What shape the spillovers of China's industrial upgrading and renminbi internationalization to ASEAN? Lessons from a New Keynesian model of endogenous firm entry and invoicing currency

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October 2015 (Very preliminary draft)

Abstract

Motivated by the observation of concurrent China's industrial upgrading and the renminbi internationalization despite steady yuan appreciation, we propose a perspective on how China's ambitious dreams would have impacted on ASEAN Economic Community (AEC)'s goal to establish an integrated regional production hub. We develop a two-country New Keynesian model featuring cross-border upstream-downstream linkage with feedback loop to account for global value chains. Firm entry into upstream skill-based sector is endogenous, so that the mass of business formation in upstream skill-based sector producing differentiated tradable intermediates determines the success of skill-biased technological progress and hence of industrial upgrading. Exporters are also allowed to self-sort into dollar-invoiced or yuan-invoiced trade. Rising yuan-invoiced trade signifies intensifying renminbi internationalization. We find that AEC industrial upgrading is favorably coupled to China's one, facilitated through global input-output linkage, dollar pricing strategy, and quality competition channel. Once China's capital account is liberalized, yuan appreciation strategy would disrupt industrial upgrading in both regions. Anchoring exchange rates either against yuan or dollar is of little help for AEC. By targeting price markup of downstream export in monetary policy deliberation, however, a stable cost environment conducive for entry in upstream skill-based sector is created, leading to more persistent skill-biased technical progress in AEC in the face of an open and catching-up China.

Keywords: Industrial upgrading, renminbi internationalization, firm entry, invoicing currency, global production
JEL classification: F12, F41, F42

*Correspondence author: wongcy@utar.edu.my. The paper was initiated and partly completed during the first author's visit to Stockholm China Economic Research Institute (SCERI) at Stockholm School of Economics as visiting research fellow. He is grateful to the generous financial support provided by Lars-Erik Thunholms Stiftelse for Vetenskaplig Forskning and warm hospitality.

1. Introduction

The Chinese yuan has been appreciating by nearly 1 percent per quarter on average for eight years consecutively in the aftermath of abandoning its dollar peg. Apparently, no trade and production structure can stay unmarked in the face of appreciation of this magnitude and longitude. Hsu et al. (2014), for instance, find that China's export structure became more similar to that of the developed countries after the currency appreciation. Meanwhile, Li et al. (2014) evidence that yuan appreciation significantly increases the probability of firm entry and products adding, more in ordinary than processing trade. Viewing these pieces of evidence together, we can infer that China is leveraging on appreciation, whether being a deliberate strategy or not, to move up the value chains.

At about the same time, trend appreciation which upholds the renminbi as a stable and even increasingly-yielding currency has greased the wheel to make the renminbi goes global. Although exporters and importers in five cities were allowed to settle cross-border trade deals in renminbi via banks in Hong Kong with direct correspondent accounts in mainland banks as late as in June 2009 under a pilot scheme launched by the People's Bank of China, within three years' time approximately 12% of China's total trade was settled in renminbi. Ito and Chinn (2015) predict that the share of renminbi invoicing in China's exports will rise to above 25% in 2015 and above 30% in 2018.

Of interest in our context is how exactly China's industrial upgrading and renminbi internationalization associated with yuan appreciation would have impacted on ASEAN Economic Community (AEC). In contrast to previous literature on the implications of China's emergence on the world economy, Southeast Asia in particular, which largely focus on export

competition/complementary (see, for instance, Roland-Holst and Weiss, 2004; Eichengreen et al., 2007; Greenaway et al., 2008; Wood and Mayer, 2011; Wong et al., 2014), we make a novel contribution that provides a new perspective on the source of linkage by probing into how China's industrial upgrading shapes AEC's own effort to upgrade industrial structure.

We do so by setting up a two-country New Keynesian model. Added to the otherwise standard macroeconomic model of international transmission is endogenous firm entry within an upstream-downstream structure closed with a feedback loop. We let firms' decision whether to form business in upstream skill-based or non-skill-based sector be endogenous to sector's profit relative to industry's overall profit, so that the mass of business formation in upstream skill-based sector producing differentiated tradable intermediates determines the success of skill-biased technological progress and hence of industrial upgrading. Moreover, we incorporate three features to shed light on two different aspects of renminbi internationalization. First, exporters are allowed to self-sort into dollar-invoiced or yuan-invoiced trade. Rising yuan-invoiced trade thus indicates intensifying renminbi internationalization in the sense of increasing use of the renminbi as invoicing currency. Second, by resorting to portfolio balance approach, we model international portfolio capital flows that explicitly account for China's capital account convertibility. Deeper sense of renminbi internationalization involves liberalization of capital account.

Previewing our findings, we show that AEC industrial upgrading can be favorably coupled to China's one, facilitated through global input-output linkage and dollar pricing strategy. Greater business formation in China's upstream skill-based sector requires larger supply of quality materials, including those exported from AEC at lower price due to yuan appreciation. This makes skill-based sector in AEC producing tradable differentiated intermediates more profitable

to induce entry. We also show that yuan appreciation strategy in the face of a liberalized capital account would instigate drastic capital flows that disrupt industrial upgrading in both regions. Anchoring exchange rates either against yuan or dollar is of little help for AEC. But interestingly, by contemplating downstream export price inflation in monetary policy deliberation, we can recoup those favorable spillovers from China's industrial upgrading to AEC even in the face of China's liberalized capital account, in fact, to a better extent: entry in skill-based sector expands much stronger and skill-biased technical progress become more persistent.

Issues we work on and modelling strategy we make use of relate our paper to several branches of literature. Above all, our paper contributes to the China's Southeast Asian spillovers literature, which usually pays attention to export competition, by introducing endogenous industrial upgrading. To the best of our knowledge, our paper is the first to address and explain the spillovers of China's industrial upgrading and renminbi internationalization simultaneously.

The model of global production we develop also allows us to contribute to another growing literature pertaining to the macroeconomic effects of global value chains (e.g., Feenstra 2010; Timmer et al., 2014; Johnson, 2014b), particularly with respect to how shocks are transmitted through vertical and sequential production linkage (e.g, Kose and Yi, 2001, 2006; Burstein et al., 2008; Arkolakis and Ramanarayanan, 2009; di Giovanni and Levchenko, 2010; Wong and Eng, 2013; and Johnson 2014a). Our novelty lies in the introduction of endogenous business formation and directed technical change as new source of cross-border linkage within a model of global production.

The concept of industrial upgrading in our paper hinges on model of directed technical change that links direction of innovation to firm entry endogenous to expected profitability in exporting

high-quality intermediates. In view of this, our paper can be placed in the literature, including Thoenig and Verdier (2003), Epifani and Gancia (2008), and Acemoglu et al. (2015), which show how international trade can induce technical changes that further increase demand for skills. We pain a different color on the literature by bridging international trade to directed technical change with endogenous firm entry.

Of all the bells and whistles, endogenous firm entry is apparently the most important one that gives a new perspective to international transmission mechanisms by underpinning five different channels, namely input-output linkage, quality competition channel, pricing channel, capital flows channel, and price markup stabilization channel. In this respect, our paper expands the boundary of literature on endogenous entry which typically investigates internal and external propagation mechanisms (eg., Bilbiie et al., 2012; Ottaviano, 2012; Cavallari, 2013; and Bergin and Corsetti, 2015). Our finding that entry in upstream skill-based sector can be induced and fostered by stabilizing downstream export price markup indeed resembles the core result of Bergin and Corsetti (2015).

The rest of the paper proceeds as follows. Section 2 presents our two-country New Keynesian model of industrial upgrading. From there we identify five mechanisms of cross-border shock transmission. The model is expanded in Section 3 to account for renminbi internationalization through the lens of endogenous choice of invoicing currency and portfolio balance approach to capital flows. Section 4 completes the model, before being parameterized in Section 5. Section 6 discusses dynamic responses of AEC to steady yuan appreciation against the U.S. dollar under different circumstances. Section 7 concludes.

2. A New Keynesian model of industrial upgrading

To illustrate we take a canonical two-country New Keynesian macroeconomic model, treat AEC explicitly as home country whereas China as foreign country (the U.S will come into play as exogenous force), and add to that three new ingredients to account for an endogenous industrial upgrading. Firstly, while upstream firms provide intermediates to downstream firms for final processing along with imported intermediates, unlike a typical New Keynesian model, part of the final products would be transformed into materials for both home and foreign upstream production. In this way, we establish a simple input-output structure with a feedback loop that resembles a global value chain.

Secondly, upstream industry consists of no-skill-based and skill-based sectors. The former uses labors and domestic materials to produce low-quality intermediates completely for downstream processing, whereas the latter uses labors and a combination of domestic and imported materials to produce high-quality intermediates. While all low-quality outputs are used by domestic downstream firms, part of the high-quality intermediates would be exported. Lastly, we let the innovation possibility frontier be determined by the numbers of firms entering low-quality or high-quality intermediate production sectors. And entry decision is endogenous to relative profitability in the spirit of Acemoglu et al.'s (2015) directed technical change.

Expanding business formation in skill-based upstream sector pushes innovation possibilities frontier outward biasedly toward high-quality intermediates. Due to the resultant shift toward high-quality intermediates in the bundle of domestic intermediates for downstream processing, the quality of final output is lifted as well. Hence, industrial upgrading can be understood as quality upgrading of overall production structure. Following industrial upgrading, it is also not unreasonable to expect a substitution of domestic materials/intermediates with better quality for imported one, leading to a rise in domestic value added in production and gross exports.

Moreover, coupled with increasing availability of high-quality intermediates at extensive margin, intermediates exports shall account for an increasing share of total exports along industrial upgrading process.

Against this backdrop, we proceed to the detailed description of the model with focus on AEC (a). The superscript * denotes transaction or production taking place in China (c), whereas no notation is assigned if it were in AEC. The subscript ac indicates a flow of products from AEC to China, and vice versa, while aa simply means products produced in AEC for AEC.

2.1. Upstream-downstream production structure

There is an upstream-downstream production linkage in the model. The final goods $Y_t(j)$ is produced by a mass continuum of monopolistically downstream firms j, for $j \in [0,1]$, using domestic $X_t(j)$ and imported high-quality intermediates $X_{ca,t}^{*h}(j)$ with a CES technology

$$Y_t(j) = e^{Z_{TFP,d,t}}\left[(1-\kappa_d)^{1/\vartheta} X_t(j)^{1-1/\vartheta} + {\kappa_d}^{1/\vartheta} X_{ca,t}^{*h}(j)^{1-1/\vartheta}\right]^{\vartheta/(\vartheta-1)} \quad (1)$$

where

$$X_{ca,t}^{*h}(j) = \left(\int_0^{N^{*h}} X_{ca,t}^{*h}(i^*)^{1-1/\epsilon^h} di^*\right)^{\epsilon^h/(\epsilon^h-1)}$$

The parameter $\vartheta > 0$ is the elasticity of substitution between domestic and foreign intermediates bundles, and κ_d denotes foreign share of intermediates in downstream production. $Z_{TFP,d,t}$is the first-order autoregressive total factor productivity (TFP) process affecting downstream industry. Of interest is the domestic intermediates bundle that consists of low-quality $X_t^{\ell}(j)$ and high-quality $X_{aa,t}^{h}(j)$ intermediates (the terms non-skill-based versus skill-based and low-quality

versus high-quality are used interchangeably throughout the text) sourced from domestic upstream sectors.

$$X_t(j) = \left[X_t^{\ell}(j)^{1-1/\rho} + X_{aa,t}^{\hbar}(j)^{1-1/\rho}\right]^{\rho/(\rho-1)} \tag{2}$$

where $\rho > 0$ is the elasticity of substitution between low-quality and high-quality domestic intermediates, which, respectively, are a CES aggregate of a continuum of intermediates of variety i,

$$X_t^{\ell}(j) = \left(\int_0^{N^{\ell}} X_t^{\ell}(i)^{1-1/\epsilon^{\ell}} di\right)^{\epsilon^{\ell}/(\epsilon^{\ell}-1)}$$

$$X_{aa,t}^{\hbar}(j) = \left(\int_0^{N^{\hbar}} X_{aa,t}^{\hbar}(i)^{1-1/\epsilon^{\hbar}} di\right)^{\epsilon^{\hbar}/(\epsilon^{\hbar}-1)}$$

where $i \in \left[0, N^{\ell}\right]$ for low-skilled sector and $i \in \left[0, N^{\hbar}\right]$ for high-skilled sector. $\epsilon^{s} > 1$ is the elasticity of substitution between varieties in upstream industry for sector $s \in \{\ell, \hbar\}$. We assume $\epsilon^{\hbar} < \epsilon^{\ell}$ as high-quality varieties are more differentiated and unique than low-quality varieties.

N^{ℓ} and $N^{\hbar}$ are the measure of firms/varieties of intermediates in upstream industry. By normalizing aggregate numbers of firms/varieties to one, $N^{\ell} + N^{\hbar} = 1$ becomes the measure of fraction of firms participating in each sector. We would detail how these fractions of firms change endogenously over time due to the new entries directed by the relative expected profitability in next section. For now, it is suffice to show that aggregators over symmetric varieties of domestic and imported intermediates can be rewritten as

$$X_t^{\ell}(j) = \left(N_t^{\ell}\right)^{\frac{\epsilon^{\ell}}{\epsilon^{\ell}-1}} X_t^{\ell}(i);\ X_{aa,t}^{\hbar}(j) = \left(N_t^{\hbar}\right)^{\frac{\epsilon^{\hbar}}{\epsilon^{\hbar}-1}} X_{aa,t}^{\hbar}(i);\ X_{ca,t}^{*\hbar}(j) = \left(N_t^{*\hbar}\right)^{\frac{\epsilon^{\hbar}}{\epsilon^{\hbar}-1}} X_{ca,t}^{*\hbar}(i) \tag{3}$$

Market for final goods is cleared by consumption of domestic C_{at} and foreign households $C_{ac,t}$, and re-investment as materials by domestic and foreign upstream firms.

$$Y_t(j) = \int_0^1 C_{a,t}(z)dz + \int_0^1 C_{ac,t}(z^*)dz^* + \int_0^{N^\ell} M_t^\ell(i)di + \int_0^{N^\hbar} M_{aa,t}^\hbar(i)di + \int_0^{N^{*\hbar}} M_{ac,t}^\hbar(i^*)di^* + f_{et}^\hbar + f_{et}^\ell \tag{4}$$

Note the wedge between output and consumption which takes the form of sunk entry cost in high-quality $f_{et}^\hbar$ and in low-quality intermediates production f_{et}^ℓ. We will elaborate its function in later section.

Turning to upstream sector $s \in (\ell, \hbar)$ 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 such a way that

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

where $Z_{TFP,u,t}$ is the AR(1) TFP shock in upstream production. $A_t^s(i)\left(=\int_0^1 A_t^s(j)dj\right)$ is the average quality of materials over variety j in sector s. 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 $M_t^\ell(i) = \left(\int_0^1 M_t^\ell(j)^{1-1/\epsilon^\ell} dj\right)^{\epsilon^\ell/(\epsilon^\ell-1)}$, whereas skill-based sector processes

domestic materials $M_{aa,t}^{\hbar}(i)\left(=\left(\int_0^1 M_{aa,t}^{\hbar}(j)^{1-1/\epsilon^{\hbar}}dj\right)^{\epsilon^{\hbar}/(\epsilon^{\hbar}-1)}\right)$ along with imported materials $M_{ca,t}^{*\hbar}(i)\left(=\left(\int_0^1 M_{ca,t}^{*\hbar}(j^*)^{1-1/\epsilon^{\hbar}}dj^*\right)^{\epsilon^{\hbar}/(\epsilon^{\hbar}-1)}\right)$ in CES aggregator

$$M_t^{\hbar}(i)=\left[(1-\kappa_u)^{1/\eta}\left(M_{aa,t}^{\hbar}(i)\right)^{1-1/\eta}+{\kappa_u}^{1/\eta}\left(M_{ca,t}^{*\hbar}(i)\right)^{1-1/\eta}\right]^{\eta/(\eta-1)} \tag{6}$$

where $\eta>0$ denotes the elasticity of substitution between domestic and imported materials in high-quality intermediates 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.

$$Y_t^{\ell}(i)=\int_0^1 X_t^{\ell}(j)dj$$

$$Y_t^{\hbar}(i)=\int_0^1 X_{aa,t}^{\hbar}(j)dj+\int_0^1 X_{ac,t}^{\hbar}(j^*)dj^* \tag{7}$$

2.2. Equilibrium condition

Facing upstream firms i in sector $s\in(\ell,\hbar)$ is the following cost minimization problem

$$\min_{H^s,M^s}\left(\frac{W_t}{P_t}\right)H_t^s(i)+p_{ut}^s M_{t-1}^s(i)$$

s.t.

$$r_{ut}^{s}(i)\{Y_t^s(i) - e^{Z_{TFP,u,t}} H_t^s(i)^{1-\alpha} M_{t-1}^s(i)^{\alpha} A_t^s(i)^{1-\alpha}\}$$

Given the real wage W_t/P_t and material price index p_{ut}^{s}, upstream firms i choose a sequence of labors and material bundles that minimizes the cost production. By denoting the Lagrangian multiplier r_{ut}^{s} as the unit real marginal cost for sector s in upstream industry, the first order conditions give us optimal demand for labor and material bundles as follows

$$H_t^s(i) = r_{ut}^{s}(i)(1-\alpha) Y_t^s(i) P_t/W_t \tag{8}$$

$$M_{t-1}^s(i) = r_{ut}^{s}(i)\alpha Y_t^s(i)/p_{ut}^{s} \tag{9}$$

which, together with Eq. (5), give us upstream real marginal cost

$$r_{ut}^{s}(i) = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)} e^{-Z_{TFP,u,t}} A_t^s(i)^{-1} (A_t^s(i) p_{ut}^{s})^{\alpha} (W_t/P_t)^{1-\alpha} \tag{10}$$

Firms i in skill-based sector have an additional decision to make: the optimal allocation between domestic and imported materials in the input bundle. The problem can also be formulated as choosing a sequence of domestic and imported materials at the market price that minimizes the cost of input bundle

$$\min_{M_{aa}^{h}, M_{ca}^{h}} P_{aa,t} M_{aa,t}^{h}(i) + \mathcal{P}_{ca,t}^{*} M_{ca,t}^{*h}(i)$$

s.t.

$$p_{ut}^{h}\left(M_t^h(i) - \left[(1-\kappa_u)^{1/\eta}\left(M_{aa,t}^{h}(i)\right)^{1-1/\eta} + {\kappa_u}^{1/\eta}\left(M_{ca,t}^{*h}(i)\right)^{1-1/\eta}\right]^{\eta/(\eta-1)}\right)$$

where p_{ut}^{h} as the Lagrangian multiplier can be defined as material price index in skill-based sector. Optimal demand schedules for $M_{aa,t}^{h}(i)$ and $M_{ca,t}^{*h}(i)$ by firm i, respectively, are

$$M_{aa,t}^{\hbar}(i) = (1-\kappa_u)\left(P_{aa,t}/\mathcal{P}_{ut}^{\hbar}\right)^{-\eta} M_t^{\hbar}(i) \tag{11}$$

$$M_{ca,t}^{*\hbar}(i) = \kappa_u\left(\mathcal{P}_{ca,t}^{*}/\mathcal{P}_{ut}^{\hbar}\right)^{-\eta} M_t^{\hbar}(i) \tag{12}$$

where material price index for upstream skille-based firm i can be solved as

$$\mathcal{P}_{ut}^{\hbar} = \left[(1-\kappa_u)\left(P_{aa,t}\right)^{1-\eta} + \kappa_u\left(\mathcal{P}_{ca,t}^{*}\right)^{1-\eta}\right]^{1/(1-\eta)} \tag{13}$$

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

Downstream firm j's optimization problem is also a two-stage decision. Firm j has to first optimally allocate resources between domestic and foreign intermediates, and next between low-quality and high-quality domestic intermediates. The corresponding cost minimization problem can be written as

$$\min_{X, X_{ca}^{*\hbar}} P_t^{ppi} X_t(j) + \mathcal{P}_{ca,t}^{*\hbar} X_{ca,t}^{*\hbar}(j)$$

s.t

$$r_{dt}(j)\left(Y_t(j) - e^{Z_{TFP,d,t}}\left[(1-\kappa_d)^{1/\vartheta} X_t(j)^{1-1/\vartheta} + \kappa_d{}^{1/\vartheta} X_{ca,t}^{*\hbar}(j)^{1-1/\vartheta}\right]^{\vartheta/(\vartheta-1)}\right)$$

and

$$\min_{X^{\ell}, X_{aa}^{\hbar}} p_t^{\ell} X_t^{\ell}(j) + \mathcal{P}_{aa,t}^{\hbar} X_{aa,t}^{\hbar}(j)$$

s.t.

$$P_t^{ppi}\left(X_t(j) - \left[X_t^{\ell}(j)^{1-1/\rho} + X_{aa,t}^{\hbar}(j)^{1-1/\rho}\right]^{\rho/(\rho-1)}\right)$$

where $r_{dt}(j)$ and P_t^{ppi} as the Lagrangian multipliers can be defined as unit downstream real marginal cost and producer price index (PPI), an index that accounts for the prices set by domestic intermediates seller from upstream industry. $\mathcal{P}_{ca,t}^{*\hbar}$ is a weighted average China's high-quality intermediates export price denominated in U.S dollar with a mix of dollar-invoiced and yuan-invoiced prices. We can solve for

$$X_t^{\ell}(j) = \left(N_t^{\ell}\right)^{\left(\rho-\epsilon^{\ell}\right)/\left(\epsilon^{\ell}-1\right)}\left(p_t^{\ell}/P_t^{ppi}\right)^{-\rho}(1-\kappa_d)\left(P_t^{ppi}/r_{dt}(j)\right)^{-\vartheta}Y_t(j) \tag{14}$$

$$X_{aa,t}^{\hbar}(j) = \left(N_t^{\hbar}\right)^{\left(\rho-\epsilon^{\hbar}\right)/\left(\epsilon^{\hbar}-1\right)}\left(p_{aa,t}^{\hbar}/P_t^{ppi}\right)^{-\rho}(1-\kappa_d)\left(P_t^{ppi}/r_{dt}(j)\right)^{-\vartheta}Y_t(j) \tag{15}$$

$$X_{ca,t}^{*\hbar}(j) = \kappa_d\left(\mathcal{P}_{ca,t}^{*\hbar}/r_{dt}(j)\right)^{-\vartheta}Y_t(j) \tag{16}$$

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

$$P_t^{ppi} = \left[\left(N_t^{\ell}\right)^{(\rho-1)/\left(\epsilon^{\ell}-1\right)}p_t^{\ell\,1-\rho} + \left(N_t^{\hbar}\right)^{(\rho-1)/\left(\epsilon^{\hbar}-1\right)}p_{aa,t}^{\hbar\;1-\rho}\right]^{1/(1-\rho)} \tag{18}$$

Eqs. (14) to (16) refer to the optimal demand for domestic and foreign intermediates, Eq. (17) is the unit real marginal cost for downstream production, and Eq. (18) shows PPI facing firms j in downstream industry.

2.3. *Firm entry, directed technical change, and industrial upgrading*

The average quality of intermediates in sector $\mathcal{s} \in \{\ell, \hbar\}$, $A_t^{\mathcal{s}}$, evolves over time according to the following difference equation as in Acemoglu et al. (2015)

Innovation possibility frontier: $$A_t^{\mathcal{s}} = (1 + \gamma^{\mathcal{s}} \text{prop} N_t^{\mathcal{s}}) A_{t-1}^{\mathcal{s}} \quad (19)$$

where $\text{prop} \in (0,1)$ is the probability of successful innovation identical across sectors $\mathcal{s}$, and $N_t^{\mathcal{s}}$ is the number of firms/varieties available in sector $\mathcal{s}$. Since the measure of total firms is normalized to one, $N_t^{\mathcal{s}}$ denotes the mass of firms involving in sector $\mathcal{s}$. In other words, $N_t^{\ell} + N_t^{\hbar} = 1$. As in Ghironi and Melitz (2005), entry $N_{et-1}^{\mathcal{s}}$ implies a one-period production lag so that all firms entering in a given period 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 $\mathcal{s}$ evolve according to

$$N_t^{\mathcal{s}} = (1 - \delta)(N_{t-1}^{\mathcal{s}} + N_{et-1}^{\mathcal{s}}) \quad (20)$$

The quality of intermediates improves by a factor of $1 + \gamma^{\mathcal{s}}$, where $\gamma^{\hbar} > \gamma^{\ell}$, conditional on the mass of firms participating in sector $\mathcal{s}$. Larger is the mass of firms, greater will be the potential to attain the growth rate $\gamma^{\mathcal{s}}$, pushing forward the quality frontier of production in sector $\mathcal{s}$. Hence, directed technical change is generally a function of the ratio of firms participating in upstream skill-based and non-skill-based sector.

Suppose an entrant can only choose to enter either sector at a point of time, $N_{et}^{\hbar} = 1 - N_{et}^{\ell}$, and ratio between the numbers of high-quality and low-quality entrants corresponds directly to ratio of expected profitability, $N_{et}^{\hbar}/N_{et}^{\ell} = V_t^{\hbar}/V_t^{\ell}$. From these assumptions, one can easily derive an "industrial upgrading function":

Industrial upgrading: $N_{et}^{\hbar} = V_t^{\hbar}/\left(V_t^{\hbar} + V_t^{\ell}\right)$ (21)

$N_{et}^{\hbar}$ can be interpreted as ex-ante decision to enter high-quality intermediates production or ex-post proportion of high-quality entrants. Either way, Eq. (21) shows that $N_{et}^{\hbar}$ is driven by expected profitability in skill-based sector compared with that of whole upstream industry. An increasingly profitable skill-based sector vis-a-vis the whole industry induces more firm entries. Because skill-based sector warrants larger sunk entry cost, firms able to enter and make profit in this sector must thus be more productive and of high quality.

Following the increasing proportion of high-quality entrants producing high-quality intermediates, innovation possibilities frontier moves outward biasedly toward high-quality intermediates. Falling price with better quality induces a substitute of domestic high-quality intermediates for domestic low-quality intermediates and imported high-quality intermediates, lifting the quality of final output as well. Hence, industrial upgrading in our context implies a process with increasing entry and hence rising proportion of high-quality firms into upstream industry, an expanding skill-biased innovation possibilities frontier, and advancement in the quality and added value in final output.

The key to industrial upgrading is the expected profitability in skill-based intermediates sector. Let total nominal cost of production $\mathbb{C}_t^{\hbar}$ for upstream skilled firm i takes the form

$$\mathbb{C}_t^{\hbar}(i) = Y_t^{\hbar}(i)\mathcal{R}_{ut}^{\hbar}(i) + \mathbb{F}_t^{\hbar} \quad (22)$$

where $\mathcal{R}_{ut}^{\hbar}$ refers to nominal marginal cost, and $\mathbb{F}_t^{\hbar}$ denotes the fixed cost incurred. In our context, it refers to entry cost $\mathbb{F}_t^{\hbar} = f_{et}^{\hbar}$, in which we follow Sutton (2012) to take an iso-elastic function

$$f_{et}^{\hbar} = \mathbb{F}^{\hbar}\left(A_t^{\hbar}\right)^{\mu_{\hbar}} \tag{23}$$

where $\mathbb{F}^{\hbar}(>0)$ denotes the minimum outlay incurred by an entrant in skill-based production. Entry cost is the total fixed and sunk cost incurred by an entrant that offers quality $A_t^{\hbar}$, where $A_t^{\hbar}$ lies in the range $[1,\infty)$. That entry cost is proportional to the level of quality implies that firms able to enter and be profitable in high-quality sector must be of high quality and productive by nature. The inversed parameter $\mu_{\hbar}$ represents the elasticity of $A_t^{\hbar}$ with respect to $f_{et}^{\hbar}$. 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 other words, higher value of μ means a relatively unresponsive quality toward R&D expenditures.

Suppose further that the firm i's total revenue function comprises revenues from domestic market and exporting:

$$\mathbb{R}_t^{\hbar}(i) = \underbrace{\mathbb{R}_{aa,t}^{\hbar}(i)}_{\substack{domestic\\ revenue}} + \underbrace{\mathbb{R}_{ac,t}^{\hbar}(i)}_{\substack{export\\ revenue}} = \mathcal{p}_{aa,t}^{\hbar} X_{aa,t}^{\hbar} + \mathcal{P}_{ac,t}^{\hbar} X_{ac,t}^{\hbar} \tag{24}$$

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

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

which can be rearranged as

$$V_t^{\hbar}(i) = \frac{1}{1-(1-\delta)\varrho_t^{\hbar}}\left\{\left(1-\frac{1-\theta(1-\delta)/\left(1+\pi_{aa,t}^{\hbar}\right)}{\omega_t^{\hbar}\varrho_t^{\hbar}}\right)\mathbb{R}_{aa,t}^{\hbar}(i) + \left(1-\frac{1-\theta(1-\delta)/\left(1+\pi_{ac,t}^{\hbar}\right)}{\omega_t^{*\hbar}\varrho_t^{\hbar}}\right)\mathbb{R}_{ac,t}^{\hbar}(i) - \mathbb{F}^{\hbar}\left(A_t^{\hbar}\right)^{\mu}\right\}$$

(25)

$\varrho_t^{\hbar}\left(=\beta\frac{u'(C_{t+1})}{u'(C_t)}\frac{e^{Z_{H,t+1}}}{e^{Z_{H,t}}}\frac{P_t}{P_{t+1}}=\mathfrak{p}_t^{\hbar}/(1-\delta)\left(\mathfrak{p}_{t+1}^{\hbar}+\Pi_{t+1}^{\hbar}\right)\right)$ is the stochastic discount factor for nominal payoffs, where $\mathfrak{p}_t^{\hbar}$ refers to share price for firms in skill-based producing intermediates, $\omega_t^{\hbar}\left(=e^{u_{\omega,t}^{\hbar}}\epsilon^{\hbar}/\left(\epsilon^{\hbar}-1\right)\right)$ and $\omega_t^{*\hbar}\left(=e^{u_{\omega,t}^{*\hbar}}\epsilon^{*\hbar}/\left(\epsilon^{*\hbar}-1\right)\right)$ are price markup for domestic and foreign high-quality intermediates market, respectively, in which $u_{\omega,t}^{\hbar}$ and $u_{\omega,t}^{*\hbar}$ are i.i.d price markup shock. The parameter θ, as in NK literature, measures price stickiness, whereas $\pi_{aa,t}^{\hbar}$ and $\pi_{ac,t}^{\hbar}$ refer to domestic and export price inflation for high-quality intermediates. By the same token, given unskilled firm i'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 in non-skilled-based intermediates production

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

(26)

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

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

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

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

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

(27)

There are four mechanisms one can conjecture from Eq. (27) wherein AEC industrial upgrading is linked to China's industrial upgrading (and renminbi internationalization).

1. (**Input-output linkage**) Linked by input-output structure, expanding China's upstream skilled sector will cause greater demand for materials produced by local as well as AEC downstream industry. Motivated by expanding and more profitable downstream market for high-quality materials, AEC's high-quality firms will be induced to enter local skill-based upstream sector. As a result, AEC industrial upgrading is favorably linked to China's one.
2. (**Quality competition channel**) An interesting and paradoxical implication of Sutton's sunk entry cost specification is that if China's innovation is more responsive to R&D outlays compared with that of AEC, meaning $\mu_c^{\hbar} < \mu_a^{\hbar}$, sunk entry cost is lower in China, allowing firms of lower quality to enter upstream intermediates production. That effectively means, despite China's skill-biased technical progress, AEC firms of better

quality can still tap on the expanding Chinese market through quality competition to move up the value chains.

3. (**Pricing channel**) As AEC's export of intermediates is mostly priced in U.S dollar, China's exchange rate policy which maintains a gradual appreciation makes AEC intermediates cheaper and thus of greater demand by China's downstream. Yuan appreciation in this respect complements AEC's effort of industrial upgrading. The momentum of industrial upgrading is strengthened if AEC anchors its currencies to the renminbi, as the ensuing stronger local currencies against the dollar implies cheaper imported high-quality materials for upstream production, facilitating firms entry into skill-based intermediates production. However, benefit like this diminishes along with rising share of yuan-invoiced trade.
4. (**Price markup stabilization channel**) By stabilizing domestic and export price markups, monetary policy can foster the profitability of high-quality intermediates sector, encouraging entry into this sector, and ultimately influencing the dynamics of industrial upgrading.

3. Modeling renminbi internationalization

Renminbi internationalization is viewed from three perspectives: an increasingly use of the renminbi as export invoicing currency in substitution for U.S dollar, liberalizing capital account, and decreasing sterilized intervention in foreign exchange market. To account for these dimensions, we lay out export pricing decision that involves U.S dollar (dollar pricing) and the renminbi as in Wong et al. (2014), we model cross-border portfolio capital flows subject to capital account restriction as in Wong and Eng (2015), and lastly, following Chang et al. (2015),

we frame 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.

3.1. Endogenous choice of invoicing currency: U.S dollar or Chinese yuan

Firms are not always able to reset price freely in each period in the sense that there is only a fraction of firms $(1-\theta)$ that can reset its price. In other words, there is a chance that the firm will get stuck with its price for multiple periods. Moreover, the firm 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 i periods into the future by $\theta^i(1-\delta)^i\varrho_{t+i}$, where $\theta(1-\delta)$ indicates a joint probability that the surviving firm may be unable to reset price, and ϱ_t is the stochastic discount factor for nominal payoffs. In particular, upstream firm $\imath$ in sector $\mathcal{s} \in \{\ell, \hbar\}$has the following dynamic pricing problem for domestic market:

$$\max_{\mathbb{p}_t^{\ell}(i)} \mathbb{E}_t \sum_{i=0}^{\infty} \theta^{\ell,i}(1-\delta)^i \varrho_{t+i}^{\ell} \left(\frac{\mathbb{p}_t^{\ell}(i)}{\mathcal{p}_{t+i}^{\ell}} - \mathcal{r}_{ut+i}^{\ell}(i) \right) X_{t+i}^{\ell}(i)$$

$$\max_{\mathbb{p}_{aa,t}^{\hbar}(i)} \mathbb{E}_t \sum_{i=0}^{\infty} \theta^{\hbar,i}(1-\delta)^i \varrho_{t+i}^{\hbar} \left(\frac{\mathbb{p}_{aa,t}^{\hbar}(i)}{\mathcal{p}_{aa,t+i}^{\hbar}} - \mathcal{r}_{ut+i}^{\hbar}(i) \right) X_{aa,t+i}^{\hbar}(i)$$

where we assume $\theta^{\ell} < \theta^{\hbar}$. Together with total demand from all firms $\jmath$, where $X_t^{\ell}(i) = \int_0^1 \left(\mathbb{p}_t^{\ell}(i)/\mathcal{p}_t^{\ell}\right)^{-\epsilon^{\ell}} X_t^{\ell}(j)dj$ and $X_{aa,t+i}^{\hbar}(i) = \int_0^1 \left(\mathbb{p}_{aa,t}^{\hbar}(i)/\mathcal{p}_{aa,t}^{\hbar}\right)^{-\epsilon^{\hbar}} X_{aa,t}^{\hbar}(j)dj$, firm $\imath$'s "frictionless" optimal price can be solved, respectively, as

$$\mathbb{p}_t^{\ell}(i) = \omega^{\ell} \mathfrak{Q}_t^{\ell} \mathcal{p}_t^{\ell} \mathcal{r}_{ut}^{\ell}(i) \tag{28}$$

$$\mathbb{p}_{aa,t}^{\hbar}(i) = \omega^{\hbar} \mathfrak{Q}_t^{\hbar} \mathcal{p}_{aa,t}^{\hbar} \mathcal{r}_{ut+i}^{\hbar}(i) \tag{29}$$

where $\mathfrak{Q}_t^{\mathcal{S}} = (1-\theta(1-\delta))^{-1}\varrho_t^{\mathcal{S}}$ is the stochastic discount factor adjusted for stickiness and firm's exit. By the same token, we can easily obtain downstream firm $\mathcal{j}$'s optimal price for domestic market

$$\mathbb{P}_{aa,t}(\mathcal{j}) = \omega_t \mathfrak{Q}_t P_{aa,t+i} \mathcal{r}_{dt+i}(\mathcal{j}) \tag{30}$$

where $\omega_t = e^{u_{\omega,t}}\epsilon/(\epsilon-1)$ is the price markup for downstream production and $u_{\omega,t}$ is i.i.d downstream price markup shock. $\mathfrak{Q}_t = (1-\theta(1-\delta))^{-1}(1+r_t)^{-1}$ is adjusted stochastic discount factor.

Of interest and importance in our context is the export pricing decision. U.S. dollar has been the dominant invoicing currency in ex-Japan Asian exports (not excluding China) to the rest of the world (Ito and Chin, 2015). Even for Japanese exporters, U.S. dollar would be the natural invoicing currency in trade throughout the production value chains if the final output is mainly for U.S. market (Ito et al., 2012). For AEC exporters who set the export price in U.S. dollar $\mathbb{d}\mathbb{p}_{ac,t}^{\hbar}$ (dollar pricing strategy thereafter) to maximize the expected discounted profits in domestic currency, the dynamic pricing problem can be written as

$$\max_{\mathbb{d}\mathbb{p}_{ac,t}^{\hbar}(i)} \mathbb{E}_t \sum_{i=0}^{\infty} \theta^{\hbar,i}(1-\delta)^i \varrho_{t+i} \left(S_{ad,t+i} \frac{\mathbb{d}\mathbb{p}_{ac,t}^{\hbar}(i)}{d\mathcal{p}_{ac,t+i}^{\hbar}} - \mathcal{r}_{ut+i}^{\hbar}(i) \right) \left(\frac{\mathbb{d}\mathbb{p}_{ac,t}^{\hbar}(i)}{d\mathcal{p}_{ac,t}^{\hbar}} \right)^{-\epsilon^{*\hbar}} X_{ac,t}^{\hbar}$$

where $S_{ad,t+i}$ denotes nominal exchange rate defined as the value of U.S dollar in domestic currency (a rise in $S_{ad,t}$ implies depreciation of domestic currency). Optimal dollar export price of upstream high-quality intermediates can be solved as

$$\mathbb{d}\mathbb{p}_{ac,t}^{\hbar}(i) = \omega_t^{*\hbar} \mathfrak{Q}_t d\mathcal{p}_{ac,t}^{\hbar} \mathcal{r}_{ut}^{\hbar}(i)/S_{ad,t} \tag{31}$$

where $\omega_t^{*\hbar} = e^{u_{\omega,t}^{*\hbar}}\,\epsilon^{\hbar*}/\left(\epsilon^{\hbar*}-1\right)$ is the price markup for foreign intermediates market and $u_{\omega,t}^{*\hbar}$ refers to its corresponding i.i.d price markup shock. Likewise, we can solve for optimal dollar price of downstream exports as follows

$$\mathbb{DP}_{ac,t}(j) = \omega_t^{*}\mathfrak{Q}_t DP_{ac,t}\mathcal{r}_{dt+i}(j)/S_{ad,t} \tag{32}$$

where $\omega_t^{*} = e^{u_{\omega,t}^{*}}\,\epsilon^{*}/(\epsilon^{*}-1)$ is the price markup for downstream export market and $u_{\omega,t}^{*}$ is i.i.d markup shock at foreign downstream market.

If dollar pricing strategy is symmetric (as U.S dollar is third-country currency for both China and AEC) for Chinese and AEC exporters, yuan pricing strategy (YP) which starts account for greater share in trade between AEC and China is indeed asymmetric, as it is a combination of producer currency pricing from Chinese exporters' perspective and local currency pricing from AEC exporters' point of view. By setting export price in the renminbi, dynamic export pricing problems facing AEC and Chinese upstream firms, respectively, are given by

$$\text{AEC:}\max_{\mathbb{yp}_{ac,t}^{\hbar}(i)}\mathbb{E}_t\sum_{i=0}^{\infty}\theta^{\hbar,i}(1-\delta)^i\varrho_{t+i}\left(S_{ac,t+i}\frac{\mathbb{yp}_{ac,t}^{\hbar}(i)}{\mathcal{yp}_{ac,t+i}^{\hbar}}-\mathcal{r}_{ut+i}^{\hbar}(i)\right)\left(\frac{\mathbb{yp}_{ac,t}^{\hbar}(i)}{\mathcal{yp}_{ac,t+i}^{\hbar}}\right)^{-\epsilon^{*\hbar}}X_{ac,t+i}^{\hbar}$$

$$\text{China:}\max_{\mathbb{yp}_{ca,t}^{*\hbar}(i^*)}\mathbb{E}_t\sum_{i=0}^{\infty}\theta^{*\hbar,i}(1-\delta)^i\varrho_{t+i}\left(\frac{\mathbb{yp}_{ca,t}^{*\hbar}(i^*)}{\mathcal{yp}_{ca,t+i}^{*\hbar}}-\mathcal{r}_{ut+i}^{*\hbar}(i^*)\right)\left(\frac{\mathbb{p}_{ca,t}^{*\hbar}(i)}{\mathcal{yp}_{ca,t+i}^{*\hbar}}\right)^{-\epsilon^{\hbar}}X_{ca,t+i}^{*\hbar}$$

which result in the following optimal export price of intermediates in own currency, respectively

$$\mathbb{yp}_{ac,t}^{\hbar}(i) = \omega_t^{*\hbar}\mathfrak{Q}_t\mathcal{yp}_{ac,t}^{\hbar}\mathcal{r}_{ut}^{\hbar}(i)/S_{ac,t} \tag{33}$$

$$\mathbb{yp}_{ca,t}^{*\hbar}(i^*) = \omega_t^{\hbar}\mathfrak{Q}_t\mathcal{yp}_{ca,t}^{*\hbar}\mathcal{r}_{ut}^{*\hbar}(i) \tag{34}$$

Following the New Keynesian literature, the survived AEC upstream and downstream firms able to reset price will do so by choosing a reset price $\tilde{\mathscr{p}}^{s}_{an,t}$ and $\tilde{P}_{an,t}$, respectively, where $s = \{\ell, \hbar\}$ and $n = \{a, c\}$, which approximates optimal frictionless price to minimize the loss of deviating from the profit-maximizing price, $\max_{\tilde{\mathscr{p}}} L = \sum_{i=0}^{\infty}(\theta(1-\delta)\beta)^{i}\mathbb{E}_t\left(\tilde{\mathscr{p}}^{s}_{an,t+i} - \boldsymbol{z}^{s}_{an,t+i}\right)^2$ and $\max_{\tilde{P}} L = \sum_{i=0}^{\infty}(\theta(1-\delta)\beta)^{i}\mathbb{E}_t\left(\tilde{P}_{an,t+i} - \boldsymbol{\mathcal{Z}}_{an,t+i}\right)^2$, where $\boldsymbol{z}^{s}_{an,t} = \left\{\mathbb{p}^{\ell}_{t}, \mathbb{p}^{\hbar}_{aa,t}, \mathbb{dp}^{\hbar}_{ac,t}, \mathbb{yp}^{\hbar}_{ac,t}\right\}$ and $\boldsymbol{\mathcal{Z}}_{an,t} = \left\{\mathbb{P}_{aa,t}, \mathbb{DP}_{ac,t}, \mathbb{YP}_{ac,,t}\right\}$. We drop the index i as all firms behave symmetrically. By solving the first-order condition, we can get optimal reset price for upstream and downstream output, respectively.

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

$$\tilde{P}_{an,t} = \theta(1-\delta)\beta\mathbb{E}_t\tilde{P}_{an,t+1} = +(1-\theta(1-\delta)\beta)\boldsymbol{\mathcal{Z}}_{an,t} \tag{35}$$

The other fraction will charge the price they charged in the previous period. This gives us aggregate price level as a combination of reset and lagged price level weighted by $\theta(1-\delta)$:

$$\boldsymbol{\mathscr{p}}_t = \left(1-\theta(1-\delta)\right)\tilde{\mathscr{p}}^{s}_{an,t} + \theta(1-\delta)\boldsymbol{\mathscr{p}}_{t-1}$$

$$\mathbf{P}_t = \left(1-\theta(1-\delta)\right)\tilde{P}_{an,t} + \theta(1-\delta)\mathbf{P}_{t-1} \tag{36}$$

for $\boldsymbol{\mathscr{p}}_t = \left\{\mathscr{p}^{\ell}_{t}, \mathscr{p}^{\hbar}_{aa,t}, d\mathscr{p}^{\hbar}_{ac,t}, y\mathscr{p}^{\hbar}_{ac,t}\right\}$ and $\mathbf{P}_t = \left\{P_{aa,t}, DP_{ac,t}, YP_{ac,t}\right\}$.

Suppose in each period, a fraction of AEC upstream firms choose to price their intermediates exports in U.S dollar $1-\phi_t$, whereas another fraction chooses to price at Chinese yuan ϕ_t. So does AEC downstream firms which follow pricing strategy of the upstream firms, as we assume, to avoid profit loss due to varying pricing strategies within production value chains. Average export prices of high-quality intermediates and downstream output in local currency are given by

$$\mathcal{P}_{ac,t}^{\hbar} = (1-\phi_t)S_{ad,t}\mathcal{dp}_{ac,t}^{\hbar} + \phi_t S_{ac,t}\mathcal{yp}_{ac,t}^{\hbar}$$

$$\mathcal{P}_{ac,t} = (1-\phi_t)S_{ad,t}DP_{ac,t} + \phi_t S_{ac,t}YP_{ac,t} \tag{37}$$

Suppose exporters can choose to quote either in U.S dollar or Chinese yuan, as far as the quoted price minimizes loss due to deviation from the optimal frictionless price, as derived in Eqs. (31) and (33). Speaking differently, exporters will be self-sorting into yuan pricing strategy if it is profit maximizing. In this way, the value ϕ_t can be interpreted as the degree of renminbi internationalization with respect to the use of renminbi as invoicing currency in AEC's export. Formally,

$$\phi_t = \zeta \frac{\exp\left(\widehat{\mathcal{yp}}_{ac,t-1}^{\hbar} - \widehat{\mathbb{yp}}_{ac,t-1}^{\hbar}\right)}{\exp\left(\widehat{\mathcal{yp}}_{ac,t-1}^{\hbar} - \widehat{\mathbb{yp}}_{ac,t-1}^{\hbar}\right) + \exp\left(\widehat{\mathcal{dp}}_{ac,t-1}^{\hbar} - \widehat{\mathbb{dp}}_{ac,t-1}^{\hbar}\right)} \tag{38}$$

where ζ is a scale parameter. $\hat{x}$ indicates log deviation of variable x from its steady state. Eq. (38) says that as the past profitability of yuan-invoiced trade improves relative to that of the dollar-invoiced trade, exporters are more likely to adopt yuan-invoiced trade.

3.2. China's capital account liberalization: Portfolio balance approach

Another important dimension of renminbi internationalization of which the implications will be investigated is capital account convertibility. Because of the restricted convertibility of capital account, domestic and foreign assets become imperfect substitute. This allows us to model capital flows across border using portfolio balance approach. In particular, we decompose gross real portfolio capital inflows from China to AEC into domestic bond $\mathbb{K}_{ca,t}^{*B}$ and stock markets $\mathbb{K}_{ca,t}^{*Q}$. Gross outflows from AEC to China are also classified into debt outflows $\mathbb{K}_{ac,t}^{B}$ and equity

outflows $\mathbb{K}_{ac,t}^{Q}$. We model the evolution of wealth accumulation (in terms of bonds B_p and equity of high-quality firms $Q^{\hbar}$) as

$$B_{p,ac,t} = (1 + r_{t-1})B_{p,ac,t-1} + e^{Z_{\mathbb{K},t}^{*}} S_{ac,t} P_t^{*} \mathbb{K}_{ca,t}^{*B} \tag{39}$$

$$\mathfrak{p}_t^{\hbar}\left(N_t^{\hbar} + N_{et}^{\hbar}\right) Q_{ac,t}^{\hbar} = \left(\mathfrak{p}_t^{\hbar} + \Pi_t^{\hbar}\right) N_t^{\hbar} Q_{ac,t-1}^{\hbar} + e^{Z_{\mathbb{K},t}^{*}} S_{ac,t} P_t^{*} \mathbb{K}_{ca,t}^{*Q} \tag{40}$$

$$B_{p,ca,t}^{*} = (1 + r_{t-1}^{*})B_{p,ca,t-1}^{*} + e^{Z_{\mathbb{K},t}} P_t \mathbb{K}_{ac,t}^{B} / S_{ac,t} \tag{41}$$

$$\mathfrak{p}_t^{*\hbar}\left(N_t^{*\hbar} + N_{et}^{*\hbar}\right) Q_{ca,t}^{*\hbar} = \left(\mathfrak{p}_t^{*\hbar} + \Pi_t^{*\hbar}\right) N_t^{*\hbar} Q_{ca,t-1}^{*\hbar} + e^{Z_{\mathbb{K},t}} P_t \mathbb{K}_{ac,t}^{Q} / S_{ac,t} \tag{42}$$

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. Eqs. (39) – (42) correspond to the growing emphasis on gross rather than net flows in the literature (see, for instance, Wong and Eng, 2015; Broner et al., 2013; Forbes and Warnock, 2012).

In each period, a unit mass of households $z \in (0,1)$ populating the home economy works for wage income W_t/P_t and receives dividend paid by upstream firms Π_t^{s} as a shareholder to finance expenditure on a bundle of final goods C_t. Households also accumulate wealth in the form of domestic $B_{p,a,t}$ and foreign bonds $B_{p,fh,t}^{*}$ that pay interest r_t and r_t^{*}, respectively, shares of incumbents and entrants, both from AEC and China's stock market, at market price, and zero-yielding domestic monies which provide liquidity services. Formally, household's flow budget constraint can be written as

$$\begin{aligned} B_{p,a,t} + \mathfrak{p}_t^{\ell} Q_t^{\ell}\left(N_t^{\ell} + N_{et}^{\ell}\right) + \mathfrak{p}_t^{\hbar} Q_{a,t}^{\hbar}\left(N_t^{\hbar} + N_{et}^{\hbar}\right) + P_t\left(\mathbb{K}_{ac,t}^{B} + \Phi_{\mathbb{K},t}^{B}\right) + P_t\left(\mathbb{K}_{ac,t}^{Q} + \Phi_{\mathbb{K},t}^{Q}\right) + \\ P_t C_t = (1 + r_{t-1})B_{p,a,t-1} + \left(\mathfrak{p}_t^{\ell} + \Pi_t^{\ell}\right) N_t^{\ell} Q_{t-1}^{\ell} + \left(\mathfrak{p}_t^{\hbar} + \Pi_t^{\hbar}\right) N_t^{\hbar} Q_{a,t-1}^{\hbar} + W_t H_t + T_t \end{aligned} \tag{43}$$

where T is lump-sum tax. We assume a cross-border portfolio adjustment cost $\Phi_{\mathbb{K},t}$ facing Chinese and AEC investors primarily due to restrictions in China's capital market. By denoting $\Phi_{\mathbb{K}} > 0$ as the degree of capital market restriction, we model portfolio adjustment cost facing AEC investors in China's bonds and equity markets as

$$\Phi^{B}_{\mathbb{K},t} = \frac{\Phi_{\mathbb{K}}}{2}\left(\frac{P_t \mathbb{K}^{B}_{ac,t}}{S_{ac,t}B^{*}_{p,ca,t-1}} - \varpi^{B}_{\mathbb{K},ac}\right)\left(\frac{S_{ac,t}B^{*}_{p,ca,t-1}}{P_t}\right)$$

$$\Phi^{Q}_{\mathbb{K},t} = \frac{\Phi_{\mathbb{K}}}{2}\left(\frac{P_t \mathbb{K}^{Q}_{ac,t}}{S_{ac,t}\mathfrak{p}^{*\hbar}_{t} Q^{*\hbar}_{ca,t-1}} - \varpi^{Q}_{\mathbb{K},ac}\right)$$

where $\varpi^{B}_{\mathbb{K},ac}$ and $\varpi^{Q}_{\mathbb{K},ac}$, respectively, refer to steady-state capital outflows into China's bond and equity markets as a share of total stock. Let λ_t, Ω^{B}_{t}, and Ω^{Q}_{t} denote Lagrangian multiplier for constraints (43), (41), and (42), respectively, we can solve for portfolio capital flows dynamics

$$\mathbb{K}^{B}_{ac,t} = \left(\frac{S_{ac,t}B^{*}_{p,ca,t-1}}{P_t}\right)\left(\frac{1}{\Phi_{\mathbb{K}}}\left(q^{B}_{ac,t}e^{Z_{\mathbb{K},t}} - 1\right) + \varpi^{B}_{\mathbb{K},ac}\right) \tag{44}$$

$$q^{B}_{ac,t}\left(\equiv \frac{\Omega^{B}_{t}}{\lambda_t}\right) = \mathbb{E}_t\left(\frac{S_{ac,t+1}}{S_{ac,t}}\right)\left(\frac{1}{1+r_t}\right)\left(q^{B}_{ac,t+1}(1+r^{*}_{t}) + pac^{B}_{ac,t+1}\right) \tag{45}$$

$$\mathbb{K}^{Q}_{ac,t} = \left(\frac{S_{ac,t}\mathfrak{p}^{*\hbar}_{t} Q^{*\hbar}_{ca,t-1}}{P_t}\right)\left(\frac{1}{\Phi_{\mathbb{K}}}\left(q^{Q}_{ac,t}e^{Z_{\mathbb{K},t}} - 1\right) + \varpi^{Q}_{\mathbb{K},ac}\right) \tag{46}$$

$$q^{Q}_{ac,t}\left(N^{*\hbar}_{t} + N^{\hbar *}_{et}\right) = \mathbb{E}_t\left(\frac{S_{ac,t+1}}{S_{ac,t}}\right)\left(\frac{1}{1+r_t}\right)\left(\frac{\mathfrak{p}^{*\hbar}_{t+1}}{\mathfrak{p}^{*\hbar}_{t}}\right)\left(q^{Q}_{ac,t+1}\left(1 + \frac{\Pi^{*\hbar}_{t+1}}{\mathfrak{p}^{*\hbar}_{t+1}}\right)N^{*\hbar}_{t+1} + pac^{Q}_{ac,t+1}\right) \tag{47}$$

where

$$pac^{B}_{ac,t+1} = \frac{\Phi_{\mathbb{K}}}{2}\left[\left(\frac{P_{t+1}\mathbb{K}^{B}_{ac,t+1}}{S_{ac,t+1}B^{*}_{p,ca,t}}\right)^{2} - \left(\varpi^{B}_{\mathbb{K},ac}\right)^{2}\right] \text{ and } pac^{Q}_{ac,t+1} = \frac{\Phi_{\mathbb{K}}}{2}\left[\left(\frac{P_{t+1}\mathbb{K}^{Q}_{ac,t+1}}{S_{ac,t+1}\mathfrak{p}^{*\hbar}_{t+1}Q^{*\hbar}_{ca,t}}\right)^{2} - \left(\varpi^{Q}_{\mathbb{K},ac}\right)^{2}\right].$$

Eqs. (45) to (47) are "Tobin's q" in domestic portfolio investments on foreign bonds and equities which correspond to capital flows dynamics (44) to (46), respectively. Accordingly, gross capital outflows are endogenously determined by expected variability in nominal exchange rates and return differentials. And the magnitude of influence is subject to the degree of Chinese capital account convertibility. A larger value of $\Phi_{\mathbb{K}}$ which indicates restrictive capital account implies that cross-border flows are insensitive to return differentials. In this way, capital account liberalization is captured by reducing the value of $\Phi_{\mathbb{K}}$.

3.3 Sterilization and Exchange Rate Policies in China

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, held by domestic and foreign investor, as well as the People's Bank of China $B^*_{g,c,t}$.

$$B^*_{g,c,t} + B^*_{p,c,t} + B^*_{p,ca,t} = (1 + r^*_{t-1})\left(B^*_{g,c,t-1} + B^*_{p,c,t-1} + B^*_{p,ca,t-1}\right) + T^*_t \tag{48}$$

At the same time, facing PBoC is the following flow-of-fund constraint

$$S_{cd,t}\left(B^d_{g,dc,t} - (1 + r^*_{t-1})B^d_{g,dc,t-1}\right) + B^*_{g,c,t} - (1 + r^*_{t-1})B^*_{g,c,t-1} = M^*_t - M^*_{t-1} \tag{49}$$

Note that foreign assets held by PBoC, as well as AEC central banks, are bonds issued by the U.S government $B^d_{g,dc,t}$. We let the amount of "safe assets" held in the coffer of central banks be determined by the system.

Under capital account restrictions with heavily managed nominal exchange rates, PBoC intervenes in foreign exchange market by purchasing foreign assets from goods exporters and securities exporters, resulting in the accumulation of foreign reserves $FXI^*_t\left(\equiv B^d_{g,dc,t} -\right.$

$B^{d}_{g,dc,t-1}\big)$. A non-sterilized foreign exchange intervention 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

$$M^{*}_{t} = M^{*}_{t-1} + \tau^{*} S_{cd,t} FXI^{*}_{t} \tag{50}$$

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

$$S_{cd,t} = e^{Z^{*}_{S,t}} S_{cd,t-1} \tag{51}$$

where $Z^{*}_{S,t}$ is the first-order autoregressive shock hitting yuan-dollar exchange rates. To reflect the trend of the renminbi since the abandonment of dollar peg in 2005, we also assume that the central bank intentionally allows yuan to appreciate against dollar at a constant rate.

4. The remaining structure

We close the model by specifying households' optimal decisions on consumption and labors, aggregate resource constraint, and interest rate rule.

4.1 Households

Consumption bundle consists of domestic $C_{a,t}$ and imported consumables $C^{*}_{ca,t}$ in CES fashion, where

$$C_{t} = \left[(1-\gamma)^{1/\varphi}\left(C^{*}_{ca,t}\right)^{1-1/\varphi} + \gamma^{1/\varphi} C^{1-1/\varphi}_{a,t}\right]^{\varphi/(\varphi-1)} \tag{52}$$

We omit the index z as households behave identically. Optimal demand for local and imported consumer goods takes the following form

$$C_{a,t} = \gamma\left(P_{aa,t}/P_t\right)^{-\varphi} C_t \tag{53}$$

$$C^*_{ca,t} = (1-\gamma)\left(\mathcal{P}^*_{ca,t}/P_t\right)^{-\varphi} C_t \tag{54}$$

where P_t is utility-based consumer price index

$$P_t = \left(\gamma {P_{aa,t}}^{1-\varphi} + (1-\gamma)\left(\mathcal{P}^*_{ca,t}\right)^{1-\varphi}\right)^{1/(1-\varphi)} \tag{55}$$

$\mathcal{P}^*_{ca,t}$ is a weighted average import price (or average export price from foreign exporters' vantage) which comprises dollar priced $DP^*_{ca,t}$ and renminbi priced $P^*_{fh,t}$ imported consumer goods

$$\mathcal{P}^*_{ca,t} = (1-\phi_t) S_{ad,t} DP^*_{ca,t} + \phi_t S_{ac,t} YP^*_{ca,t} \tag{56}$$

Households optimally choose the sequences of $C_t, H_t, M^d_t, B_{p,a,t}, Q^{\ell}_t$, and $Q^{\hbar}_{a,t}$ to maximize the following utility function

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

subject to flow constraint (43). 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. Solving the first-order conditions with some rearrangements gives us 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.

$$\chi {C_t}^{\sigma} = W_t/P_t \tag{57}$$

$$M_t^d/P_t = \psi {C_t}^{\sigma}(r_t/1+r_t)^{-1} \tag{58}$$

$$C_t^{\sigma} = \beta^{-1}(1+r_t)^{-1}e^{Z_{H,t}}\mathbb{E}_t[C_{t+1}^{\sigma}(1+\pi_{t+1})e^{Z_{H,t+1}}] \tag{59}$$

$$\mathfrak{p}_t^{\ell} = (1-\delta)\mathbb{E}_t\mathfrak{p}_{t+1}^{\ell}\left(1+\Pi_{t+1}^{\ell}/\mathfrak{p}_{t+1}^{\ell}\right)/(1+r_t) \tag{60}$$

$$\mathfrak{p}_t^{\hbar} = (1-\delta)\mathbb{E}_t\mathfrak{p}_{t+1}^{\hbar}\left(1+\Pi_{t+1}^{\hbar}/\mathfrak{p}_{t+1}^{\hbar}\right)/(1+r_t) \tag{61}$$

where $\pi_t = P_t/P_{t-1} - 1$ is CPI inflation.

4.2. Aggregate resource constraint

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 EX_t, gross imports IM_t, gross capital inflows GKI_t, and gross capital outflows GKO_t net of sunk resources.

$$S_{ad,t}FXI_t = r_{t-1}^d\left(\frac{S_{ad,t}}{P_t}\right)B_{g,da,t-1}^d + EX_t - IM_t + S_{ac,t}\left(\frac{P_t^*}{P_t}\right)GKI_t - GKO_t \tag{62}$$

where $EX_t = C_{ac,t} + N_t^{*\hbar}M_{ac,t}^{\hbar} + N_t^{\hbar}X_{ac,t}^{\hbar}$, $IM_t = C_{ca,t}^* + N_t^{\hbar}M_{ca,t}^{*\hbar} + X_{ca,t}^{*\hbar}$, $GKI_t = \mathbb{K}_{ca,t}^{*B} + \mathbb{K}_{ca,t}^{*Q}$, and $GKO_t = \mathbb{K}_{ac,t}^{B} + \mathbb{K}_{ac,t}^{Q}$. Defining real GDP as the sum of consumption and net exports, we get

$$RGDP_t \equiv \mathrm{C}_t + EX_t - IM_t + \mathbb{F}^{\hbar}\left(A_t^{\hbar}\right)^{\mu_{\hbar}} + \mathbb{F}^{\ell}\left(A_t^{\ell}\right)^{\mu_{\ell}} \tag{63}$$

where $\mathrm{C}_t = \left(\frac{P_{hh,t}}{P_t}\right) C_{h,t} + \left(\frac{\mathcal{P}^*_{fh,t}}{P_t}\right) C^*_{fh,t}$ is defined based on accounting basis instead of a consumption behavior as defined in Eq. (52). Entry sunk cost defines the wedge between output and absorption.

4.3 Monetary policy

Lastly, we close the model by imposing a simple feedback interest rate rule

$$\frac{1+r_t}{\bar{R}} = \left(\frac{1+r_{t-1}}{\bar{R}}\right)^{\rho_r} \left(\left(\frac{1+\pi_t}{1+\bar{\pi}}\right)^{\rho_\pi} \left(\frac{RGDP_t/RGDP_{t-1}}{1+\overline{\Delta RGDP}}\right)^{\rho_{gdp}}\right)^{1-\rho_r} e^{u_{r,t}} \tag{64}$$

where $u_{r,t}$ is i.i.d interest rate shock, $\bar{R}$ is steady-state interest rate, $\overline{\Delta RGDP}$ 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.

5. 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. We assume a subject discount rate of 4 percent per year, giving us $\beta = 0.99$. Share of materials used in the production of 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 renminbi internationalization. Assume that proportion of high-quality firm in steady state is $\bar{N}^{\hbar} = 0.2$. By setting $\gamma^{\hbar} = 8$, $\gamma^{\ell} = 1$, and $\text{prop} = 0.00625$, we obtain annual skilled-biased growth rate of 4 percent and unskilled-biased growth rate of 2 percent. High-quality innovation is assumed to be more responsive to R&D expenditure, so $\mu_{\hbar} = 0.5$. In the process of getting a consistent steady state values for upstream output, materials, and wages, we set $\bar{A}^{\hbar} = 1.24$, as compared with a predetermined $\bar{A}^{\ell} = 1$. In a zero profit steady state, wherein there is neither entry nor exit in upstream industry, we find $\mathbb{F}^{\hbar} = 0.184$ and $\mathbb{F}^{\ell} = 0.01$. 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 intermediates are more differentiated and hence less elastic compared with low-quality intermediates, so $\epsilon^{\hbar}(= 6) < \epsilon^{\ell}(= 11)$. 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 $\tau^{*} = 0.01$, whereas AEC central banks are not $\tau = 1$.

[INSERT TABLE 1 HERE]

6. Responses of AEC toward China's dreams

The renminbi has been gradually but continuously (almost a one-way bet) appreciating against the dollar even since de-pegging the dollar in July 2005. By the end of 2013 before the trend reversed to accommodate the slowing-down China's economy, the renminbi has nearly

appreciated 1% in a quarter for 33 consecutive quarters. In this section, we will simulate the parameterized benchmark model with restrictive capital account hit by one standard deviation negative shock to yuan-dollar exchange rate which results in a persistent appreciation of yuan against dollar according to Eq. (51) (yuan appreciation thereafter). Light is shed on the dynamic responses of AEC to yuan appreciation to identify the underlying mechanism.

6.1. Does China upgrade its industrial structure and internationalize renminbi at AEC's expense?

Figure 1 illustrates benchmark impulse responses of China and AEC to yuan appreciation. Persistent appreciation, as it happened, induces entry of Chinese high-quality firms, pushing innovation biasedly toward skill-based sector which upgrade China's industrial quality. The real economy is not hurt by persistent appreciation, as exporting and importing activities expand. So does the real GDP. At the same time, as yuan-invoiced trade becomes more rewarding, Chinese exporters are more willing to quote their exports in yuan, leading to renminbi internationalization.

[INSERT FIGURE 1 HERE]

Spillover effects are benign to AEC too. Despite a smaller magnitude, yuan appreciation still results in rising entry of AEC high-quality firms into upstream skilled sector, improving the overall quality of AEC products. China's greater demand for AEC's exports of quality materials throughout the process of industrial upgrading has become the impetus to AEC high-quality firms to climb up the value chains to produce high-quality intermediates for downstream processing. The wheel of increasing demand for AEC's exports is further greased by yuan appreciation which makes AEC's dollar-invoiced products cheaper. That also explains why AEC exporters choose not to quote their exports in yuan as dollar pricing strategy amid lofcal currency

depreciation is more profiting. In short, input-output linkage and pricing channel pivot AEC favorably to China's industrial upgrading and renminbi internationalization.

Figure 2 makes a comparison between the responses to yuan appreciation of a model in which AEC's innovation is far less responsive to fixed cost expenditure and that of the benchmark model. We reset $\mu_a^h = 5$, which is even less responsive than AEC non-skill-based innovation $\mu_a^\ell = 3$, while maintaining the one for China. Despite the sluggishness, as Figure 2 shows, benevolent spillovers of China's industrial upgrading are even stronger. China's catching up creates demand for high-quality intermediates that can be filled up by AEC firms of better quality. Quality competition underlies AEC's effort to move up the value chains.

[INSERT FIGURE 2 HERE]

6.2. How does China's capital account liberalization matter?

Given China's commitment to liberalize her capital account, which constitutes a critical milestone for renminbi internationalization, an interesting question to ask is how does China's industrial upgrading would have impacted on AEC once China's capital account is convertible? We address this question by considering two types of reforms. First, we reset portfolio adjustment cost parameter in China to $\Phi_{\mathbb{K}} = 0.01$ which indicates a nearly fully convertible capital account. Next, we set $\tau = 1$ so that PBoC does not sterilize foreign exchange interventions. Figure 3 illustrates impulse responses of China's economy to yuan appreciation when capital account is liberalized and foreign exchange intervention is unsterilized.

[INSERT FIGURE 3 HERE]

Capital account liberalization drastically alters the way yuan appreciation impacts on industrial upgrading and the economy. Liberalized capital account induces massive gross equity and bond capital flows. Fabulous sense of prosperity drives up consumption at the expense of falling exports and hence imports. Diminishing expectation on export profitability then discourages firm entry in skill-based sector. Increases in stock price of high-quality firm are merely a reflection of a combination of decreasing number of securities floating in the market (due to declining numbers of skill-based firms) amid net gross capital inflows. In short, capital account liberalization changes the composition of real GDP toward consumption, supporting an economic expansion that costs potential industrial upgrading.

AEC would have the worst of all. In responding to yuan appreciation under convertible China's capital account, as Figure 4 has shown, trade shrinks due to demand deficiency from China, dismaying the prospect for entering skill-based sector that cause skill-biased technical regression. Real GDP declines and inflation rises as depreciation against U.S dollar and the renminbi increases import cost. Inflation pressure forces monetary policy to be tightened up, further worsening the weakening economy through depressed consumption. All these negative spillovers cannot be fenced off by maintaining a managed floating. Figure 5 replicates yuan appreciation as in Figure 3, and illustrates responses of AEC when local currency vis-à-vis the U.S dollar and the renminbi, respectively, is included in monetary policy reaction function. It is clear that responses resemble those in Figure 4. In other words, AEC's attitude toward exchange rate fluctuation against the renminbi as well as the dollar is of little relevance in shaping the spillovers from China with convertible capital account.

[INSERT FIGURES 4 & 5 HERE]

6.*3. Price markup stabilization to benefit from China's success?*

How can AEC central bank do, if not stabilizing local currency fluctuations against the dollar or renminbi, in the face of the China moving up the quality ladder and liberalizing capital account? We consider the role of stabilizing downstream export price markup in the sense that rising export price inflation is followed by an increasing interest rate, and vice versa. We include export price inflation in the policy reaction function (64) and assign a weightage of 1.5. We theorize that when downstream export price goes up, price of materials for domestic upstream sector will follow in ensuing. Increasing the interest rate that appreciates local currency against the dollar can moderate if not offset the impact in two ways: it reduces the cost of imported materials on the one hand, and makes export price lower in local currency (see Eq. (56)) on the other hand, which in turn restrain the tendency to raise price of materials for domestic upstream sector. In short, in our context, monetary policy that targets downstream export price inflation creates an environment that provides cost stability conducive for quality upgrading.

This is what we have illustrated in Figure 6 that compares impulse responses of AEC when downstream export price inflation is targeted in the face of liberalized China's capital account with those of benchmark model and modified benchmark model with higher sunk entry cost. Very interestingly, the responses resemble those under which China's capital account is restricted. The difference is they are more encouraging: business formation in skill-based sector is stronger, skill-biased technical progress sustains lengthier, and the favorable effects on the real economy stay longer.

[INSERT FIGURE 6 HERE]

7. Concluding thoughts

This paper explores how China's ambition to move up production value chains and to internationalize the renminbi in association with yuan appreciation would have affected Southeast Asia. We inspect the potential mechanisms through the lens of two-country New Keynesian model of global production with endogenous firm entry and currency choice in trade invoicing. In our context, industrial upgrading is viewed as expanding business formation in upstream skill-based sector which results in skill-biased technical progress, whereas renminbi internationalization is considered in terms of increasing use of the renminbi as trade invoicing currency and capital account liberalization.

Overall, we find the China's dream a sweet one for Southeast Asia, or ASEAN Economic Community in specific, when China's capital account is inconvertible, in the sense that, by leveraging on the increasing demand for high-quality inputs from China's catching up, ASEAN can realize its own dream of industrial upgrading through more firm entries in upstream skill-based sector. This demand effect propagated through global input-output linkage is lubricated by the dollar pricing practice in ASEAN's exports to China. However, favorable spillovers are overturned when China's capital account is liberalized. It hurts the pace of China's industrial upgrading, taking a toll on ASEAN's one. Anchoring local currency to the renminbi is of little help for ASEAN to withstand the adverse effect of China's capital account liberalization. To tap the benefit of China's industrial upgrading associated with yuan appreciation under such circumstance, as we have shown, ASEAN central bank could choose to create a stable cost environment conducive to firm entry in upstream skill-based sector by targeting downstream export price inflation.

Although our narrative is about China and ASEAN Economic Community, we believe that the lesson can be generalized to other economies connected to China through global production.

There are two important extensions to our model which we believe to be important for future research: direct investment and financial friction. Trade within global production is closely related to foreign direct investment. It would be interesting to see how direct investment flows would be an underlying transmission mechanism. Besides, trade needs financing, and financing requires collateral, of which the value can be affected by exchange rates and share price driven by international portfolio capital flows. Adding these two ingredients will further enrich the spillovers mechanisms.

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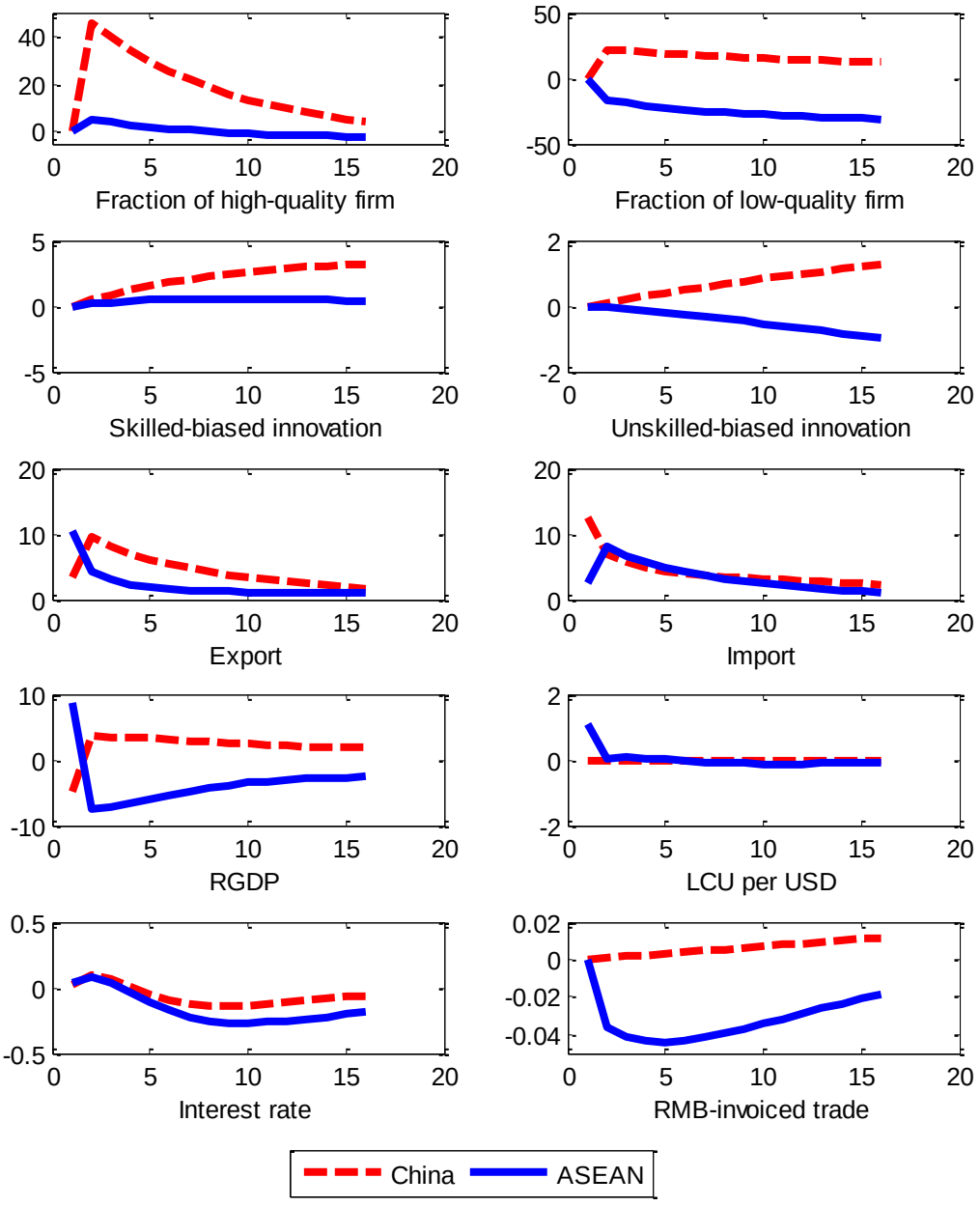
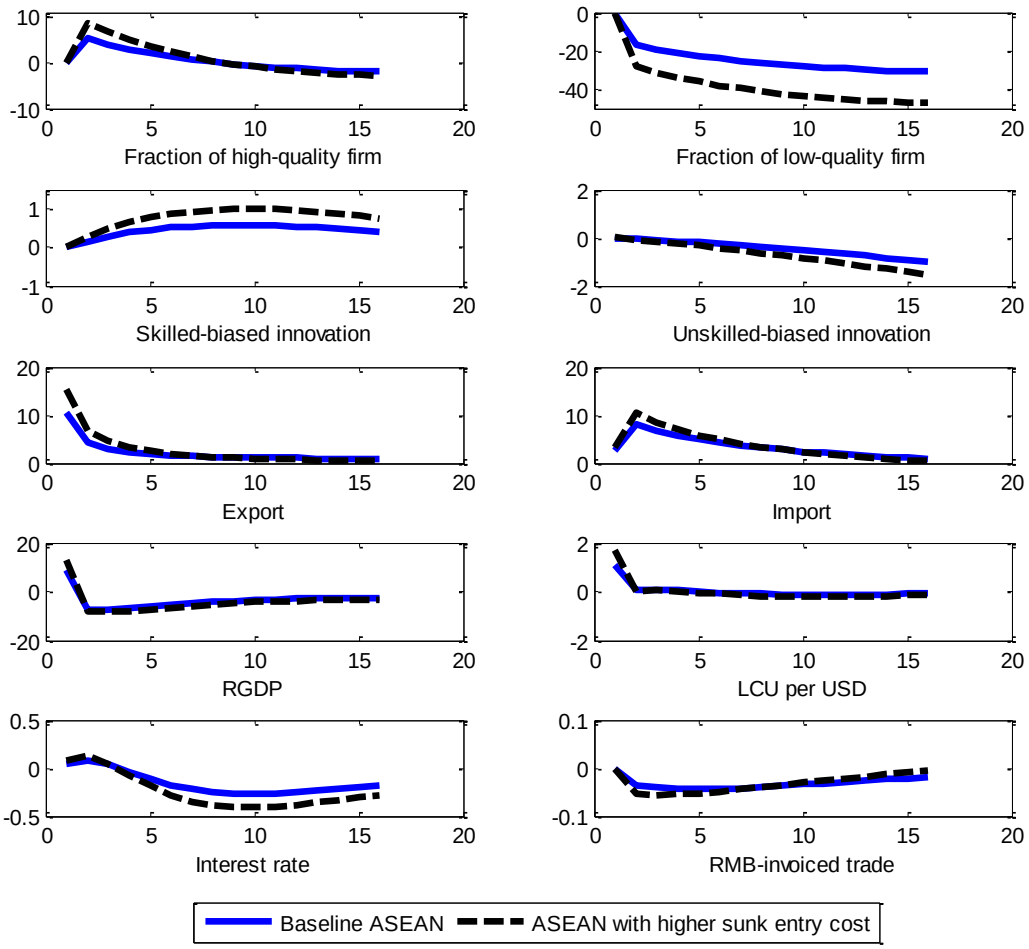
Table 1. Parameterization

		Industrial upgrading & RMB internationalization related	
Share of materials in upstream production α	0.6		
Subject discount rate β	0.99	Fixed cost parameter in high-quality production $\mathbb{F}^{\hbar}$	0.184
Constant relative risk aversion σ	1	Fixed cost parameter in low-quality production $\mathbb{F}^{\ell}$	0.01
Weight of labor disutility χ	0.2	Scale parameter for high-quality innovation growth rate $\gamma^{\hbar}$	8
Price stickiness at downstream production θ	0.75	Scale parameter for low-quality innovation growth rate γ^{ℓ}	1
Share of imported materials in upstream κ_u	0.5	Probability of successful innovation prop	0.00625
Share of imported intermediates in downstream κ_d	0.5	Elasticity of high-quality innovation to expenditure $1/\mu^{\hbar}$	2
Share of imported materials in China's upstream κ_u^*	0.5	Elasticity of low-quality innovation to expenditure $1/\mu^{\ell}$	0.333
Share of imported intermediates in China's downstream κ_d^*	0.5	Fraction of firm exit	0.025
AEC's home bias in consumption γ	0.7	Price stickiness at high-quality production $\theta^{\hbar}$	0.75
China's home bias in consumption γ^*	0.5	Price stickiness at low-quality production θ^{ℓ}	0.75
Els between home and imported consumer goods φ	1.5	Els between high-quality varieties $\epsilon^{\hbar}$	6
Els between home and imported materials in high-quality intermediates production η	1.5	Els between low-quality varieties ϵ^{ℓ}	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	AEC's 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



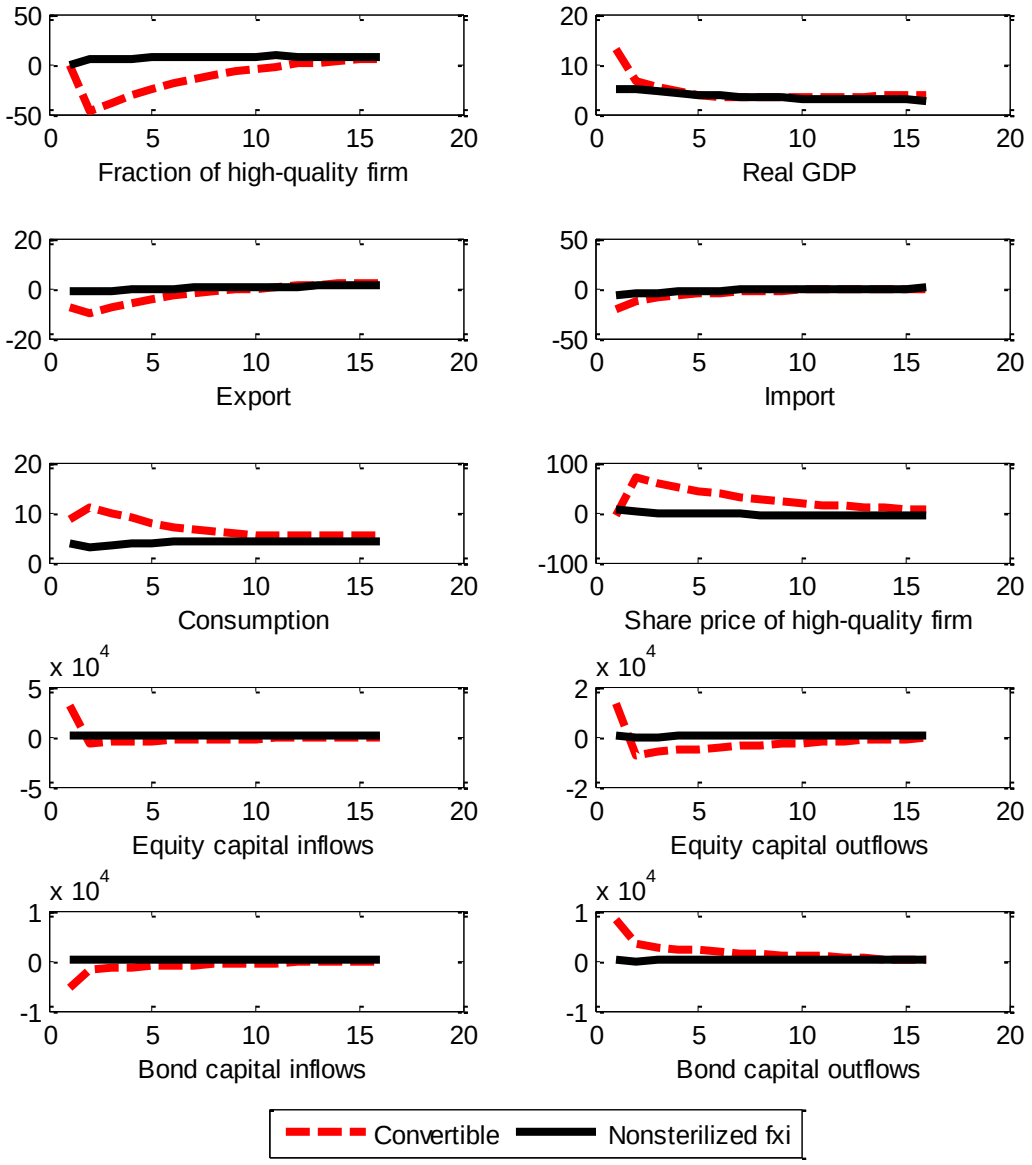
Note: y-axis: quarter; x-axis: % deviation from steady state

Fig.1 Responses to a persistent 1 percent appreciation of yuan against dollar per quarter



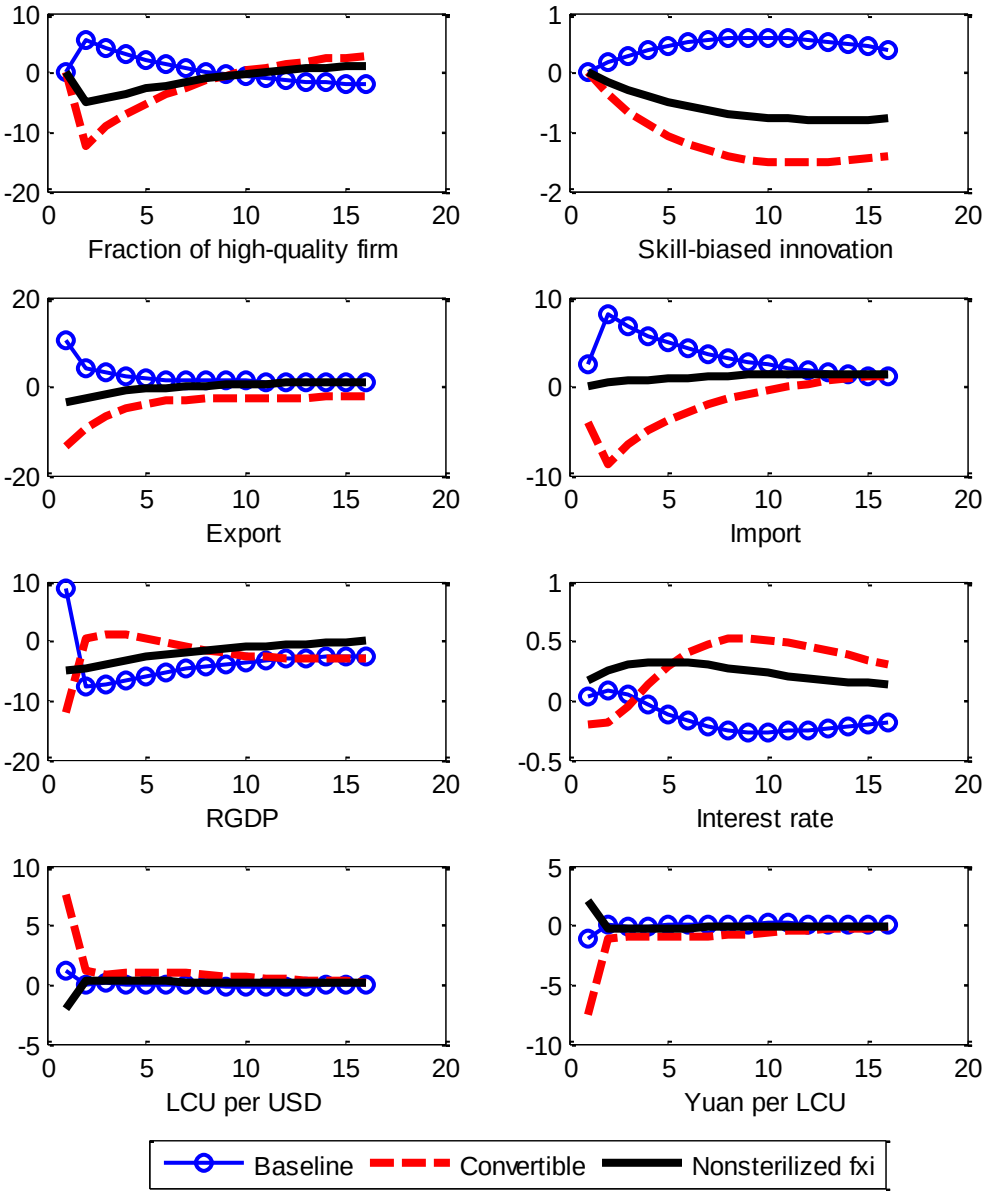
Note: y-axis: quarter; x-axis: % deviation from steady state

Fig.2 More favorable responses to yuan appreciation when sunk entry cost in AEC is larger



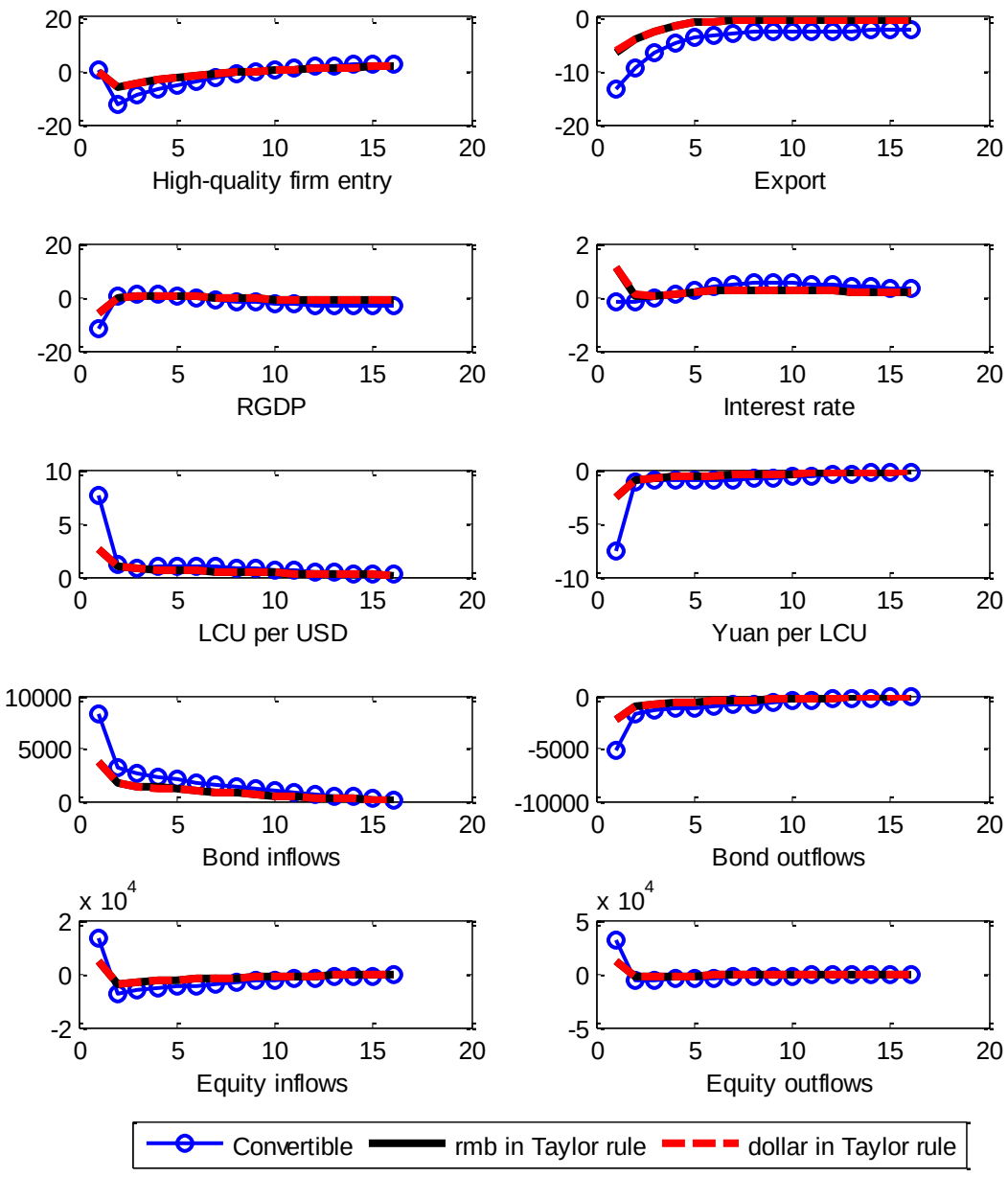
Note: y-axis: quarter; x-axis: % deviation from steady state

Fig.3 Capital account liberalization and unsterilized foreign exchange intervention overturn China's responses to yuan appreciation



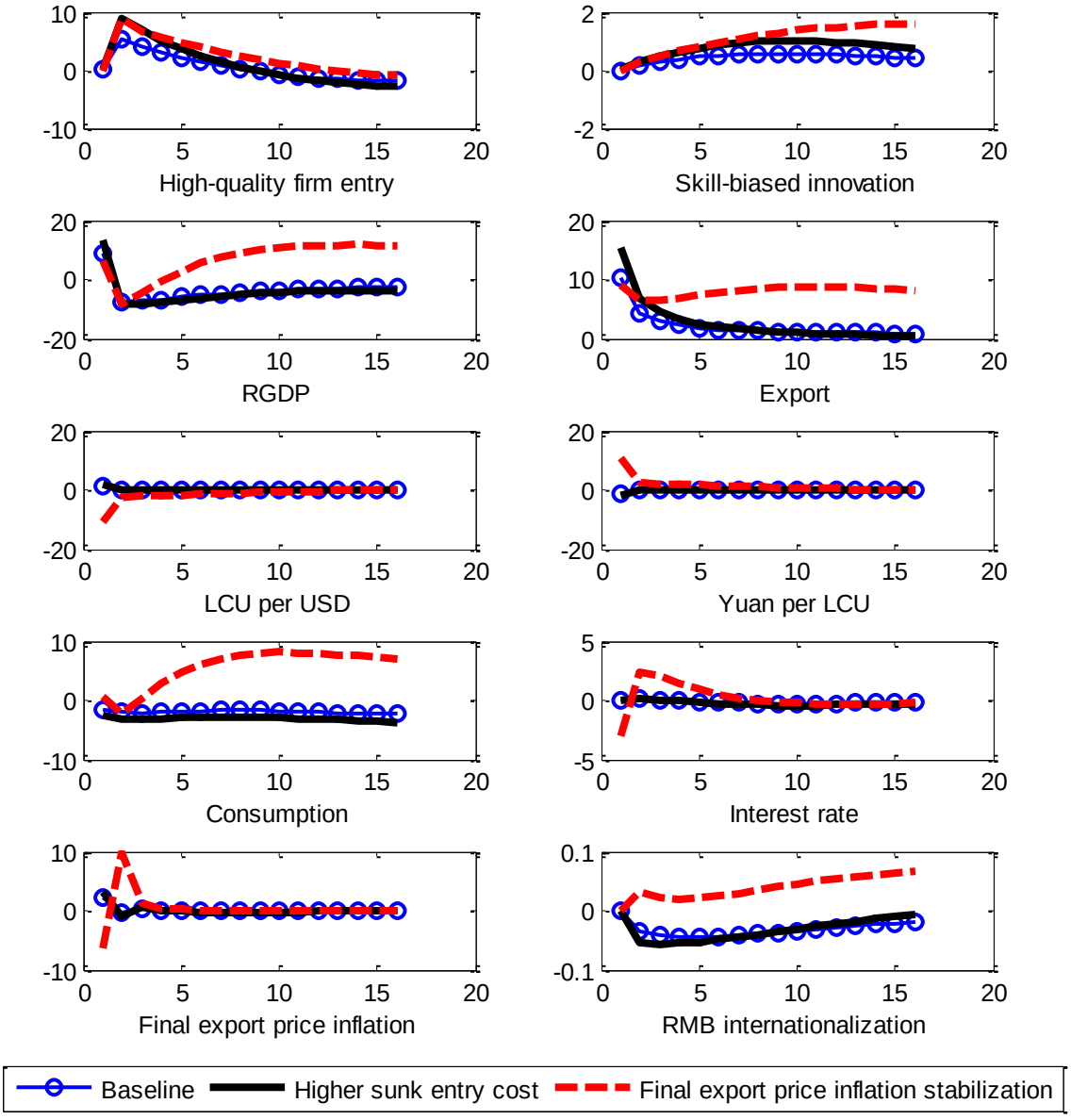
Note: y-axis: quarter; x-axis: % deviation from steady state

Fig.4 AEC's responses to persistent yuan appreciation under China's liberalized capital account are uninspiring



Note: y-axis: quarter; x-axis: % deviation from steady state

Fig.5 Stabilizing exchange rates is of little help to shield AEC from adverse effects of persistent yuan appreciation under China's liberalized capital account



Note: y-axis: quarter; x-axis: % deviation from steady state

Fig.6 Stabilizing final export price inflation generates benign spillover effects from China's industrial upgrading even when China's capital account is convertible