary theory.

The literature on the dynamic H–O theory originated with Oniki and Uzawa (1965). Although Chen (1992) propounds that the long-term pattern of trade is determined by the initial world distribution of capital, Nishimura and Shimomura (2002) find that the introduction of a production externality can induce dynamic indeterminacy and may reverse the trade pattern along the transition path. Bond et al. (2003) develop a dynamic two-country model of endogenous growth to relate factor abundance to trade patterns to compare the static and dynamic versions of the H–O hypothesis. By using the variant of dynamic two-country H–O models, the role of the trade pattern in terms of endogenous business fluctuations is further elaborated by Nishimura and Yano (1993) and Doi et al. (2007). Nonetheless, all of these papers focus on the real-economy aspect without money.

Over the past two decades, inflation targeting has received more attention in monetary economics [see a comprehensive survey by Bernanke and Mishkin (1997)]. Although inflation targeting countries tend to be more open to international trade, most of the existing studies on inflation targeting restrict their focus to its stabilization effects on business cycles under a closed setting [e.g., Bernanke and Woodford (1997, Huang et al. (2009)]. Svensson (2000) and Mansoorian and Mohsin (2006) extend conventional closed economy models of inflation targeting to open economies and show that a higher inflation target reduces employment and capital accumulation. Nevertheless, both papers adopt a one-sector model with a single traded good. As a result, one cannot study how monetary innovations may affect the pattern of trade, which is the central issue addressed by our paper. Moreover, in their model the *capital redistribution effect* is absent—the reversed Mundell–Tobin effect on capital accumulation can be overturned in a two-country setting with capital redistribution. In addition, there is also a new open-economy macroeconomics literature [e.g., Obstfeld and Rogoff (2000)] proposing that the optimal monetary policy for an open economy may entail a floating exchange rate and inflation targeting regime. These studies focus on the welfare analysis on the exchange rate variability rather than the pattern of international trade in goods and services.

To the best of our knowledge, Stockman (1985) is the only exception, investigating the relationship between monetary policy and trade patterns in a perfect-foresight, perfectly competitive, open-economy model. In this sense, his paper is most closely related to ours, so it is informative to contrast our analysis with his seminal work at some length. In Stockman (1985), the analysis is based on a *small open economy* with a conventional money-growth setup with a central banker controlling the rate of monetary expansion *in the absence of any purposeful objectives*, where the endogenous labor–leisure choice, together with a cash requirement on both consumption and investment goods, is the main driver of the nonneutrality of monetary expansion. By contrast, we consider a *dynamic two-country model* of money with explicit *inflation targeting* by the monetary authority where the international redistribution of capital plays a central role. Moreover, our paper differs from Stockman's in two additional respects that are of significance. Although Stockman focuses exclusively on the long-run effect of money growth on the domestic economy, we study not only the long-run but also the *short-run* effects of inflation targeting, and investigate the transmission mechanism of money in both the domestic and the world economy. Most importantly, rather than examining the inflation effects of the unanticipated permanent policy, we show that even a *temporary* change in the domestic inflation target can lead to a *permanent* change in the pattern of international trade and the performance of the macroeconomy. Such findings are due to a new channel through the world distribution of capital that is not yet established in the literature. In addition to its intellectual merit, this new insight is also valuable because we offer very different short- and long-run policy implications from previous studies.

2. THE BENCHMARK FRAMEWORK

The benchmark framework we build is a deterministic continuous-time, two-good, two-factor, two-country model in which factors are internationally immobile and goods can be freely traded (the framework will be generalized to permit international asset flows in Section 5 below).[13] One traded good is a consumption good, whereas another is an investment good. Both are produced with capital and labor, where labor is inelastically supplied. The two countries (home and foreign) are identical except for their initial capital stocks and inflation targets. Money is introduced into this model through a CIA constraint. Following Lucas (1980), we assume that real money balances are required prior to purchasing the consumption good (the framework will be generalized to require a fraction of the investment good to be subject to cash purchases in Section 5 below). In particular, under this simple setup in the absence of a labor–leisure trade-off, money would be superneutral if the model economy were assumed to be either closed or small-open. Thus, if the different inflation targeting policies between the two countries are able to generate any long-run effects, they must be purely the results of changes in inflation targets under this two-country setting.[14]

2.1. Firms

Each country is endowed with one unit of labor and a stock of capital at $k(t)$ and $k^*(t)$, respectively. In each country, both the consumption (c) and investment (i) goods markets are perfectly competitive. Capital and labor [$\ell(t)$] are allocated to the two sectors freely:

$$k_c(t) + k_i(t) = k(t), \quad \ell_c(t) + \ell_i(t) = 1, \tag{1}$$

where $k_c(t)$ and $\ell_c(t)$ [$k_i(t)$ and $\ell_i(t)$] denote the capital and labor services in the consumption (investment) sector, respectively. The production functions take the prototypical Cobb–Douglas form with constant returns:

$$y_c(t) = k_c^{\alpha_c}(t)\ell_c^{1-\alpha_c}(t), \quad y_i(t) = k_i^{\alpha_i}(t)\ell_i^{1-\alpha_i}(t). \tag{2}$$

Denote by $P(t) = \frac{P_c(t)}{P_i(t)}$ the price of the consumption good $[P_c(t)]$ relative to the investment good $[P_i(t)]$. Define the real wage rate as $w(t) = \frac{W(t)}{P_i(t)}$ [where $W(t)$ is the nominal wage rate] and the real interest rate as $r(t) = \frac{R(t)}{P_i(t)}$ [where $R(t)$ is the nominal interest rate]. The first-order conditions for the profit maximization of the consumption good producer are given by

$$r(t) = P(t)\alpha_c \frac{y_c(t)}{k_c(t)} \text{ and } w(t) = P(t)(1-\alpha_c)\frac{y_c(t)}{\ell_c(t)}. \tag{3}$$

Similarly, in the investment sector the first-order conditions for profit maximization are

$$r(t) = \alpha_i \frac{y_i(t)}{k_i(t)} \text{ and } w(t) = (1-\alpha_i)\frac{y_i(t)}{\ell_i(t)}. \tag{4}$$

These are the standard "factor price equalization" conditions under free factor mobility, which can be used jointly to solve the factor prices as functions of the relative price alone:

$$w(t) = w\,(P(t)) \quad \text{and} \quad r(t) = r\,(P(t))\,, \tag{5}$$ Q1

where $w' = \frac{\partial w(t)}{\partial P(t)} = -\frac{\alpha_i}{\alpha_c - \alpha i}\frac{w(t)}{P(t)}$ and $r' = \frac{\partial r(t)}{\partial P(t)} = \frac{1-\alpha_i}{\alpha_c - \alpha i}\frac{r(t)}{P(t)}$, whose signs depend crucially on the factor intensity rankings (i.e., the sign of $\alpha_c - \alpha_i$). In the absence of trade barriers, since both countries face the same relative price $P(t)$ (i.e., the terms of trade), the same wage $w\,(P(t))$and interest $r\,(P(t))$rates prevail in the Q2 foreign country as well. With (5) and (1), we can further derive the outputs of Q3 the consumption and investment goods as follows:

$$y_c(t) = \frac{(1-\alpha_i)\,r\,(P(t))\,k(t) - \alpha_i w\,(P(t))}{(\alpha_c - \alpha_i)\,P(t)} \quad \text{and}$$

$$y_i(t) = \frac{\alpha_c w\,(P(t)) - (1-\alpha_c)\,r\,(P(t))\,k(t)}{(\alpha_c - \alpha_i)}, \tag{6}$$ Q4

whichare functions of $P(t)$ and $k(t)$ alone.

2.2. Households

Each country is populated by a unit measure of identical infinitely lived households. For illustrative purposes, let us focus on the home country. Each household is endowed with one unit of time together with $k_0 > 0$ and $M_0 > 0$ units of physical capital and money. The representative household's optimization problem is specified as

$$\max_{c(t),i(t),k(t),m(t)} \int_0^\infty \ln c(t) \cdot e^{-\rho t} dt, \tag{7}$$

subject to,

$$\dot{m}(t) = w(t) + r(t)k(t) + \mathrm{TR}(t) - P(t)c(t) - i(t) - \pi(t)m(t), \tag{8}$$

$$\dot{k}(t) = i(t) - \delta k(t), \tag{9}$$

$$P(t)c(t) \leq m(t), \tag{10}$$

where $\rho > 0$ is the (constant) rate of time preference, $\delta > 0$ is the (constant) rate of capital depreciation, $m(t) = \frac{M(t)}{P_i(t)}$ is real money balances [with $M(t)$ denoting nominal money holdings] and $\pi(t) = \frac{\dot{P}_i(t)}{P_i(t)}$ is the inflation rate (measured in units of the investment good).[15] The flow budget constraint (8) states that the sum of real income $[w(t) + r(t)k(t)]$ and the government's lump-sum transfers [TR(t)] net of household expenditure on consumption $[P(t)c(t)]$ and investment $[i(t)]$ and net of inflation tax $[\pi(t)m(t)]$ can be used to increase real money holdings. Although (9) is a standard law of motion for capital accumulation, (10) is the Lucasian CIA constraint. Most notably, despite money only being required for purchasing the consumption good (and not the investment good), the benchmark model can still yield interesting long-run and short-run effects in response to changes in the inflation target.

Let $\lambda(t)$ and $q(t)$ denote, respectively, the co-state variables associated with (8) and (9) and $\varepsilon(t)$ the Lagrangian multiplier associated with (10). Since all assets are perfectly substitutable, $q(t) = \lambda(t)$. Straightforward manipulations of the necessary conditions for the household's optimization problem lead to the following no-arbitrage condition (see online Appendix B):

$$\frac{\varepsilon(t)}{\lambda(t)} - \pi(t) = r(t) - \delta. \tag{11}$$

As stressed by Bond et al. (1996), this no-arbitrage condition states that the real rate of return on money $[\frac{\varepsilon(t)}{\lambda(t)} - \pi(t)]$ and the real rate of return on capital $[r(t) - \delta]$ must be equalized when both assets are held. Thus, by adjusting the inflation target upward, the real rate of return on money is lower, other things being equal. This encourages individuals to switch from monetary assets to capital stocks, thereby raising the marginal valuation of money relative to capital $(\frac{\varepsilon(t)}{\lambda(t)})$ to restore the no-arbitrage relationship. With the no-arbitrage condition, we can derive the following Euler equation:

$$\frac{\dot{\lambda}(t)}{\lambda(t)} = \rho + \delta - r(t). \tag{12}$$

2.3. Government

Under flexible exchange rates, foreign reserves are constant. In line with Agénor and Montiel (1996, pp. 323–326), the constant level of foreign reserves is assumed to be zero for convenience. Accordingly, changes in real money balances are equal to changes in real domestic credit, i.e.,

$$\frac{\dot{m}(t)}{m(t)} = \mu(t) - \pi(t), \tag{13}$$

where $\mu(t) = \dot{M}(t)/M(t)$ is the growth rate of money (or domestic credit). The government runs a balanced budget by collecting tax revenues from seigniorage tax and uses them to provide rebates to all households in a lump-sum manner. Thus, its period budget constraint is given by

$$\mathrm{TR}(t) = \mu(t)m(t). \tag{14}$$

Notice that under the regime of inflation targeting, the government controls the inflation rate, and as a result $\mu(t)$ [and hence $\mathrm{TR}(t)$] is endogenously determined.

The relationship between the targeted domestic and foreign inflation rates (π^*) is further specified as

$$\pi(t) = \tau(t) \cdot \pi^*, \ \text{with}\ \tau(t) = 1 + (\tau_0 - 1)\, e^{-at};\ a > 0, \tag{15}$$

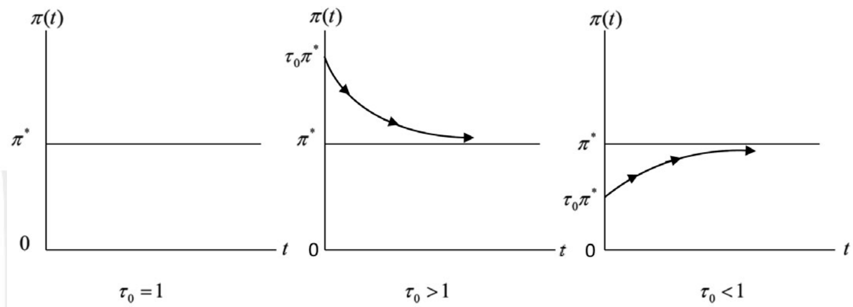

FIGURE 2. Policy change of inflation targeting.

which implies that $\dot{\tau}(t) = -a\,(\tau_0 - 1)\,e^{-at} = a\,(1 - \tau(t))$. This is a monotone smooth approximation of a typical step function, where a is inversely related to the target horizon, which measures the persistence of the inflation targeting policy and is crucial for characterizing transitional dynamics. The above equation indicates that the home government can control the intermediate tool τ_0 to whatever level the target rate of inflation $\pi(t)$ needs to reach. If the home government sets $\tau_0 = 1$ [hence, $\tau(t) = 1$], inflation in the home country will be maintained at the same rate as in the foreign country $\pi(t) = \pi^*$, given that the two countries follow the same monetary policy. However, if the home government raises (lowers) τ_0 to $\tau_0 > 1$ ($\tau_0 < 1$), then $\pi(t) > \pi^*$ ($\pi(t) < \pi^*$) along the transition path, while eventually reaching $\lim_{t\to\infty} \pi(t) = \pi^*$ in the steady state (see Figure 2). We shall refer to $\tau_0 > 1$ ($\tau_0 < 1$) as a loose (tight) monetary policy where the corresponding $\mu(t)$ is higher (lower). In reality, when the central banker deviates the inflation rate from its target, the return to the target should be gradual and the horizon for the return of inflation to the target after such a deviation may be one or two years [see Mishkin and Schmidt-Hebbel (2001)]. Such a specification therefore allows us to examine not only the short-run, but also the long-run responses of the world economy to an inflation-driven monetary shock τ_0. In particular, we are interested in examining whether a *temporary* change in the pattern of world inflation (i.e., a temporary inflation deviation between the home and foreign countries) could have a persistent effect, leading to a permanent change in the steady-state trade patterns.

Q5

Q6

By putting the individual budget constraint (8) [with the evolution of capital (9)] and the government budget constraint (14) together, we have the economy-wide resource constraint in the home country:

$$\dot{k}(t) = w(t) + r(t)k(t) - P(t)c(t) - \delta k(t). \quad \mathbf{(16)}$$

3. EQUILIBRIUM

In this section, we begin by characterizing the equilibrium in the dynamic two-country model and, accordingly, then investigate the steady-state trade patterns in the long run without any policy change. Next, we turn to the dynamic analysis.

3.1. Steady-State Equilibrium

Recall that both the home and foreign countries have the same technologies and preferences—they only differ in the initial capital stock and inflation targets. Let an asterisk (*) denote the relevant variables for the foreign country. Given $w(t) = w\left(P(t)\right)$ and $r(t) = r\left(P(t)\right)$ as reported in (5), the world equilibrium of the two-country model is summarized by 12 equilibrium conditions (see online Appendix B), plus the world market-clearing condition for the consumption good:

$$c(t) + c^*(t) = y_c(t) + y_c^*(t), \tag{17}$$

and the world market-clearing condition for the investment good:

$$\begin{aligned} \dot{K}(t) &= \dot{k}(t)+\dot{k}^*(t) = y_i(t)+y_i^*(t) - \delta K(t) \\ &= \frac{1}{\alpha_c - \alpha_i}\left[2\alpha_c w\left(P(t)\right) - (1-\alpha_c)\, r\left(P(t)\right) K(t)\right] - \delta K(t), \end{aligned} \tag{18}$$

where the world capitalstock is defined as: $K(t) = k(t) + k^*(t)$.

A *dynamic world equilibrium* is a sequence of prices $\{P(t), w(t), r(t)\}$, resource allocations $\{c(t), i(t), \ell_c(t), \ell_i(t), k_c(t), k_i(t), K(t), m(t)\}$, and policy variables $\{\pi(t)(\tau_0), \mu(t)\}$, such that in each country:

(i) the representative firm maximizes its profits, i.e., the optimizing conditions (3)–(5) hold;
(ii) the representative household maximizes its lifetime utility (7), subject to constraints (8)–(10), i.e., all the optimizing conditions hold;
(iii) the real money balances evolution equation and the flow government budget constraint hold, i.e., (13)–(15) are met;
(iv) the economy-wide resource constraint (16) is met;
(v) the world consumption good and investment good markets clear, i.e., (17) and (18) are met.

A *steady-state equilibrium* is a dynamic world equilibrium such that all price and quantity variables become time invariant. The stationary values for all steady-state variables are denoted by a "*hat.*"

By following Nishimura and Shimomura (2002), we define

$$n(t) = \frac{\lambda^*(t)}{\lambda(t)} = \frac{q^*(t)}{q(t)}, \tag{19}$$

and then characterize the model accordingly. Given the terms of trade $P(t)$ faced by the two countries, it follows from (A7) (in online Appendix B) that

$$\frac{\dot{n}(t)}{n(t)} = \frac{\dot{\lambda}^*(t)}{\lambda(t)} - \frac{\dot{\lambda}(t)}{\lambda(t)} = 0 \tag{20}$$

always holds, implying that the ratio of the foreign to home marginal utilities of wealth is constant over time (in the dynamic adjustment). As argued by the Nishimura-Shimomura (2002) model, the condition $\frac{\dot{n}(t)}{n(t)} = \frac{\dot{\lambda}^*(t)}{\lambda^*(t)} - \frac{\dot{\lambda}(t)}{\lambda(t)} = 0$ must be met for all time so that $n(t)$ will jump to its long-run equilibrium value $\widehat{n}$ immediately after any shock hits the economy and will remain constant at this value along the transition path. Nevertheless, the once-and-for-all jump in the ratio of the foreign to home marginal utilities of wealth $n(t)$ is not arbitrary; it will be endogenously determined by initial conditions as a part of the equilibrium (this will be made clear in the next section). For a similar illustration, one may refer to Obstfeld (1983) and Sen and Turnovsky (1989).

Consider the following assumption.

Assumption 1. $\frac{(1-\alpha_c)\rho+(1-\alpha_i)\delta}{(1+\alpha_c)\rho+(1-\alpha_i)\delta} < \widehat{n} < \frac{(1+\alpha_c)\rho+(1-\alpha_i)\delta}{(1-\alpha_c)\rho+(1-\alpha_i)\delta}$.

This assumption ensures that the ratio of the foreign to home marginal utilities of wealth is not too far away from one: $\widehat{n} > \frac{(1-\alpha_c)\rho+(1-\alpha_i)\delta}{(1+\alpha_c)\rho+(1-\alpha_i)\delta}$ (which is smaller than one) and $\widehat{n} < \frac{(1+\alpha_c)\rho+(1-\alpha_i)\delta}{(1-\alpha_c)\rho+(1-\alpha_i)\delta}$ (which is larger than one). With this restriction, the home and foreign marginal utilities of wealth are not so different as to lead to degenerate outcomes. As a result, the existence and uniqueness of the nondegenerate equilibrium of the two-country model will be guaranteed.

THEOREM 1 (Existence and Uniqueness of the Equilibrium). *Under Assumption 1, there exists a nondegenerate, unique equilibrium of the dynamic two-country model.*

Proof. All proofs are relegated to online Appendix B.

Given Theorem 1, we characterize the long-run patterns of international trade in the following proposition.

PROPOSITION 1 (Equilibrium Trade Patterns). *Under Assumption 1 with $\tau_0 = 1$, in the long-run equilibrium the capital(labor)-abundant country exports the good that is produced in the capital(labor)-intensive sector.*

This result is consistent with the dynamic H–O theorem. For example, Chen (1992) has shown that in a dynamic two-country model, the long-run pattern of trade is determined by the initial world distribution of capital. In our model, in the absence of differential inflation targets ($\tau_0 = 1$), (i) if $\widehat{n} = 1$, implying that $\widehat{k} = \widehat{k}^* = \frac{\widehat{K}}{2}$, there is no trade in the world economy; (ii) if $\widehat{n} > 1$, the home country is capital abundant ($\widehat{k} > \widehat{k}^*$) and exports the consumption (investment) good when the consumption (investment) sector is capital intensive, i.e., $\alpha_c > \alpha_i$ ($\alpha_c < \alpha_i$); and (iii) if $\widehat{n} < 1$, the home country is labor-abundant ($\widehat{k} < \widehat{k}^*$) and exports the investment (consumption) good when the investment (consumption) sector is labor intensive, i.e., $\alpha_c > \alpha_i$ ($\alpha_c < \alpha_i$).

3.2. Equilibrium Dynamics

First of all, we consider the following assumption.

Assumption 2. $\max\{\alpha_c, \alpha_i\} > r(t)$.

Recall that $r(t) = P(t)\alpha_c \frac{y_c(t)}{k_c(t)} = \alpha_i \frac{y_i(t)}{k_i(t)}$. Since the aggregate output–capital ratio $[\frac{P(t)y_c(t)+y_i(t)}{k_c(t)+k_i(t)}]$ is far below one, one would expect this assumption to hold in reality. Define

$$\Omega = \frac{r'}{\alpha_c - \alpha_i} \frac{(1-\alpha_i)\,\widehat{K}\,(1+\rho+\pi^* + \widehat{r})}{1+\rho+\pi^*} + \frac{2\alpha_i\,[\alpha_i(1+\rho+\pi^*) - \widehat{r}\,(1-\alpha_i)]}{(1+\rho+\pi^*)\,(\alpha_c-\alpha_i)^2} \frac{\widehat{w}(\widehat{P})}{\widehat{P}},$$

which is positive under Assumption 2 regardless of the factor intensity ranking.[16] The sign of $\Omega > 0$ guarantees the validity of Walrasian stability so that the Walrasian equilibrium can be achieved.[17] Given this, we can derive the instantaneous relationship of the relative price $P(t)$ as follows.

LEMMA 1 (The Relative Price). *Under Assumption 2, the relative price in dynamic world equilibrium can be written as*

Q10
$$P(t) = p\,(\lambda(t), \tau(t), n(t), K(t))\,, \qquad (\mathbf{21})$$

where $p_\lambda < 0$, $p_\tau < 0$, $p_n < 0$ and $p_K \lesseqgtr 0$ iff $\alpha_c \gtreqless \alpha_i$.

Given Lemma 1, the dynamical system of our model can be reduced to a 4×4 one in terms of $\tau(t)$, $\lambda(t)$, $K(t)$, and $k(t)$. Let ϕ_1, ϕ_2, ϕ_3, and ϕ_4 be the four characteristic roots of the dynamical system. We can establish the following proposition.

PROPOSITION 2 (Local Determinacy). *Under Assumption 2, the steady-state equilibrium is locally determinate.*

There are two roots with negative real parts (say, $\phi_1 = -a < 0$ and ϕ_2), whereas the other two characteristic roots are positive (say, ϕ_3 and $\phi_4 = \rho > 0$). The model consists of one control variable $\lambda(t)$ [which is associated with a once-and-for-all jump variable $n(t)$] and two predetermined variables $K(t)$ and $k(t)$, and τ_0 is the home country's policy of inflation targeting that governs the dynamic adjustment $\tau(t)$ [and hence $\pi(t)$]. This implies that the equilibrium exhibits saddle path stability and, as a result, local determinacy.

Upon solving the general solution to the dynamical system, we can further characterize the following corollary.

COROLLARY 1 (The Ratio of the Foreign to Home Marginal Utilities of Wealth). *Under Assumptions 1 and 2, the ratio of the foreign to home marginal utilities of wealth is given by*

Q11

$$\widehat{n} = \left\{ \frac{(1-\alpha_i)\, r(\widehat{P})\widehat{K} - 2\alpha_i w(\widehat{P})}{(\alpha_c - \alpha_i)\left\{\rho\left[k_0 + \frac{1}{h_{11}}(1-\tau_0) - \frac{1}{h_{32}}\left(K_0 - \widehat{K} + \frac{h_{31}}{h_{11}}(1-\tau_0)\right)\right] + w(\widehat{P})\right\}} - 1 \right\}^{-1}. \tag{22}$$

Although we relegate the exact expressions of h_{ij} to online Appendix B, it is clear from the above equation that in response to a monetary innovation (a change in τ_0), $n(t)$ will take a once-and-for-all jump to its long-run equilibrium value $\widehat{n}$ and afterward will remain unchanged along the transition path (recall that $\frac{\dot{n}(t)}{n(t)} = 0$). It is worth noting that changes in the home country's monetary innovation will alter the relative shadow price of wealth between the two countries ($\widehat{n}$). As a consequence, an international redistribution of wealth (e.g., capital) will occur, which will subsequently result in different patterns of international trade. This key role played by $n(t)$ in governing the redistribution of capital and the pattern of international trade will be examined thoroughly in the next section, to which we now turn.

4. INFLATION TARGETING, CAPITAL ACCUMULATION, TERMS OF TRADE, AND TRADE PATTERN

In this section, we will investigate both the long-run steady-state effects and the short-run transitional effects of the home policy of inflation targeting. Assume that the economy starts out in the steady state with $\widehat{n} = 1$ and $\tau_0 = 1$. It is easy to see that if $\widehat{n} = 1$, $\widehat{\lambda} = \widehat{\lambda}^*$ and $\widehat{c} = \widehat{c}^*$ are true, and accordingly, $k = \widehat{k}^* = \frac{\widehat{K}}{2}$ and $\widehat{y}_c = \widehat{y}_c^*$ must hold. As a result, the world market clearing condition for the consumption good (17) indicates that $\widehat{c} = \widehat{y}_c = \widehat{c}^* = \widehat{y}_c^*$, implying that the initial equilibrium of the economy features no trade.

Consider now that the home government raises its relative level of inflation targeting from 1 to $\tau_0^{'} > 1$ and the instantaneous adjustment can be specified as

$$\tau(t) = \begin{cases} 1, & t = 0^- \\ 1 + \left(\tau_0^{'} - 1\right) e^{-at}, & t \geq 0^+ \end{cases},$$

where 0^- and 0^+ denote the instant before and after the policy change, respectively (see Figure 2). This policy change leads the ratio of the foreign to home marginal utilities of wealth to change from $\widehat{n} = 1$ to $\hat{n}^{'}$.

4.1. The Long-Run Effects

We first investigate the steady-state effects of a change in the home policy of inflation targeting τ_0.

PROPOSITION 3 (Long-Run Effects). *Under Assumptions 1 and 2, the rise in the level of inflation targeting of the home country increases the ratio of the foreign to home marginal utilities of wealth* $\widehat{n}$ *and the steady-state capital stock of the home country* $\widehat{k}$*, but has no impact on the steady-state terms of trade* $\widehat{P}$ *or the capital stock in the world* $\widehat{K}$*. As a result of differential inflation targets, the home country will export the capital-intensive good (the investment good if* $\alpha_c < \alpha_i$*).*

Our result indicates that the home country's monetary innovation has no impact on the world capital stock $\widehat{K}$ in the steady state. Nonetheless, raising the home country's inflation target, on the one hand, favors capital accumulation in the home country $\widehat{k}$ and, on the other hand, is harmful to the foreign capital accumulation $\widehat{k}^*$. In other words, the domestic inflation targeting policy is a beggar-thy-neighbor one.[18] Intuitively, when the home government raises the level of inflation targeting τ_0, the home inflation rate will rise in response and be higher than that of the foreign country. A higher inflation rate will increase the opportunity costs of holding money. Due to the intertemporal no-arbitrage condition (11), it is favorable for the home country to shift away from holding nominal assets (money) and instead to holding real assets (capital). By rewriting this condition as

$$\frac{1}{\lambda(t)} = \frac{\pi(t) + r(t) - \delta}{\varepsilon(t)},$$

Q12 where $\frac{1}{\lambda(t)} = c(t)P(t)[1 + r\,(P(t)) + \tau(t)\pi^* - \delta]$, it is clear that consumption $c(t)$ rises. Under diminishing returns, the home marginal utility of real assets $\lambda(t)$ falls, and the relative ratio of the foreign to home marginal utilities of wealth $n(t)$ rises**.** Moreover, we can show

Q13
$$\widehat{k} - \widehat{k}^* = \frac{w(\widehat{P})\left(1 - \frac{1}{\hat{n}}\right)}{\rho\left(1 + \frac{1}{\hat{n}}\right)} \left\{ \frac{(1+\alpha_c)\,\rho + (1-\alpha_i)\,\delta}{(1-\alpha_c)\,\rho + (1-\alpha_i)\,\delta} + 1 \right\} > 0 \text{ iff } \hat{n} > 1. \quad \mathbf{(23)}$$

Hence, a rise in the ratio of marginal utilities ($\hat{n} > 1$) generates a positive capital redistribution effect in equilibrium. That is, starting from a symmetric equilibrium ($\tau_0 = \hat{n} = 1$), the domestic country becomes capital abundant when it raises the inflation target temporarily and unilaterally ($\tau_0 > 1$ for a finite duration) that subsequently increases the ratio of marginal utilities ($\hat{n} > 1$). Since the world capital stock remains unchanged in the long run but home capital accumulation is enhanced, the foreign capital accumulation must decline, i.e., there is a *beggar-thy-neighbor effect*. Therefore, our model yields a long-run monetary policy effect that resembles Mundell–Tobin's asset substitution effect via a very different channel—namely, *intertemporal no-arbitrage in asset holdings* together with an *international redistribution of capital*. We shall refer, for brevity, to this channel as the *capital redistribution effect*.[19]

One of the most controversial issues is the usefulness of low inflation targets adopted by several industrial and developing countries in the 1990s. Proposition 3 predicts that, as a result of international capital redistribution, lowering the home country's inflation target could lead to a long-lasting detrimental effect on its own capital accumulation, even though the change in inflation targets is temporary. This provides theoretical support for the so-called Great Canadian Slump documented by Fortin (1996) as a result of the low inflation targets set by the Bank of Canada, as well as the evidence established by Brito and Bystedt (2010) that adopting inflation targeting tends to lower output growth in developing countries.

Our result also shows that inflation targeting has no impact on the steady-state relative price $\widehat{P}$. Thus, as indicated in (5), the factor allocation of real resources is solely determined by factor price equalization, which is not affected by the monetary innovation. It is of particular importance to point out that the policy of inflation targeting does change the pattern of international trade. Since the steady-state relative price is unchanged, the positive effect of a higher τ_0 on the home country's capital stock ($\widehat{k} > \widehat{k}^*$) implies that the home country, starting with no trade, will now export a capital-intensive good (e.g., the investment good if $\alpha_c < \alpha_i$).

Importantly, the policy of inflation targeting in our model exhibits a persistent effect: a temporary inflation difference between the home and foreign countries has a long-term effect on the steady-state consequences. A temporary monetary policy innovation in one country can lead to a permanent change in the steady state, since it affects the initial values of the ratio of the foreign to home marginal utilities of wealth $n(t)$ and in turn changes the distribution of world capital. With the persistent effect, a temporary change in domestic monetary policy can cause a permanent change in the pattern of international trade even in the absence of any change in the terms of trade. Given that the persistent effect refers to systems that may exhibit path dependence, this result also potentially reveals that it may be difficult to predict the outcome of trade patterns without looking at the history of the input monetary innovations (i.e., the path that the monetary shock followed before the economy reached its current value). Nonetheless, the persistent effect does shed light on the importance of examining the transitional effects of a monetary innovation, which will be elaborated on in the next section.

It is worth noting that in a three-good model of a small economy, Stockman (1985) finds that a permanent increase in monetary growth could change the pattern of trade. In our paper, we show that in a two-country model, even a temporary monetary innovation can alter the pattern of international trade. Moreover, in the Stockman (1985) model of a small open economy, inflation affects the pattern of international trade through its negative effects on factor inputs (employment and capital) and its effect on the relative price of the nontraded to the traded good. By contrast, in our model of a two-country world economy, inflation affects the trade pattern only through its effects on intertemporal no-arbitrage in asset holdings and hence the international redistribution of capital, without any changes in the relative price or factor re-allocation.

Finally, one may also investigate the policy effect on the nominal foreign exchange rate $E(t)$. To this end, we define $z(t) = \frac{m(t)}{m^*(t)}$, with $m(t) = \frac{M(t)}{P_i(t)}$

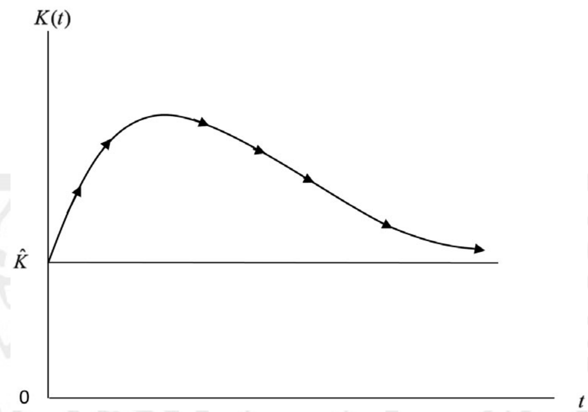

FIGURE 3. Effect on the world capital stock.

and $m^*(t) = \frac{M^*(t)}{P_i^*(t)}$. Due to the CIA constraint, the transformed variable is also equal to $z(t) = \frac{c(t)}{c^*(t)}$. Moreover, the law of one price implies that $E(t) = \frac{P_i(t)}{P_i^*(t)}$. Thus, the foreign exchange rate can be represented as

$$E(t) = \frac{M(t)}{M^*(t)} \frac{1}{z(t)}.$$

On the one hand, in order to raise the inflation target, the home money growth rate $\mu(t) = \dot{M}(t)/M(t)$ has to increase. On the other hand, a higher inflation rate will increase the opportunity costs of holding money and hence of consumption under a CIA constraint. Thus, given that the home inflation rate becomes higher than that of the foreign country, it is intuitive to see that the domestic currency will depreciate (i.e., $\widehat{E}$ rises) in the long run. Notably, the nominal foreign exchange rate positively responds to the monetary policy shock, whereas the terms of trade keep $\widehat{P}$ unchanged. This result indicates that without any distortion in the allocation of the domestic resources [as shown in (5)], inflation targeting can give rise to a favorable effect on international competitiveness (i.e., exports).

4.2. The Transitional Dynamics

We now turn to the transitional analysis. Define $\Psi(a) = \frac{1}{2}\{(\Omega - \eta) a^2 + [\Omega(\phi_2 + \phi_3) - \eta\rho] a + \Omega\phi_2\phi_3\}$. Under Assumption 2, we can show that $\Psi(0) < 0$ and that $\lim_{a\to\infty} \Psi(a) > 0$; thus, the mean value theorem implies that there exists $\overline{a} > 0$ such that $\Psi(\overline{a}) = 0$. Recall that the parameter a measures the persistence of the policy of inflation targeting: as it is sufficiently low $a < \overline{a}$ (resp. high, $a > \overline{a}$), the policy is more persistent (resp. temporary).[20]

The transitional dynamics in response to changes in the home inflation target are depicted in Figures 3–7.

We summarize the main results in the following two propositions.

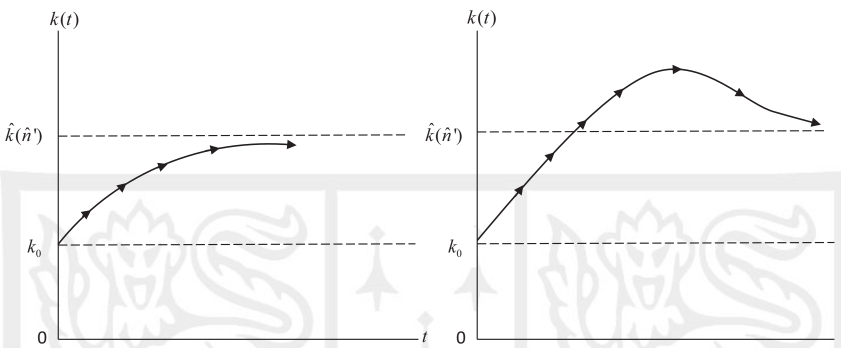

FIGURE 4. Effect on the home capital stock.

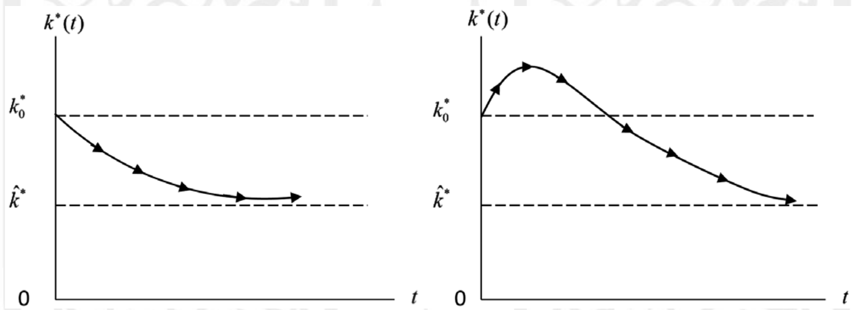

FIGURE 5. Effect on the foreign capital stock.

PROPOSITION 4 (Dynamic Transition I). *Under Assumptions 1 and 2, in response to an increase in the home inflation target* ($\tau_0^{'} > 1$),

(i) *(effect on the world capital stock) in transition, the world capital stock* $K(t)$ *first increases and then returns to the original level;*

(ii) *(effect on the home capital stock)*
  - *(a) when the policy is more persistent* ($a < \overline{a}$), *home capital* $k(t)$ *increases monotonically to its new equilibrium level along the transition;*
  - *(b) when the policy is less persistent* ($a > \overline{a}$), *home capital* $k(t)$ *overshoots the long-run equilibrium level along the transition and then eventually converges to the new steady-state value;*

(iii) *(effect on the foreign capital stock) in transition, foreign capital* $k^*(t)$ *may either monotonically decrease to a lower steady-state level or first increase and then gradually decrease to the lower level of a new equilibrium.*

Proposition 4 shows that in response to the monetary policy change of the home country, the world economy exhibits very rich transitional dynamics that provide important policy implications. First of all, in transition capital accumulation for the whole world will benefit from the policy change of inflation targeting even

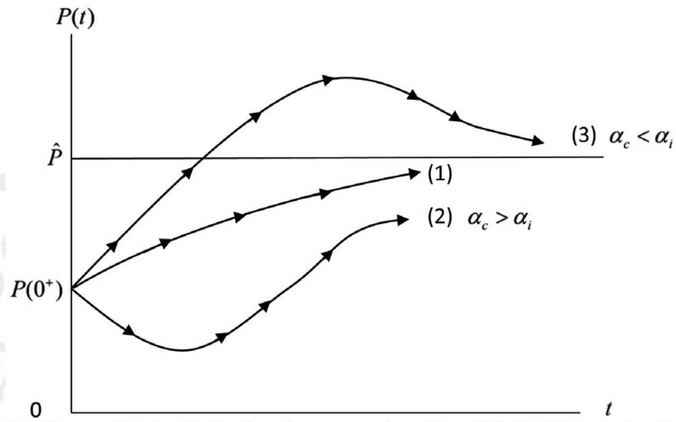

FIGURE 6. Effect on the terms of trade.

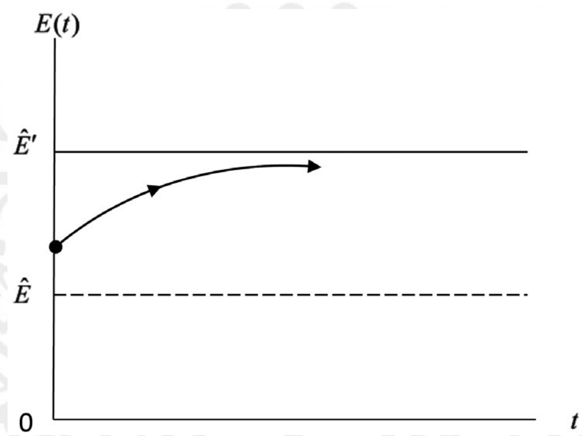

FIGURE 7. Effect on the foreign exchange rate.

though this monetary policy is a beggar-thy-neighbor one. Second, the home capital stock will overshoot the long-run equilibrium along the transition under the condition $a > \overline{a}$. This implies that capital accumulation in the home country responds more strongly in the short run when the policy of inflation targeting is less persistent. When the policy of inflation targeting is more persistent, the home capital stock will adjust monotonically to the long-run equilibrium in transition. Last, even though the monetary policy is a beggar-thy-neighbor one in the long run, the foreign capital stock may increase in the short run.

We further investigate the transitional dynamics of the terms of trade $P(t)$ and the foreign exchange rate $E(t)$, which are summarized as the following proposition.

PROPOSITION 5 (Dynamic Transition II). *Under Assumptions 1 and 2, in response to an increase in the home inflation target ($\tau_0^{'} > 1$),*

- (i) *(effect on the terms of trade) there are two types of transition path:*
  - *(a) if $\alpha_c < \alpha_i$, on impact the relative price $P(t)$ falls instantaneously to a level below the steady-state value, whereas in transition it overshoots the long-run equilibrium level and then decreases to the original level of the equilibrium;*
  - *(b) if $\alpha_c > \alpha_i$, on impact the relative price $P(t)$ falls instantaneously to a level below the steady-state value, whereas in transition it may either increase monotonically to the original equilibrium level or decrease first and then increase to the original equilibrium level;*
- (ii) *(effect on the foreign exchange rate) The nominal exchange rate $E(t)$ depreciates on impact and then continuously depreciates to reach its new steady state.*

Intuitively, since a higher inflation rate raises the costs of holding money and hence consumption in the CIA constraint, the relative price of the consumption to investment good $P(t)$ falls immediately on impact. Afterward, the favorable effect of inflation targeting on the domestic capital, $P(t)$ will gradually recover to the original level. If the investment good sector is capital intensive, i.e., $\alpha_c < \alpha_i$, the relative price has to rise more in transition in order to ensure that the steady-state allocation of the resources is unchanged and, consequently, may overshoot its long-run equilibrium level. By contrast, the nominal foreign exchange rate always increases monotonically in response to higher inflation.

Given that the terms of trade and the foreign exchange rate exhibit different transitional dynamics, an interesting result appears. Consider the case where the consumption good sector is capital intensive (i.e., $\alpha_c > \alpha_i$). In response to a rise in the home inflation rate, the domestic consumption declines as a result of the cash requirement. However, as shown in Transition Path 2 in Figure 6, its relative price continues to decrease for a while after the impact, which in conjunction with a gradual depreciation [$E(t)$ rises], makes the consumption good produced by the home country more competitive in the international market (exports of the consumption good rise). As a consequence, the reduction in the home demand for the consumption good is compensated by the rise in the foreign demand in the early stage of dynamic transition.

At last, we shall address the key issue of the paper, namely, what are the short- and long-run effects of adopting a low inflation target on the trade pattern? Recall that changes in inflation targets have no permanent effect on the terms of trade. By adopting tightened inflation targets, a less-developed, relatively labor-abundant country will, in the longer run, export more labor-intensive goods to and import more capital-intensive goods from its more-advanced, relatively capital-abundant trading partners. On impact, its terms of trade measured by the relative price of the labor-intensive consumption good rises, thereby discouraging its exports of labor-intensive goods. Thus, although the longer run effect of such an inflation targeting policy on the trade pattern is clear-cut, the short-run effects are likely to be inconclusive. These findings therefore lend theoretical support to the casual observations reported in the introduction.

5. EXTENSIONS

In this section, we will extend the benchmark model in three interesting respects. First, we endogenize the labor–leisure choice. Second, we allow for international asset trading to account for the observation that international asset markets have become more integrated over the past few decades. Third, we consider that a fraction of investment purchases are also subject to the CIA constraint. We will show that our main findings are robust to the generalization of the dynamic H–O setup with the three extensions.

5.1. Endogenous Labor–Leisure Choice

The labor–leisure trade-off is abstracted from the benchmark model to shed light on the capital distribution effect. To endogenize the labor–leisure choice, we modify the utility function (7) as

$$\max_{c(t),\ell(t),i(t),k(t),m(t)} \int_0^\infty \left[\ln c(t) - \frac{\ell(t)^{1+\chi}}{1+\chi}\right] e^{-\rho t} dt, \qquad (\mathbf{24})$$

where χ is the inverse Frisch labor supply elasticity. Given that the economy starts out in the steady state with $\widehat{n} = 1$ and $\tau_0 = 1$, we can re-derive the steady-state effects of an increase in the home inflation target τ_0 as follows:

$$\frac{\Delta\widehat{n}}{\Delta\tau_0} = \frac{\pi^*}{2(a+\rho)\widehat{\lambda}(1+\rho+\pi^*)^2 \frac{\Delta\widehat{k}}{\Delta\widehat{n}}} > 0,$$

$$\frac{\Delta\widehat{k}}{\Delta\tau_0} = \frac{\pi^*}{2(a+\rho)\widehat{\lambda}(1+\rho+\pi^*)^2} > 0,$$

$$\frac{\Delta\widehat{K}}{\Delta\tau_0} = 0 \text{ and } \frac{\Delta\widehat{P}}{\Delta\tau_0} = 0,$$

Q14 where $\frac{\Delta\widehat{k}}{\Delta\widehat{n}} = \frac{1}{2\rho}\left(\frac{1}{\widehat{\lambda}(1+\rho+\pi^*)} + \frac{w(\widehat{P})\widehat{\ell}}{\chi}\right) > 0$. As is evident, the steady-state effects of an increase in the home policy of inflation targeting τ_0 are robust to an endogenous labor–leisure choice without relying on any assumptions or conditions.

5.2. International Asset Trading

Under the benchmark H–O setup, only goods are allowed to be traded internationally. Since asset markets have become less segregated in the world, one may inquire whether the effects of inflation target changes through capital distribution may be upset if international asset trading is permitted.

To examine this, we allow households to hold foreign bonds. Thus, the flow budget constraint (8) facing a domestic household is now modified as

$$\dot{m}(t)+\dot{b}(t)=r^{f}(t)b(t)+w(t)+r(t)k(t)-P(t)c(t)-i(t)+\mathrm{TR}(t)-\pi(t)m(t),$$

where $b(t)$ is the holding of foreign bonds of the home country and $r^{f}(t)$ is the return rate for foreign bonds. As in the imperfect international asset market literature, we set the return rate of international bonds as

$$r^{f}(t)=\bar{r}^{f}+\varrho(b(t),b^{*}(t)),\ \text{with}\ \varrho(0,0)=0,$$

Q15

where$\bar{r}^{f}$ is an exogenously given world interest rate, and ϱ captures the lending/borrowing premium. More specifically, if $b(t)>0$ and $b^{*}(t)>0$, then ϱ is the lending premium (that reflects the holding costs of foreign assets), which is diminishing in the amount of such holdings [i.e., $\frac{\partial\varrho}{\partial b(t)}<0$ and $\frac{\partial\varrho}{b^{*}(t)}<0$]. If $b(t)<0$ and $b^{*}(t)<0$, then this term is the borrowing premium associated with default risk. Thus, there is a downward-sloping (upward-sloping) supply of credit (debt) to the world credit (debt) market. Although the return rate $r^{f}(t)$ depends on the amount of the international bonds held by these two countries in equilibrium, it is taken as given by all individual households. This international asset market setup in a two-country world yields a well-defined steady state.

Let $f(t)=k(t)+b(t)$ and $f^{*}(t)=k^{*}(t)+b^{*}(t)$. The economy starts out in the steady state of no trade with $\tau_0=1$ ($\pi=\pi^{*}$) and $\widehat{n}=1$, which implies that $\widehat{c}=\widehat{y}_c=\widehat{c}^{*}=\widehat{y}_c^{*}$, $\widehat{k}=\widehat{k}^{*}=\frac{\widehat{K}}{2}$, and $\widehat{b}=\widehat{b}^{*}=0$ initially (hence, $\widehat{f}=\widehat{f}^{*}=\widehat{k}=\widehat{k}^{*}=\frac{\widehat{K}}{2}$). Thus, by solving the household's optimization problem, we obtain a modified intertemporal no-arbitrage condition as follows:

$$\frac{\varepsilon(t)}{\lambda(t)}-\pi(t)=r(t)-\delta=r^{f}(t).$$

This condition indicates that the real rates of return on money, capital, and foreign assets are all equalized.

In a two-country model, the net foreign assets must be zero in equilibrium, i.e., $\widehat{b}+\widehat{b}^{*}=0$. We can then easily show that the equilibrium conditions remain unchanged, whereas the aggregate resource constraint is replaced by

$$\dot{f}(t)=w\,(P(t))+[r\,(P(t))-\delta]f(t)-\frac{1}{\lambda(t)[1+r\,(P(t))+\tau(t)\pi^{*}-\delta]}.$$ Q16

These equationsallow us to solve $\lambda(t)$, $n(t)$, $P(t)$, $K(t)$, $\tau(t)$, and $f(t)$. By comparing with the benchmark model, we essentially obtain the same equilibrium conditions once we replace capital $k(t)$ with total assets $f(t)=k(t)+b(t)$. As a consequence, the steady-state effect of the home policy of inflation targeting τ_0 on the ratio of the foreign to home marginal utilities of wealth $\widehat{n}$ and the assets of the home country $\widehat{f}$ can be easily characterized as follows:

$$\frac{\triangle\widehat{n}}{\triangle\tau_0} = -\frac{p_\tau\rho\widehat{\lambda}\Omega\left(1+\rho+\pi^*\right)}{a+\rho} > 0 \text{ and } \frac{\triangle\widehat{f}}{\triangle\tau_0} = -\frac{p_\tau\Omega}{2\left(a+\rho\right)} > 0. \qquad \mathbf{(25)}$$

The effects are very similar to those in the benchmark model. It follows from (5) and (12) with $\dot{\lambda}(t) = 0$ that the steady-state terms of trade $\widehat{P}$ is pinned down by the exogenous time preference ρ and the depreciation rate δ. Given that the terms of trade $\widehat{P}$ is fixed in the steady state, the steady-state bond holdings by the home country $\widehat{b}$ and foreign country $\widehat{b}^*$ must return to their respective initial levels, i.e., $\widehat{b} = \widehat{b}^* = 0$ in order to satisfy the intertemporal no-arbitrage condition between capital and foreign assets $r(\widehat{P}) - \delta = \bar{r}^f + \varrho(\widehat{b}, \widehat{b}^*)$ and the zero-net-foreign-bond condition $\widehat{b} + \widehat{b}^* = 0$. As a result, we can see from (25) that, in the steady state, $\frac{\triangle\widehat{f}}{\triangle\tau_0} = \frac{\triangle\widehat{k}}{\triangle\tau_0} > 0$ still holds true, and the main findings in Section 4 remain qualitatively unchanged.

Remark (International Capital Flows). Alternatively, one may consider that domestic households have access to foreign physical capital, which is a perfect substitute for domestic physical capital in production. Let $i^s(t)$ be the domestic investment in the foreign country and $s(t)$ be the corresponding capital stock. Following Stulz (1987) and Froot and Stein (1991), we consider a holding cost of foreign capital as a result of monitoring costs and/or barriers to cross-border investments, which discounts the net returns on foreign capital at a rate of $d \in (0, 1)$.[21] Now define total capital holdings of the home country as: $f(t) = k(t) + s(t)$. When both face the same depreciation rate, the evolution of these capital stocks, $\dot{k}(t) = i(t) - \delta k(t)$ and $\dot{s}(t) = i^s(t) - \delta s(t)$, can be combined as follows:

$$\begin{aligned}\dot{f}(t) = [i(t) + i^s(t)] - \delta f(t) = w\left(P(t)\right) + r\left(P(t)\right)k(t) + d \cdot r^*\left(P(t)\right)s(t) \\ - P(t)c(t) - \delta f(t).\end{aligned}$$

Q17

Since the terms oftrade $P(t)$ facing the two countries is the same, we obtain: $r(t) = r^*(t) = r\left(P(t)\right)$, implying that the net real rate of return on home capital is larger than that on foreign capital given $d < 1$. By reproducing a similar set of equilibrium conditions focusing on total domestic capital holdings $f(t)$, it is straightforward to show that the steady-state effect of a rise in home inflation targeting is to induce the redistribution of capital toward domestic production and to encourage the home country to export more capital-intensive goods. That is, the main findings in Section 4 remain valid, provided that holding foreign capital incurs a cost. One may imagine that as the world financial market becomes more integrated, households in the home country would have more international asset trading options when they re-balance their asset portfolios after a rise in the inflation target. As a consequence, it is expected that the increase in physical capital in the home country will be smaller and the pattern of trade will be less responsive in the long run.

5.3. Generalized CIA Constraint

In the benchmark model, only the consumption good is subject to the CIA constraint. Dotsey and Sarte (2000, p. 637) argue that "[f]or the US and most OECD countries, [the CIA requirement on investment] is probably close to zero,[22] ... However, [it] may better characterize the payments technology in many developing economies and it is important to consider these cases as well." Thus, we further examine whether a temporary inflation difference between the home and foreign countries still has a long-term effect on the world capital distribution and trade pattern if not only consumption, but also a fraction of investment goods are subject to the CIA constraint.

Following Wang and Yip (1992), we specify the generalized CIA constraint as

$$P(t)c(t) + \theta i(t) \leq m(t);\ 0 \leq \theta \leq 1, \qquad (\mathbf{10'})$$

where θ measures the degree of cash requirements for purchasing the investment good. When $\theta = 0$, it reduces to the benchmark Lucasian setup; when $\theta = 1$, it captures the Stockman (1981) model where all consumption and investment goods purchases require cash.

Define $x(t) = \frac{q(t)}{\lambda(t)}$, $x^* = \frac{q^*(t)}{\lambda^*(t)}$, $n(t) = \frac{q^*(t)}{q(t)}$, and $u(t) = x^*(t) - x(t)$. As in the benchmark, the economy starts out in the steady state with $\tau_0 = 1$ and hence $\pi = \pi^*$ with no trade initially, where $\widehat{n} = 1$, $\widehat{c} = \widehat{y}_c = \widehat{c}^* = \widehat{y}_c^*$, $\widehat{k} = \widehat{k}^* = \frac{\widehat{K}}{2}$, $\hat{x} = \hat{x}^* = 1 + \theta(\rho + \pi^*)$ and so $\hat{u} = 0$. Thus, the equilibrium conditions can be obtained by repeating the same solution procedure as in the benchmark model. A major difference from the benchmark $n(t)$ is no longer a once-and-for-all jump variable.[23] The economy constitutes of a 7×7 dynamical system in $(\tau(t), u(t), n(t), q^*(t), x^*(t), k(t), K(t))$. We can show that the dynamical Q18
system can be reduced to a 5×5 one in $(n(t), q^*(t), x^*(t), K(t), k(t))$. By doing Q19
so, we can prove that in the dynamical system there are two roots with negative real parts (say, φ_1 and φ_4), four roots with positive real parts (say, φ_2, φ_5, φ_6, and φ_7), and one zero root (say, φ_3). As a result, the steady state is locally determinate as in Proposition 2 under the benchmark setup.

With these dynamical properties, we can further investigate the long-run, steady-state effects of a temporary rise in the home country's inflation target. Let a rise in the inflation target of the home country (from 1 to $\tau_0^{'} > 1$) lead the relative ratio of $n(t) = \frac{q^*(t)}{q(t)}$ from the initial $\hat{n} = 1$ to a new steady state $\hat{n}^{'}$. Since the policy is temporary, in the steady state the inflation rate of the home country π must equal that of the foreign country π^*, as indicated by (15). This implies: $\hat{x} = \hat{x}^* = 1 + \theta(\rho + \pi^*)$. As a result, (A28) with $\dot{q}^*(t) = 0$ allows us to determine the steady-state terms of trade:

$$\widehat{P} = \frac{[\alpha_i^{\alpha_i}(1-\alpha_i)^{1-\alpha_i}]^{(1-\alpha_c)/(1-\alpha_i)}}{\alpha_c^{\alpha_c}(1-\alpha_c)^{1-\alpha_c}} \left\{(\rho+\delta)[1+\theta(\rho+\pi^*)]\right\}^{(\alpha_c-\alpha_i)/(1-\alpha_i)} .$$

With this, we can then use (A14) to solve for the world capital stock:

$$\widehat{K} = \frac{2\alpha_c w(\widehat{P})}{(1-\alpha_c)\,\rho + (1-\alpha_i)\delta + \theta\,(1-\alpha_c)\,(\rho+\delta)(\rho+\pi^*)}.$$

As in the benchmark model, the steady-state terms of trade $\widehat{P}$ and the world capital stock $\widehat{K}$ are independent of the policy τ_0. That is, a temporary domestic monetary policy changing its inflation target has no long-run effect on the world capital stock or the terms of trade as in Proposition 3, even under a generalized CIA constraint setting.

In addition, by using the optimal conditions of consumption, we can easily reexpress (A25) as: $\widehat{\lambda} = \lambda(\hat{n})$, with $\frac{\Delta\widehat{\lambda}}{\Delta\hat{n}} = -\frac{\widehat{\lambda}}{2} < 0$. From (A30) with $\dot{k}(t) = 0$, the steady-state capital stock of the home country is given by

$$\widehat{k} = \frac{\frac{1}{\lambda(\hat{n})(1+\rho+\pi^*)} - w(\widehat{P})}{r(\widehat{P}) - \delta}. \qquad \textbf{(26)}$$

Obviously, given that the steady-state terms of trade $\widehat{P}$ is unchanged, the steady-state capital stock of the home country $\widehat{k}$ increases with $\hat{n}$, i.e., $\frac{\Delta\widehat{k}}{\Delta\widehat{n}} = \frac{1}{2\widehat{\lambda}[r(\widehat{P})-\delta](1+\rho+\pi^*)} > 0$, the same as in the benchmark case.

Tedious manipulations lead to

$$\hat{n}^{'} = 1 - \frac{\sigma}{\frac{\Delta\widehat{k}}{\Delta\widehat{n}}}\frac{\tilde{\Omega}\Theta}{2[a + r(\hat{P}) - \delta]}(\tau_0^{'} - 1) \lesseqgtr 1,\ \text{iff}\ \theta \gtreqless \bar{\theta} = \frac{a}{a+(\rho+\delta)(1+\rho+\pi^*)}, \qquad \textbf{(27)}$$

where $\sigma = \frac{\pi^*(\rho+\delta)}{a(a+2\rho+\frac{1}{\theta}+\pi^*+\delta)} > 0$, $\tilde{\Omega} = \frac{(1-\alpha_i)r^{'}\hat{K}-2\alpha_i w^{'}}{\alpha_c-\alpha_i} > 0$, and $\Theta = \frac{\hat{x}^*}{\tilde{\Omega}\hat{q}^*(1+\rho+\pi^*)}[1 - \frac{(1-\theta)a}{\theta(1+\rho+\pi^*)(\rho+\delta)}]$. As illustrated in Figure 8(a), when the investment good is not subject to the CIA constraint ($\theta = 0$), the adjustment of $n(t)$ exhibits a once-and-for-all jump (the benchmark model). When at least a fraction of the investment good is subject to the CIA constraint ($0 < \theta \leq 1$), there are well-defined transitional dynamics in $n(t)$, with the two possible patterns as shown in Figure 8(b) (c). Figure 8(b) depicts the case with less cash requirements for purchasing the investment good ($0 < \theta < \bar{\theta}$). In this case, (27) indicates that $\hat{n}^{'} > 1$, implying that in response to an increase in τ_0, $n(t)$ jumps up on impact and afterwards gradually converges toward a higher new steady state $\hat{n}^{'} > \widehat{n} = 1$. Accordingly, as shown in (26), a temporary rise in inflation in the home country permanently increases the steady-state domestic capital stock $\widehat{k}$ via the international redistribution of capital, which motivates the home country to export the capital-intensive good (the investment good if $\alpha_c < \alpha_i$). This result is identical to that of Proposition 3 in the benchmark model. In the case with more cash requirements for purchasing the investment good ($\bar{\theta} < \theta < 1$), as shown in Figure 8(c), $n(t)$ jumps up on impact and then gradually converges toward a lower steady state $\hat{n}^{'} < \widehat{n} = 1$. Although the steady-state ratio of $\widehat{n}$ decreases, this temporary inflation difference between the home and foreign countries also changes the international trade pattern: of interest, the home country may export the capital-intensive good (the investment good if $\alpha_c < \alpha_i$) on impact and in the shorter run, whereas exporting the labor-intensive good (the consumption good if $\alpha_c < \alpha_i$) in the longer run and in the steady state.[24]

PROPOSITION 6 (Generalized CIA). *Under Assumptions 1 and 2, the rise in the level of inflation targeting of the home country* ($\tau_0^{'} > 1$) *has no impact on the steady-state terms of trade* $\widehat{P}$ *or the capital stock in the world* $\widehat{K}$. *Moreover, in response to this higher home inflation target,*

(i) *(less cash requirements for investment good purchases) when* $0 < \theta < \bar{\theta}$, *the ratio of the foreign to home marginal utilities of wealth* $\widehat{n}$ *and the capital stock of the home country* $\widehat{k}$ *both increase in the steady state, with the home country exporting the capital-intensive good (the investment good if* $\alpha_c < \alpha_i$*);*

(ii) *(more cash requirements for investment good purchases) when* $\bar{\theta} < \theta < 1$, *the ratio of the foreign to home marginal utilities of wealth* $\widehat{n}$ *and the capital stock of the home country* $\widehat{k}$ *both decrease in the steady state, with the home country exporting the labor-intensive good (the consumption good if* $\alpha_c < \alpha_i$*).*

Furthermore, for any $\theta < 1$, *the ratio of the foreign to home marginal utilities of wealth* $n(t)$ *is higher in the shorter run and, when the terms of trade effect is dominated by the capital redistribution effect, the capital stock of the home country* $k(t)$ *also rises in the shorter run.*

It is worth noting that the inflation difference between two countries is more likely to increase the home capital stock and to induce the home country to export the investment good, if the policy is more transitory (a higher a leads to a negative Θ, resulting in $\hat{n}^{'} > 1$). In other words, as long as the CIA constraint on the investment good is partial ($\theta < 1$), which is realistic as estimated by Dotsey and Sarte (2000) and Brown and Petersen (2009), we can *always* find an inflation target adjustment that is more transitory (a high a) to yield the same result as in the benchmark model.

We shall reiterate that our key channel stated above relies on the condition that investment goods are not as cash-constrained as consumption goods. Under this circumstance, investment goods are *more attractive as an escape from high inflation* because the purchase of investment goods is less affected by inflation than the purchase of consumption goods. As a result, high inflation in the home country will generate a Mundell–Tobin effect favoring physical capital over money due to the differential holding costs, thus yielding an international redistribution of capital from the foreign to the home country.[25]

6. QUANTITATIVE ANALYSIS

In Section 4, we have established analytically unambiguous long-run effects of inflation target changes, although the patterns of transitional dynamics may depend

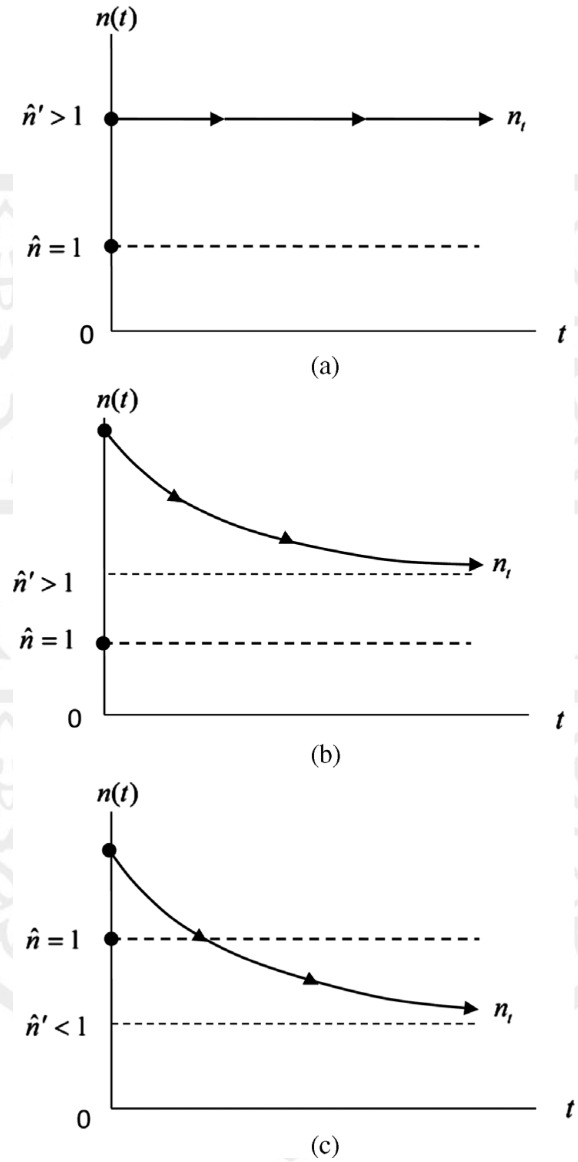

FIGURE 8. Effect on the ratio of the foreign to home marginal utilities of wealth. (a) Case: $\theta = 0$. (b) Case: $0 < \theta < \bar{\theta}$. (c) Case: $\bar{\theta} < \theta < 1$.

on specific parameters. In this section, we will calibrate the economy with a generalized CIA constraint delineated in Section 5.3 to real-world data. We can then quantify the long-run effects of a 1 percentage point increase in the inflation target as well as the transitional dynamics of an array of key indicators. In addition, we investigate the quantitative effect of inflation targeting on welfare in both the short and long run. Finally, we conclude the section by examining how much the IT adoption alone may serve to explain the Great Canadian Slump and by conducting counterfactual analysis to investigate what would have happened had Canada never adopted IT.

6.1. Long- and Short-Run Effects

Specifically, we follow the conventional macroeconomics literature, setting the time preference rate at $\rho = 3\%$ and the depreciation rate at $\delta = 2.5\%$. Given that the aggregate capital income share is about one-third, we set $\alpha_c = 0.3 < \alpha_i = 0.35$. By following Dotsey and Sarte (2000), we choose $\theta = 0.1$ to measure the degree of cash requirements for purchasing the investment good in the Organisation for Economic Co-operation and Development (OECD) countries. The long-run average inflation rate is computed as $\pi = \pi^* = 3.8\%$, based on the global inflation rate estimated by the Central Intelligence Agency World Factbook. Accordingly, in our quantitative exercises, we shall examine the responses to a 1 percentage point temporary rise in the home country's inflation target from $\pi = 3.8\%$ to $\pi = 4.8\%$.

As shown in Mishkin and Schmidt-Hebbel (2001), inflation targeting has been, in practice, implemented with a specific length of target horizon ranging from 1 to 3 years. We therefore choose the half-life of the inflation target adjustment as 2 years. This enables us to calculate the benchmark value of the persistence parameter of the inflation targeting policy at $a = 0.23$. In the sensitivity analysis below, we will allow the half-life to be either 1 year or 3 years.

Under our benchmark parameterization, one can easily calculate that $\bar{\theta} = 0.79$, which is greater than $\theta = 0.1$. This implies that Case (i) of Proposition 6 can be viewed as the benchmark case. Interestingly, this is the case that produces comparative statics resembling the results in Section 4 under a simple CIA constraint.

We are now ready to evaluate quantitatively the long-run effects of inflation target changes. In response to a 1 percentage point temporary rise in the home country's inflation target, the steady-state home capital $\hat{k}$ increases by 0.223%, from 14.0297 to 14.0611, whereas the steady-state real GDP $\hat{Y} = \widehat{P}\hat{y}_c + \hat{y}_i$ increases by 0.0687%, from 2.5311 to 2.5329. This translates into a 0.0086 percentage point increase in the capital to real GDP ratio, $\frac{\hat{k}}{\hat{Y}}$, from 5.5428 to 5.5514. This further leads to a 0.0245 percentage point increase in the investment good exports and a 0.0094 percentage point increase in the ratio of the investment good exports to real GDP $\frac{\hat{y}_i - \hat{\imath}}{\hat{Y}}$ (from the initially no-trade equilibrium).

We turn next to examine the patterns of the transition effects of inflation target changes. We focus on six key indicators, including home capital $[k(t)]$, foreign capital $[k^*(t)]$, world capital $[K(t)]$, the terms of trade $[P(t)]$, investment good exports $[EX(t)]$, and real GDP $[Y(t) = P(t)y_c(t) + y_i(t)]$. Their transitional dynamics in response to a 1 percentage point temporary rise in the home country's inflation target are plotted in Figure 9. We find that home capital overshoots the long-run equilibrium level along the transition and then eventually converges to the new steady-state value [which resembles Case (b) of Proposition 4(ii)]. At the peak of the transition, which is about 11.6 years after the policy shock, home capital rises by about 0.314%, almost 50% more than the percentage increase in the steady state. On the contrary, foreign capital monotonically decreases to a lower steady-state level along the entire transition path. The theoretically unambiguous hump-shaped pattern of world capital is reconfirmed. As for the terms of trade, these on impact fall instantaneously to a level below the steady-state value, whereas in transition they overshoot the long-run equilibrium level and then decrease to the original level of the equilibrium [which resembles Case (a) of Proposition 5(i)]. Not surprisingly, the transitional dynamics of both the investment good exports and real GDP are hump-shaped, similar to that of home capital. At the peak of the transition, about 12.1 years after the policy shock, real GDP increases by about 0.102%, which is about 50% higher than its percentage increase in the steady state.

To the end, we perform sensitivity analysis, considering $a = 0.452$ (the half-life of the inflation target adjustment is 1 year) and $a = 0.151$ (the half-life is 3 years). In the less persistent case with $a = 0.452$, in response to a 1 percentage point temporary rise in the home country's inflation target, the steady-state home capital and real GDP rise by 0.120% and 0.0371%, respectively, a little more than half the increase in the benchmark case. The capital to real GDP ratio increases by 0.0047 percentage points, whereas the investment good exports to real GDP ratio increases by 0.0051 percentage points, slightly more than half the increase in the benchmark case. In the more persistent case with $a = 0.151$, the steady-state home capital and real GDP increase by 0.321% and 0.0984%, respectively. The associated percentage point increases in the capital to real GDP ratio and the investment good exports to real GDP ratio are 0.0124 and 0.0133, respectively. The increases are a little less than 50% more than those of their benchmark counterparts. As is evident, when the inflation targeting policy is more persistent, the effects turn out to be larger.

To sum up, our quantitative results suggest that the long-run effects of a 1 percentage point increase in the inflation target on the home country's capital, investment good exports and real GDP are nonnegligible. Because all these responses over the transition are hump-shaped, their intermediate run effects are even larger.

6.2. Welfare Analysis

In the welfare analysis, we focus on two objectives: (i) the trade-off between the capital redistribution and direct inflation effects and (ii) long-run and short-run consumer welfare.

Recall from the previous subsection that the transitional dynamics of the real GDP is hump- shaped. Likewise, the transitional dynamics of consumption in response to a 1 percentage point temporary rise in the home country's inflation target is also hump-shaped (see Figure 9), with the steady-state home consumption

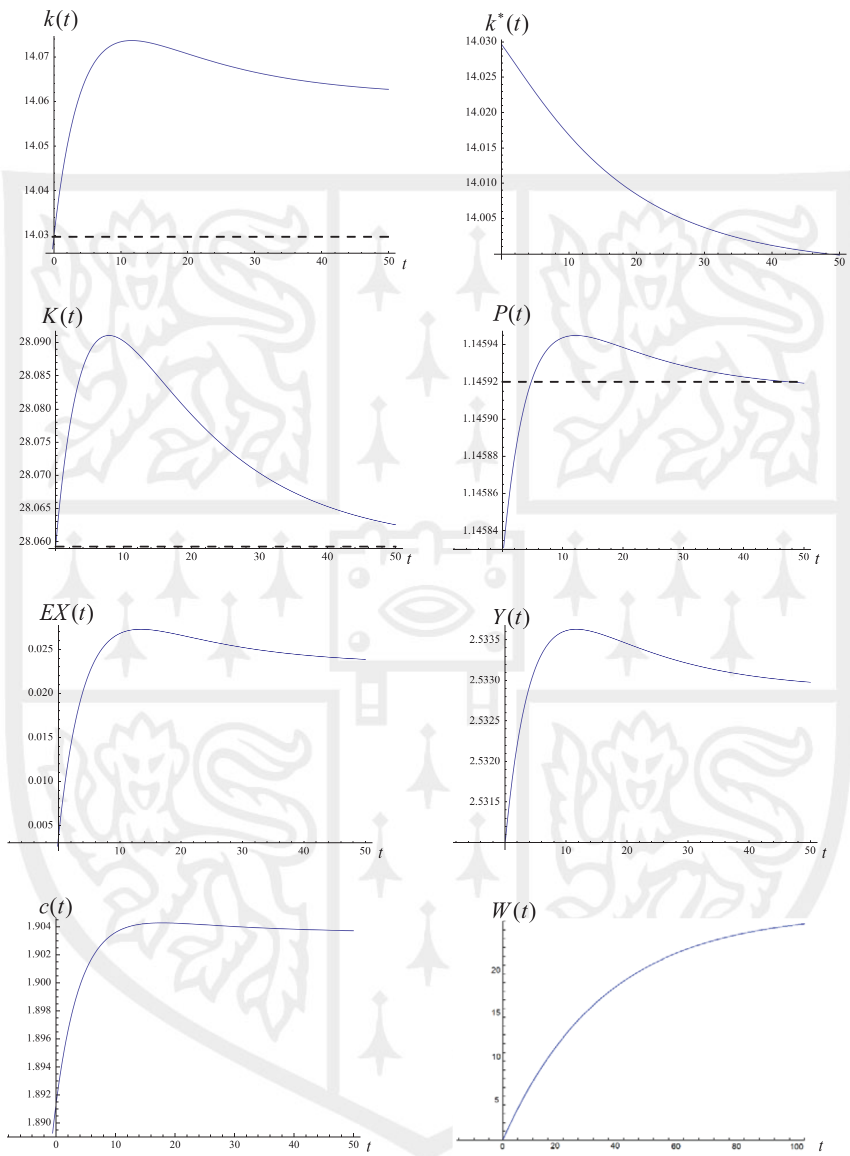

FIGURE 9. Effects of inflation targeting under a generalized CIA constraint.

$\hat{c}$ increasing by 0.0423%, from 1.9028 to 1.9036. At the peak of the transition, consumption increases by about 0.0788%, which is about 1/3 higher than its percentage increase in the steady state.

Intuitively, an expansionary domestic IT policy generates a positive capital redistribution effect, as discussed in the preceding section; in addition, it induces an adverse effect as a result of the accompanied rise in inflation that limits consumption purchases (due to the CIA constraint). Thus, our finding of a positive consumption growth effect implies that the favorable capital redistribution effect dominates the harmful inflation effect. Moreover, because the capital redistribution effect is much stronger in the shorter run, it is expected that the consumption growth effect of an expansionary domestic IT policy would be lower than the output growth effect throughout the transition.

Turning next to consumer welfare, we note that the positive capital redistribution effect of an expansionary domestic IT policy is permanent. As a consequence, in spite of time discounting, the cumulated consumer welfare, $W(t) = \int_0^\infty \ln c(t)e^{-\rho t}dt$, is monotonically increasing along the entire transition path.

6.3. On the Great Canadian Slump: Counterfactual Analysis

In this subsection, we calibrate the economy with a generalized CIA constraint (Section 5.3) to fit the Canadian inflation data 10 years prior to and after its IT adoption in 1991. In Canada, the target aimed to keep the CPI inflation rate at 2% in the medium term (the midpoint over a target range of 1–3%) where the length of the target horizon was about 6–8 quarters (cf. Inflation Targeting Frameworks, DICE Database, 2017). The average inflation rate 10 years prior to the adoption (1981–1990) is 5.98%, dropped sharply to 1.7% following the adoption (1992–2001).

Q20 We begin by examining how much the IT adoption *alone* may serve to explain the Great Canadian Slump. Specifically, this exercise is conducted by lowering the inflation rate from $\pi = 5.98\%$ to the target level of $\pi = 2\%$ with a 2-year target horizon (i.e., the persistence parameter of the IT policy is $a = 0.23$). We set the time preference rate at $\rho = 3.5\%$, according to the estimate by Boardman et al. (2009) for the case of Canada. The depreciation rate for Canada is $\delta = 3.7\%$, based on the average depreciation rates of the total capital stock in Canada from PWT 8.0 during 1950–2011. The capital shares in the average consumption good market (including trade, transport, and communications, financial and business services, market services, the business sector excluding agriculture, etc.) and the average investment good market (manufacturing, industry, construction, etc.) are computed as $\alpha_i = 0.42$ and $\alpha_c = 0.31$, respectively, based on the data of the Annual Labour Income Share (Real ULC) during 1995–2008. In the absence of Canadian data, we set the cash requirement parameter for investment goods purchases as $\theta = 0.1$, using the measure by Dotsey and Sarte (2000) for all OECD countries.

To study the Great Canadian Slump in the early 1990s, we detrend the data by taking logged differences of the time series of the capital stock $K(t)$ and real GDP $Y(t)$ (which are commonly believed to have unit roots). We then compute the percentage deviations of $K(t)$ and $Y(t)$ from their respective levels in 1990 prior to the adoption of IT. Their model counterparts are the pre-adoption values, which are assumed to be at an initial steady state under $\pi = 2\%$ with $a = 0.23$ (see Figure 10 for their data and model time series in or before 1990).

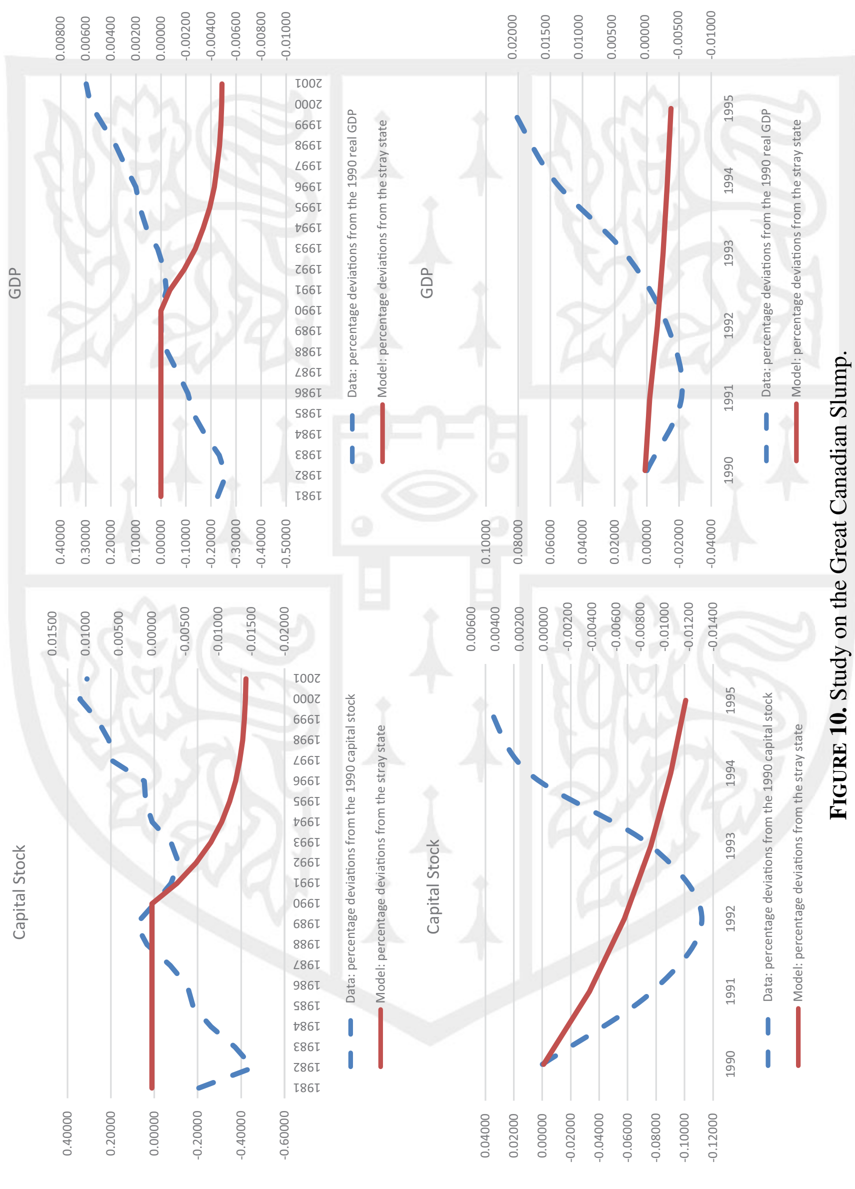

FIGURE 10. Study on the Great Canadian Slump.

We next plot in Figure 10 the simulated time series based on the calibrated economy and compare these simulations with the data. Our model predicts that, in response to the adoption, both capital and real GDP exhibit a U-shaped pattern in the intermediate term (i.e., 5–8 years), decreasing first, then increasing and eventually approaching the new steady states that are lower than the initial levels. Not surprisingly, the model-predicted "dips" in both series are more modest than the data. This is because IT adoption is the only "shock" in the simulated model. Our exercise provides valuable insights toward understanding the role of IT adoption played in the Great Canadian Slump.

More specifically, we investigate how much of the Great Canadian Slump can be explained by the IT adoption alone. Relative to 1990, the model shows that the adoption of IT is able to account for 4.89%, 5.95%, and 11.61% of the decline in capital in 1991, 1992, and 1993, respectively. The average annual growth reduction is about 2.5% over the 3-year period, whereas the model prediction is about 0.30%; that is, about 12% of the reduction in capital over 1991–1993 can be explained by the IT adoption alone, which supports the capital redistribution effect. Regarding the real GDP, the dip lasted only 2 years (1991 and 1992) and the adoption of IT is able to account for 3.33% and 14.60% of the real GDP reduction in these years. Although the average annual growth decline is about 0.63% over 1991–1992, the model predicts an average reduction of 0.09%, or, IT adoption explained about 15% of the real GDP slowdown in this episode.

One may then inquire what would have happened had Canada never adopted inflation targeting. To address this, we perform counterfactual analysis rooted on our model. In particular, consider the following scenario: Canada maintained throughout a "nonbinding" target of 6% that barely exceeded the observed average inflation rate of 5.98% over the period of 1981–1990 prior to the IT adoption. We then change the modeled target from 2% to 6% to produce the counterfactual outcomes in capital and real GDP. Thus, we compare the differences in capital and real GDP between the benchmark model (under a 2% IT target) and the counterfactual (under the hypothetical 6% IT target). Our counterfactual analysis suggests that if Canada had never adopted IT, it would have raised capital by about 0.31% (averaged over 1991–1993) and real GDP by about 0.10% (averaged over 1991-92), thereby mitigating about 16% of the recession.

7. CONCLUDING REMARKS

In this paper, we have developed a two-country, dynamic H–O model where money is introduced via a cash-in-advance constraint on consumption purchases. We have examined how a country's inflation targeting policy may affect the international trade patterns, the terms of trade, the foreign exchange rate, and the capital accumulation of each country and of the whole world economy, both in the steady state and in the transition. We have established that a temporary increase in the domestic inflation target can generate permanent effects, redistributing the world capital stock from the foreign to the domestic country, and changing the pattern of international trade by encouraging the home country to export capital-intensive goods. These main findings are robust to the generalization of the dynamic H–O setup with international asset trading/capital flows and to the generalization of the CIA constraint with a limited fraction of investment purchases requiring cash. Moreover, such a monetary innovation may raise the foreign capital stock in the short run despite the beggar-thy-neighbor effect in the long run. It also creates a short-run Mundell–Tobin effect, causing the world capital stock to rise in a nonmonotone fashion along the transition path. In response to this monetary innovation, the terms of trade always falls on impact, but may overshoot the long-run equilibrium level if the consumption good sector is labor intensive.

Our analytic findings and quantitative results help explain at least partly the Great Canadian Slump in the early 1990s, the slowdown of real output growth in some emerging countries after adopting inflation targeting, as well as changes in the bilateral trade patterns of several countries since adopting inflation targeting. Moreover, they also yield useful policy implications for policy makers to evaluate whether to adopt this monetary policy paradigm and whether to adjust the inflation target if it is already adopted. For instance, based on our counterfactual analysis, should Canada have never adopted IT, 16% of its recession in the early 1990s would have been mitigated.

A natural extension along these research lines would be to re-evaluate the gains from international monetary coordination by taking into account the international capital redistribution channel established in our paper. Another avenue for future work would be to introduce stochastic shocks such as productivity and monetary disturbances into the model following a typical dynamic stochastic general equilibrium (DSGE) setting. This is beyond the scope of the current paper, because one would no longer be able to analytically characterize the dynamic equilibrium. Yet, by focusing exclusively on quantitative exercises, it would then be possible to investigate whether a lower inflation target might reduce the volatility of inflation and output growth.[26]

NOTES

1. See Svensson (1999) for a thorough survey, comparing inflation targeting with monetary targeting and nominal-GDP targeting.

2. These include a number of European countries (such as the United Kingdom, Switzerland, Sweden, and Poland), several American countries (such as Canada, Mexico, and Chile), some Asian countries (such as Korea and Thailand) and two South Pacific countries (Australia and New Zealand). Recently, Baxa et al. (2014) have performed an econometric analysis of the evolution of monetary policy for five of these IT countries.

3. Most IT studies have been empirical or theoretical but in closed economy setups, whereas there has been little theoretical analysis of the international effects of IT [Rose (2007)].

4. Although the World Bank criterion (generally with relative income reaching at least 40% of that of the United States) is commonly used, based on the OECD criterion countries with much lower relative income such as Hungary and Poland are often regarded as developed. On balance, we classify 11 countries with relative income exceeding 50% at the time they adopted IT as advanced, and 13

countries with relative income below 28% as less developed. To avoid any potential controversies, we exclude South Korea, the Czech Republic, Hungary, and Poland that fall in the intermediate range. We also exclude the countries with insufficient data: given the limited availability of the bilateral trade data (only since 1990) and to avoid the influence of the worldwide financial tsunami since 2008, our country selection must be limited to those adopting IT neither too early nor too late. After the attrition, the final list consists of five advanced countries (Norway, Switzerland, Sweden, Australia, and Iceland) and eight developing countries (Mexico, Brazil, South Africa, Thailand, Colombia, Peru, the Philippines, and Turkey).

5. Based on data availability over the sample period for the IT countries, the list consists of 10 developed and 29 less developed countries.

6. Specifically, these pairs meet three qualifications: (i) each pair of countries features one that is more advanced and is exporting capital goods, and another that is less developed and is exporting labor-intensive household consumption; (ii) each pair of countries features one with relatively steady inflation targets and another with significant changes in inflation targets of at least 3%; and (iii) the paired countries are major exporting partners in the sense that each country is among the top six destinations among all IT countries to which the paired country exports.

7. In most cases, the effects of IT adoption show up over a 2–10 year horizon. To reduce tedious details, we thus choose to report 5- and 8-year averages.

8. As for the trade pattern, Table 1 shows that inflation targeting at a lower rate reduces the country's net capital good exports if it is more advanced, but raises its net consumption good exports if it is less developed.

9. Based on consumer installment credit data collected by the Board of Governors of the Federal Reserve, the ratio of consumer credit to personal income in theUnited States was around 20% in 2012, indicating that credit-financed consumer expenditure is limited. By contrast, as argued by Dotsey and Sarte (2000), only a small fraction of investment purchases in OECD countries is cash-constrained.

10. It generates empirical predictions consistent with real-world observations, as long as cross-country technology gaps are controlled. Although the more recent developments pioneered by Eaton and Kortum (2002) and Melitz (2003) yield great insights toward understanding firm distributions, such models are difficult to generalize to allow for the endogenous evolution of multiple state variables (e.g., capital and money).

11. Despite its simple setup, the CIA approach can be readily applied to examining money demand stability and money velocity issues [e.g., Lucas and Stokey (1987)], monetary transmission and business cycles [e.g., Christiano and Eichenbaum (1995)], monetary rules and policy [e.g., Woodford (1994)], the welfare cost of inflation [e.g., Lucas (2000)], and money and credit [e.g., Chang et al. (2007)], to name but a few.

12. In practice, the inflation targeting framework has been implemented with specific lengths of target horizon ranging from 1 to 3 years [e.g., see Mishkin and Schmidt-Hebbel (2001)]. More specifically, 16 of the 28 countries adopting inflation targeting by the end of 2008 have adjusted their targets at least 3 times over a horizon of 6 years, with each target lasting 2 or fewer years on average.

13. It is easier to analyze the transitional dynamics using a continuous-time model.

14. As will be seen later, changes in inflation targets do not generate any long-run effect on the world capital stock but lead to the redistribution of capital between the two countries. It is purely this redistribution effect that results in such long-run effects.

15. Our findings remain qualitatively unchanged regardless of the selection of the numéraire.

16. More precisely, Assumption 2 is sufficient (but not necessary) for $\Omega > 0$.

17. Let the excess demand of the consumption good market be $ED_c = (c(t)+c^*(t))-(y_c(t)+y_c^*(t))$. A Walrasian equilibrium indicates that the following stability condition $\frac{\partial \dot{P}(t)}{\partial P(t)} = \frac{\partial ED_c}{\partial P(t)} < 0$ must be satisfied. Since $\frac{\partial ED_c}{\partial P(t)} = \frac{-\Omega}{P(t)}$, $\Omega > 0$ allows us to guarantee the validity of Walrasian stability.

18. This beggar-thy-neighbor effect is similar to that of Mundell (1968, Chap. 18). He argues that positive monetary policy innovations raise domestic output but, through the effects of real depreciation, lower foreign output.

19. As is evident, a pure portfolio argument is not sufficient to lead to the results.

20. We have used $\hat{n} = 1$ in the original steady state in deriving Ψ.

21. As argued by Stulz (1987, p. 923), "while it is obviously not true that asset markets are completely segmented between countries, there is evidence of barriers to international investment. ... [E]mpiricism suggests that ... in every country investors, on average, hold more domestic assets than would be required if they held the world market portfolio."

22. A recent empirical study by Brown and Petersen (2009) confirms such an argument. By investigating 1970–2006 US firm-level data, they find that the investment–cash flow sensitivity has declined sharply.

23. When $\theta = 0$, the model reduces to the benchmark one where $q(t) = \lambda(t)$, $x^* = x(t) = 1$ and hence $u(t) = 0$, thus implying that $\dot{n}(t) = 0$ and $n(t)$ is a jump variable.

24. It can be shown that in response to a temporary rise in the home inflation target, $n(t)$ must jump up on impact regardless of the value of θ.

25. In the unlikely event where investment goods are more cash constrained than consumption goods (i.e., $\theta > 1$), high inflation will become unfavorable to the home country's capital accumulation.

26. In their studies on a group of developing countries, Batini and Laxton (2007) and Lin and Ye (2009) find that IT adoption may enhance economic performance by lowering the volatility of inflation and output growth.

Q22

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