Do RMBI and capital account liberalization complement China’s industrial upgrading? A new Keynesian view

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Abstract

Motivated by the fact that China experiences industrial upgrading while the renminbi starts go global during the period of persistent yuan appreciation, the paper throws light on the conditions which industrial upgrading can be promoted by currency appreciation. We present an otherwise standard two-country New Keynesian model with three new ingredients, namely, innovation possibility frontier shaped by the number of firms participating in the skill-based upstream sector, endogenous firm entry subject to sunk entry cost varying along with technological level, and input-output production structure with feedback loop. Pieced together, it provides a novel macroeconomic lens of industrial upgrading, through which we find that yuan appreciation does promote industrial upgrading without hurting real economic growth, especially when quality threshold for firm entry is lower due to innovation that is responsive to R&D expenditure, upstream skill-based production uses more imported inputs, and scope of competition in upstream product market is broader. While renminbi internationalization is irrelevant to industrial upgrading, we find that capital account liberalization does matter, especially whether China’s capital account liberalization is associated with heavily managed or clean float.

Keywords: Industrial upgrading, capital account liberalization, renminbi internationalization, firm entry, global production

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1. Introduction

Chinese yuan has been appreciating nearly by 1% per quarter in the aftermath of the abolishment of official dollar peg in July 2005. The trend was reversed only when China's economy starts revealing syndrome of losing steam in the early 2014. Of surprise is eight years of appreciation didn't take a toll on China's growth potential. Throughout this period, industrial production and per capita real GDP grew at a rate just as rapid as those under dollar peg time in the aftermath of WTO accession.

This development, however, is not aligned with what used to be universally shared. Conventional contributions argue that real depreciation promotes economic growth through technology transfers and learning-by-doing externalities (see Eichengreen 2008 for a survey). The much-debated Rodrik (2008) shows panel evidence on undervaluation is correlated with economic growth in developing countries (See also Nouira et al., 2011). Alvarez and Lopez (2009) argue that firms facing real exchange rate depreciation enjoy an increase in export profitability, accelerating the use of skill-intensive techniques and product quality upgrading.

Yet the fact that undervaluation or real depreciation promotes growth through quality upgrading does not by default imply that appreciation hurts growth. In a sample of 128 countries over the period 1960-2008, Kappler et al. (2013), for instance, find that even large appreciations have limited effect on growth. Bussiere et al. (2015) with a sample of extended periods demonstrate that an appreciation associated with a productivity boom is generally associated with higher growth.

More interestingly, empirical evidence on how renminbi appreciation may have greased China's effort to upgrade industrial structure starts accumulating. By using highly disaggregated

Chinese data through the lens of a heterogeneous-firm trade model, Li et al. (2014) find that yuan appreciation significantly encourages firm entry that adds to the new product and thus greater import. On the other hand, Hsu et al. (2014) also show that China's export structure became more similar to that of the developed countries after the currency appreciation, as stiff competition reallocates resource for low-markup to high-markup sector[1].

Against this backdrop, this paper throws some light on how, and under what conditions, an industrial upgrading can be promoted by currency appreciation. We present a two-country New Keynesian model expanded with three novel features to account for industrial upgrading: a global input-output structure with feedback loop, an innovation possibility frontier a-la Acemoglu et al. (2015) shaped by the number of firms participating in the skill-based upstream sector, and endogenous firm entry in skill-based upstream sector subject to sunk entry cost a-la Sutton (2012).

The latter makes our framework different from either Bilbiee et al. (2012) and Ghironi and Melitz (2005) which model entry cost in terms of labor cost, Bergin and Corsetti (2008) and Cavallari (2013) which model entry cost in terms of relative investment goods price, or a weighted average of both as in Cavallari (2015) and Bergin and Corsetti (2015) in a novel way that entry cost increases along with skill-biased technical change. Expanding business formation in skill-based sector promotes skill-biased technical advancement, lifting the quality threshold that makes succeeding firm entry only profitable for firms of higher quality. Because upstream products are used as intermediate inputs in downstream processing that produces outputs which

[1] See Xu (2008) and Chen et al. (1994) on how appreciation of the new Taiwan dollar had accelerated industrial upgrading in Taiwan.

subsequently become materials for upstream production, product quality upgrading is transmitted throughout the whole production structure, enabling overall industrial upgrading.

The model calibrated on Chinese economy makes three points. First, Chinese yuan appreciations do facilitate firm entry in skill-based sector, promoting skill-biased innovation that facilitates industrial upgrading without hurting real economic growth on average.

Second, of the three transmission mechanisms identified in the model, *quality threshold channel* stands out to be the most critical factor to industrial upgrading. Higher threshold due to a less responsive innovation toward R&D expenditure, for instance, utterly mute the quality-upgrading effect of yuan appreciation. We also find that having greater access to imported inputs (*imported input channel*) also significantly increases the share of skill-based firms, leading to a stronger and more sustainable skill-biased innovation (see, for empirical instance, Amiti and Khandelwal, 2013; Bas and Strauss-Kahn, 2015, and Feng et al., 2012).

Last but not least, in a robustness exercise against different assumptions of the elasticity of substitution, we find a novel role of the *scope of competition* in promoting quality upgrading. If the bundle of domestic intermediate inputs irrespective of its components (low-quality or high-quality) in downstream production is complementary to the imported high-quality foreign intermediate inputs, there is no scope for quality competition that motivates local quality upgrading. Only in a competing relationship domestic inputs have to be of high-quality as well. Larger is the scope of competition, greater will be the postinnovation rents (to borrow Aghion et al.'s (2005) terminology) for firm entry in skill-based sector. This finding contributes to the growing literature that inspects how competition fosters quality upgrading[2].

We take one more step in the paper to ask if renminbi internationalization (RMBI) and capital account liberalization, which have been perceived as external impetus to financial sector reform in China, complement industrial upgrading. While increasing use of the renminbi as invoicing currency in international trade neither complement nor obstruct industrial upgrading in non-trivial way, the way capital account liberalization is pursued does matter for industrial upgrading. In particular, liberalizing capital account without hands-off attitude toward exchange rates fosters quality-upgrading effect of yuan appreciation, whereas full liberalization involving a clean float nearly kills the effect off.

The structure of the paper is as follows. Section 2 lays out a New-Keynesian model of endogenous industrial upgrading and choice of invoicing with detailed discussion on the new bells and whistles. The model is parameterized in Section 3 to match dynamics in China's economy. Impulse responses of the model economy to innovation that appreciates yuan-dollar exchange rates are discussed in Section 4, throughout which the underlying mechanisms of transmission is identified and robustness of the findings against the relationship between domestic and imported inputs are investigated. In Section 5, we address the central question of the paper on whether RMBI and capital account liberalization complement China's industrial upgrading. We conclude in Section 6.

2. A model of endogenous industrial upgrading and choice of invoicing currency

[2] See, for instance, Amiti and Khandelwal (2013) which explore the role of import competition in input markets, Aghion et al. (2005) that examine on how preinnovation and postinnovation rents vary along with the distance to frontier, affecting the outcome of the interaction between "escaping competition effect" and "Schumpeterian effect" of innovation.

2.1 Defining industrial upgrading, RMBI and capital account liberalization

By treating China as home country and the rest of the world as foreign country, we set up an otherwise canonical two-country New Keynesian model that features three new ingredients to account for an endogenous industrial upgrading. Firstly, there is a global upstream-downstream production structure with feedback loop such that part of the final products manufactured in downstream industry using local and imported upstream components will be transformed and reinvested as materials for upstream production, both locally and abroad. In this way, the model is able to capture "trade in intermediate inputs" necessary to account for international business cycles among countries bounded in global value chain (see Wong and Eng, 2013 for thorough discussion).

Secondly, upstream industry consists of skill-based and non-skill-based sectors. Only skill-based sector is tradable: the participating firms process imported materials along with other factors to produce intermediate inputs, of which part of them will be exported. We allow firm's decision on whether to participate in skill-based or non-skill-based sector to be endogenously determined by expected profitability. Closely related is the third novelty in which we let the innovation possibility frontier in the spirit of Acemoglu et al.'s (2015) directed technical change to be shaped by the numbers of firms entering skill-based and non-skill-based upstream production sectors. By doing so, we make industrial upgrading synonymous to endogenous quality upgrading.

Another three new elements are introduced to account for renminbi internationalization (RMBI hereafter), which is defined as increasing adoption of the renminbi as invoicing currency in export, and capital account liberalization. First, we endogenize export pricing decision that involves U.S dollar (dollar pricing) and the renminbi (yuan pricing). Next, we model capital account convertibility as the degree of restriction on cross-border portfolio capital flows as in Wong and Eng (2015). Lastly, following Chang et al. (2015), we assume that the People's Bank of China (PBoC) intentionally allows the nominal exchange rate to appreciate at a constant rate, and we formulate a central bank's sterilization policy that varies the share of foreign-asset purchases (sales) financed by money creation to manage a constant rate of appreciation.

In following subsections, we illustrate the model structure by paying attention to home country (h). The subscript hf indicates a flow of goods exported from home to foreign country, so on and so forth. The superscript * denotes consumption or production occurring in foreign country, whereas no notation is assigned if China was the place of origin.

2.2. Global upstream-downstream production structure

A unit mass continuum of monopolistically downstream firms j, for $j \in [0,1]$, processes domestic $X_t(j)$ and imported high-quality intermediate inputs $X^{*s}_{fh,t}(j)$ from foreign upstream skill-based sector to produce final goods $Y_t(j)$ with a CES technology.

$$Y_t(j) = e^{Z_{a,d,t}}\left[(1-\kappa_d)^{1/\vartheta} X_t(j)^{1-1/\vartheta} + \kappa_d{}^{1/\vartheta} X^{*s}_{fh,t}(j)^{1-1/\vartheta}\right]^{\vartheta/(\vartheta-1)} \tag{1}$$

where

$$X^{*s}_{fh,t}(j) = \left(\int_0^{N^{*s}} X^{*s}_{fh,t}(i^*)^{1-1/\epsilon^s} di^*\right)^{\epsilon^s/(\epsilon^s-1)}$$

and

$$X_t(j) = \left[X^u_t(j)^{1-1/\rho} + X^s_{hh,t}(j)^{1-1/\rho}\right]^{\rho/(\rho-1)} \tag{2}$$

The parameter $\vartheta > 0$ is the elasticity of substitution between domestic and foreign intermediate inputs bundles, whereas $\rho > 0$ is the elasticity of substitution between domestic low-quality and high-quality intermediate inputs. κ_d denotes share of foreign intermediates in downstream production. $Z_{a,d,t}$ is the first-order autoregressive total factor productivity (TFP) process affecting downstream industry. Eq. (2) shows that domestic bundle consists of low-quality $X_t^u(j)\left(= \left(\int_0^{N^u} X_t^u(i)^{1-1/\epsilon^u} di\right)^{\epsilon^u/(\epsilon^u-1)}\right)$ produced by upstream non-skill-based sector and high-quality intermediate inputs $X_{hh,t}^s(j)\left(= \left(\int_0^{N^s} X_{hh,t}^s(i)^{1-1/\epsilon^s} di\right)^{\epsilon^s/(\epsilon^s-1)}\right)$ produced by by upstream skill-based sector. $\epsilon^i > 1$ is the elasticity of substitution between varieties in upstream industry for sector $i \in \{u, s\}$. We assume $\epsilon^s < \epsilon^u$ as high-quality varieties are more differentiated than low-quality varieties.

N^u and N^s are the measure of firms or varieties of low-quality and high-quality intermediates in upstream industry, respectively. By normalizing aggregate numbers of firms to one, $N^u + N^s = 1$ becomes the measure of fraction of firms participating in each sector. By aggregating over symmetric varieties of all the intermediates, we get

$$X_t^u(j) = (N_t^u)^{\omega^u} X_t^u; \qquad X_{hh,t}^s(j) = (N_t^s)^{\omega^s} X_{hh,t}^s; \qquad X_{fh,t}^{*s}(j) = (N_t^{*s})^{\omega^s} X_{fh,t}^{*s} \tag{3}$$

where $\omega^u = \epsilon^u/(\epsilon^u - 1)$ and $\omega^s = \epsilon^s/(\epsilon^s - 1)$. Market for downstream goods is cleared by domestic consumption C_{ht} and reinvestment as materials for upstream skill-based $M_{hh,t}^s$ and non-skill-based sector M_t^u, as well as exporting to foreign households and upstream skill-based firms.

$$Y_t(j) = \int_0^1 C_{ht}(z)dz + \int_0^1 C_{hf,t}(z^*)dz^* + \int_0^{N^u} M_t^u(i)di + \int_0^{N^s} M_{hh,t}^s(i)di + \int_0^{N^{*s}} M_{hf,t}^s(i^*)di^*$$
$$+ f_{et}^s + f_{et}^u \tag{4}$$

With market clearing condition (4), we can feature "trade in intermediate inputs" in the sense that firms import intermediates for processing and re-exporting as intermediates for further fabrication. This feature is important for any macroeconomic model with vertical specialization to generate international business cycles (Wong and Eng, 2013). Note the wedge between output and absorptions which takes the form of sunk entry cost in upstream skill-based f_{et}^s and non-skill-based production f_{et}^u. We will elaborate its function in later section.

Turning to upstream sector $i \in (u, s)$, which consists of non-skill-based sector producing low-quality products and skill-based sector producing high-quality products, monopolistically competitive firms i combine a continuum of previously purchased, transformed, and re-invested type-specific materials from downstream firms j with laborer services in Cobb-Douglas technology

$$Y_t^i(i) = e^{Z_{a,u,t}} H_t^i(i)^{1-\alpha} M_{t-1}^i(i)^{\alpha} A_t^i(i)^{1-\alpha} \tag{5}$$

where $Z_{a,u,t}$ is the AR(1) TFP shock in upstream production. $A_t^i(i) \left(= \int_0^1 A_t^i(j)dj\right)$ is the average quality of materials over variety j in sector i. This is one of the key variables of the model which we would discuss in details in next section. What makes skill-based sector different from non-skill-based sector is the composite of materials: non-skill-based sector uses only domestic materials $M_t^u(i) = \left(\int_0^1 M_t^u(j)^{1/\omega^u} dj\right)^{\omega^u}$, whereas skill-based sector processes domestic materials $M^{s}_{hh,t}(i)\left(=\left(\int_0^1 M^{s}_{hh,t}(j)^{1/\omega^{s}} dj\right)^{\omega^{s}}\right)$ along with imported materials $M^{s}_{fh,t}(i)\left(=\left(\int_0^1 M^{s}_{fh,t}(j^*)^{1/\omega^{s}} dj^*\right)^{\omega^{s}}\right)$ in CES aggregator.

$$M^{s}_t(i) = \left[(1-\kappa_{\mathrm{u}})^{1/\eta}\left(M^{s}_{hh,t}(i)\right)^{1-1/\eta} + \kappa_{\mathrm{u}}{}^{1/\eta}\left(M^{s}_{fh,t}(i)\right)^{1-1/\eta}\right]^{\eta/(\eta-1)} \tag{6}$$

where $\eta > 0$ denotes the elasticity of substitution between domestic and imported materials in skill-based production. The parameter κ_{u} indicates foreign share of materials in upstream skill-based sector. While low-quality intermediate goods are solely used by the unit mass continuum of domestic downstream firms, part of the high-quality intermediate goods would be exported for further processing abroad.

$$Y^{u}_t(i) = \int_0^1 X^{u}_t(j)dj$$

$$Y^{s}_t(i) = \int_0^1 X^{s}_{hh,t}(j)dj + \int_0^1 X^{s}_{hf,t}(j^*)dj^* \tag{7}$$

2.3. Optimal allocations

Given the real wage W_t/P_t and material price index $p^{i}_{\mathrm{u}t}$, upstream firms i choose a sequence of labors and material bundles that minimizes the cost production. By denoting $r^{i}_{\mathrm{u}t}$ the Lagrangian multiplier, first order conditions give us firm i's optimal demand for labor and material bundles as follows

$$H^{i}_t(i) = r^{i}_{\mathrm{u}t}(i)(1-\alpha)Y^{i}_t(i)P_t/W_t \tag{8}$$

$$M_{t-1}^{\imath}(\imath) = \mathscr{r}_{\mathrm{ut}}^{\imath}(\imath)\alpha Y_t^{\imath}(\imath)/\mathscr{p}_{\mathrm{ut}}^{\imath} \quad (9)$$

Putting Eqs. (8) and (9) into Eq. (5), we get upstream firm $\imath$'s unit real marginal cost in each sector $\imath \in \{\mathcal{u}, \mathcal{s}\}$

$$\mathscr{r}_{\mathrm{ut}}^{\imath}(\imath) = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}e^{-Z_{a,u,t}}A_t^{\imath}(\imath)^{\alpha-1}\left(\mathscr{p}_{\mathrm{ut}}^{\imath}\right)^{\alpha}(W_t/P_t)^{1-\alpha} \quad (10)$$

Facing skill-based firm $\imath$ is another cost minimization problem involving optimal allocation between domestic and imported materials. By denoting $\mathscr{p}_{\mathrm{ut}}^{\mathcal{s}}$ as the Lagrangian multiplier, we can solve for firm $\imath$'s optimal demand functions for $M_{hh,t}^{\mathcal{s}}(\imath)$ and $M_{fh,t}^{*\mathcal{s}}(\imath)$

$$M_{hh,t}^{\mathcal{s}}(\imath) = (1-\kappa_{\mathrm{u}})\left(P_{hh,t}/\mathscr{p}_{\mathrm{ut}}^{\mathcal{s}}\right)^{-\eta}M_t^{\mathcal{s}}(\imath) \quad (11)$$

$$M_{fh,t}^{*\mathcal{s}}(\imath) = \kappa_{\mathrm{u}}\left(\mathcal{P}_{fh,t}^{*}/\mathscr{p}_{\mathrm{ut}}^{\mathcal{s}}\right)^{-\eta}M_t^{\mathcal{s}}(\imath) \quad (12)$$

where $\mathscr{p}_{\mathrm{ut}}^{\mathcal{s}}$ can be further solved as material price index for upstream skill-based firm $\imath$

$$\mathscr{p}_{\mathrm{ut}}^{\mathcal{s}} = \left[(1-\kappa_{\mathrm{u}})\left(P_{hh,t}\right)^{1-\eta} + \kappa_{\mathrm{u}}\left(\mathcal{P}_{fh,t}^{*}\right)^{1-\eta}\right]^{1/(1-\eta)} \quad (13)$$

$P_{hh,t} = \left(\int_0^1 P_{hh,t}(\jmath)^{1-\epsilon}\right)^{1/(1-\epsilon)}$ refers to CES aggregate material price index for domestic varieties of downstream output, whereas $\mathcal{P}_{fh,t}^{*} = \left(\int_0^1 \mathcal{P}_{fh,t}^{*}(\jmath^{*})^{1-\epsilon}\right)^{1/(1-\epsilon)}$ is the CES aggregate imported material price index of a variety with a mix of invoicing currency (which we will discuss later).

Facing downstream firm $\jmath$ is also a two-dimension cost minimization decision. On the one hand, firm $\jmath$ has to optimally allocate resources between domestic and foreign intermediates, and on the other hand, she has to decide on allocation between low-quality and high-quality domestic intermediate inputs. In this sense, we can solve for the following optimal allocations that minimize firm j's production cost

$$X_t^u(j) = (N_t^u)^{(\rho-\epsilon^u)/(\epsilon^u-1)} \left(p_t^u / P_t^{ppi}\right)^{-\rho} X_t(j) \tag{14}$$

$$X_{hh,t}^s(j) = (N_t^s)^{(\rho-\epsilon^s)/(\epsilon^s-1)} \left(p_{hh,t}^s / P_t^{ppi}\right)^{-\rho} X_t(j) \tag{15}$$

$$X_t(j) = (1-\kappa_d)\left(P_t^{ppi} / r_{dt}(j)\right)^{-\vartheta} Y_t(j); \quad X_{fh,t}^{*s}(j) = \kappa_d \left(\mathcal{P}_{fh,t}^{*s} / r_{dt}(j)\right)^{-\vartheta} Y_t(j) \tag{16}$$

$$r_{dt}(j) = e^{-Z_{a,d,t}} \left[(1-\kappa_d)\left(P_t^{ppi}\right)^{1-\vartheta} + \kappa_d \left(\mathcal{P}_{fh,t}^{*s}\right)^{1-\vartheta}\right]^{1/(1-\vartheta)} \tag{17}$$

$$P_t^{ppi} = \left[(N_t^u)^{(\rho-1)/(\epsilon^u-1)} {p_t^u}^{1-\rho} + (N_t^s)^{(\rho-1)/(\epsilon^s-1)} {p_{hh,t}^s}^{1-\rho}\right]^{1/(1-\rho)} \tag{18}$$

where $p_t^u = \left(\int_0^{N^u} p_t^u(i)^{1-\epsilon^u}\right)^{1/(1-\epsilon^u)}$ and $p_{hh,t}^s = \left(\int_0^{N^s} p_{hh,t}^s(i)^{1-\epsilon^s}\right)^{1/(1-\epsilon^s)}$. Eqs. (14) and (15) show optimal demand for low- and high-quality domestic intermediate inputs, whereas Eq. (16) indicates optimal demand for domestic and imported intermediate inputs. $r_{dt}(j)$ is unit real marginal cost in downstream production as indicated by Eq. (17), which consists of intermediate price index P_t^{ppi} shown in Eq. (18) and import price for high-quality intermediates from foreign upstream firms $\mathcal{P}_{fh,t}^{*s}$. P_t^{ppi} resembles the producer price index (PPI), as the index accounts for the prices set by domestic intermediates seller from upstream skill-based and non-skill-based firms, whereas $\mathcal{P}_{fh,t}^{*s}$ comprises yuan-quoted import price $p_{fh,t}^{*s}$ and dollar-quoted import price $dp_{fh,t}^{*s}$ weighted by the share of yuan-invoiced trade ϕ_t in such a way that $\mathcal{P}_{fh,t}^{*s} = (1-\phi_t) S_{hd,t}\, dp_{fh,t}^{*s} + \phi_t p_{fh,t}^{*s}$.

2.4. Pricing decision

On top of the conventional Calvo pricing in which a fraction of firms θ can get stuck with its price set earlier for multiple periods, the firm also faces an exogenous probability of exiting the market δ (an exogenous death shock). Hence, firms that survive will set an optimal price which discounts profits k periods into the future by $\theta^k(1-\delta)^k\varrho_{t+k}$, where $\theta(1-\delta)$ indicates a joint probability that the surviving firm may be unable to reset price, and $\varrho_t^{s}\left(=\beta\frac{u'(C_{t+1})}{u'(C_t)}\frac{e^{Z_{H,t+1}}}{e^{Z_{H,t}}}\frac{P_t}{P_{t+1}}=\mathfrak{p}_t^{s}/(1-\delta)(\mathfrak{p}_{t+1}^{s}+\Pi_{t+1}^{s})\right)$ is the stochastic discount factor for nominal payoffs. For domestic market, both upstream and downstream firms choose an optimal price that maximizes profit in the face of marginal cost and its market demand, respectively. Optimal price for low-quality intermediates, high-quality intermediates, and downstream output can be solved as

$$\mathbb{p}_t^{u}(i)=\omega^{u}\boldsymbol{\varrho}_t^{u}\mathcal{p}_t^{u}\mathcal{r}_{\mathrm{ut}}^{u}(i) \tag{19}$$

$$\mathbb{p}_{hh,t}^{s}(i)=\omega^{s}\boldsymbol{\varrho}_t^{s}\mathcal{p}_{hh,t}^{s}\mathcal{r}_{\mathrm{ut}}^{s}(i) \tag{20}$$

$$\mathbb{P}_{hh,t}(j)=\omega_t\boldsymbol{\varrho}_t P_{hh,t+i}\mathcal{r}_{dt}(j) \tag{21}$$

where $\boldsymbol{\varrho}_t^{i}=(1-\theta(1-\delta))^{-1}\varrho_t^{i}$ is the stochastic discount factor adjusted for stickiness and firm's exit.

Of interest in our context is the export pricing decision, as upstream skill-based firms export part of its high-quality outputs to foreign country for further processing while downstream firms also export part of its outputs as final goods as well as parts & components. Give the evidence wherein U.S dollar is the dominant invoicing currency in world trade (see, for instance, Ito et al., 2012, Goldberg & Tille, 2008), we let dollar pricing (DP) be an important part of the export pricing strategy for upstream skill-based and downstream exports in choosing an optimal dollar price denominated in domestic currency to maximize export profits in the face of marginal cost and demand in foreign market. We can solve for

$$\mathbb{dp}_{hf,t}^{s}(i) = \omega_t^{*s}\varrho_t d p_{hf,t}^{s} r_{\mathrm{ut}}^{s}(i)/S_{hd,t} \tag{22}$$

$$\mathbb{DP}_{hf,t}(j) = \omega_t^{*}\varrho_t DP_{hf,t} r_{dt}(j)/S_{hd,t} \tag{23}$$

where $S_{hd,t}$ refers to nominal exchange rates defined as the value of a U.S dollar in home currency. As an increasingly popular alternative to dollar pricing strategy, exporters can choose to quote export price in Chinese yuan (Ito and Chinn, 2015). By setting up a dynamic pricing problem facing both upstream and downstream exporters in that an optimal yuan price is chosen to maximize export profits denominated in domestic currency, we get

$$\mathbb{yp}_{hf,t}^{s}(i) = \omega_t^{*s}\varrho_t y p_{hf,t}^{s} r_{\mathrm{ut}}^{s}(i) \tag{24}$$

$$\mathbb{YP}_{hf,t}(j) = \omega_t^{*}\varrho_t YP_{hf,t} r_{dt}(j) \tag{25}$$

Leaving the degree of competitiveness that determines price markup aside, Eqs. (24) and (25) are exactly identical to Eqs. (20) and (21), as from China's perspective yuan pricing is exactly producer currency pricing.

Following the New Keynesian literature, those survived upstream and downstream firms able to reset price will do so by choosing a reset price $\tilde{p}_t^i\left(=\left\{\tilde{p}_t^u, \tilde{p}_{hh,t}^s, \widetilde{dp}_{hf,t}^s, \widetilde{yp}_{hf,t}^s\right\}\right)$ and $\tilde{P}_t\left(=\left\{\tilde{P}_{hh,t}, \widetilde{DP}_{hf,t}, \widetilde{YP}_{hf,t}\right\}\right)$ that approximates optimal price to minimize losses due to deviation from profit-maximizing price. By solving the first-order condition, we can get optimal reset price for upstream and downstream output, respectively.

$$\tilde{p}_t^i = \theta(1-\delta)\beta\mathbb{E}_t\tilde{p}_{t+1}^i + (1-\theta(1-\delta)\beta)\boldsymbol{z}_t^i$$

$$\tilde{P}_t = \theta(1-\delta)\beta\mathbb{E}_t\tilde{P}_{t+1} + (1-\theta(1-\delta)\beta)\boldsymbol{\mathcal{Z}}_t \tag{26}$$

where $\boldsymbol{z}_t^i = \{\mathbb{p}_t^u, \mathbb{p}_{hh,t}^s, \mathbb{d}\mathbb{p}_{hf,t}^s, \mathbb{y}\mathbb{p}_{hf,t}^s\}$ and $\boldsymbol{\mathcal{Z}}_t = \{\mathbb{P}_{hh,t}, \mathbb{D}\mathbb{P}_{hf,t}, \mathbb{Y}\mathbb{P}_{hf,t}\}$. We drop the index i as all firms behave symmetrically. The other fraction of firms not able to reset price will charge the price they charged in previous period. This gives us an aggregate price level comprising reset and lagged price level weighted by $\theta(1-\delta)$:

$$\boldsymbol{p}_t = \big(1-\theta(1-\delta)\big)\tilde{p}_t^i + \theta(1-\delta)\boldsymbol{p}_{t-1}$$

$$\mathbf{P}_t = \big(1-\theta(1-\delta)\big)\tilde{P}_t + \theta(1-\delta)\mathbf{P}_{t-1} \tag{27}$$

for $\boldsymbol{p}_t = \{p_t^u, p_{hh,t}^s, dp_{hf,t}^s, yp_{hf,t}^s\}$ and $\mathbf{P}_t = \{P_{hh,t}, DP_{hf,t}, YP_{hf,t}\}$.

Suppose in each period a fraction of home exporters chooses to price their exports in U.S dollar $1-\phi_t$ while another fraction chooses to price at Chinese yuan ϕ_t. Average export price of high-quality intermediate inputs and downstream output denominated in domestic currency, respectively, is given by

$$\mathcal{P}_{hf,t}^s = (1-\phi_t)S_{hd,t}dp_{hf,t}^s + \phi_t yp_{hf,t}^s$$

$$\mathcal{P}_{hf,t} = (1-\phi_t)S_{hd,t}DP_{hf,t} + \phi_t YP_{hf,t} \tag{28}$$

2.5. Renminbi internationalization

Whether to price the export in U.S dollar or Chinese yuan depends on the profitability. If the profitability of yuan-invoiced trade improves relative to that of the dollar-invoiced trade, exporters are more likely to quote the export in yuan in next period. In other words, exporters will be self-sorting into yuan pricing strategy if it is more rewarding. In this way, we can interpret ϕ_t as the degree of RMBI with respect to the use of renminbi as invoicing currency in trade.

$$\phi_t = \zeta \frac{\exp\left(\widehat{\mathscr{yp}}^{s}_{hf,t-1} - \widehat{\mathbb{yp}}^{s}_{hf,t-1}\right)}{\exp\left(\widehat{\mathscr{yp}}^{s}_{hf,t-1} - \widehat{\mathbb{yp}}^{s}_{hf,t-1}\right) + \exp\left(\widehat{\mathscr{dp}}^{s}_{hf,t-1} - \widehat{\mathbb{dp}}^{s}_{hf,t-1}\right)} \tag{29}$$

where ζ is a scale parameter. $\hat{x}$ indicates log-deviation of variable x from steady state.

2.6. Skill-biased technical change, firm entry, and industrial upgrading

In the spirit of Acemoglu et al. (2015), average quality of intermediate inputs in sector $\imath \in \{u, s\}$, A^{s}_{t}, evolves over time according to the following difference equation

$$A^{\imath}_{t} = \left(1 + \gamma^{\imath}\mathrm{prop}N^{\imath}_{t}\right)A^{\imath}_{t-1}, \text{ for } \gamma^{s} > \gamma^{u} \tag{30}$$

where prop $\in (0,1)$ is the probability of successful innovation identical across sectors, $N^{\imath}_{t}$ is the number of firms and varieties available in upstream sector $\imath$. Since the measure of total firms is normalized to one, where $N^{u}_{t} + N^{s}_{t} = 1$, $N^{\imath}_{t}$ denotes the mass of firms participating in sector $\imath$. And the implication of firm mass in skill-biased technical change is straightforward: greater is business formation in skill-based sector, larger is the mass of firms to catalyze scale effect, and stronger will be the potential to attain growth rate γ^{s} which pushes the quality frontier of production biasedly toward skill-based sector. In other words, direction of technical change is shaped by firm entry, for which the equilibrium profit threshold is in turn affected by level of average quality, as we will discuss later.

As in Ghironi and Melitz (2005), entry implies a one-period production lag so that all firms entering sector i in a given period N_{et-1}^{i} are able to produce in all subsequent periods. At the same time, there is a constant probability $\delta \in (0,1)$ that both incumbents and entrants are hit by a death shock and hence leave the market. On net, the numbers of firm in upstream sector i evolve according to

$$N_t^{i} = (1-\delta)\left(N_{t-1}^{i} + N_{et-1}^{i}\right) \tag{31}$$

Of question is what influences a firm's entry decision? The underlying mechanism is expected profitability. The intuition is straightforward. Suppose total nominal cost of production $\mathbb{C}_t^{s}$ for upstream skill-based firm i takes the form

$$\mathbb{C}_t^{s}(i) = Y_t^{s}(i)\mathcal{R}_{\mathrm{u}t}^{s}(i) + \mathbb{F}_t^{s} \tag{32}$$

where $\mathcal{R}_{\mathrm{u}t}^{s}$ refers to nominal marginal cost, and $\mathbb{F}_t^{s}$ denotes the industry-wide fixed cost in skill-based production. In our context, it is the entry cost $\mathbb{F}_t^{s} = f_{et}^{s}$, which we follow Sutton (2012) to take an iso-elastic function, setting

$$f_{et}^{s} = \mathbb{F}^{s}(A_t^{s})^{\mu_s} \tag{33}$$

where $\mathbb{F}^{s}(> 0)$ denotes the minimum outlay incurred by an entrant into skill-based production. Entry cost is thus defined as fixed and sunk cost incurred by an entrant that offers quality A_t^{s}, where A_t^{s} lies in the range $[1, \infty)$. By modelling entry cost in such way, firm entry and technical change are mutually linked: while expanding business formation in skill-based sector lifts the average level of quality of the sector, quality advancement increases entry cost and thus slows down business formation in skill-based sector. However, firms able to enter the sector sequentially will be of better quality and more profitable.

Meanwhile, the inversed parameter $\mu_{\mathscr{s}}$ represents the elasticity of $A_t^{\mathscr{s}}$ with respect to $f_{et}^{\mathscr{s}}$. A low value of μ means that fixed cost outlays, which we may think of as R&D outlays, is very effective in raising the quality. In contrast, higher value of μ means a relatively unresponsive quality toward R&D expenditures.

Let skill-based firm $\imath$'s total revenue function be the sum of revenue from domestic market and exporting:

$$\mathbb{R}_t^{\mathscr{s}}(\imath) = \underbrace{\mathbb{R}_{hh,t}^{\mathscr{s}}(\imath)}_{\substack{domestic \\ revenue}} + \underbrace{\mathbb{R}_{hf,t}^{\mathscr{s}}(\imath)}_{\substack{export \\ revenue}} = \wp_{hh,t}^{\mathscr{s}} X_{hh,t}^{\mathscr{s}} + \mathcal{P}_{hf,t}^{\mathscr{s}} X_{hf,t}^{\mathscr{s}} \tag{34}$$

The present discounted value of the expected stream of profit for a new entrant if survived into skill-based upstream production can be formulated as

$$V_t^{\mathscr{s}}(\imath) = \mathbb{E}_0 \sum_{i=0}^{\infty} (1-\delta)^i \varrho_{t+i}^{\mathscr{s}} \Pi_{t+i}^{\mathscr{s}}(\imath) = \mathbb{E}_0 \sum_{i=0}^{\infty} (1-\delta)^i \varrho_{t+i}^{\mathscr{s}} \left(\mathbb{R}_t^{\mathscr{s}}(\imath) - \mathbb{C}_t^{\mathscr{s}}(\imath)\right)$$

which can be rearranged as

$$V_t^{\mathscr{s}}(\imath) = \frac{1}{1-(1-\delta)\varrho_t^{\mathscr{s}}} \left\{ \left(1 - \frac{1-\theta(1-\delta)/\left(1+\pi_{hh,t}^{\mathscr{s}}\right)}{\omega_t^{\mathscr{s}} \varrho_t^{\mathscr{s}}}\right) \mathbb{R}_{hh,t}^{\mathscr{s}}(\imath) \right.$$
$$\left. + \left(1 - \frac{1-\theta(1-\delta)/\left(1+\pi_{hf,t}^{\mathscr{s}}\right)}{\omega_t^{*\mathscr{s}} \varrho_t^{\mathscr{s}}}\right) \mathbb{R}_{hf,t}^{\mathscr{s}}(\imath) - \mathbb{F}^{\mathscr{s}}(A_t^{\mathscr{s}})^{\mu_{\mathscr{s}}} \right\} \tag{35}$$

where $\pi_{hh,t}^{\mathscr{s}}$ and $\pi_{hf,t}^{\mathscr{s}}$ refer to domestic input price inflation for local and export markets, respectively. By the same token, given non-skill-based firm $\imath$'s total revenue from domestic sales and total cost which also involves R&D, the present discounted value of the expected stream of profit for a new entrant if survived into non-skill-based upstream production

$$V_t^{u}(i) = \frac{1}{1-(1-\delta)\varrho_t^{u}}\left\{\left(1 - \frac{1-\theta(1-\delta)/\left(1+\pi_{hh,t}^{u}\right)}{\omega_t^{u}\varrho_t^{u}}\right)\mathbb{R}_{hh,t}^{u}(i) - \mathbb{F}^{u}(A_t^{u})^{\mu_u}\right\} \tag{36}$$

By aggregating $V_t^{s}(i)$ and $V_t^{u}(i)$ over for all firms in upstream industries, we can get sector's profit in the form

$$V_t^{s} = \int_0^{N^{s}} V_t^{s}(i)di$$

$$= \frac{N_t^{s}}{1-(1-\delta)\varrho_t^{s}}\left\{\left(1 - \frac{1-\theta(1-\delta)/\left(1+\pi_{hh,t}^{s}\right)}{\omega_t^{s}\varrho_t^{s}}\right)\mathbb{R}_{hh,t}^{s}\right.$$

$$\left. + \left(1 - \frac{1-\theta(1-\delta)/\left(1+\pi_{hf,t}^{s}\right)}{\omega_t^{*s}\varrho_t^{s}}\right)\mathbb{R}_{hf,t}^{s} - \mathbb{F}^{s}(A_t^{s})^{\mu_s}\right\}$$

$$V_t^{u} = \int_0^{N^{u}} V_t^{u}(i)di = \frac{N_t^{u}}{1-(1-\delta)\varrho_t^{u}}\left\{\left(1 - \frac{1-\theta(1-\delta)/\left(1+\pi_{hh,t}^{u}\right)}{\omega_t^{u}\varrho_t^{u}}\right)\mathbb{R}_{hh,t}^{u} - \mathbb{F}^{u}(A_t^{u})^{\mu_u}\right\} \tag{37}$$

Suppose an entrant can choose to enter either sector at a point of time such that $N_{et}^{s} = 1 - N_{et}^{u}$, and ratio between the numbers of skill-based and non-skill-based entrants in the industry corresponds directly to ratio of expected profitability, $N_{et}^{s}/N_{et}^{u} = V_t^{s}/V_t^{u}$. We can easily derive an "industrial upgrading function"

$$N_{et}^{h} = V_t^{h}/\left(V_t^{h} + V_t^{\ell}\right) \tag{38}$$

Viewed with firm dynamics (31) and quality frontier (30), Eq. (38) can be interpreted as an industrial upgrading process, as expanding numbers of entrants into skill-based upstream production direct technical change biasedly toward skill-based sector, advancing overall quality of products of the value chains.

2.7. Households

In each period, a unit mass of households $z \in (0,1)$ populating our model economy works for wage income W_t/P_t, consumes a bundle of final goods C_t and accumulate wealth in the form of domestic bonds $B_{p,h,t}$ that pay interest r_t and equity of both incumbent and entrants producing low-quality Q_t^{u} and high-quality intermediates $Q_{h,t}^{s}$ at market price $\mathfrak{p}_t^{u}$ and $\mathfrak{p}_t^{s}$, respectively. These upstream firms return profits Π_t^{i} to shareholders in the form of dividend. Households also invest in foreign bonds $B_{p,fh,t}^{*}$ which pay r_t^{*} and foreign equity $Q_{fh,t}^{*s}$ priced at $\mathfrak{p}_t^{*s}$ that yields dividend Π_t^{*s}. The households also hold domestic monies which provide liquidity services. Formally, household z maximizes the following utility function

$$u = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t e^{Z_{H,t}} \left(\frac{{C_t}^{1-\sigma}}{1-\sigma} - \chi H_t + \psi \ln\left(\frac{M_t^d}{P_t}\right)\right)$$

subject to the flow budget constraint as follows

$$\begin{aligned} B_{p,h,t} + \mathfrak{p}_t^{u} Q_t^{u}(N_t^{u} + N_{et}^{u}) + \mathfrak{p}_t^{s} Q_{h,t}^{s}(N_t^{s} + N_{et}^{s}) + P_t\left(\mathbb{K}_{hf,t}^{B} + \Phi_{\mathbb{K},t}^{B}\right) + P_t\left(\mathbb{K}_{hf,t}^{Q} + \Phi_{\mathbb{K},t}^{Q}\right) + \\ P_t C_t + M_t^d = (1 + r_{t-1}) B_{p,h,t-1} + (\mathfrak{p}_t^{u} + \Pi_t^{u}) N_t^{u} Q_{t-1}^{u} + (\mathfrak{p}_t^{s} + \Pi_t^{s}) N_t^{s} Q_{h,t-1}^{s} + W_t H_t + \\ M_{t-1}^d + T \end{aligned} \quad (39)$$

where σ is the risk aversion parameter, χ and ψ are parameters indicating weight assigned to labor disutility and liquidity utility, respectively. $Z_{H,t}$ is the first-order autoregressive preference shock. T is lump-sum tax. $\mathbb{K}_{hf,t}^{B}$ and $\mathbb{K}_{hf,t}^{Q}$, respectively, refer to portfolio investment by domestic households on foreign bonds and equities. $\Phi_{\mathbb{K},t}^{B}$ and $\Phi_{\mathbb{K},t}^{Q}$ denotes portfolio adjustment costs which we detail in next section. Lastly, consumption bundle consists of domestic $C_{h,t}\left(=\left(\int_0^1 C_{h,t}(j)^{1-1/\epsilon}\,dj^*\right)^{\epsilon/(\epsilon-1)}\right)$ and imported consumables $C_{fh,t}\left(=\left(\int_0^1 C_{fh,t}(j^*)^{1-1/\epsilon}dj^*\right)^{\epsilon/(\epsilon-1)}\right)$ in CES fashion

$$C_t = \left[(1-\gamma)^{1/\varphi}\left(C_{fh,t}^*\right)^{1-1/\varphi} + \gamma^{1/\varphi} C_{h,t}^{1-1/\varphi}\right]^{\varphi/(\varphi-1)} \tag{40}$$

where φ denotes elasticity of substitution between home and imported consumer goods. We omit the index z as households behave identically. Solving the first-order conditions with some rearrangements gives us optimal demand for domestic and imported consumer goods, utility-based consumer price index, marginal rate of substitution between consumption and leisure, money demand, Euler consumption function, and share price of firms producing low-quality and high-quality intermediates, respectively.

$$C_{h,t} = \gamma\left(P_{hh,t}/P_t\right)^{-\varphi} C_t, \qquad C_{fh,t}^* = (1-\gamma)\left(\mathcal{P}_{fh,t}^*/P_t\right)^{-\varphi} C_t \tag{41}$$

$$P_t = \left(\gamma {P_{hh,t}}^{1-\varphi} + (1-\gamma)\left(S_{hd,t}\mathcal{P}_{fh,t}^*\right)^{1-\varphi}\right)^{1/(1-\varphi)} \tag{42}$$

$$\chi {C_t}^{\sigma} = W_t/P_t \tag{43}$$

$$M_t^d/P_t = \psi {C_t}^{\sigma}(r_t/1+r_t)^{-1} \tag{44}$$

$$C_t^{\sigma} = \beta^{-1}(1+r_t)^{-1} e^{Z_{H,t}} \mathbb{E}_t[C_{t+1}^{\sigma}(1+\pi_{t+1})e^{Z_{H,t+1}}] \tag{45}$$

$$\mathfrak{p}_t^{\ell} = (1-\delta)\mathbb{E}_t \mathfrak{p}_{t+1}^{\ell}\left(1+\Pi_{t+1}^{\ell}/\mathfrak{p}_{t+1}^{\ell}\right)/(1+r_t) \tag{46}$$

$$\mathfrak{p}_t^{\hbar} = (1-\delta)\mathbb{E}_t \mathfrak{p}_{t+1}^{\hbar}\left(1+\Pi_{t+1}^{\hbar}/\mathfrak{p}_{t+1}^{\hbar}\right)/(1+r_t) \tag{47}$$

where $\pi_t = P_t/P_{t-1} - 1$ is CPI inflation and $\mathcal{P}_{fh,t}^{*}\left(= (1-\phi_t)S_{hd,t}DP_{fh,t}^{*} + \phi_t YP_{fh,t}^{*}\right)$ is import price weighted by choice of currency pricing.

2.8. Capital account convertibility

An important dimension of RMBI of which the implications will be investigated is capital account convertibility. When capital account is inconvertible, domestic and foreign assets are imperfect substitute. This allows us to model capital flows across border using portfolio balance approach. In particular, we interpret gross portfolio capital inflows (in real term) into domestic debt $\mathbb{K}_{fh,t}^{*B}$ and stock markets $\mathbb{K}_{fh,t}^{*Q}$ as the decisions of foreign investors to change their holdings of domestic assets comprising bonds $B_{p,hf,t}$ and equities $Q_{hf,t}^{\mathcal{s}}$, whereas gross capital outflows into foreign bond market $\mathbb{K}_{hf,t}^{B}$ and stock market $\mathbb{K}_{hf,t}^{Q}$ as the decisions of domestic investors to change their holdings of foreign assets.

$$B_{p,hf,t} = (1+r_{t-1})B_{p,hf,t-1} + e^{Z_{\mathbb{K},t}^{*}}S_{hd,t}P_t^{*}\mathbb{K}_{fh,t}^{*B} \tag{48}$$

$$\mathfrak{p}_t^{\mathcal{s}} Q_{hf,t}^{\mathcal{s}}(N_t^{\mathcal{s}} + N_{et}^{\mathcal{s}}) = (\mathfrak{p}_t^{\mathcal{s}} + \Pi_t^{\mathcal{s}})N_t^{\mathcal{s}} Q_{hf,t-1}^{\mathcal{s}} + e^{Z_{\mathbb{K},t}^{*}}S_{hd,t}P_t^{*}\mathbb{K}_{fh,t}^{*Q} \tag{49}$$

$$B_{p,fh,t}^{*} = (1+r_{t-1}^{*})B_{p,fh,t-1}^{*} + e^{Z_{\mathbb{K},t}}P_t\mathbb{K}_{hf,t}^{B}/S_{hd,t} \tag{50}$$

$$\mathfrak{p}_t^{*\mathcal{s}} Q_{fh,t}^{*\mathcal{s}}(N_t^{*\mathcal{s}} + N_{et}^{*\mathcal{s}}) = (\mathfrak{p}_t^{*\mathcal{s}} + \Pi_t^{*\mathcal{s}})N_t^{*\mathcal{s}} Q_{fh,t-1}^{*\mathcal{s}} + e^{Z_{\mathbb{K},t}}P_t\mathbb{K}_{hf,t}^{Q}/S_{hd,t} \tag{51}$$

where $Z_{\mathbb{K},t}^{*}$ and $Z_{\mathbb{K},t}$ are first-order autoregressive capital inflow and outflow shocks by foreign and domestic residents, respectively. Our strategy is in line with the growing emphasis on gross rather than net capital flows in the recent literature (see, for instance, Wong and Eng, 2015; Broner et al., 2013; Forbes and Warnock, 2012).

We assume a cross-border portfolio adjustment cost facing domestic and foreign investors primarily due to restrictions in China's capital market. By denoting $\Phi_{\mathbb{K}} > 0$ as the degree of China's capital market restriction, we model domestic and foreign residents' portfolio adjustment cost as

$$\Phi_{\mathbb{K},t}^{B} = \frac{\Phi_{\mathbb{K}}}{2}\left(\frac{P_t \mathbb{K}_{hf,t}^{B}}{S_{hd,t} B_{p,fh,t-1}^{*}} - \varpi_{\mathbb{K},hf}^{B}\right),\ \Phi_{\mathbb{K},t}^{Q} = \frac{\Phi_{\mathbb{K}}}{2}\left(\frac{P_t \mathbb{K}_{hf,t}^{Q}}{S_{hd,t} \mathfrak{p}_t^{*\mathcal{s}} Q_{fh,t-1}^{*\mathcal{s}}} - \varpi_{\mathbb{K},hf}^{Q}\right)$$

$$\Phi_{\mathbb{K},t}^{*B} = \frac{\Phi_{\mathbb{K}}}{2}\left(\frac{S_{hd,t} P_t^{*} \mathbb{K}_{fh,t}^{*B}}{B_{p,hf,t-1}} - \varpi_{\mathbb{K},fh}^{*B}\right),\ \Phi_{\mathbb{K},t}^{*Q} = \frac{\Phi_{\mathbb{K}}}{2}\left(\frac{S_{hd,t} P_t^{*} \mathbb{K}_{fh,t}^{*Q}}{\mathfrak{p}_t^{\hbar} Q_{hf,t-1}^{\hbar}} - \varpi_{\mathbb{K},fh}^{*Q}\right) \tag{52}$$

where $\varpi_{\mathbb{K},hf}^{B}$, $\varpi_{\mathbb{K},hf}^{Q}$, $\varpi_{\mathbb{K},fh}^{*B}$, and $\varpi_{\mathbb{K},fh}^{*Q}$ refer to steady-state capital outflows and inflows into equity and bond markets as a share of total stock, respectively. By optimizing stock and flow of their portfolio investments, we can solve for portfolio capital flows dynamics

$$\mathbb{K}_{fh,t}^{*B} = B_{p,hf,t-1} S_{hd,t}^{-1} P_t^{*-1}\left(\Phi_{\mathbb{K}}^{-1}\left(q_{fh,t}^{*B} e^{Z_{\mathbb{K},t}^{*}} - 1\right) + \varpi_{\mathbb{K},fh}^{*B}\right) \tag{53}$$

$$\mathbb{K}_{fh,t}^{*Q} = \mathfrak{p}_t^{\mathcal{s}} Q_{hf,t-1}^{\mathcal{s}} S_{hd,t}^{-1} P_t^{*-1}\left(\Phi_{\mathbb{K}}^{-1}\left(q_{fh,t}^{*Q} e^{Z_{\mathbb{K},t}^{*}} - 1\right) + \varpi_{\mathbb{K},fh}^{*Q}\right) \tag{54}$$

$$\mathbb{K}_{hf,t}^{B} = S_{hd,t} P_t^{-1} B_{p,fh,t}^{*}\left(\Phi_{\mathbb{K}}^{-1}\left(q_{hf,t}^{B} e^{Z_{\mathbb{K},t}} - 1\right) + \varpi_{\mathbb{K},hf}^{B}\right) \tag{55}$$

$$\mathbb{K}_{hf,t}^{Q} = S_{hd,t} \mathfrak{p}_t^{*\mathcal{s}} Q_{hf,t-1}^{*\mathcal{s}} P_t^{-1}\left(\Phi_{\mathbb{K}}^{-1}\left(q_{hf,t}^{Q} e^{Z_{\mathbb{K},t}} - 1\right) + \varpi_{\mathbb{K},hf}^{Q}\right) \tag{56}$$

$$q_{fh,t}^{*B} = \mathbb{E}_t\left(\frac{S_{hd,t}}{S_{hd,t+1}}\right)\left(\frac{1}{1+r_t^{*}}\right)\left(q_{fh,t+1}^{*B}(1+r_t) + \mathfrak{A}_{fh,t+1}^{*B}\right) \tag{57}$$

$$q_{fh,t}^{*Q} = \mathbb{E}_t\left(\frac{S_{hd,t}}{S_{hd,t+1}}\right)\left(\frac{1-\delta}{1+r_t^{*}}\right)\left(\frac{\mathfrak{p}_{t+1}^{\mathcal{s}}}{\mathfrak{p}_t^{\mathcal{s}}}\right)\left(q_{fh,t+1}^{*Q}(1+\Pi_{t+1}^{\mathcal{s}}/\mathfrak{p}_{t+1}^{\mathcal{s}}) + \mathfrak{A}_{fh,t+1}^{*Q}/N_{t+1}^{\mathcal{s}}\right) \tag{58}$$

$$q^{B}_{hf,t} = \mathbb{E}_t \left(\frac{S_{hd,t+1}}{S_{hd,t}}\right)\left(\frac{1}{1+r_t}\right)\left(q^{B}_{hf,t+1}(1+r^*_t) + \mathfrak{A}^{B}_{hf,t+1}\right) \tag{59}$$

$$q^{Q}_{hf,t} = \mathbb{E}_t \left(\frac{S_{hd,t+1}}{S_{hd,t}}\right)\left(\frac{1-\delta}{1+r_t}\right)\left(\frac{\mathfrak{p}^{*\mathcal{S}}_{t+1}}{\mathfrak{p}^{*\mathcal{S}}_t}\right)\left(q^{Q}_{hf,t+1}(1+\Pi^{*\mathcal{S}}_{t+1}/\mathfrak{p}^{*\mathcal{S}}_{t+1}) + \mathfrak{A}^{Q}_{hf,t+1}/N^{*\mathcal{S}}_{t+1}\right) \tag{60}$$

where

$$\mathfrak{A}^{*B}_{fh,t} = \frac{\Phi_{\mathbb{K}}}{2}\left(\left(\frac{S_{hd,t}P^*_t\mathbb{K}^{*B}_{fh,t}}{B_{p,hf,t-1}}\right)^2 - \left(\varpi^{*B}_{\mathbb{K},fh}\right)^2\right)\ ,\quad \mathfrak{A}^{*Q}_{fh,t} = \frac{\Phi_{\mathbb{K}}}{2}\left(\left(\frac{S_{hd,t}P^*_t\mathbb{K}^{*Q}_{fh,t}}{\mathfrak{p}^{\mathcal{S}}_t Q^{\mathcal{S}}_{hf,t-1}}\right)^2 - \left(\varpi^{*Q}_{\mathbb{K},fh}\right)^2\right)\ ,\quad \mathfrak{A}^{B}_{hf,t} =$$

$$\frac{\Phi_{\mathbb{K}}}{2}\left(\left(\frac{P_t\mathbb{K}^{B}_{hf,t}}{S_{hd,t}B^*_{p,fh,t-1}}\right)^2 - \left(\varpi^{B}_{\mathbb{K},hf}\right)^2\right), \text{ and } \mathfrak{A}^{Q}_{hf,t} = \frac{\Phi_{\mathbb{K}}}{2}\left(\left(\frac{P_t\mathbb{K}^{Q}_{hf,t}}{S_{hd,t}\mathfrak{p}^{*\mathcal{S}}_t Q^{*\mathcal{S}}_{fh,t-1}}\right)^2 - \left(\varpi^{Q}_{\mathbb{K},hf}\right)^2\right).$$

Eqs. (53) – (56) describe the way gross capital inflows and outflows into bond and equity markets can be driven by exogenous shock and the "Tobin's *q*" in portfolio investments. As indicated by Eqs. (57) and (59), the "*q* ratio" in bond investment is influenced by expected variability in nominal exchange rates, pure expectation on future "*q* ratio", and return differentials between home and foreign bonds. Whereas for equity "*q* ratio" described in Eqs. (58) and (60), on top of expected depreciation, present value of expected capital gain and dividend yield is the major determinant. Note that the magnitude of influence of all the underlying determinants is subject to the degree of Chinese capital account convertibility. When capital account is inconvertible, $\Phi_{\mathbb{K}} \longrightarrow \infty$, capital flows are simply unresponsive to both exogenous shock and endogenous state of the economy.

2.9. Closing the model

As we focus on financial and capital account policies, for the sake of simplicity we assume a passive role of fiscal authority in the sense that government bonds are issued to pay for the last-period bonds and lump-sum transfer.

$$B_{g,h,t} + B_{p,h,t} + B_{p,hf,t} = (1 + r_{t-1})\left(B_{g,h,t-1} + B_{p,h,t-1} + B_{p,hf,t-1}\right) + T \tag{61}$$

where $B_{g,h,t}$ is bonds held in the coffer of central bank as domestic credit according to the following flow-of-fund constraint

$$S_{hd,t}\left(B^*_{g,fh,t} - (1 + r^*_{t-1})B^*_{g,fh,t-1}\right) + B_{g,h,t} - (1 + r_{t-1})B_{g,h,t-1} = M_t - M_{t-1} \tag{62}$$

There is an interesting asymmetry with respect to government bonds as global asset: while foreign bonds $B^*_{g,fh,t}$ are held by People's Bank of China (PBoC) as in Eq. (62), sovereign bonds issued by Chinese government are not held by foreign central bank as foreign reserves. This in a way reflects the prevailing situation that Chinese sovereign bonds are not yet a global safe asset.

Under capital account restrictions with heavily managed nominal exchange rates, PBoC intervenes in foreign exchange market by purchasing foreign assets from exporters, resulting in the accumulation of foreign reserves. A non-sterilized foreign exchange intervention $FXI_t\left(\equiv B^*_{g,fh,t} - B^*_{g,fh,t-1}\right)$ involves a proportional money creation. On contrary, a sterilized intervention is associated with a sale of domestic bonds to the market without a change in money supply. In this respect, we can write a money supply-cum-sterilization rule as below

$$M_t = M_{t-1} + \tau S_{hd,t} FXI_t \tag{63}$$

where $\tau = 0$ refers to full sterilization, $\tau = 1$ unsterilized intervention, and $0 < \tau < 1$ partially sterilized intervention. Following Chang et al. (2015), we let

$$S_{hd,t} = e^{Z_{s,t}} S_{hd,t-1} \tag{64}$$

where $Z_{s,t}$ is the first-order autoregressive shock hitting exchange rates. To reflect the trend of the renminbi since the abandonment of dollar peg in 2005, we assume that the central bank intentionally allows the nominal exchange rate to appreciate at a constant rate.

By adding all the market clearing conditions for upstream and downstream productions, income distribution of downstream sales revenue, stock and labor markets equilibrium, and the central bank's flow-of-funds constraint to the household's flow budget constraint, we get an external resource constraint comprising gross exports $\mathbb{X}_t$, gross imports $\mathbb{M}_t$, gross capital inflows GKI_t, and gross capital outflows GKO_t.

$$S_{hd,t}FXI_t = r^*_{t-1}\left(\frac{S_{hd,t}}{P_t}\right)B^*_{g,fh,t-1} + \mathbb{X}_t - \mathbb{M}_t + S_{hd,t}\left(\frac{P^*_t}{P_t}\right)GKI_t - GKO_t \tag{65}$$

where $\mathbb{X}_t = C_{hf,t} + N_t^{*\mathcal{s}} M^{\mathcal{s}}_{hf,t} + N_t^{\mathcal{s}} X^{\mathcal{s}}_{hf,t}$, $\mathbb{M}_t = C^*_{fh,t} + N_t^{\mathcal{s}} M^{*\mathcal{s}}_{fh,t} + X^{*\mathcal{s}}_{fh,t}$, $GKI_t = \mathbb{K}^{*B}_{fh,t} + \mathbb{K}^{*Q}_{fh,t}$, $GKO_t = \mathbb{K}^{B}_{hf,t} + \mathbb{K}^{Q}_{hf,t}$. Defining real GDP as the sum of consumption and net exports net of sunk resources, we get

$$RGDP_t \equiv \mathrm{C}_t + \mathbb{X}_t - \mathbb{M}_t + \mathbb{F}^{\mathcal{s}}(A^{\mathcal{s}}_t)^{\mu_{\mathcal{s}}} + \mathbb{F}^{\mathcal{u}}(A^{\mathcal{u}}_t)^{\mu_{\mathcal{u}}} \tag{66}$$

where $\mathrm{C}_t\left(= C_{h,t} + C^*_{fh,t}\right)$ is defined based on accounting basis instead of a consumption behavior as defined in Eq. (40). Lastly, we close the model by imposing a simple feedback interest rate rule

$$\frac{1+r_t}{\bar{R}} = \left(\frac{1+r_{t-1}}{\bar{R}}\right)^{\rho_r}\left(\left(\frac{1+\pi_t}{1+\bar{\pi}}\right)^{\rho_\pi}\left(\frac{RGDP_t/RGDP_{t-1}}{1+\Delta\overline{RGDP}}\right)^{\rho_{gdp}}\right)^{1-\rho_r} e^{u_{r,t}} \tag{67}$$

where $u_{r,t}$ is i.i.d interest rate shock, $\bar{R}$ is the steady-state interest rate, $\Delta\overline{RGDP}$ refers to steady-state real GDP growth rate, ρ_r denotes the persistence of interest rate, ρ_π and ρ_{gdp} denote weight of CPI inflation and real GDP growth stabilization in interest rate rule, respectively.

3. Parameterization

Table 1 shows the value the parameters used for baseline simulation. For parameters commonly seen in the New Keynesian model, value assigned is pretty standard. For instance, we assume a subject discount rate of 4 percent per year, giving us $\beta = 0.99$. Share of materials used in the production of upstream intermediate sector, which presumes the role of capital stock in typical Cobb-Douglas production function, takes a value of 0.6. Households are assumed to be risk neutral so that $\sigma = 1$. Price of downstream output is revised once in a year as $\theta = 0.75$. Approximating the Bayesian estimates of the share of imported materials/intermediates in upstream and downstream production available in Wong et al. (2014), we assume the share to be 0.5 in both economies. Elasticity of substitution of all types takes the value of 1.5. Efficient shocks are persistent at the value of $\rho_Z = \rho_H = 0.8$. Last but not least, parameters of the interest rate rule take conventional values, in which weight on inflation stabilization is 1.5 and that on yearly real growth stabilization is 0.125.

There are another set of parameters specifically related to industrial upgrading and RMBI. Assume that proportion of skill-based firm in steady state is $\bar{N}^{s} = 0.2$. By setting $\gamma^{s} = 8$, $\gamma^{u} = 1$, and $\text{prop} = 0.00625$, we obtain annual skill-biased growth rate of 4 percent and non-skill-biased growth rate of 2 percent. High-quality innovation is assumed to be more responsive to R&D expenditure, so $\mu_s = 0.5$ vis-à-vis $\mu_u = 3$. In the process of getting a consistent steady state values for upstream output, materials, and wages, we set $\bar{A}^{s} = 1.24$, as compared with a predetermined $\bar{A}^{s} = 1$. In a zero profit steady state, wherein there is neither entry nor exit in upstream industry, we find $\mathbb{F}^{s} = 0.184$ and $\mathbb{F}^{u} = 0.01$. The latter implies that entry cost in non-skill-based sector is nearly zero. Following the literature of endogenous firm entry (see, for instance, Bergin and Corsetti, 2015), firm's death rate is set at $\delta = 0.025$ per quarter. High-quality intermediate inputs are more differentiated and hence less elastic compared with low-quality intermediates, so $\epsilon^{s}(= 6) < \epsilon^{u}(= 11)$. The scale parameter for endogenous choice of invoicing currency takes the value of $\zeta = 0.1$ so that proportion of yuan-invoiced trade accounts for 5 percent of total trade in steady state. Cross-border adjustment cost is set at $\Phi_{\mathbb{K}} = 6$. PBoC is assumed to heavily sterilize foreign exchange intervention $\tau = 0.01$ compared with unsterilized intervention by foreign central bank, $\tau = 1$.

[INSERT TABLE 1 HERE]

We check the appropriateness of the calibrated model by comparing the simulated dynamics with those exhibited in the data. In particular, as the ensuing discussion focuses on industrial upgrading, RMBI and capital account liberalization associated with yuan appreciation, we try to replicate the persistence of dynamics exhibited in yuan-dollar nominal exchange rates spanning the periods from 2005 third quarter to 2013 first quarter. We hit the model with innovations in yuan-dollar exchange rate, upstream and downstream TFP, and price markup in upstream skill-based production by one standard deviation. Figure 1 illustrates the autocorrelations in Chinese real GDP growth rates, CPI inflation rates, short-term interest rates, and yuan-dollar exchange rates. The simulated model replicates the dynamics of real GDP growth and CPI inflation, especially in the first four lags, particularly well. It is also able to trace the direction of persistence in interest rates and exchange rates.

[INSERT FIGURE 1]

4. Implications of persistent appreciation on industrial upgrading

To shed light on how industrial upgrading and RMBI take effect under a persistent yuan appreciation, we hit the model with an innovation in yuan-dollar exchange rate (Eq. 64) by one standard deviation that has a first-order lag with coefficient 0.8. This AR(1) process approximates the autocorrelation function exhibited in the data as shown in Figure 1. Shock hitting yuan-dollar exchange rates is presumed for all subsequent experiments.

4.1. Baseline dynamics

Figure 2 illustrates the responses of the model economy to the persistent shock hitting yuan-dollar exchange rate. Yuan appreciation is seemingly beneficial to industrial upgrading and RMBI (to smaller extent). Firms are apparently induced to participate in skill-based upstream sector, leading to a greater expansion in the share of skill-based firms compared with non-skill-based upstream sector, which in turn, results in a skill-biased innovation. As businesses are formed more actively in skill-based upstream sector that requires the import of materials, importing activity is expected to react more than exporting activity. Despite the fact that appreciation hurts the real GDP growth on impact, it supports a stronger growth in subsequent periods, though short-lived. On balance, it can be concluded that yuan appreciation facilitates industrial upgrading that instigates skill-biased innovation and stimulates trade without being impactful on the real economic growth.

Turning to RMBI, the share of Chinese export priced in the renminbi has also expanded in responding to yuan appreciation. This is mainly due to the lowering profitability of dollar-priced export denominated in local currency. The effect sustains even when the appreciation shock is diminishing over time.

[INSERT FIGURE 2HERE]

4.2. Identifying the underlying mechanisms

What underlie the mechanisms of industrial upgrading in associated with yuan appreciation? Based on Eq. (37), four channels can be identified. First is the *quality threshold channel* that influences sunk entry cost and thus expected profitability of participating in skill-based sector. In baseline model, by setting $\mu_{s}(= 0.5) < \mu_{u}(= 3)$, we indeed assume that innovations of firms in skill-based sector is more responsive to investment expenditure than those of non-skill-based firms. What if they are not? Is this assumption important to the dynamics illustrated in Figure 2? We reset the parameter to $\mu_{s} = 3$ so that firms' innovations in both sectors are equally responsive to investment expenditure. This new assumption also implies an increase in quality threshold from 0.205 to 0.351, making profitable entry into skill-based sector more demanding.

Second is the *imported input channel*. As upstream skill-based sector uses both domestic and imported inputs, is industrial upgrading promoted by the use of imported inputs? To answer this question, we reset the share of imported inputs in upstream skill-based sector to $\kappa_{\mathrm{u}} = 0.8$ so that imported inputs account for a greater role in the production. Third is the *global demand channel*. Given the model setting that part of the upstream skill-based outputs will be exported to foreign downstream for further processing, a natural question to ask is if global demand for upstream export is critical as a driving factor to induce firm entry into upstream skill-based sector. We probe into this channel by increasing the share of domestic intermediate inputs in foreign downstream production to $\kappa_d^* = 0.8$. It is noteworthy to mention that having a greater κ_u and κ_d^* implies a closer integration of China's production structure into global value chain.

The last channel is *capital flow channel*, which indirectly influences expected profitability of forming business in skill-based sector and thus industrial upgrading through discount factor and Euler consumption. By allowing for unrestricted cross-border capital flows, expectation of continuous appreciation can pull capital inflows, driving up today's equity prices. According to arbitrage condition in Eq. (47) and Euler consumption in Eq. (45), rising equity price implies a lower interest rate, which in turn stimulates current consumption, grabbing downstream resources available for upstream production as materials (see market clearing condition in Eq. (4)). Discouraged by the more expensive materials, entry in upstream sector can be lackluster. We leave the discussion on capital flow channel to next session when we probe into the implication of liberalizing China's capital account.

[INSERT FIGURE 3]

Dynamic responses of the economy to yuan appreciation under alternative assumptions while holding capital flow channel absent are illustrated in Figure 3. Quality threshold channel stands out to be the most critical factor to the decision of firm entry. A slightly higher quality threshold (due to innovation that is less responsive to R& D expenditure) is adequate to offset the beneficial effect of yuan appreciation on industrial upgrading. In contrast, being able to export the output does not influence firm's decision to enter skill-based sector in non-trivial way. However, using more imported inputs significantly increases the share of skill-based firm, leading to a stronger and more sustainable skill-biased innovation. In our context wherein number of firms indicates number of product varieties, being able to engage in greater import of inputs also results in the availability of more product varieties. This finding is interestingly coherent with the available empirical evidence which generally finds that importing inputs benefits sector producing high-quality product (Amiti and Khandelwal, 2013), creates new products (Colantone and Crino, 2014), and contributes to quality and industrial upgrading (Bas and Strauss-Kahn, 2015; Crino, 2012; Feng et al., 2012).

4.3. Role of quality competition

In this section, we check the robustness of the results against the degree of elasticity of substitution. There are three types of elasticity of substitution related to production in the model: that between domestic and imported materials in upstream skill-based production, between low-quality and high-quality domestic intermediate inputs, and between domestic and imported intermediate inputs in downstream production. Instead of being substitutable, we now assume that these inputs are complementary to each other in respective category. To do so we set $\eta = \rho = \vartheta = 0.7$. As illustrated in Figure 4, while the relationship between domestic and imported materials in upstream skill-based sector and that between low-quality and high-quality domestic intermediate inputs in downstream production are irrelevant to the dynamics, complementarity between domestic and imported intermediate inputs in downstream production can demotivate firm's decision to enter skill-based sector, thwarting skill-biased innovation.

[INSERT FIGURE 4]

The key is the *scope of quality competition*. Recall Eq. (2) that domestic intermediate inputs bundle comprises both low-quality and high-quality upstream output as intermediate inputs in downstream production. If domestic bundle irrespective of the components is complementary to the imported high-quality foreign intermediate inputs, there is no scope for quality competition that motivates local quality upgrading. Put it differently, in a competing relationship with imported high-quality intermediate inputs, domestic inputs have to be of high-quality as well. This incentivizes firm entry in skill-based upstream sector, producing high-quality intermediate inputs in substitution of the imported one for downstream production.

5. Do RMBI and capital account liberalization complement industrial upgrading?

We revisit the central question of the paper in this last section by considering three circumstances. First, suppose the renminbi has been widely used as invoicing currency such that the share of yuan-priced export accounts for 50% of total trade. We fix $\phi = 0.5$ and $\zeta = 1$. What if PBoC liberalizes China's capital account but maintains a tight control on yuan-dollar exchange rates and a sterilized foreign exchange intervention? In the second circumstance of partial capital account liberalization, we lower the parameter value governing capital account restriction to $\Phi_{\mathbb{K}} = 0.01$ while $\tau = 0.01$ and Eq. (64) remains. Last, we presume full capital account liberalization in the sense that cross-border capital account restriction is lifted and PBoC abandons the heavily managed floating exchange rate regime for a market-determined, unsterilized floating exchange rate. Figure 5 illustrates the responses of the economy when being hit by one standard deviation innovation in yuan-dollar exchange rates under "RMBI", "Partial CA liberalization", and "Full CA liberalization" that correspond to the aforementioned circumstances, respectively.

[INSERT FIGURE 5]

Obviously, although increasing use of the renminbi as invoicing currency neither complement nor obstruct industrial upgrading in non-trivial way, capital account liberalization does matter for industrial upgrading in that partial capital account liberalization further foster industrial upgrading whereas full capital account liberalization nearly offset the quality-upgrading effect of yuan appreciation. While the absence of quality-upgrading effect under full liberalization can be partly explained by the temporary yuan appreciation, negative capital flow channel takes the blame as well. Unlike the case of partial liberalization, in which current consumption falls most drastically, releasing resource for upstream production that supports consumption in the future, consumption under full liberalization barely changes.

6. Conclusion

The paper contributes to the literature by probing into macroeconomic environment conducive for industrial upgrading in China associated with yuan appreciation. Added to an otherwise two-country New Keynesian macroeconomic model are three interconnected features to account for industrial upgrading, which include innovation possibility frontier in Acemoglu et al.'s (2015) style, endogenous firm entry subject to sunk entry cost varying with the level of technology in the spirit of Sutton (2012), and input-output structure with feedback loop to account for vertical trade in intermediate inputs (Wong and Eng, 2013). Although separately these features are not new, pieced together it makes a novel contribution on how to view quality and industrial upgrading through macroeconomic lens.

To sum up, we find that a persistent yuan appreciation could promote industrial upgrading without hurting real economic growth, especially when innovation is very elastic to R&D expenditure, upgrading leverages on imported quality inputs, and scope of competition in upstream product market is broader. The former lowers quality threshold, the middle adds to the product variety, while the latter creates postinnovation rents in terms of substitution of imported intermediate inputs for downstream processing. All empower greater business formation in skill-based sector to instigate skill-biased technological progress.

Back to the central question of the paper: do renminbi internationalization and capital account liberalization complement industrial upgrading? The answers are no and yes. While renminbi internationalization is irrelevant, how capital account liberalization proceeds is impactful on industrial upgrading. Whether to maintain a managed or clean float after liberalizing capital account particularly deserves further scrutiny.

Although our narrative is about China's industrial upgrading, we believe that the lesson can be generalized to other developing economies fighting to break through the middle. There are two important extensions to our model which we believe are important to gain richer insight on the underlying mechanism for upgrading: direct investment and financial friction. Trade within global production is closely related to direct investment. It would be interesting to see how direct investment flows would incentive quality upgrading on top of the existing mechanisms. Trade needs financing, and financing requires collateral, of which the value can be affected by exchange rate and share price driven by international portfolio capital flows ensuing capital account liberalization. Embedding financial friction into the model shall enrich quality-upgrading effect of capital flows.

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Table 1
Parameterization

		Industrial upgrading & RMB internationalization related	
Share of materials in upstream production α	0.6	Fixed cost parameter in skill-based production $\mathbb{F}^{s}$	0.184
Subject discount rate β	0.99	Fixed cost parameter in non-skill based production $\mathbb{F}^{u}$	0.01
Constant relative risk aversion σ	1	Scale parameter for skill-biased innovation growth rate γ^{s}	8
Weight of labor disutility χ	0.2	Scale parameter for non-skill-biased innovation growth rate γ^{u}	1
Price stickiness at downstream production θ	0.75	Probability of successful innovation prop	0.00625
Share of imported materials in upstream production κ_{u}, κ_{u}^{*}	0.5	Elasticity of skill-biased innovation to R& D expenditure $1/\mu^{\hbar}$	2
Share of imported intermediate input in downstream production κ_{d}, κ_{d}^{*}	0.5	Elasticity of non-skill-biased innovation to expenditure $1/\mu^{\ell}$	0.333
Foreign home bias in consumption γ^{*}	0.7	Fraction of firm exit	0.025
China's home bias in consumption γ	0.5	Price stickiness	0.75
Els between home and imported consumer goods φ	1.5	Els between high-quality varieties ϵ^{s}	6
Els between home and imported materials in skill-based upstream production η	1.5	Els between low-quality varieties ϵ^{u}	11
Els between low-quality and high-quality intermediates in downstream production ρ	1.5	Portfolio adjustment cost $\Phi_{\mathbb{K}}$	6
Els between home and imported high-quality intermediates in downstream production ϑ	1.5	Scale parameter for endogenous choice of invoicing currency ζ	0.1
Persistence of TFP/preference shocks ρ_Z	0.8	China's FXI sterilization τ	0.01
Interest rate persistence ρ_r	0.7	Foreign FXI sterilization τ^{*}	1
Weight on inflation stabilization ρ_π	1.5	Persistence of capital outflow shock	0.7
Weight on real growth stabilization ρ_g	0.03125	Persistence of capital inflow shock	0.7

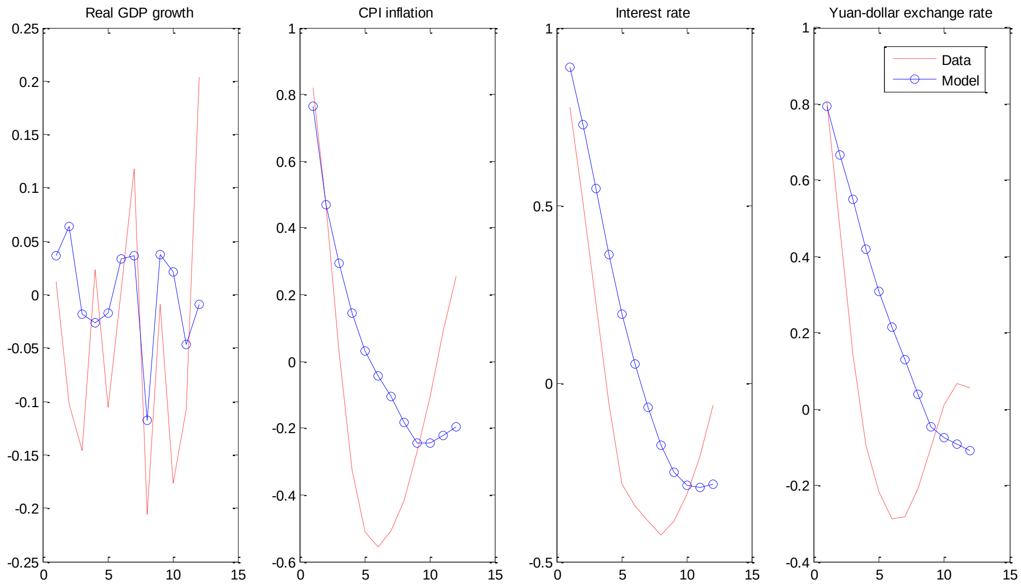
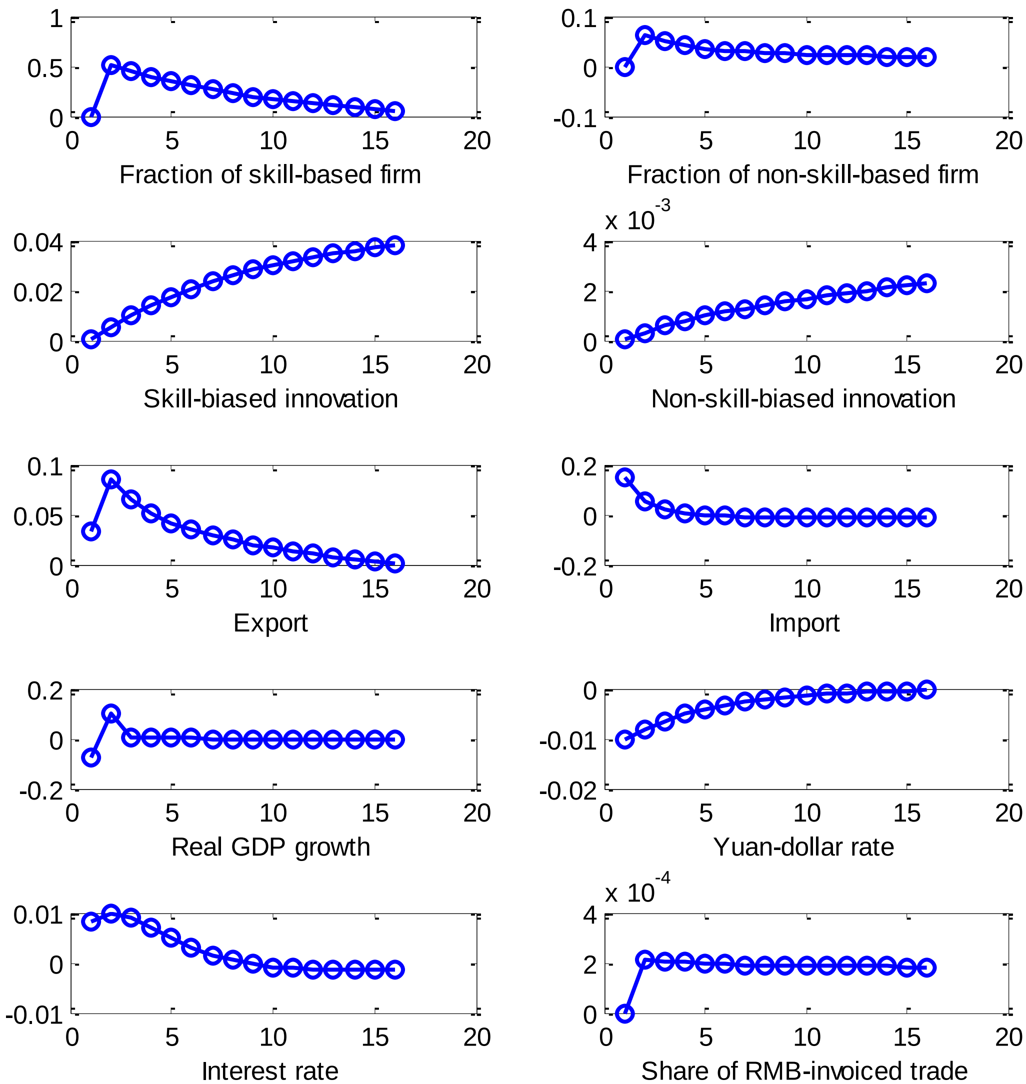
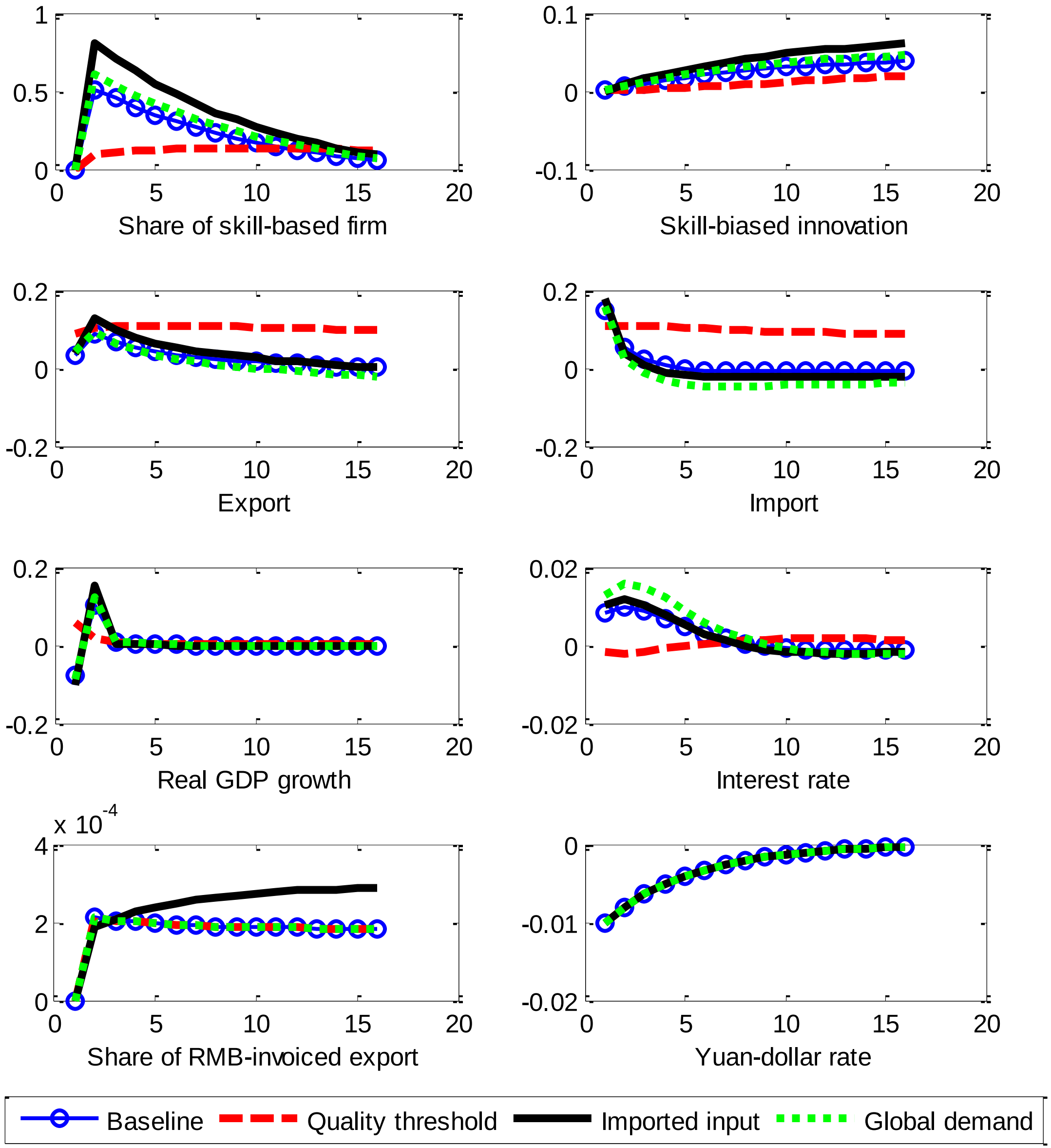


Fig. 1. Autocorrelation



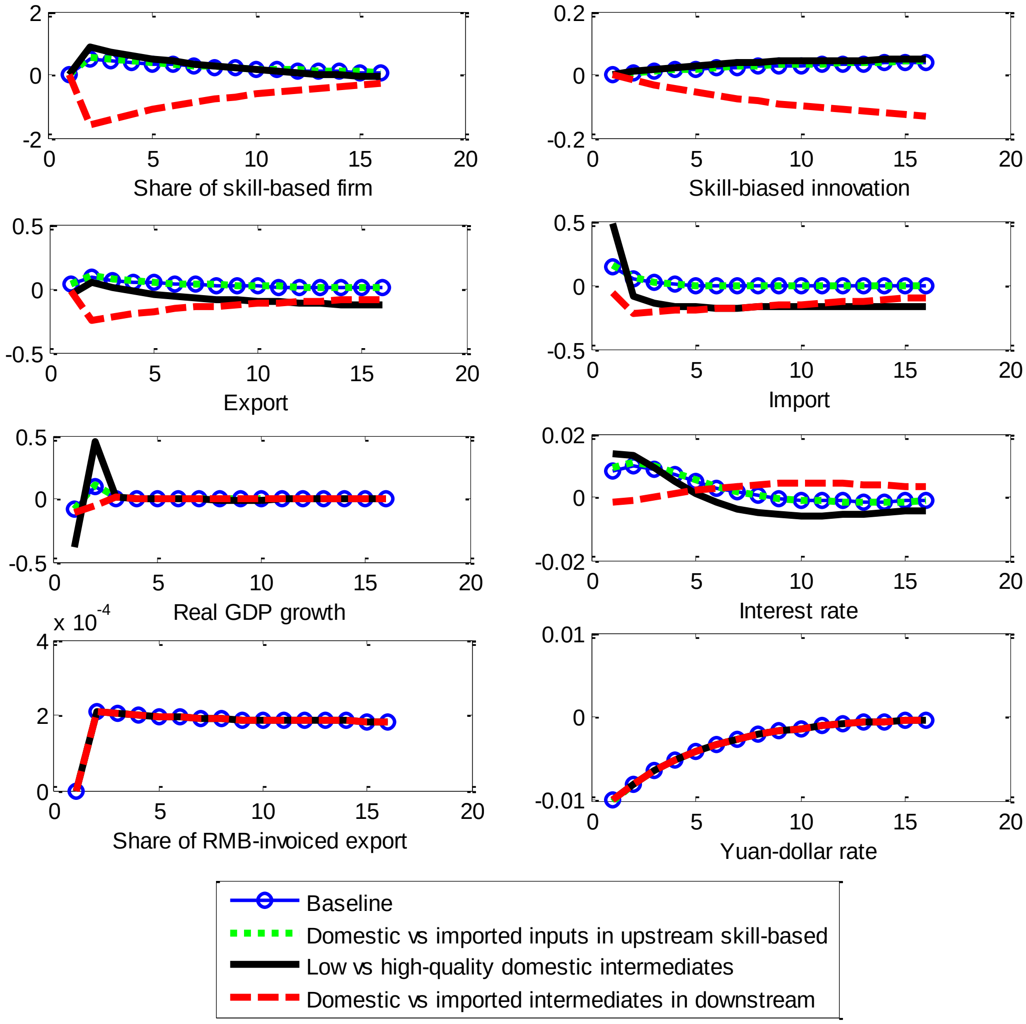
Note: Y-axis: Percentage change; *X*-axis: Quarters

Fig. 2. Dynamic responses to shock hitting yuan-dollar nominal exchange rate by one s.d.



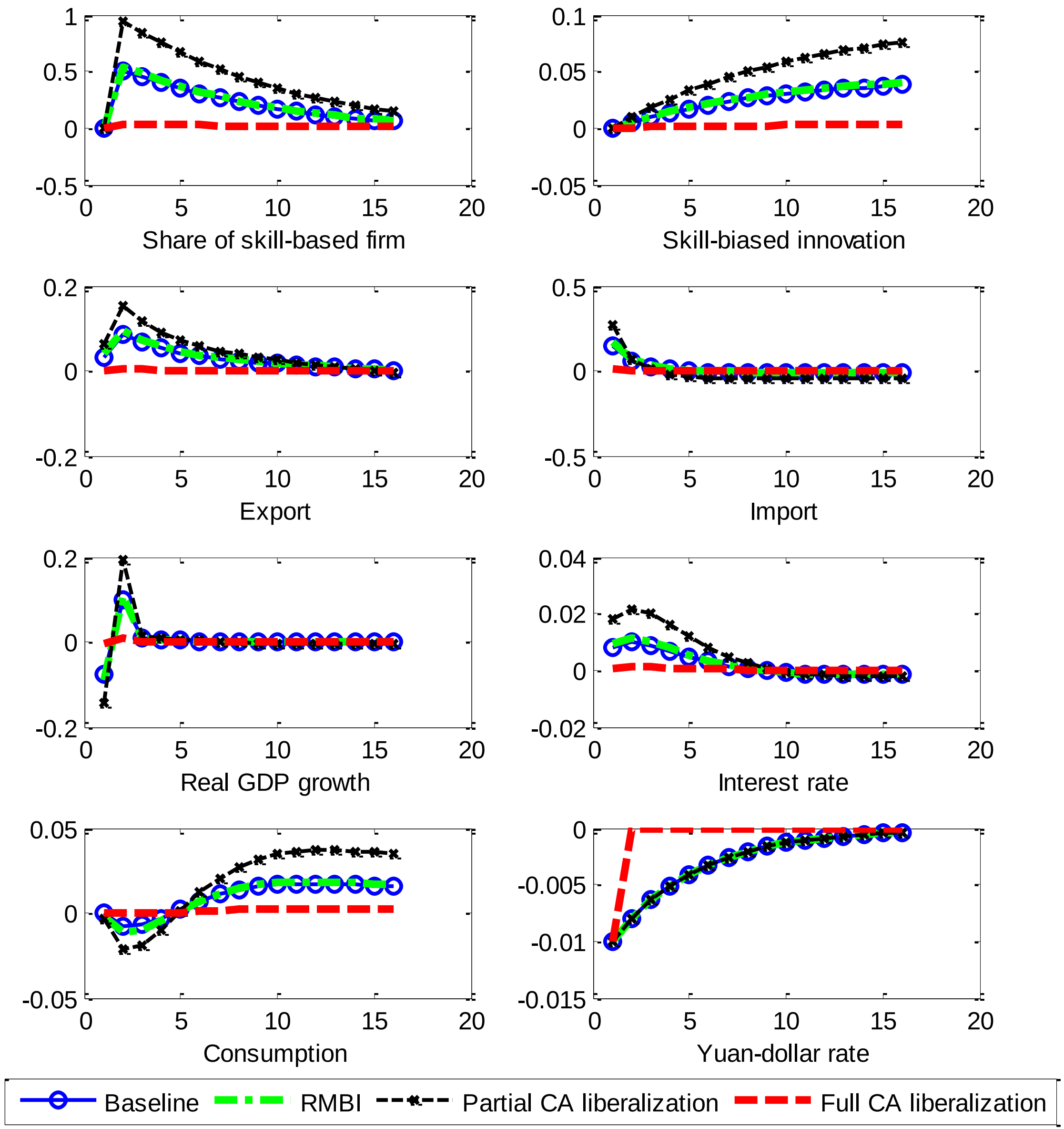
Note: Y-axis: Percentage change; *X*-axis: Quarters

Fig. 3. Identifying the underlying mechanisms



Note: Y-axis: Percentage change; *X*-axis: Quarters

Fig. 4. The role of elasticity of substitution



Note: Y-axis: Percentage change; *X*-axis: Quarters

Fig. 5. Do RMBI and capital account liberalization complement industrial upgrading?