Industrial Transformation with Heterogeneous Labour and Foreign Experts

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Abstract

This paper develops an imitation-innovation model with heterogeneous labour and foreign MNCs to examine industrial transformation for a developing host economy. With FDI modelled at the disaggregated level of foreign experts, we formalise a MNC composition-determination framework that explains Dunning's 'internalisation advantage' (from his renowned *Eclectic Paradigm*) as being driven by the presence of asymmetric views on productivity of domestic workers. As the skills acquisition decision and foreign subsidiaries' operational mode choice are determined along the same ability distribution in the model, policy complementarities between human capital and FDI-promoting policies are established using calibrated analysis. Further, an additional asymmetry between Vertical MNCs and other MNCs leads to policy dynamics that favour balanced, broad-based FDI-promoting policies over those disproportionate ones biased towards selected types of foreign firms. Also, the policy complementarities uncovered are stronger with endogenous technological change.

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1 Introduction

Ever since Saggi (2002) documented the scarcity of studies modelling relative importance of the different types of FDI in the industrial transformation process of developing economies, this remains an under-studied area in the growth literature. On industrial transformation, recent studies such as Agénor and Dinh (2013) and Agénor and Alpaslan (2014) developed a growth framework with heterogeneous labour to examine the non-linear transitional dynamics associated with industrial transformation in a developing economy. However, they do not account for the role of foreign multinationals (MNCs), which play a significant role in the East Asian development experience [Nelson and Pack 1999; Amsden 2001].

In terms of MNCs' role in developing economies, while literature surveys such as Faeth (2009) indicate that the FDI phenomenon is largely a tale of heterogeneity, the most prominent theory on MNCs' motives remains Dunning's Eclectic Paradigm (1977). He introduces the *Ownership-Location-Internalisation advantages* (OLI) framework to explain the international activities of MNCs as being driven by *ownership-specific*, *location-specific*, and *internalisation advantages*. In essence, the OLI framework links the strength of the firms, be it in physical or human capital endowments, to location-specific factors of a host economy in influencing the internalisation decisions made. While the OLI framework is static, it suggests that there appears to be sequential entry dynamics for foreign subsidiaries with regards to the operational mode chosen for their activities in a host economy. Of the three main determinants posited by Dunning, the ownership-specific and location-specific advantages have been well-incorporated in many theoretical contributions [Faeth 2009], but there remains a vacuum for theoretical explanation of internalisation advantages. Further, the internalisation decisions within MNCs with respect to establishing foreign subsidiaries are often influenced by various micro-mechanisms tied to the incentives of foreign experts.

Given that a foreign expert-based, stylised 'internalisation advantage' framework for FDI is not an angle explored in the literature, this paper examines industrial transformation for a developing host economy by developing an imitation-innovation model with heterogeneous labour and a stylised heterogeneous MNC composition-determination framework, where MNC is modelled in the disaggregated form of foreign experts, as suggested by Markusen and Trofimenko (2009). In the model, the MNC composition-determination framework explains Dunning's 'internalisation advantage' (1977) as being driven by the presence of asymmetric views on productivity of domestic workers. Specifically, foreign experts perceive heterogeneity among the productivity of domestic workers. As productivity is a transformation of ability, the skills acquisition decision and foreign subsidiaries' operational mode choice are linked along the same ability distribution in the host economy. This allows for the examination of transitional dynamics of human capital and FDI-promoting policies, so to uncover policy complementarities when a mixture of these policies are used. Further, consistent with some well-documented stylised facts in the FDI literature, an additional asymmetry between Vertical MNCs and other MNCs is also modelled. This then enables us to lend some insights into the conventional debate on how best to implement FDI-promoting policies in developing economies.

The rest of the paper is structured as follows. Given the scarcity of literature and the inherent difficulties in the modelling of the different types of MNCs in a developing host economy, Section 2 provides a brief discussion on the rationale of the modelling approach for the FDI-composition framework, guided by the FDI literature on the various policy issues that the model attempts to address. Section 3 presents an overview of the model. Model calibrations are discussed in Section 4. In Section 5, the various policy experiments analysed are reviewed. Section 6 concludes the paper.

2 FDI heterogeneity in developing host economy

To guide the construction of a FDI-composition framework for such an inherently heterogeneous phenomenon, we first establish a *hierarchy of internalisation decision-making* with regards to MNC mode, and the order of *Nonmandated-Horizontal-Vertical* matches their respective importance in the host economy's spillover. Consistent with Dunning, firms are said to opt for Horizontal over Vertical mode as the initial form of entry due to know-how advantage over rivals, and the latter tends to be more costly too [Markusen 1995; Horstmann and Markusen 1996]. However, due to factors such as agency or information cost, MNCs tend to first establish basic nonmandated subsidiaries as default entry mode [Saggi 2002], which does not seem to play much of a role in driving industrial development, save for the poorest low-income economies deprived of basic industrial structures.[1]

After that, both Horizontal and Vertical MNCs tend to invest in knowledge-intensive industries and therefore prefer host economies with human capital [Borensztein et al. 1998]. However, given that the costs incurred by not getting access to high quality human capital is much lower for horizontal operations, foreign firms would more likely opt for the Horizontal FDI mode. Indeed, foreign subsidiaries are only inclined to send in foreign experts with sophisticated innovation know-how if the pool of human capital of a host economy is highly productive [Gersbach and Schmutzler 2011]. This implies that the top foreign experts coming in via Vertical MNCs are likely to have an additional layer of preference to distinguish the brightest of the most skilled workers.[2]

For a developing host economy with some stocks of human capital, a Horizontal MNC is likely to benefit the imitation activities, while a Vertical MNC would benefit innovation. Furthermore, a mixture of policies is often needed in the context of middle-income economies as they often do not have the appropriate policy combination to improve technology transfer, absorption capacity, and diffusion [Agénor 2015]. There appears to be indirect, nonlinear

[1] The various FDI-targeting rules and ownership stipulations imposed in developing economies often inadvertently result in many nonmandated subsidiaries of MNCs, in forms such as technological licensing agreements and minority stakes in joint-ventures [Saggi 2002]. As MNCs often treat such commitments as nonmandated subsidiaries internally, these result in MNCs that are neither imitation- nor innovation-enhancing [see D'Costa (2002), for example]. We group these FDI mode as 'Nonmandated MNC'.

[2] Empirically, this is consistent with the global FDI flows documented by Brainard (1997) and Markusen and Maskus (2002), which document a predominant type in Horizontal MNCs. Further, the context established is also consistent with international production fragmentation studies such as Athukorala (2005), Athukorala and Hill (2010), which implies that truly innovative MNCs consist only of a small share of all the vertically-integrated MNCs due to vastly different resource requirements in production fragmentation, resulting in some being technological- and skill-intensive than others.

relationships between human capital and FDI-promoting policies [Javorcik 2004; Liu 2008; Kottaridi and Stengos 2010], suggesting potential policy complementarities to be gained by using a mixture of these policies. Nonetheless, overly narrowed investment incentives have also been documented to result in adverse signalling effects in many developing economies, in that many generous incentives targeted solely at top quality MNCs have often failed to achieve intended results. This is often the key finding of the 'race-to-the-bottom' literature[3], and is treated as a stylised fact for MNCs in developing economies that we also seek to model.

3 The Model

We build on the industrial transformation model of Agénor and Dinh (2013) and Agénor and Alpaslan (2014) by introducing non-pecuniary externalities associated with presence of foreign experts. Specifically, the skills acquisition feature and five production sectors are retained. For the foreign sector, to avoid further complicating a sophisticated model, the determination of the different *types* of foreign subsidiary mode operating in the host economy is largely independent of domestic production.

It is assumed that there is only one foreign source country that deploys subsidiary units in the form of experts to the host economy. Dunning's '*internalisation advantage*' seeks to understand how foreign MNCs shape their 'in-house' preference with respect to the involvement in different production of a host economy. To construct a stylized framework that links this idea to the human capital distribution of the host economy, we adopt a nested Dixit-Stiglitz CES value function framework that is often used empirically to model heterogeneous firms along a continuous distribution [see Brambilla et al. (2009) for example]. Then, drawing on the ideas of Markusen and Trofimenko (2009), each subsidiary unit consists of one foreign expert with specific process know-how that is only available in the foreign source country. Specifically, *standardisation* know-how [used in imitation] for Horizontal MNC, and

[3] For examples, see Blomström (2002), OECD (2008), and Olney (2013).

sophisticated know-how [used in innovation] for Vertical MNC. Consequently, the presence of Vertical MNC is a necessary condition for innovation sector to exist. As our focus is on middle-income economy with both imitation and innovation sectors, the role of nonmandated subsidiaries in domestic production is largely abbreviated, modelled only as a base entry mode.

As a result of foreign firms being effectively experts with specialised human capital, a dichotomous relationship exists between domestic and foreign firms. For domestic firms, only the average productivity of workers matters. For foreign subsidiaries, they perceiving heterogeneity among the productivity of domestic workers. As individual ability of domestic workers is not fully observable to foreign firms [though they do know the overall distribution], for two different skilled workers used to produce a same blueprint variety, foreign experts would have an additional layer of preference to be 'matched' to a worker with higher productivity—a trasformation of ability—hence resulting in a Melitz (2003) type of sorting process. In deciding on operational mode, foreign experts are therefore sorted along the ability distribution of the host economy, resulting in different threshold values for different modes of operation. Consequently, these create an indirect link between the foreign MNCs' operational choice and domestic workers' skills acquisition decision. In other words, we explain '*internalisation advantage*' as resulting from the implicit 'productivity requirement'-induced information cost[4] Lastly, a demand feedback channel from the industrial state of host economy to MNC composition-determination is also introduced using an endogenous preference parameter in the foreign experts' objective function, consistent with the international product market dimension described by Felipe et al. (2012).

[4]Uncertainty of such nature may broadly be known as some sort of information cost, arising from asymmetry in either demand or supply factors. An example of such cost is examined in Hortsmann and Markusen (1996), though our paper specifically attempts to link this choice of MNCs to the ability distribution of workers in the host economy.

3.1 Domestic Sectors in Host Economy

Households: There is a continuum of dynastic representative households growing at an exogenous rate $n > 0$. Given initial number of members , L_0 in each household, the size of the representative family at time t is $L_t = \exp(nt)L_0$. Each individual members within a household is assumed to possess identical ability level, a, though different abilities are assumed at the household level. Ability follows a Pareto distribution, indexed by $a \in [a_m, \infty)$, with probability density function $f(a) = \chi a_m^\chi / a^{1+\chi}$, cumulative distribution function $F(a) = 1 - (a_m/a)^\chi$, and mean ability of the population given by $\chi a_m/(\chi - 1)$, $\chi > 2$ and $a_m > 1$. χ is the Pareto index, where the larger the value, the smaller the proportion of people with high cognitive ability. Solving the household's intertemporal utility maximisation problem,

$$\max U_t^a = \int_t^\infty \exp[-(\rho - n)(s-t)] L_0 \left[\frac{1 - (c_t^a)^{1/\sigma}}{1 - \frac{1}{\sigma}} \right] ds, \tag{1}$$

subject to budget constraint, $\dot{W}_t^a = r_t W_t^a + (1-\tau)Y_t - L_t c_t^a$, yields the familiar Euler equation at the aggregate level,

$$\frac{\dot{C}_t}{C_t} = \sigma(r_t - \rho) + n, \tag{2}$$

where r_t is the riskfree interest rate, Y_t the economy's final output, $\tau \in (0, 1)$ the tax rate on income, $\rho > 0$ the subjective discount rate, σ the constant elasticity of intertemporal substitution. The utility function of individual household member [depends on individual member's consumption, c_t^a] assumes a constant relative risk aversion form. It is also assumed that agents do not value leisure. Each representative household allocates consumption equally among its members. In addition, household is not allowed to borrow, with the standard transversality condition assumed.

In terms of skills acquisition, individual members decide whether to acquire skills or work immediately as unskilled workers, taking wages and interest rate as given. Skill acquisition decisions are therefore made to maximise each member's discounted wage income. An individual with ability $a \in [a_m, \infty)$, fully observable by both domestic firms and individuals, can either choose to enter the labour force at t as an unskilled worker and earn from then on the wage w_t^U [which is independent of worker's ability] or decide to undergo training by incurring a training cost, Γ, with efficiency of training being $\xi > 0$, before entering labour force at $t+T$ as a skilled worker and earns a wage of $a^{\xi} w_t^S$. The education process occurs during the period of $(t, t+T)$, and a direct cost of $t\acute{c}_t$ is incurred.

Based on a generalised specification of Dinopoulos and Segerstrom (1999), an individual with ability $a \in [a_m, \infty)$ would opt to become a skilled worker if and only if

$$\int_{t+T}^{\infty} \exp[-\rho(s-t)] a^{\xi} w_s^S ds - t\acute{c}_t \geq \int_t^{\infty} \exp[-\rho(s-t)] w_s^U ds, \tag{3}$$

where $t\acute{c}_t = \int_{t+T}^{\infty} \exp[-\rho(s-t)] \Gamma a^{-\xi} w_s^S ds$ is the discounted value of the skills acquisition cost, assumed to be proportional to the skilled wages at $\Gamma \in (0,1)$. The inequality (3) shows that the discounted value of the lifetime income of a skilled worker, after accounting for skills acquisition cost during the period (t, T), must be higher or at least equal to the opportunity cost of discounted unskilled wage. Hence, there exists a threshold level of ability $\hat{a}_t$ such that (3) holds as an equality, expressed as $\hat{a}_t = [\exp(\rho T).(w_t^U/(1-\Gamma)w_t^S)]^{1/\xi}$.

If skills acquisition is assumed to take place instantaneously[5], we can simplify to

$$\hat{a}_t = [w_t^U/(1-\Gamma)w_t^S]^{1/\xi}. \tag{4}$$

Given Pareto distribution for abilities, and that productivity of unskilled workers is assumed to equal unity, the share of unskilled labour supply, $\theta_{U,t}$ at time t equals

$$\theta_{U,t} = \frac{L_{U,t}}{L_t} = \int_{a_m}^{\hat{a}_t} f(a) da = a_m^{\chi} \left[-a^{-\chi}\right]_{a_m}^{\hat{a}_t} = \left[1 - (a_m/\hat{a}_t)^{\chi}\right]. \tag{5}$$

Given (5), the raw supply of skilled labour at time t is calculated as $L_t \int_{\hat{a}_t}^{\infty} f(a) da = (a_m/\hat{a}_t)^{\chi} L_t$, though the average productivity of workers with ability $a \in [\hat{a}_t, \infty)$ who have

[5]Given the infinite horizon nature of the model, we follow Eicher and García-Peñalosa (2001) and Agénor and Dinh (2013) in imposing the assumption of $T = 0$.

acquired skills need to be accounted for. This gives the share of effective supply of skilled labour at time t, $\theta_{S,t}$, as

$$\theta_{S,t} = \frac{L_{S,t}}{L_t} = \int_{\hat{a}_t}^{\infty} af(a)da = \chi a_m^{\chi} \left[\frac{a^{1-\chi}}{1-\chi}\right]_{\hat{a}_t}^{\infty} = \frac{\chi a_m^{\chi}}{\chi - 1}(\hat{a}_t)^{1-\chi}. \tag{6}$$

Imitation: Following Agénor and Dinh (2013), the imitation sector produces imitative blueprints that are purchased by firms producing basic intermediate inputs in the intermediate goods sector. Firms specialized in imitation employ only unskilled labour, in quantity $L_{U,I,t}$. There is no aggregate uncertainty in the research technology. The production flow, $\dot{M}_t^I$ at any time t is given by:

$$\dot{M}_t^I = (n_{FH,t})^{\psi_1^I}(M_t^I + \psi_2^I n_{FV,t} M_t^R)(\frac{L_{U,I,t}}{L_t}), \quad \text{where } \psi_1^I \geq 0 \text{ and } \psi_2^I \in \mathbb{R}, \tag{7}$$

with the labour specification following the 'dilution effect' of Dinopoulos and Segerstrom (1999).

The productivity component of imitative goods depends on: (i) a standard initial stock of blueprints (M_t^I), as in Jones's (2005) '*standing-on-shoulders*' effect, though at constant return [Ang and Madsen 2015] ; (ii) size of the presence of Horizontal MNCs, which given our definition of foreign firms, refers to the total number of foreign experts that bring 'know-how' to imitation production [expressed in proportion of total foreign firms, $n_{FH,t}$]; and (iii) an externality term associated with the size of Vertical MNCs in the innovation sector. As implied in studies such as Markusen and Maskus (2002), on aggregate, Horizontal FDIs are most likely to be imitation-enhancing, though an argument could be made for $\psi_1^I < 0$ if multinationals preemptively price domestic competition out of markets using their ownership of superior technology, as described in Horstmann and Markusen (1987). The externality term, $\psi_2^I n_{FV,t} M_t^R$, indicates a spillover channel from the innovation sector. Consistent with the industrial transformation thesis, as the size of the innovation sector grows and more foreign subsidiaries opt to switch to operating as Vertical MNCs, we would expect the sign of ψ_2^I to be negative. Nonetheless, given that positive empirical evidence is often reported in regards to leading foreign innovators' impacts on domestic firms' productivity, there is a possibility of a mildly positive ψ_2^I too. As such, the parameter, ψ_2^I, as well as the *stepping stone* parameter, ψ_2^R, introduced in the innovation sector, is examined across different values using sensitivity analysis.

The optimisation problem of firms in the imitation sector is to select the amount of unskilled labour to employ so as to maximise profits of $\Pi_t^I = R_t^I \dot{M}_t^I - (1+\Lambda^I) w_t^U L_{U,I,t}$, subject to (7), taking the imitative blueprint price (R_t^I) and unskilled wage rate (w_t^U) as given. The parameter Λ^I is introduced as a proportionate cost factor in the imitation sector that captures the impact of labour market distortions (for instance, additional hiring costs arising from non-competitive labour market practices). The interior solution for unskilled labour employment in imitation ($L_{U,I,t} > 0$) is given by the following first-order condition:

$$w_t^U = \frac{1}{1+\Lambda^I} \frac{R_t^I \Phi_t^I}{L_t}. \tag{8}$$

Innovation: Firms in the innovation sector produce innovative blueprints using only skilled labour ($L_{S,R,t}$). In comparison to the employment specification made for imitation, innovation sector is therefore skill-intensive. There is no aggregate uncertainty in innovation. The research production flow at any time t is given by

$$\dot{M}_t^R = (n_{FV,t})^{\psi_1^R} (M_t^R + \psi_2^R M_t^I)(\frac{L_{S,R,t}}{L_t}), \text{ where } \psi_1^R \geq 0 \text{ and } \psi_2^R \geq 0. \tag{9}$$

As in the imitation sector, the production technology of innovative goods captures the key knowledge spillover properties. Following Agénor and Dinh (2013), the research process of innovation depends on both the stock of innovative and imitative blueprints, consistent with the *stepping stone* effect of imitation introduced by Glass (2010). The productivity gains associated with the *stepping stone* effect of imitative goods may be equal, stronger ($\psi_2^R > 1$), or weaker ($\psi_2^R < 1$) than that of innovative goods. Consistent with studies such as

Markusen (1995, 1998) and Braconier et al. (2005), Vertical MNCs, $n_{FV,t}$, are specified as the relatively skill-intensive type that engage in leading-edge innovation and therefore beneficiary to domestic innovation of host economy. Similar to the imitation sector, $n_{FV,t}$, refers to the total number of foreign experts that bring sophisticated 'know-how' to innovation production in the domestic economy.[6] Likewise, to eliminate scale effects, innovation employment is specified as a ratio to total population.

The optimisation problem of firms in the innovation sector is to select the amount of skilled labour to employ so as to maximise profits, $\Pi_t^R = Q_t^R \dot{M}_t^R - (1+\Lambda^R) w_t^S L_{S,R,t}$, subject to (9), taking the patent price (Q_t^R) and skilled wage rate (w_t^S) as given. The wage in the innovation sector is affected proportionally again by a cost parameter Λ^R. When $\Lambda^R > \Lambda^I$, it is comparatively costlier to hire skilled workers in innovation than unskilled workers in imitation. This specification is consistent with the general finding documented in Haaland and Wooton (2001).[7]

For an interior solution for skilled labour employment in innovation to exist ($L_{S,R,t} > 0$), the first-order condition is given by

$$w_t^S = (\frac{1}{1+\Lambda^R})(\frac{Q_t^R}{L_t})(n_{FV,t})^{\psi_1^R}[1+\psi_2^R(\frac{m_t^I}{m_t^R})]M_t^R. \tag{10}$$

Intermediate Goods: The two intermediate goods (IG) sectors are monopolistically competitive. Each producer in the basic IG sector pays a one-off royalty payment, R_t^I, to purchase one unit of imitative blueprint to produce one unit of basic intermediate input, while each firm in the sophisticated IG sector pay patent price, Q_t^R, to purchase one unit of innovative blueprint to produce one unit of sophisticated input. In both sectors, each basic IG firm maximizes profits by setting price $P_t^{k,s} = 1/\eta$ for good s, $\forall s = 1, ...M_t^k$, where $k = I, R$.

[6] A more accurate modelling approach would be to introduce top domestic experts, but such experts are usually non-existent in a developing economy. Instead, we introduce a *foreign-to-domestic innovation expertise ratio*, $\Psi_t = n_{FV,t}/\ \theta_{S,R,t}$, where $\theta_{S,R,t} = L_{S,R,t}/L_t$, later as a proxy measure to compare across policy outcomes.

[7] In their studies, Haaland and Wooton (2001) examine the effects of labour market rigidities, especially redundancy payments, on MNCs' choice of investment destination. They document that, those sectors with relatively less certainty in production, such as the innovation sector, tend to have more rigid labour market.

In symmetric equilibrium, the associated quantity demanded for basic, x_t^I, and sophisticated intermediate, x_t^R, at individual firm level are given by

$$x_t^I = \gamma\eta\nu(\frac{Y_t}{M_t^I}) \text{ and } x_t^R = \gamma\eta(1-\nu)(\frac{Y_t}{M_t^R}), \tag{11}$$

where $\nu \in (0,1)$ is the share of basic intermediates in composite intermediates.

The maximum profit for basic IG producers in a current period t is then derived as

$$\Pi_t^I = (1-\eta)\gamma\nu(\frac{Y_t}{M_t^I}). \tag{12}$$

Standard arbitrage implies that the blueprint price must be equal to the present discounted stream of profits. For simplicity, we follow Agénor and Canuto (2012) and assume that all the profits of an imitative blueprint, excluding capital gain, go into the imitative blueprint price, R_t^I set in equilibrium. This yields $R_t^I = \Pi_t^I$.

Meanwhile, unlike imitative blueprints, patented blueprints are infinitely-lived. Each sophisticated IG firm sets its price to maximise profits, given the perceived demand function. Their maximum profit is derived as

$$\Pi_t^R = (1-\eta)\gamma(1-\nu)(\frac{Y_t}{M_t^R}). \tag{13}$$

To derive the equilibrium price of a patent for sophisticated input, Q_t^R, recall that standard no-arbitrage condition requires that the rate of return on private capital must equal to the rate of return on the exclusive holding of an innovative blueprint for sophisticated intermediate inputs, that is $r_t = \Pi_t^R/Q_t^R + \dot{Q}_t^R/Q_t^R$, which can be rearranged to yield

$$\dot{Q}_t^R = r_t Q_t^R - \Pi_t^R. \tag{14}$$

Final Output: There is a continuum of identical domestic firms producing a homogenous final good, indexed by $i \in (0,1)$. Production by individual domestic firm i requires the use of firm-specific private capital, K_t^i, skilled labour, $L_{S,Y,t}$, unskilled labour, $L_{U,Y,t}$, and composite intermediate input, X_t^i. Production by individual firm i takes the form of a standard Cobb-Douglas specification:

$$Y_t^i = (L_{S,Y,i,t})^{\beta^S}(L_{U,Y,i,t})^{\beta^U}(X_t^i)^{\gamma}(K_t^i)^{\alpha}[\frac{K_t}{(L_t)^{\iota}}]^{\varrho}, \tag{15}$$

where $\varrho > 0$, $\iota > 0$, $\alpha \in (0,1)$, $\beta^S \in (0,1)$, $\beta^U \in (0,1)$, $\gamma \in (0,1)$, and $\alpha + (\beta^S + \beta^U) + \gamma = 1$ to reflect constant returns to scale in firm-specific inputs $L_{S,Y,i,t}$, $L_{U,Y,i,t}$, X_t^i, and K_t^i. The aggregate private capital stock, $K_t = \int_0^1 K_t^i di$, asserts a conventional learning externality at magnitude ϱ, but is subject to a population congestion effect of ι.

Faced with competitive markets for private inputs, standard profit maximisation by identical firms in a symmetric equilibrium yields first-order conditions for r_t, w_t^S, w_t^U, $x_{s,t}^I$, and $x_{s,t}^R$:

$$r_t = \alpha\frac{Y_t}{K_t} - \delta, \tag{16}$$

$$w_t^S = \frac{\beta^S}{1+\Lambda^Y}\frac{Y_t}{L_{S,Y,t}}, \quad w_t^U = \frac{\beta^U}{1+\Lambda^Y}\frac{Y_t}{L_{U,Y,t}}, \tag{17}$$

$$x_{s,t}^k = (\frac{\gamma\nu^k Z_t^k}{P_t^{k,s}})^{1/(1-\eta)}, \quad s = 1,...M_t^{\varkappa}, \quad \text{with} \ \ Z_t^k = Y_t / \int_0^{M_t^k}(x_{s,t}^k)^{\eta}ds, \tag{18}$$

where $k = I, R$, $\nu^I = \nu$, $\nu^R = 1-\nu$, $P_t^{I,s}$ ($P_t^{R,s}$) is the price of basic (sophisticated) intermediate good s, w_t^S (w_t^U) the skilled (unskilled) wage rate, r_t the net rental rate of private capital, and $\delta \in (0,1)$ the rate of depreciation for private capital. Note that a third cost mark-up parameter Λ^Y is introduced again for the sector-specific hiring.

Given that both the technology and demand for all intermediate types are the same, the equilibrium for both intermediate types are symmetric too. In a symmetric equilibrium, $\int_0^{M_t^I}(x_{s,t}^I)^{\eta}ds = M_t^I(x_t^I)^{\eta}$ and $\int_0^{M_t^R}(x_{s,t}^R)^{\eta}ds = M_t^R(x_t^R)^{\eta}$. The composite intermediate inputs can then be written as

$$X_t = [(M_t^I)^{1/\eta} x_t^I]^\nu [(M_t^R)^{1/\eta} x_t^R]^{1-\nu}, \tag{19}$$

where $x_{s,t}^I$, $s \in (0, M_t^I)$ refers to basic intermediate inputs, $x_{s,t}^R$, $s \in (0, M_t^R)$ sophisticated intermediate inputs, $\eta \in (0,1)$ and $1/(1-\eta) > 1$ the price elasticity of demand for each intermediate input.

To derive an expression for the aggregate final output of the economy, the number of firms engaged in the production of final goods is normalised to unity, $Y_t = \int_0^1 Y_t^i di$, which implies that the aggregate skilled and unskilled labour used in the final output sector are given by $L_{S,Y,t} = \int_0^1 L_{S,Y,i,t} di$ and $L_{U,Y,t} = \int_0^1 L_{U,Y,i,t} di$ respectively. Using (15), the aggregate final output Y_t can be written as

$$Y_t = (L_{S,Y,t})^{\beta^S} (L_{U,Y,t})^{\beta^U} (X_t)^\gamma (K_t)^\alpha [\frac{K_t}{(L_t)^\iota}]^\varrho. \tag{20}$$

Finally, the law of motion for the private capital is given by the standard form of:

$$\dot{K}_t = I_t - \delta K_t. \tag{21}$$

3.2 Foreign Sector

Stylised Framework to explain 'Internalisation advantage': To characterise the mechanics of foreign subsidiaries' deployment, we use a three-staged, nested Dixit-Stiglitz CES objective function framework adapted from Allanson and Montagna (2005) and Brambilla et al. (2009). In each period, it is assumed that there is a mass of foreign subsidiaries, $j = 1, ..., N_F$, entering the host economy, with the salaries/profits of the experts/subsidiaries assumed, for simplicity, to be paid by the planner of the foreign source economy.[8]

[8] A more conventional approach is to specify that the salaries/profits of foreign experts/subsidiaries to be determined in the host economy. However, as applicable to most actual instances in real life, experts of MNC subsidiaries deployed to developing economies for assignments do receive their remuneration from the headquarters. In addition, unlike models treating FDI as capital stock, our main emphasis is on heterogeneous FDI compositions and how such choice is affected by skills distribution of a host economy. The usual returns

Specifically, in the first stage, the planner of the foreign source economy determines the allocation of aggregate salary expenditure for experts deployed overseas. Based on a standard Cobb-Douglas value maximisation specification, max $u_t^F = z_{H,t}^{\varrho} z_{q,t}^{1-\varrho}$, in each time period, where the exogenously given aggregate salary expenditure (I^F) is allocated between salary expenditure for experts in our host economy of interest (z_q) and for simplicity, other host economies collectively (z_H). This yields $y_t^F = (1-\varrho)I_t^F$, where y^F is the total salary expenditure allocated for the specific host economy examined. By definition, $y_t^F = w^F N_{F,t}$ too, where w^F is some exogenously given wage rate paid by the foreign headquarter and $N_{F,t}$ is the total number of foreign experts in the host economy studied.

Having determined the allocation in the first stage, a stylised institutional approach is specified in the second stage. Depending on the mode chosen, 'investment' in the host economy is assumed to be in terms of the intermediate variety an expert is randomly matched to. Collectively, the pool of foreign experts assigned to the host economy forms a representative value function over a composite of intermediate varieties, with a further layer of 'shadow quality' ascribed to capture the preference of foreign experts to be matched to workers of higher productivity, within the same variety type that they are matched to.[9]

Specifically, the value function is given by

$$\begin{aligned} U_t^F &= \{ \left([\int_{s=0}^{\bar{M}^{FP}} (\bar{x}_{s,FP}^0)^{\frac{\sigma^F-1}{\sigma^F}} ds]^{\frac{\sigma^F}{\sigma^F-1}}]^{\frac{\theta^F-1}{\theta^F}} \right) \\ &+ \{ (\int_{j=0}^{N_F} [\int_{s=0}^{M_t^I} \gamma_{1,t} (x_{s,FH,t}^I)^{\frac{\sigma^F-1}{\sigma^F}} ds + \int_{s=0}^{M_t^R} \gamma_{2,t} (x_{s,FV,t}^R)^{\frac{\sigma^F-1}{\sigma^F}} ds]^{\frac{\theta^F-1}{\theta^F}} dj) \}^{\frac{\theta^F}{\theta^F-1}}, \end{aligned} \tag{22}$$

where $\bar{M}^{FP}, M_t^I, M_t^R$ denote the default, imitative, and innovative varieties over Nonmandatory, Horizontal, $x_{s,FH,t}^I$, and Vertical investments, $x_{s,FV,t}^R$; σ^F and θ^F are elasticities of substitution within and between intermediates, with $\sigma^F > \theta^F > 1$ assumed as in Brambilla et al.

motive is therefore abridged and simplified as an exogenous salary expenditure paid by foreign planner to the entire pool of foreign experts.

[9] By construction, the 'quality difference' between investments in a host country for the foreign experts in this model reflects solely the perceived difference in productivity among the domestic workers.

(2009). $\gamma_{2,t}$ and $\gamma_{1,t}$ represent foreign preferences for investment of Vertical and Horizontal MNC respectively.[10]

Solving the optimisation problem with a nested foreign preference structure would yield a series of theoretical investment demand functions and shadow investment prices for each variety s and productivity difference-induced quality j.

FDI Compositions in Host Economy: In stage three, a firm's dynamic entry decision is modelled as a static decision in opting for investment mode.[11] Upon entry, foreign firms first assume a nonmandated MNC mode and to simplify matters, no subsequent exit is allowed. Further, in each period t, a firm can opt to stay as nonmandated MNC [incurring a basic 'doing-business' cost of F_0]; incurring additional cost, F_1 on top of F_0 to upgrade into Horizontal MNC; or incur F_0+F_2 to operate as a Vertical MNC. $F_2 > F_1 > F_0$ is assumed. In the context of each foreign subsidiary being a foreign expert, these mean foreign subsidiaries have the option to 'upgrade' and bring in an expert with more advanced processes in every period, by incurring higher cost.[12]

As stated, unlike domestic firms, each foreign expert coming in with know-how perceives heterogeneity among productivity of domestic workers. This asymmetry leads to a 'productivity requirement'-induced information cost component, $1/\varpi$, that is implicitly priced in by foreign experts when deciding on the choice of operational mode. This productivity is a transformation of ability. For simplicity, a one-to-one relationship is assumed, where $\varpi = a/\tilde{a}$, with a being value along the ability distribution of the host economy and $1 < \tilde{a} < \infty$ some exogenously specified constant value. $1/\varpi$ is therefore also characterised by a Pareto distribution. Due to persistence, for those who have become skilled, it is assumed that a more

[10] As shown later, foreign preferences are endogenous to the state of industrial development of a host economy, providing a key feedback channel of the host economy's industrial state to FDI via the product market dimensions. Nevertheless, it is taken as given by the pool of foreign experts when solving for the optimisation problem in every period.

[11] Similarly, we also adopt their assumptions where heterogeneous foreign firms are assumed to behave in a homogenous manner within the same MNC type.

[12] Consistent with the nature of most common 'doing-business' costs surveyed, such as time to acquire permits and number of administrative procedures in transactions, these costs are treated as deadweight losses in this model, instead of being fees collected by the host government.

able individual pre-skills acquisition would remain more productive over another individual with lower ability pre-skills acquisition, resulting in a Melitz (2003) type of sorting of foreign subsidiaries on $1/\varpi$. Specifically, for any intermediate variety s at time t, solving (22), we can express an optimal shadow price of investment [from the perspective of foreign experts] as a function of productivity, ϖ, that is,

$$P_{s,t} = \left(\frac{\sigma^F}{\sigma^F - 1}\right)(\varpi_{s,t}), \tag{23}$$

priced at $\sigma^F/(\sigma^F - 1) > 1$ times of $\varpi_{s,t}$.[13]

This implies that, for any investment of variety s, the larger the 'productivity requirement'-induced information cost is (lower $\varpi_{s,t}$), the lower is the theoretical investment price ascribed by the foreign experts. The basic idea is as follows. While a lower value of $\hat{a}_t$ from the labour supply side indicates a larger pool of skilled labour in the host economy, a lower value of a from the perspective of foreign investors would imply a stricter entry threshold. We would expect an order of the threshold values for the three FDI types to be $a_{FV} < a_{FH} < a_{FP}$, since a potential Vertical MNC would have a stricter entry threshold than a potential Horizontal MNC.

Further, a second source of asymmetry between Vertical and other MNCs is introduced. The introduction of this asymmetry seeks to account for the decreasing returns of labour factors on the MNCs' benefits, as documented in studies such as Blomström and Kokko (2003). It turns out that this decreasing return feature is key in preventing non-converging explosive growth. It also allows us to provide an alternative proposition to Braconier et al. (2005) or the 'race-to-the-bottom' literatures in explaining the empirical documentation of weak Vertical MNC activities in developing economies, despite most developing governments competing for their inward presence. Specifically, when a foreign subsidiary is confronted with the decision to upgrade to Vertical mode, the cost associated with the productivity

[13] Given that the perceived quality difference among investment is driven by perceived heterogeneity among productivity of domestic workers, this price is implicit in nature and reflects the 'value' placed by foreign experts on a specific intermediate variety s.

requirement is subject to a parameter ϕ, such that $\varpi^{\phi} > 0, \varpi'(\phi) < 0$ is now priced by the foreign experts to reflect the increasing difficulties in telling apart the best (highest productivity) among the brightest of skilled workers. To explain intuitively, say for example, as a given value of a gets smaller [$1/\varpi$ gets larger] and smaller [note that if from the supply side, it means the actual quantity of skilled labour in host economy is actually larger], a negative value for parameter ϕ would indicate increasing difficulties in identifying and matching to the most productive skilled workers. As the pool of skilled workers gets larger, the most productive would be harder to distinguish from other skilled workers.

The two dichotomous features discussed in the foreign sector characterise the stylised '*internalisation advantage*' framework that determines FDI compositions in this model. Equation (23), together with theoretical investment demand functions across different varieties, allow us to express individual value function for a typical foreign expert j opting for either nonmandated (π_{FP}), Horizontal (π_{FH}), or Vertical (π_{FV}) operational mode [see Appendix B]. Imposing zero profits for foreign experts across the three types, we set $\pi_{FP}(\varpi_{FP}) = 0$, $\pi_{FH}(\varpi_{FH}) = \pi_{FP}(\varpi_{FH})$, and $\pi_{FH}(\varpi^{\phi}_{FV}) = \pi_{FV}(\varpi^{\phi}_{FV})$. Then, given that $P_j = P_s = LI$ is assumed in symmetric equilibrium [Lerner Index, LI is a time-invariant structural parameter generalising market competitiveness in host economy], the three minimum threshold values for MNCs' internalisation decision in any period t can be expressed as

$$\varpi_{FP,t} = \frac{a_{FP,t}}{\tilde{a}} = \left[\frac{F_0}{\left((\sigma^F - 1)^{\sigma^F - 1}/(\sigma^F)^{\sigma^F - 1}(y_t^F)^{-1}\right) P_{F,t}^{\theta^F - 1}} \right]^{1/(1-\sigma^F)}, \tag{24}$$

$$\varpi_{FH,t} = \frac{a_{FH,t}}{\tilde{a}} = \left[\frac{F_1}{\left((\sigma^F - 1)^{\sigma^F - 1}/(\sigma^F)^{\sigma^F - 1}(y_t^F)^{-1}\right) P_{F,t}^{\theta^F - 1}[\gamma_{1,t}^{\sigma^F}(LI)^{\sigma^F - \theta^F} - 1]} \right]^{1/(1-\sigma^F)}, \tag{25}$$

$$\varpi_{FV,t} = \frac{a_{FV,t}}{\tilde{a}} = \left[\frac{(F_2 - F_1)}{\left((\sigma^F - 1)^{\sigma^F - 1}/(\sigma^F)^{\sigma^F - 1}(y_t^F)^{-1}\right) P_{F,t}^{\theta^F - 1}(LI)^{\sigma^F - \theta^F}[\gamma_{2,t}^{\sigma^F} - \gamma_{1,t}^{\sigma^F}]} \right]^{1/[\phi(1-\sigma^F)]}, \tag{26}$$

where F_0, F_1, F_2 are the 'doing-business' costs; σ^F, θ^F, y_t^F, ϕ, $\gamma_{1,t}$, $\gamma_{2,t}$ are as defined earlier;

and $P_{F,t}$ is a theoretical aggregate investment price index that is substituted out later.

To calculate the shares of foreign firms by FDI type, recall that the sorting of foreign firms follows that of $1/\varpi$. We know that the cumulative distribution function of a typical Pareto distribution z, takes the form of $F(z) = 1 - (z_{\min}/z)^{\chi}$ for some minimum of z, $z_{\min}$. Let $F(1/\varpi) = F(\tilde{a}/a)$. Further, by assuming that there is no exit option for MNCs, we can set $a_{FP} = \tilde{a}/a_{\min} \forall t$, where $\tilde{a}/a_{\min}$ denotes some minimum threshold value of entry by foreign firms (a large value along the ability distribution). At any time t, the proportion of the three types of foreign firms are given by

$$n_{FP,t} = \frac{N_{FP,t}}{N_{F,t}} = [F(1/\varpi_{FH,t}) - F(1/\varpi_{FP,t})] = [1 - (\frac{a_{FH,t}}{a_{FP}})^{\chi}] \ , \tag{27}$$

$$n_{FH,t} = \frac{N_{FH,t}}{N_{F,t}} = [F(1/\varpi_{FV,t}) - F(1/\varpi_{FH,t})] = [(\frac{a_{FH,t}}{a_{FP}})^{\chi} - (\frac{a_{FV,t}}{a_{FP}})^{\chi}], \tag{28}$$

$$n_{FV,t} = \frac{N_{FV,t}}{N_{F,t}} = [1 - F(1/\varpi_{FV,t})] = (\frac{a_{FV,t}}{a_{FP}})^{\chi}, \tag{29}$$

where a_{FP}, a_{FH}, a_{FV} give the host economy-specific threshold value of entry for Nonmandated, Horizontal, and Vertical MNCs. While $n_{FH,t}$ in (28) is determined by both $a_{FH,t}$ and $a_{FV,t}$, given fixed a_{FP}, (29) shows that the lower the value of a_{FV} [therefore the stricter the entry criteria for Vertical MNC], the smaller share of Vertical MNCs in the host economy. Also, (27) shows that the lower the value of a_{FH} [therefore stricter criteria for Horizontal MNC], the larger the share of Nonmandated MNCs.

Some straightforward algebraic manipulations using (24)-(26) allow us to substitute out y_t^F and $P_{F,t}$, and establish two threshold conditions of

$$a_{FH,t} = \left[\frac{F_0}{F_1}((LI)^{\sigma^F - \theta^F}(\gamma_{1,t})^{\sigma^F} - 1)\right]^{-1/(1-\sigma^F)} a_{FP}, \text{ and} \tag{30}$$

$$a_{FV,t} = \left[\frac{F_2 - F_1}{F_0} \frac{1}{(LI)^{\sigma^F - \theta^F}[\gamma_{2,t}^{\sigma^F} - \gamma_{1,t}^{\sigma^F}]}\right]^{1/[\phi(1-\sigma^F)]} a_{FP}^{1/\phi} \tilde{a}^{(\phi-1)/\phi}. \tag{31}$$

In addition, a feedback channel on the state of industrial development of a host economy to FDI composition is introduced. Given that FDI inflows into the Southeast Asian regions are found empirically to follow a Weibull distribution by Gander et al. (2009), we simplify by modelling the two foreign preference parameters $\gamma_1$and γ_2 using a Weibull distribution, governed by a hazard function of

$$\gamma_1 = [1 - h(\gamma_2; \omega_k, \omega_\lambda)]\gamma_2 = [1 - (\frac{\omega_k}{\omega_\lambda}(\frac{\gamma_2}{\omega_\lambda})^{\omega_k - 1})]\gamma_2, \tag{32}$$

where $h(\gamma_2; \omega_k, \omega_\lambda)$ denotes the hazard rate of γ_2[14], and ω_k and ω_λ are the shape and scale parameter respectively. As γ_1 is given by the expected value of $E(\gamma_2)$, this allows us to endogenise foreign preference in a single parameter, Q^F, a demand-side feedback channel depending on the state of industrial development of a host economy. This allows us to rewrite (30) and (31) as

$$a_{FH,t} = \left[\frac{F_0}{F_1}((LI)^{\sigma^F - \theta^F}(Q_t^F - \Theta_1(Q_t^F)^{\omega_k})^{\sigma^F} - 1)\right]^{-1/(1-\sigma^F)} a_{FP}, \text{ and} \tag{33}$$

$$a_{FV,t} = \left[\frac{F_2 - F_1}{F_0}\frac{1}{(LI)^{\sigma^F - \theta^F}[(Q_t^F)^{\sigma^F} - (Q_t^F - \Theta_1(Q_t^F)^{\omega_k})^{\sigma^F}]}\right]^{1/[\phi(1-\sigma^F)]} a_{FP}^{1/\phi}\tilde{a}^{(\phi-1)/\phi}, \tag{34}$$

respectively, where $\Theta_1 = (\omega_k/\omega_\lambda)(1/\omega_\lambda)^{\omega_k - 1}$. For tractability, we assume that the foreign MNCs set $\dot{Q}^F = \dot{m}_t^I$ in each period.[15]

Finally, using (27)-(29), (33), and (34), we write $n_{FH,t}$ and $n_{FV,t}$ as

$$n_{FH,t} = \left[\frac{F_0}{F_1}((LI)^{\sigma^F - \theta^F}(Q_t^F - \Theta_1(Q_t^F)^{\omega_k})^{\sigma^F} - 1)\right]^{-\chi/(1-\sigma^F)} - n_{FV,t}, \text{ and} \tag{35}$$

[14] This means we assume that foreign investment preference in the mode of Horizontal MNC would reduce over time in regards to investment preference in the mode of Vertical MNC. While this assumption seems arbitrary, it provides a reasonable simplification that allows for feedback of industrial state in the host economy to FDI composition through only a single foreign preference channel.

[15] The use of m_t^I in the feedback channel as a proxy that reflects the state of industrial development in a developing host economy is consistent with studies such as Yusuf and Nabeshima (2009). It also provides a more general feature given that there are developing host economies that have only imitation production.

$$n_{FV,t} = \left(a_{FP}^{1/\phi}\tilde{a}^{(\phi-1)/\phi}\right)^{\chi}\left[\frac{F_2 - F_1}{F_0}\frac{1}{(LI)^{\sigma^F-\theta^F}[(Q_t^F)^{\sigma^F} - (Q_t^F - \Theta_1(Q_t^F)^{\omega_k})^{\sigma^F}]}\right]^{\chi/[\phi(1-\sigma^F)]}, \tag{36}$$

where $\Theta_1 = (\omega_k/\omega_\lambda)(1/\omega_\lambda)^{\omega_k-1}$ and $Q_t^F = w_m m_t^I$ (w_m is a multiplicative constant).

As a result of the perceived heterogeneity of productivity among workers, and the assumed ability-productivity relationship, the determination of $n_{FH,t}$ and $n_{FV,t}$ in any period t is driven by the sorting process along the same ability distribution, and depends on threshold ability values, $a_{FH,t}$ and $a_{FV,t}$. Naturally, these result in some degree of direct tradeoff between $n_{FH,t}$ and $n_{FV,t}$, as can be seen in (35), though it is also possible that an economy can gain in both $n_{FH,t}$ and $n_{FV,t}$.

3.3 Government and Market-clearing Conditions

Government: Most of the public policies in this paper are assumed to be financed by reallocating spending within the budget, so that the tax rate remains the same and the overall balance remains. As such, we can assume a simplified government sector. A balanced budget is maintained, and the government cannot issue bonds to borrow. At each time t, the government taxes on final output at the rate τ to finance its expenditure G_t, as in

$$G_t = \tau Y_t. \tag{37}$$

Market Equilibrium Conditions: Given that $\int_0^{M_t^I} x_{s,t}^I ds = M_t^I x_t^I$ and $\int_0^{M_t^R} x_{s,t}^R ds = M_t^R x_t^R$, the market-clearing condition for the final goods market is given by

$$Y_t = L_t c_t^a + M_t^I x_t^I + M_t^R x_t^R + I_t + G_t. \tag{38}$$

Using (11), (37), equation (38) is rewritten to express private investment as

$$I_t = L_t c_t^a - (1 - \gamma\eta - \tau)Y_t. \tag{39}$$

For the skilled and unskilled labour markets, we have

$$L_{S,Y,t} + L_{S,R,t} = L_{S,t}, \text{ or } \quad \theta_{S,Y,t} + \theta_{S,R,t} = \theta_{S,t}, \text{ and} \tag{40}$$

$$L_{U,Y,t} + L_{U,I,t} = L_{U,t}, \text{ or } \theta_{U,Y,t} + \theta_{U,I,t} = \theta_{U,t}. \tag{41}$$

In any given period t, the shares of foreign experts/subsidiaries in Nonmandated, Horizontal, and Vertical mode in the host economy must sum up to one. This means

$$n_{FP,t} = 1 - n_{FH,t} - n_{FV,t} \ , n_{FP,t} \geq 0. \tag{42}$$

3.4 Dynamic System and Steady-state

To generate endogenous growth, we impose the knife-edge conditions: **Assumptions**: $\beta^S + \beta^U - \varrho\iota = 0$, $(\gamma/\eta) + \alpha + \varrho = 1$.

Specifically, define $m_t^I = M_t^I/K_t$, $m_t^R = M_t^R/K_t$, and using (19), (11), (20) can be written as

$$Y_t = (\theta_t^{S,Y})^{\beta^S} (\theta_t^{U,Y})^{\beta^U} L_t^{\beta^S+\beta^U-\varrho\iota} \tag{43}$$
$$\times \left\{ (\gamma\eta\nu^\nu(1-\nu)^{1-\nu})(m_t^I)^{\nu(1-\eta)/\eta}(m_t^R)^{(1-\nu)(1-\eta)/\eta}(\frac{Y_t}{K_t}) \right\}^\gamma (K_t)^{(\gamma/\eta)+\alpha+\varrho},$$

where $(L_t)^0 = 1$ if and only if $\beta^S + \beta^U - \varrho\iota = 0$. The level of output, Y_t, is linear to the private capital stock, K_t, if and only if $(\gamma/\eta) + \alpha + \varrho = 1$.

The dynamic system of the economy is characterised by a differential algebraic system consisting of four first-order differential equations and seven static equations, as follows:

$$\frac{\dot{m}_t^R}{m_t^R} = (n_{FV,t})^{\psi_1^R}[1 + \psi_2^R(\frac{m_t^I}{m_t^R})](\theta_{S,t} - \theta_{S,Y,t}) - (1 - \gamma\eta - \tau)(\frac{Y_t}{K_t}) + z_t^C + \delta, \tag{44}$$

$$\frac{\dot{m}_t^I}{m_t^I} = (n_{FH,t})^{\psi_1^I}[1 + \psi_2^I n_{FV,t}(\frac{m_t^R}{m_t^I})](\theta_{U,t} - \theta_{U,Y,t}) - (1 - \gamma\eta - \tau)(\frac{Y_t}{K_t}) + z_t^C + \delta, \tag{45}$$

$$\frac{\dot{z}_t^C}{z_t^C} = n + [\sigma\alpha - (1 - \gamma\eta - \tau)](\frac{Y_t}{K_t}) + z_t^C - \sigma(\rho + \delta) + \delta, \tag{46}$$

$$\frac{\dot{Q}_t^R}{Q_t^R} = [\alpha(\frac{Y_t}{K_t}) - \delta] - (1 - \eta)\gamma(1 - \nu)(\frac{Y_t}{K_t})(\frac{1}{Q_t^R})(\frac{1}{m_t^R}), \tag{47}$$

of which m_t^I and m_t^R are backward-looking state variables, while z_t^C and Q_t^R are forward-looking jump variables.

The seven static equations are

$$\frac{Y_t}{K_t} = \frac{\Theta_2}{[(\theta_{S,Y,t})^{\beta^S}(\theta_{U,Y,t})^{\beta^U}]^{-1/(1-\gamma)}} \left\{(m_t^I)^{\nu(1-\eta)/\eta}(m_t^R)^{(1-\nu)(1-\eta)/\eta}\right\}^{\gamma/(1-\gamma)}, \tag{48}$$

$$\theta_{S,Y,t} = \frac{\beta^S(1+\Lambda^R)}{(1+\Lambda^Y)}(\frac{Y_t}{K_t})[Q_t^R(m_t^R)]^{-1}(n_{FV,t})^{-\psi_1^R}[1 + \psi_2^R(\frac{m_t^I}{m_t^R})]^{-1}, \tag{49}$$

$$\theta_{U,Y,t} = \frac{\beta^U(1+\Lambda^I)}{(1+\Lambda^Y)(1-\eta)\nu\gamma}(n_{FH,t})^{-\psi_1^I}[1 + \psi_2^I n_{FV,t}(\frac{m_t^R}{m_t^I})]^{-1}, \tag{50}$$

$$\theta_{U,t} = 1 - a_m^{\chi}[\frac{\beta^U}{\beta^S(1-\Gamma)}\frac{\theta_{S,Y,t}}{\theta_{U,Y,t}}]^{-\chi/\xi}, \tag{51}$$

$$\theta_{S,t} = \frac{\chi a_m^{\chi}}{\chi - 1}[\frac{\beta^U}{\beta^S(1-\Gamma)}\frac{\theta_{S,Y,t}}{\theta_{U,Y,t}}]^{(1-\chi)/\xi}, \tag{52}$$

$$n_{FH,t} = \left[\frac{F_0}{F_1}((LI)^{\sigma-\theta}(w_m m_t^I - \Theta_1(w_m m_t^I)^{\omega_k})^{\sigma^F} - 1)\right]^{-\chi/(1-\sigma^F)} - n_{FV,t}, \tag{53}$$

$$\begin{aligned} n_{FV,t} \quad = \quad & \left(a_{FP}^{1/\phi}\tilde{a}^{(\phi-1)/\phi}\right)^{\chi} \\ & \times \left[\frac{F_2 - F_1}{F_0}\frac{1}{(LI)^{\sigma^F-\theta^F}[(w_m m_t^I)^{\sigma^F} - (w_m m_t^I - \Theta_1(w_m m_t^I)^{\omega_k})^{\sigma^F}]}\right]^{\chi/[\phi(1-\sigma^F)]}, \end{aligned} \tag{54}$$

where $\Theta_1 = (\omega_k/\omega_\lambda)(1/\omega_\lambda)^{\omega_k - 1}$ and $\Theta_2 = (\gamma\eta\nu^\nu(1-\nu)^{1-\nu})^{\gamma/(1-\gamma)}$.

The steady-state equilibrium is defined as an equilibrium path where the growth rate of the aggregate representative households' consumption $(n_t + (\dot{c}_t^a/c_t^a))$, the growth rate of the private capital stock ($\dot{K}_t/K_t$), the growth rate of imitative blueprints ($\dot{M}_t^I/M_t$), and the growth rate of innovative blueprints ($\dot{M}_t^R/M_t^R$) are all equal, whereas the imitative blueprint price (R_t^I), the patent price (Q_t^R), rate of return on private capital (r_t), real prices ($P_t^{I,s}$, P_t^R), and shadow aggregate price index ($P_{F,t}$) are constant. From the five static conditions in domestic sectors, (48)-(52), and the two equations determining number of Horizontal MNCs and Vertical MNCs, (35) and (36), we also know that Y_t/K_t , $\theta_t^{S,Y}$, $\theta_t^{U,Y}$, θ_t^U , θ_t^S, $n_{FH,t}$, and $n_{FV,t}$ are constant. These imply that: (i) final output, private capital stock, and therefore private consumption are growing at a same constant rate in steady-state; (ii) labour supplies grow at the same rate as the population growth rate in steady-state; and (iii) the number of foreign experts in imitation, $n_{FH,t}$, and innovation, $n_{FV,t}$, are constant.

In steady-state, these constancies indicate that the innovative blueprint-private capital ratio (m_t^R), imitative blueprint-private capital ratio (m_t^I), as well as the private consumption-private capital ratio (z_t^C) are constant, resulting in $\dot{m}_t^R = \dot{m}_t^I = \dot{z}_t^C = \dot{Q}_t^R = 0$. Hence, the left-hand side (LHS) of equations (44)-(47) can be set equal to zero to derive steady-state values, $\tilde{m}^I$, $\tilde{m}^R$, $\tilde{z}^C$, and $\tilde{Q}^R$. Given the non-linearities associated with m_t^R and m_t^I, complete reduced form expressions for $\tilde{m}^I$, $\tilde{m}^R$, $\tilde{z}^C$, and $\tilde{Q}^R$are determined numerically.

The complexity of the model means saddlepath stability cannot be established analytically, though local stability in the vicinity of computationally derived steady-states can be established for selected configurations of model parameters. Nonetheless, since it cannot be fully established analytically, some configurations of the model may result in the model being locally indeterminate. This necessitates the use of a numerical method solving for a two-point boundary value problem in any policy experiment, such as the relaxation algorithm of Trimborn et al. (2008).[16] Unlike conventional forward shooting methods and finite-horizon discrete time approximation methods (see Judd, 1998), or the backward integration method

[16] The relaxation algorithm is a specific type of finite-difference method designed to overcome typical problems faced when solving high-dimensional continuous time growth models. In addition to approximating the system of differential equations with finite-difference equations on a mesh of points in time, the algorithm also applies a typical error minimisation procedure when approximating the time path of solutions. See Trimborn et al. (2008) for further details.

[Brunner and Strulik, 2002], the relaxation algorithm is more efficient in dealing with high dimensional systems and therefore allows us to trace out the unique transition dynamics numerically for each of the policy experiments implemented. Likewise, local saddlepath stability is also established numerically by calculating the eigenvalues of the Jacobian of the linearised system for each simulation case considered.

4 Model Parameterisation

The model is calibrated for an upper-middle income country with both innovation and imitation sectors, as well as having non-zero Vertical MNCs. Malaysia, a Southeast Asian economy that has successfully positioned itself as part of the global MNCs' production value chain yet struggles to switch to an innovation-led growth strategy, is chosen as the economy studied.

On the *household* side, the annual discount rate, ρ, and the elasticity of intertemporal substitution, σ, are set at 0.04 and 0.27 [Agénor and Montiel 2008]. L_0 is normalised to unity, with the constant population growth rate, n, set at the five-year average of 1.73 percent as in 2008-12. The supply of skilled labour is measured in efficient units of human capital, and is therefore adjusted for average ability. For calibration purposes, given that firm-level distribution of skills and training expenditure in Malaysia are not reported in surveys [Sander and Hanusch 2012], the number of effective skilled labour is proxied by the number of workers with tertiary education. The calibration strategies for the remaining household parameters would focus on producing an initial share of skilled workers, θ_S at 0.240. This involves assuming initial skills acquisition cost, Γ, to be high at 25 percent of skilled wages, though given the recent establishment of meso-organisations fr human capital development, such as *Pembangunan Sumber Manusia Berhad* (PSMB), the efficiency of training, ξ is set highly at 0.9. For the ability distribution, both the lower bound value, a_m and the Pareto index parameter, χ, are set at minimum values that would satisfy $\chi > 2$ and $a_m > 1$.

For *imitation* parameter, ψ_1^I, Lim (2015), in an empirical study using *Productivity and Investment Climate Survey* (PICS) dataset for Malaysia, obtains econometric estimates in the range of $0.20 - 0.35$ for a foreign ownership dummy. The upper estimate is used in our calibration to reflect reasonable strength of spillover in the imitation sector, therefore $\psi_1^I = 0.35$. On the multiplicative parameter of ψ_2^I, we set $\psi_2^I = -0.3$ for the initial baseline to reflect a mildly negative tradeoff between the productivity of domestic imitators and the cross-term of leading foreign innovation experts and innovative blueprint stock.[17]

In the *innovation* sector, for ψ_1^R, based on Yusuf and Nabeshima (2009), we set $\psi_1^R = 0.40$. The *stepping stone* effect parameter, ψ_2^R, is set initially to a high value of 9.5 to reflect the well-documented established industrial base of Malaysia (Kharas et al., 2010), though sensitivity analysis reported later will further assess the effect of a change in this parameter.

In the *final output* sector, the elasticity of output with respect to private capital, α, is set at a fairly standard value of 0.3. The elasticity with respect to composite intermediates, γ, is set at 0.3, which is double the value of 0.15 used by Agénor and Alpaslan (2014) for a low-income economy to reflect the industrial status of Malaysia, though it remains slightly lower than the 0.36 used by Funke and Strulik (2000) for developed economies. By implication of the constant returns-to-scale assumption, that leaves a total of 0.4 between skilled and unskilled labour. Agénor and Dinh (2013) set β^U at 0.2 for low-income economies. To adjust for Malaysia's middle-income country status while based on similar proportions to β^S, the parameter β^U is set at 0.15, which leaves $\beta^S = 0.25$. The relative share of basic intermediate in the composite intermediate inputs, ν, is set at 0.57. By comparison, Agénor and Alpaslan (2014) use a high value of 0.90 for low-income economies. As we might expect ν to change with industrial transformation over time, a specific sub-section on endogenous ν is presented as part of the sensitivity analysis later. Lastly, following Agénor and Dinh (2013), the depreciation rate for private capital, δ, is set at 0.068.

[17] As discussed earlier, the parameter ψ_2^I can be interpreted as either a direct negative effect on imitators' productivity as the size of innovation grows or a positive productivity spillover from leading foreign innovators to domestic imitators, as documented econometrically by Kam (2013) specifically for Malaysia. Sensitivity analysis is therefore implemented to examine the steady-state implications under both cases.

For the hiring cost mark-up parameters, an initial order of innovation, imitation, and final output sector in terms of rigidity is calibrated, in consistent with Sander and Hanusch (2012). In Zeufack and Lim (2013), the hiring cost parameter in the knowledge-intensive sector [their model does not distinguish between imitation and innovation] is set at 0.10. We set this as the value for Λ^I, with $\Lambda^Y = 0.05$ being half of it while $\Lambda^R = 0.20$ doubles the value to reflect greater difficulties in hiring innovation workers. In the *intermediate goods* sectors, the substitution parameter η for domestic production is set at 0.39 to capture a lower elasticity of substitution between intermediate inputs, in comparison to the 0.54 used by Funke and Strulik (2000) or the 0.60 used by Iacopetta (2011), but similar to the non-competitive scenario of 0.40 studied in Sequeira (2011). In our views, this captures the unique context of the Malaysian industry— a highly specialised global electrical and electronic component manufacturing hub, and part of the production network of large foreign MNCs. Lastly, the tax rate, τ, is set to 0.25, which corresponds to the average effective tax rate.

Moving on to the *foreign* sector, in the representative objective function for foreign experts, recall the assumption of $\sigma^F > \theta^F > 1$, as in Brambilla et al. (2009). The between-variety elasticity, σ^F, is first set arbitrarily at 2. The across-variety elasticity for foreign preference, θ^F, is then set at 1.64, which is calibrated to reflect a corresponding substitution parameter of 0.61, the value used by Agénor and Alpaslan (2014) for substitution parameter in the production side. This is calibrated to reflect the different preferences of foreign experts who come in with different know-how, though the combination of calibrated values for σ^F and θ^F is reasonably consistent with studies using nested utility framework. The calibration for the Lerner Index, LI, is based on the average empirical estimates of profit margin, 0.2544, for Malaysian manufacturing firms by Zeufack and Lim (2013). A simple approximation measure for LI is just $1 - 0.2544 = 0.7456$. For the basic doing-business cost of F_0, a value of 0.2733 is calibrated, based on the average cost of business start-up procedures reported in the World Bank Doing Business Surveys 2004-08. For $F_1$and F_2, given the imposed assumption of $F_2 > F_1 > F_0$, $F_1 = 0.33$ and $F_2 = 0.40$ are set, which imply that the cost incurred by foreign subsidiaries to come in with experts with *standardisation* and *sophisticated* know-how would be one-third and 40 percent of a baseline price. As policy scenarios involving cuts in $F_1$and F_2 are examined extensively in simulation exercises later, these initial calibrated values are intended to reflect an initial situation where it is expensive for foreign experts to operate in the host economy. The asymmetric cost parameter, $\phi = -1$ is conveniently set to reflect a constant rate of decreasing return associated with $1/\varpi$.[18]

The total number of foreign experts entering the host economy, $N_{F,t}$ in each period is normalised to one. In terms of the parameters in the Weibull process used to model the evolution of foreign preferences, the shape parameter, ω_k, and the scale parameter, ω_λ, are set equal to 1 and 2 respectively. For the shares of the three different *types*, the FDI compositions for Malaysia are estimated using data from the U.S. Bureau of Economic Analysis (BEA). Due to the constraints of existing FDI statistics classification (by broad industry or country, not MNCs' operations or value chain), the breakdown based on American MNCs' foreign affiliates from BEA is used, as it is the only national agency with sufficiently long time series of such detail nature.[19] Based on the estimates, the initial proportion of Nonmandated (n_{FP}), Horizontal (n_{FH}), and Vertical MNCs (n_{FV}) are calibrated to equal 0.3099, 0.6737, and 0.0164 respectively. To obtain these initial values for the FDI compositions in an initial steady-state that is saddlepath stable, it turns out that the constant value $\tilde{a}$, and the constant term, w_m in the international product market dimension feedback channel are set simultaneously at 9.55 and 3.6 respectively. Lastly, based on all the calibrated parameters, we estimate the initial value of a_{FP} at 24.656.

To establish that the initial steady-state is consistent with $a_{FV} < a_{FH} < a_{FP}$, first, rearranging (29) would allow us to calculate the threshold entry value for Vertical FDI, a_{FV}, to equal 3.155. Then, given the values for a_{FV}, a_{FP}, the initial steady-state value

[18]For robustness check, we experimented with an increasing rate of decreasing return ($\phi < -1$), and a decreasing rate of decreasing return ($0 < \phi < -1$). For the range of ϕ values where the model still solves, the calibration of ϕ does not produce significant difference to the policy experiment results later.

[19]The classification is based on Markusen (1998) and Braconier et al. (2005). The BEA data on US majority-owned nonbank foreign affiliates is used to estimate the MNC compositions. See Appendix A.

for n_{FH}, and other calibrated parameters, the threshold value for Horizontal FDI, a_{FH}, is calculated by rearranging (28), yielding $a_{FH} = 23.392 < a_{FP}$. The theoretical condition of $a_{FV} < a_{FH} < a_{FP}$ is therefore satisfied in the initial steady-state.

For the main variables of interest, the calibrations are as follows. As stated, from data, we know $\theta_S = 0.240$. Further, based on the percentage share of R&D researchers in Malaysia, the share of effective skilled labour in innovation, $\theta_{S,R}$, is estimated at 0.045. These imply that $\theta_{S,Y} = 0.195$. Knowing the initial values for θ_S and $\theta_{S,Y}$, as well as other calibrated values (a_m, χ, ξ, β^S, β^U), we can rearrange (52) to calculate for the unskilled labour share in final output sector, $\theta_{U,Y} = 0.0231$. Then, rearranging (51), the share of unskilled labour, θ_U, would equal 0.9856. By implication, $\theta_{U,I}$ is then 0.9625. On the industrial composition ratio, the average of Malaysia's share of high technological exports as percentage of total manufactured exports is calculated for the year between 2008 and 2011, yielding 0.4164. The industrial composition ratio measures the ratio, $m_t = m_t^I/(m_t^R + m_t^I)$, which means its initial steady-state value would equal $1 - 0.4164 = 0.5836$. In terms of relative domestic innovation expertise, the *foreign-to-domestic innovation expertise ratio,* Ψ_t, is defined as the ratio of the number of foreign experts with sophisticated know-how to the number of skilled workers in innovation sector. Recalling that both $N_{F,t}$ and L_t are normalised to one, we can therefore write $\Psi_t = n_{FV,t}/\ \theta_{S,R,t}$ to compute for the innovation expertise ratio in each period. The initial steady-state value is $\Psi_t = 0.3672$. Finally, for the initial steady-state growth rate of final output, a multiplicative constant is introduced to yield both the initial final output and private capital stock growth rates to equal 4.3 percent per annum, which corresponds to the average growth rate for Malaysia during 2008-13. By implication of the steady-state properties, private consumption growth equals 4.3 percent. Table 1-3 summarise the parameter values.

Table 1
Calibrated Parameter Values: Benchmark (for Host Economy)

Parameter	Value	Description
Households		
ρ	0.04	Annual discount rate
σ	0.27	Elasticity of intertemporal substitution
n	0.0173	Population growth rate
ξ	0.9	Productivity parameter (efficiency of skills acquisition)
Γ	0.25	Skills acquisition cost (in proportion of skilled wage)
χ	2.001	Pareto index, breadth of ability distribution in host economy
Final Output		
α	0.3	Elasticity with respect to private capital
β^U	0.15	Elasticity with respect to unskilled labour
β^S	0.25	Elasticity with respect to skilled labour
γ	0.3	Elasticity wrt composite intermediate input
ν	0.57	Share of basic input in composite intermediate input
Λ^Y	0.05	Cost mark-up due to labour market distortions
δ	0.068	Rate of depreciation, private capital
Intermediate goods		
η	0.39	Substitution parameter for production, intermediate goods

Table 2
Calibrated Parameter Values: Benchmark (for Host Economy, continue)

Parameter	Value	Description
Imitation sector		
ψ_1^I	0.35	Elasticity wrt number of foreign experts in Horizontal mode
ψ_2^I	−0.3	Externality, Vertical MNCs and innovative blueprint
Λ^I	0.1	Cost mark-up due to labour market distortions
Innovation sector		
ψ_1^R	0.4	Elasticity wrt number of foreign experts in Vertical mode
ψ_2^R	9.5	*Stepping stone* effect, from stock of imitative goods
Λ^R	0.2	Cost mark-up due to labour market distortions
Government		
τ	0.25	Effective tax rate on final output

Table 3
Calibrated Parameter Values: Benchmark (for Foreign sector)

Parameter	Value	Description
σ^F	2.0	Elasticity of foreign preference, between varieties
θ^F	1.64	Elasticity of foreign preference, across varieties
P_0	1.0	Baseline price, Platform FDI's investment
LI	0.7456	Lerner Index, proxy for pricing competition
F_0	0.2733	Basic doing-business cost incurred on foreign experts
F_1	0.33	Additional cost incurred on Horizontal MNC
F_2	0.40	Additional cost incurred on Vertical MNC
$\tilde{a}$	9.55	Constant value linking productivity to ability
ϕ	−1.0	Asymmetric cost parameter, Vertical MNC-specific
ω_k	1.0	Shape parameter, Weibull function
ω_λ	2.0	Slope parameter, spread of Weibull distribution
w_m	3.6	Constant, feedback to foreign preference

5 Policy Experiments

Similar to Agénor and Dinh (2013) and Agénor and Alpaslan (2014), policy outcomes concerning the industrial structure [measured by the industrial composition ratio of $m_t = m_t^I/(m_t^R + m_t^I)$] and total skilled workforce expansion [measured by both skilled labour share, $\theta_{S,t}$, and skilled labour in innovation, $\theta_{S,R,t}$] are the key policy indicators to be examined. To measure progress on the deepening of domestic innovation expertise, the foreign-to-domestic innovation expertise ratio, Ψ_t, is examined as it provides a more meaningful policy interpretation than the individual measure of share of Vertical MNCs, $n_{FV,t}$, and share of skilled labour in innovation, $\theta_{S,R,t}$.

Given that the key interest here is structural transformation (a long-term policy reform issue and therefore needs to be analysed independent of business cycle influence), and the fact that FDI, unlike portfolio investment, is stable over time, all policy experiments considered are permanent in nature. Policies considered in addition to foreign investment liberalisation measures are in the broad area of human capital policies, specifically a permanent reduction in skills acquisition cost and a permanent removal of hiring cost mark-up in the innovation sector. In addition, to ensure that households do not permanently lose out due to transformation, the long run steady-state effect on aggregate private consumption growth ($\dot{C}_t/C_t$) is also evaluated, with a policy option considered to be acceptable only if the growth rate is sustained or increases in steady-state.[20] Individual policies are first discussed, followed by three variations of composite programme. These are then followed by a specific subsection on sensitivity analysis on endogenous technological change, where the parameter ν is made endogenous to the state of industrial transformation.

5.1 Individual Policies

Skills Acquisition Cost: Consider first a permanent reduction in skills acquisition cost, Γ, from 0.25 to 0.18. The 28 percentage reduction is consistent with the reported target of PSMB in Malaysia, and may be thought of as a subsidy scheme designed to reduce the cost of pursuing advanced skills, obtained by reallocating spending within the budget, so that the tax rate and the overall balance remain the same.

The cost reduction associated with skills acquisition induces more workers to invest in skills. This leads to an expansion in both the shares of skilled labour employed in the final output and the innovation sector. At first, the increase in skilled labour supply lowers skilled wages. At the same time, the rise in skilled employment promotes activities in final output sector, hence raising the marginal product of unskilled workers and consequently, unskilled wages. This nets off some of the skills acquisition incentive, resulting in 'scaling back' for both effective shares of total skilled labour and those employed in innovation. The respective

[20] When solving for the transitional dynamics, the numerical method of relaxation algorithm allocates mesh points unevenly such that the time difference between result observations generated increasingly widens over time. The steady-state result therefore would dominate other observations along the time path in any integrable measure like the conventional welfare calculations. Higher steady-state growth in aggregate private consumption therefore necessarily reflects improvement in welfare.

absolute deviations from initial steady-state are 0.69 and 0.13 percentage points.

The innovation sector expands while the imitation sector contracts, leading to a decline in the industrial composition ratio by 0.43 percentage points. Similar to θ_S, the initial contraction of imitative varieties is more significant than the end steady-state effect. However, as the ratio of skilled and unskilled employment is ultimately tied to the relative wage ratio, the eventual 'scale-back' of unskilled employment causes the industrial composition ratio to settle at a slightly lower level than initial steady-state. This is the same for the proportion of foreign experts with sophisticated know-how, n_{FV}, where despite uneven paths along the transition, long run permanent changes are negligible. In terms of the relative measure of foreign-to-domestic innovation expertise ratio, Ψ declines from 0.3672 to 0.3527. This indicates a small deepening of relative domestic innovation expertise by 3.9 percent. Lastly, the steady-state effect on aggregate private consumption growth is negligible though the policy is able to sustain a positive absolute deviation.

In Table 4, additional sensitivity analysis on key elasticity parameters in both the innovation (ψ_1^R and ψ_2^R) and imitation (ψ_1^I and ψ_2^I) sectors are carried out. It can be seen that the impact on industrial transformation is more profound the larger the learning effect (ψ_2^R) is, as the economy benefits from the greater strength of the *stepping stone* from imitation. The difference for the other variables are generally negligible. These results are consistent with those in Agénor and Dinh (2013), where strong learning effects mean greater improvement in the productivity of innovation workers. In the case of ψ_2^I, if the externality associated with the cross term, $n_{FV,t}M_t^R$, is specified as a positive feedback to imitation, the industrial transformation outcomes are similar to the benchmark case though the gain in domestic innovation expertise is smaller.

Hiring Cost in Innovation Sector: Next, consider a reduction of cost mark-up in the hiring of skilled researchers, with a permanent reduction in Λ^R from 0.2 to 0.0.

As seen in Figure 1, transitional dynamics are largely similar to skills acquisition cost-cut, though the ‘scale-back’ effect is less pronounced, as the policy effects here operate mainly through the skilled labour market reallocation channel. As skilled workers become relatively cheaper in the production of innovative blueprints, more skilled labour are employed away from the final output sector. However, similar to skills acquisition cost cut, there is the secondary ‘scale-back’ effect that mitigates the expansion. The decline in the cost of skilled labour in innovation tends to raise the unskilled-skilled wage ratio, which would then take away some of the skills acquisition incentive associated with the initial expansion. The re-allocation of skilled labour away from $\theta_{S,Y}$ to $\theta_{S,R}$ would result in $\theta_{S,R}$ increasing by 0.72 percentage points at end steady-state, while $\theta_{S,Y}$ declining by 0.58 percentage points. Overall, total effective skilled labour share expands by 0.14 percentage points.

Similarly, the expansion in innovation relative to imitation is also more effective, as seen in a larger permanent reduction of 3.25 percentage points in the industrial ratio, m. Similar to the results of skills acquisition cost cut, the steady-state effect on n_{FV} resulting from this policy is negligible. However, the policy impact on the relative measure of Ψ is much larger due to the strong reallocation effect, where domestic innovation expertise improves considerably relative to foreign expertise [Ψ declines from 0.3672 to 0.3119, indicating a relative deepening of domestic innovation expertise by 15.1 percent]. Lastly, in the steady-state, aggregate private consumption growth increases marginally by 0.1 percentage points.

In terms of sensitivity analysis, a larger *stepping stone* effect, $\psi_2^R = 15.5$, brings about a ‘larger-than-baseline’ decline in industrial ratio by 3.83 percentage points, a result consistent with findings in Agénor and Dinh (2013). Similar to the skills acquisition cost cut, when the externality associated with the foreign innovation expert-innovation blueprint cross-term $(n_{FV,t}M_t^R)$ is specified as having positive feedback ($\psi_2^I = 0.3$) to imitation [instead of negative as in the benchmark calibration], a more favourable outcome is observed for the industrial composition ratio without the corresponding decline in share of Vertical MNCs, $n_{FV,t}$.

Foreign Investment Liberalisation Measures: The policy measures considered here involve a permanent reduction in the 'doing-business' costs for foreign experts, namely the basic doing-business cost, F_0; the additional cost incurred by foreign subsidiaries of Horizontal nature, F_1; and the additional cost incurred by Vertical operation with leading foreign innovation experts, F_2. The reduction of these costs may be interpreted as an outcome from some targeted investment liberalisation measures, such as specific tax holidays, implemented by the host economy. Recall that F_0 is incurred by all types of foreign experts in the host economy, while $F_1$and F_2 are additional costs incurred by the specific type of foreign experts.

Simulations on F_2: Consider a permanent reduction of F_2 from 0.40 to 0.37, which is a three percent reduction in terms of the baseline theoretical price [equivalently, in relative terms, a 7.5 percent drop]. While a host economy may intend to attract more foreign experts with sophisticated know-how by reducing the additional cost incurred on them, this results in an adverse signalling effect where the proportion of foreign subsidiaries in Vertical mode is reduced. A reduction in F_2 would ceteris paribus, be expected to result in an expansion of the perceived investment value for a typical foreign experts j with sophisticated know-how. Nevertheless, the asymmetric productivity term, ϖ_{FV}^{ϕ}, would have to adjust, as seen from (26). The reduction in F_2 puts a downward pressure on ϖ_{FV} [and increases the information cost associated with perceived productivity difference, $1/\varpi_{FV}$], and this results in a lower and stricter threshold value for Vertical MNCs, a_{FV}. Foreign subsidiaries are therefore less willing to operate with experts in sophisticated know-how in the host economy, resulting in a reduction of n_{FV}.

Intuitively, these effects may be interpreted as follows. While typical direct investment incentives may be attractive to new firms, the reduction in F_2, without an accompanying cut in F_0, can lead to an adverse signalling type of outcome. Given the duo asymmetric structures specified for the internalisation decision of a typical Vertical MNC, foreign innovation experts would face increasing difficulties in discriminating the best among the most productive ones. This productivity uncertainty associated with the asymmetric cost structure of a typical Vertical MNC means a smaller F_2 in (26), resulting in existing foreign subsidiaries of the host economy being relatively more wary of the information cost associated with perceived productivity difference for a typical Vertical operation, $1/\varpi_{FV}$ [compares to $1/\varpi_{FH}$], therefore preferring the alternative of bringing in an expert with standardisation know-how. Hence, n_{FH} increases by 4.4 percentage points while n_{FV} drops by 0.5 percentage points. While the decline of n_{FV} seems to be counter-intuitive, it actually corroborates well with the findings in the OECD comparative study on tax holidays, which presents cases where the elimination of such narrowed incentives did lead to long-term improvements in FDI performance for certain developing economies (OECD 2008). Likewise, it is also consistent with the empirical findings documented in the various 'race-to-the-bottom' studies.[21]

The expansion in n_{FH} further creates a secondary effect: it leads to an expansion in imitative goods relative to innovative goods due to a rise in productivity of imitation. This results in industrial composition ratio, m, rising by 5.6 percentage points. The corresponding increase in unskilled workers hired in imitation, $\theta_{U,I}$, given a fixed number of unskilled workers, θ_U, means a fall in the unskilled workers employed in final output production, $\theta_{U,Y}$. The relative wage ratio is determined in the final output sector, which hires both skilled and unskilled workers. A decline in $\theta_{U,Y}$, ceteris paribus, results in an increase of the unskilled-skilled wage ratio. This in turn disincentivizes skills acquisition and subsequently, employment in the innovation sector. In the steady-state, this is reflected as a decline in θ_S and $\theta_{S,R}$ by 0.36 and 0.09 percentage points respectively. Nevertheless, as the decline in $\theta_{S,R}$ is much milder relative to n_{FV}, the relative domestic innovation expertise improves, with Ψ

[21] Examples of the 'race-to-the-bottom' studies include Blomström (2002), Vogel and Kagan (2004), and Olney (2013). In essense, this branch of the literature argues that the quality of the enabling environment of investment (for examples, human capital quality), especially for foreign firms with investments in technological leadership areas, affects a country's ability to attract quality FDI more than direct investment incentives. Indeed, it can be counterproductive to offer investment incentives if the 'fundamentals' of the potential host economy are bad. These studies document similar adverse signalling effects of narrowed FDI-promoting policies. In the context of the analysis here, a cut in F_2, without an accompanying F_0 cut, is viewed adversely by foreign subsidiaries as a signal of shortage in domestic innovation expertise and lower productivity of domestic workers they are going to be matched to.

declining from 0.3672 to 0.2563. This indicates a relative deepening of domestic innovation expertise by 30.2 percent, though much of this is driven by the significant drop of foreign experts with sophisticated know-how in the host economy. Lastly, in the steady-state, as imitation-based varieties remain the main intermediate type used in final output production, the expansion in innovative varieties raises aggregate final output growth by 0.2 percentage points. By implication of an increase in final output-to-private capital ratio (Y_t/K_t) and therefore r_t as in (16), aggregate private consumption grows by the same percentage points.

Other sensitivity results concerning this specific shock are summarised in Table 4, where the adverse signalling steady-state effects associated with F_2 cut are consistently observed, with the effects on m being stronger the higher ψ_1^R [greater reliance of domestic innovation in Vertical MNCs], or the higher ψ_2^R [greater learning associated with the *stepping stone* effect] is. Indeed, the simulation results are largely consistent with the Malaysian experience over the past two decades, where the Malaysian administration had been among the most active 'open-door' regime in offering targeted incentives to attract foreign firms at the global frontier, yet failed to attract many of such firms (Yusuf and Nabeshima 2009).

Simulations on F_1: Next, consider a permanent reduction of F_1 from 0.33 to 0.30, equivalent to a 9.1 percent drop from the initial 0.33 in relative terms. While the steady-state effects presented in Table 4 show largely opposite results to the previous cut in F_2, the underlying operating mechanism for a reduction in F_1, without an accompanying cut in F_0, is slightly different. Unlike the F_2 cut, in the primary sorting channel, a direct investment incentive in the form of a F_1 cut would bring about positive effects to both n_{FH} and n_{FV}. As seen from (25), a reduction in F_1 would bring about an increase in ϖ_{FH} [or equivalently, a reduction in information cost associated with perceived productivity difference, $1/\varpi_{FH}$]. This in turn would result in a relaxation of the threshold value of entry for a Horizontal mode of operation, a_{FH}, therefore providing greater incentive for foreign experts with standardisation know-how to come into the host economy. This is what would have been expected in the previous shock if there is no asymmetry cost structure for Vertical FDI [arising from the growing difficulty in identifying the best among the most productive talents at the 'deeper ends' of ability distribution, as a_{FV} gets more restrictive]. In (26), given fixed F_2, the reduction in F_1 widens the comparative cost gap, $F_2 - F_1$. In this case, the asymmetric cost structure for Vertical MNCs brings about a positive signalling effect, therefore resulting in higher ϖ_{FV} [or equivalently, a reduction in $1/\varpi_{FV}$]. This leads to a relaxation of the threshold value of entry for Vertical MNCs, a_{FV}, therefore providing greater incentives for foreign experts with sophisticated know-how to come into the host economy.

The shares of foreign innovation experts, n_{FV}, increases, and this then results in an expansion of the innovation sector relative to the imitation sector, hence a drop in the industrial composition ratio, m. As the flow of innovation production increases, there is more skilled labour hired in the innovation sector. Given initial fixed supply of skilled labour, this reallocates skilled labour away from final output production, which then puts downward pressure on the unskilled-skilled wage ratio, w^U/w^S. This creates greater incentives for skills acquisition. In the steady-state, the shares of effective skilled labour, θ_S, and those employed in innovation, $\theta_{S,R}$, expand by 0.38 and 0.09 percentage points respectively. Overall, the steady-state effect for the industrial composition ratio, m, is a decline of 3.33 percentage points. In terms of the foreign-to-domestic innovation expertise ratio, Ψ, increases from 0.3672 to 0.4103, indicating a growing reliance on foreign experts in innovation expertise.

In terms of sensitivity analysis, it can be observed from Table 4 that the outcome of industrial transformation tends to be more favourable when either of the four elasticity parameters in the blueprint-production sectors examined is larger. This is notable for the two parameters in the innovation sector (ψ_1^R and ψ_2^R). Nevertheless, in all four cases, the disadvantage of this specific policy shock is that it is achieved through a growing reliance on foreign experts in innovation expertise since n_{FV} grows at a larger magnitude than $\theta_{S,R}$. This is especially so when there is positive feedback from the cross-term of $n_{FV,t}M_t^R$ to the productivity of imitation ($\psi_2^I = 0.3$).

Simulations on F_0: Next, consider a permanent reduction of F_0 from 0.2733 to 0.2433. This is equivalent to an 11 percent cut from its initial value. This may be interpreted as an economy-wide liberalisation attempt aimed at reducing general administrative cost for all foreigners in the host economy. As F_0 is the basic cost involved for all foreign MNCs, this would create incentives for all foreign firms to adopt an improved mode of operation and bring in foreign experts with more advanced know-how. Given that n_{FP} is treated as a residual, this would result in an unambiguous increase for both n_{FH} and n_{FV}. For Vertical MNCs, the reduction in total cost required to be paid every period $(F_0 + F_2)$ means there will be an unambiguous increase of n_{FV} in steady-state, of 0.2 percentage points. Similarly, for Horizontal MNCs, the reduction in total cost $(F_0 + F_1)$ results in an increase of n_{FH} by 3.8 percentage points.

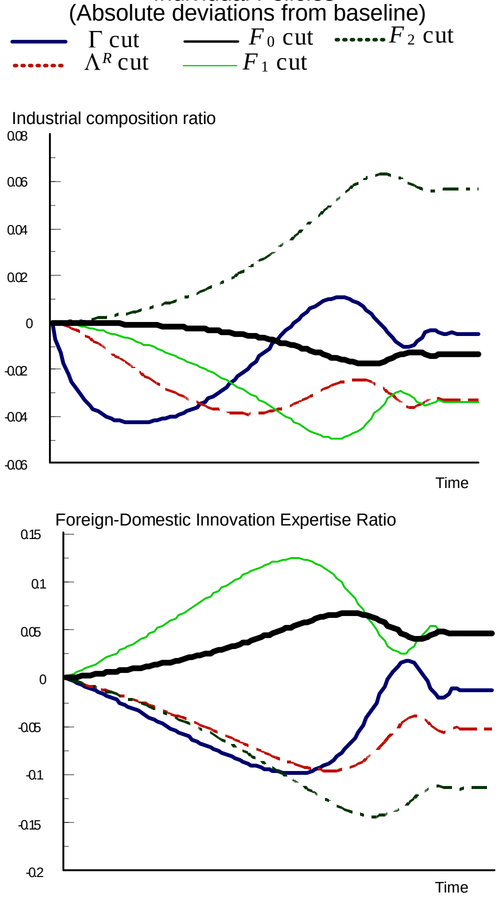
The increase in both n_{FH} and n_{FV} leads to an expansion for both the imitation and the innovation sector, though the latter grows more in relative terms. Specifically, the industrial composition ratio, m, declines by 1.34 percentage points in the steady-state. As the innovation sector expands relatively faster than the imitation sector, more skilled workers are relocated out of final output production compared to unskilled workers' reallocation to imitation. This tends to put a downward pressure on the relative wage ratio, w^U/w^S [recall that it is determined by a function of $\theta_{S,Y}/\theta_{U,Y}$]. This then creates greater skills acquisition incentives and leads to an increase in the effective supply of skilled labour. In the steady-state, these effects translate to moderate expansions in θ_S and $\theta_{S,R}$. The relatively small increase in $\theta_{S,R}$ comparing to n_{FV} also means that the foreign-to-domestic innovation expertise ratio, Ψ, increases from 0.3672 to 0.4111, indicating a growing reliance on foreign innovation experts in the host economy.

In terms of sensitivity analyses presented in Table 4, cases with larger parameters in the innovation sector ($\psi_1^R = 0.8$ and $\psi_2^R = 15.5$) would produce more effective industrial transformation results, underlying the importance of the strength of learning effects in the innovation sector–the former (ψ_1^R) denoting the direct learning from foreign experts in Vertical mode, the latter (ψ_2^R) denoting the *stepping stone* effect from imitative knowledge–to drive industrial transformation.

Table 4
Individual Policies: Steady-state Effects
(Absolute deviations from baseline)

Benchmark	Initial values	Γ cut	Λ^R cut	F_0 cut	F_1 cut	F_2 cut
m	0.5836	-0.0043	-0.0325	-0.0134	-0.0333	0.0560
θ_S	0.2400	0.0069	0.0014	0.0003	0.0038	-0.0036
θ_{SR}	0.0446	0.0013	0.0072	0.0001	0.0009	-0.0009
C/C	0.0430	0.0003	0.0009	-0.0002	-0.0022	0.0022
n_{FV}	0.0164	-0.0002	-0.0002	0.0020	0.0023	-0.0052
Ψ	0.3672	-0.0145	-0.0553	0.0439	0.0431	-0.1109
Sensitivity Test 1 - $\psi_1^R = 0.8$						
m	0.5836	-0.0031	-0.0276	-0.0159	-0.0380	0.0699
θ_S	0.2400	0.0068	0.0015	0.0000	0.0016	-0.0016
θ_{SR}	0.0446	0.0012	0.0072	-0.0001	0.0008	-0.0004
C/C	0.0430	0.0002	0.0009	0.0002	-0.0018	0.0010
n_{FV}	0.0164	-0.0002	-0.0002	0.0016	0.0023	-0.0051
Ψ	0.3672	-0.0138	-0.0544	0.0373	0.0440	-0.1124
Sensitivity Test 2 - $\psi_1^I = 0.7$						
m	0.5836	-0.0045	-0.0326	-0.0135	-0.0334	0.0562
θ_S	0.2400	0.0068	0.0014	0.0002	0.0037	-0.0035
θ_{SR}	0.0446	0.0012	0.0072	0.0001	0.0009	-0.0009
C/C	0.0430	0.0003	0.0010	-0.0001	-0.0022	0.0021
n_{FV}	0.0164	-0.0001	-0.0001	0.0020	0.0023	-0.0052
Ψ	0.3672	-0.0124	-0.0533	0.0455	0.0439	-0.1127
Sensitivity Test 3 - $\psi_2^I = 0.3$						
m	0.5836	-0.0046	-0.0330	-0.0136	-0.0336	0.0568
θ_S	0.2400	0.0068	0.0013	0.0002	0.0037	-0.0034
θ_{SR}	0.0446	0.0012	0.0072	0.0000	0.0009	-0.0008
C/C	0.0430	0.0003	0.0010	-0.0001	-0.0021	0.0020
n_{FV}	0.0164	-0.0001	0.0000	0.0021	0.0025	-0.0053
Ψ	0.3672	-0.0119	-0.0513	0.0466	0.0468	-0.1153
Sensitivity Test 4 - $\psi_2^R = 15.5$						
m	0.5836	-0.0051	-0.0383	-0.0158	-0.0391	0.0682
θ_S	0.2400	-0.0044	0.0015	0.0003	0.0039	-0.0038
θ_{SR}	0.0446	0.0013	0.0072	0.0001	0.0010	-0.0009
C/C	0.0430	0.0003	0.0009	-0.0002	-0.0022	0.0022
n_{FV}	0.0164	-0.0003	-0.0003	0.0019	0.0022	-0.0051
Ψ	0.3672	-0.0159	-0.0576	0.0423	0.0413	-0.1095

Figure 1
Individual Policies
(Absolute deviations from baseline)



5.2 Composite Policy Reform Programmes

A key goal that policymakers in developing economies often seek to achieve when implementing composite reform programmes involves identifying the best combination to reap the benefits of policy complementarities. The main premise of this study is that a composite programme delivering the best outcome of industrial transformation, overall skills expansion, and a deepening of domestic innovation expertise, while simultaneously attaining positive changes in final output and aggregate private consumption growth rates, will be the preferred composite programme.

Consider three different composite programmes, which combine the policies of a skills acquisition cost cut [Γ from 0.25 to 0.18], hiring cost cut in innovation sector [Λ^R from 0.2 to 0.0], and different combinations of the three foreign investment liberalisation measures discussed. Specifically, *Composite Programme A* combines both the Γ and Λ^R shocks with a balanced combination of foreign cost cuts [simultaneous reduction in F_0, F_1, and F_2 by 0.03]. *Composite Programme B* combines the two with a proportionate cost cutting programme tilted towards providing investment incentives for foreign experts with know-how of technological leadership [F_0 reduced by 0.01, F_1 reduced by 0.03, and F_2 reduced by 0.05], while *Composite Programme C* combines the Γ and Λ^R reductions with a third proportionate cost cutting programme tilted towards providing basic investment incentives to all foreigners [F_0 reduced by 0.05, F_1 reduced by 0.03, and F_2 reduced by 0.01].

The results of the three composite programmes implemented in the benchmark model are illustrated in Table 5 and Figure 2. The transition paths of the key policy variables examined largely conform to what would have been expected when the effects of the individual policies are combined. Both the simultaneous foreign cost cutting programme and the proportionate cost cutting programme with F_0 cut by 0.05 produce positive deviation in the share of Vertical MNC, n_{FV}. At the same time, the human capital policies of Γ and Λ^R cuts would create greater incentives for labour to not only undergo training, but also work in the innovation sector. The increase in skilled labour supply would initially put a downward pressure on skilled wages. However, due to the overall increase in skilled employment in both the innovation ($\theta_{S,R}$) and final output sector ($\theta_{S,Y}$), a secondary effect would also be at play: the expansion of innovative blueprints relative to imitative blueprints, and conversely, the varieties of sophisticated intermediate inputs relative to basic inputs. This shift raises the productivity of skilled labour. Nonetheless, the increase in skilled labour supply in final output sector would also raise marginal product of unskilled workers, which then raises unskilled wages. This then mitigates the initial effect on incentives to acquire skills, and the labour market adjustment dynamics are reflected in the hump-shaped pattern associated with m and Ψ in Figure 2.

The decline in imitative varieties would further feed back into the foreign firms' internalisation process, which creates a tertiary dynamic that is then reflected in the cyclical pattern of m and Ψ. The decline in imitative varieties makes the host economy less attractive as a host to Horizontal MNCs, but at the same time improves the incentive for foreign innovation experts with sophisticated know-how to enter. In the case of *Composite Programme A*, this therefore mitigates the initial decline in n_{FV} and results in an overall increase of n_{FV} in steady-state, while in the case of *Composite Programme C*, it further leads to growth in the share of Vertical MNCs. Overall, while the host economy would experience improvements in both industrial composition and relative domestic innovation expertise under both *Composite Programme A* and *Composite Programme C*, the balanced *Composite Programme A* would be the better programme as it sustains aggregate private consumption growth whereas *Composite Programme C* would lead to a slight decline in steady-state.

In contrast, *Composite Programme B* results in largely opposite results. The share of Vertical MNCs, n_{FV}, would decline in steady-state due to the adverse signalling effects associated with the large F_2 cut. This then results in 'reverse transformation' towards imitation, less incentive to acquire skills and work in innovation sector, hence a drop in both θ_S and $\theta_{S,R}$. In terms of steady-state aggregate private consumption growth, *Composite Programme B* predictably delivers the largest gain of 0.22 percentage points, but unlike the preferred *Composite Programme A*, this is maintained by not making much progress in industrial transformation.

Tables 5 and 6 present additional simulation results for nine sensitivity tests. We focus on the two key variables of industrial composition ratio (m) and foreign-domestic innovation expertise ratio (Ψ). When the elasticity of blueprint production with respect to foreign experts in either the innovation (ψ_1^R) or imitation sector (ψ_1^I) is calibrated at a higher value, *Composite Programme C* [which depends more on the inflow of foreign innovation experts to drive industrial transformation] would see a larger decline in m at the cost of a larger Ψ. On the other hand, while the policy effects on both indicators are milder under *Composite Programme A* when foreign experts have a greater influence on the host economy's design activities [hence 'taking away' some of the effectiveness of the human capital policies], the more balanced reform program continues to have the edge over *Composite Programme C* for the gains made in the deepening of domestic innovation expertise, as well as sustaining growth rates in private consumption. Similar results are also observed when sensitivity analysis is implemented with a positive externality specification for the parameter, ψ_2^I. In a nutshell, the relatively balanced *Composite Programme A* would tend to deliver more effective industrial transformation outcomes compared to *Composite Programme B*, while being much better at promoting the deepening of domestic innovation expertise when compared to *Composite Programme C*. The policy experiment results are generally consistent with the consensus views documented in Saggi (2002) and Faeth (2009), where evidence on the direct role of FDI in promoting domestic innovation is mixed, but their indirect impacts tend to be positive if their presence leads to a deepening of domestic innovation expertise.

Meanwhile, when the externality parameter associated with learning effects in both the innovation sector [the *stepping stone* effect from the stock of imitative goods, ψ_2^R] is calibrated at a higher value, the steady-state effects on both the industrial composition ratio (m) and foreign-domestic innovation expertise ratio (Ψ) are unambiguously better in all three composite programmes. As an illustration, Figure 3 presents results on the steady-state deviations of m across different combinations of ψ_2^R and ψ_2^I, and the strong effects associated with a larger *stepping stone* observed are consistent with Agénor and Dinh (2013) and Agénor and Alpaslan (2014). Table 6 presents other sensitivity analysis results.

Table 5
Composite Programmes: Steady-state Effects
(Absolute deviations from baseline)

Benchmark	Initial values	Composite A	Composite B	Composite C
m	0.5836	-0.0489	-0.0048	-0.0830
θ_S	0.2400	0.0092	0.0067	0.0121
θ_{SR}	0.0446	0.0089	0.0082	0.0097
C/C	0.0430	0.0007	0.0022	-0.0010
n_{FV}	0.0164	0.0007	-0.0036	0.0039
Ψ	0.3672	-0.0477	-0.1256	0.0063
Sensitivity Test 1 - $\psi_1^R = 0.8$				
m	0.5836	-0.0461	0.0115	-0.0886
θ_S	0.2400	0.0088	0.0079	0.0107
θ_{SR}	0.0446	0.0088	0.0085	0.0093
C/C	0.0430	0.0008	0.0014	-0.0003
n_{FV}	0.0164	0.0008	-0.0035	0.0040
Ψ	0.3672	-0.0456	-0.1252	0.0102
Sensitivity Test 2 - $\psi_1^I = 0.7$				
m	0.5836	-0.0493	-0.0050	-0.0837
θ_S	0.2400	0.0090	0.0066	0.0066
θ_{SR}	0.0446	0.0088	0.0082	0.0096
C/C	0.0430	0.0008	0.0023	-0.0009
n_{FV}	0.0164	0.0010	-0.0035	0.0043
Ψ	0.3672	-0.0427	-0.1238	0.0149
Sensitivity Test 3 - $\psi_1^R = 0.8$, $\psi_2^I = 0.3$				
m	0.5836	-0.0486	0.0116	-0.0938
θ_S	0.2400	0.0084	0.0079	0.0100
θ_{SR}	0.0446	0.0087	0.0085	0.0091
C/C	0.0430	0.0011	0.0014	0.0000
n_{FV}	0.0164	0.0011	-0.0035	0.0047
Ψ	0.3672	-0.0386	-0.1253	0.0256
Sensitivity Test 4 - $\psi_1^I = 0.7$, $\psi_2^I = 0.3$				
m	0.5836	-0.0501	-0.0050	-0.0835
θ_S	0.2400	0.0088	0.0066	0.0115
θ_{SR}	0.0446	0.0088	0.0082	0.0096
C/C	0.0430	0.0009	0.0023	-0.0007
n_{FV}	0.0164	0.0012	-0.0035	0.0046
Ψ	0.3672	-0.0386	-0.1239	0.0199

Figure 2
Composite Programmes:
(Absolute deviations from baseline)

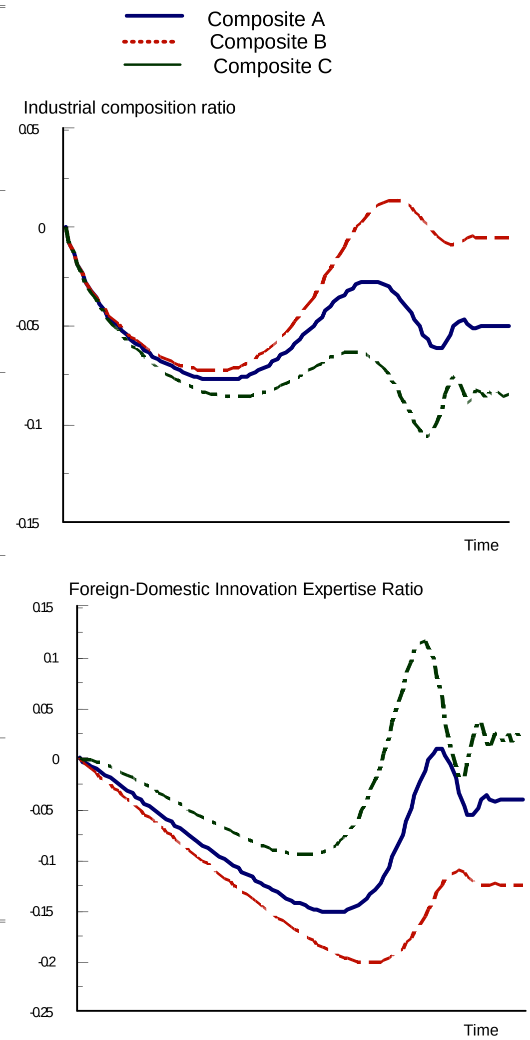
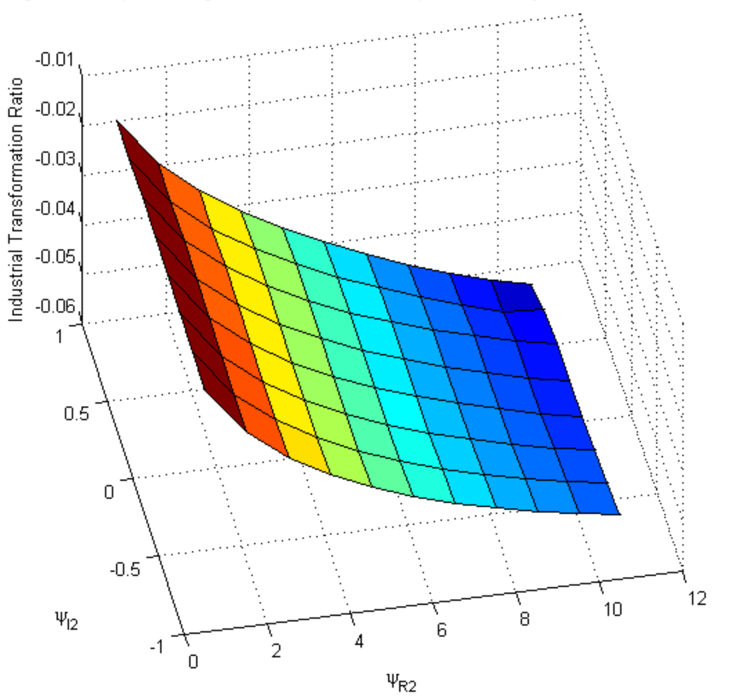


Table 6

Composite Policy Reform Programmes: Steady-state Effects (continue)

	Initial values	Composite A	Composite B	Composite C		Composite A	Composite B	Composite C
Sensitivity Test 4 - $\psi_1^I = 0.7, \psi_2^I = 0.3$					**Sensitivity Test 7** - $\eta = 0.54$			
m	0.5836	-0.0501	-0.0050	-0.0835	m	-0.0303	-0.0066	-0.0481
θ_S	0.2400	0.0088	0.0066	0.0115	θ_S	0.0092	0.0078	0.0109
θ_{SR}	0.0446	0.0088	0.0082	0.0096	θ_{SR}	0.0095	0.0091	0.0099
C/C	0.0430	0.0009	0.0023	-0.0007	C/C	0.0004	0.0012	-0.0006
n_{FV}	0.0164	0.0012	-0.0035	0.0046	n_{FV}	0.0006	-0.0040	0.0042
Ψ	0.3672	-0.0386	-0.1239	0.0199	Ψ	-0.0533	-0.1374	0.0098
Sensitivity Test 5 - $\psi_2^R = 15.5$					**Sensitivity Test 8** - $LI = 0.25$			
m	0.5836	-0.0571	-0.0058	-0.0955	m	-0.0523	-0.0093	-0.0860
θ_S	0.2400	0.0096	0.0068	0.0128	θ_S	0.0097	0.0053	0.0137
θ_{SR}	0.0446	0.0090	0.0083	0.0099	θ_{SR}	0.0090	0.0078	0.0102
C/C	0.0430	0.0006	0.0022	-0.0012	C/C	0.0004	0.0031	-0.0021
n_{FV}	0.0164	0.0005	-0.0037	0.0034	n_{FV}	0.0000	-0.0023	0.0014
Ψ	0.3672	-0.0526	-0.1268	-0.0040	Ψ	-0.0612	-0.0982	-0.0423
Sensitivity Test 6 - $\psi_1^R = 0.8, \psi_2^R = 15.5$					**Sensitivity Test 9** - $\omega_k = 1.2$			
m	0.5836	-0.0541	0.0141	-0.1006	m	-0.0483	-0.0083	-0.0798
θ_S	0.2400	0.0092	0.0080	0.0113	θ_S	0.0094	0.0000	0.0127
θ_{SR}	0.0446	0.0089	0.0086	0.0095	θ_{SR}	0.0090	0.0080	0.0099
C/C	0.0430	0.0007	0.0014	-0.0005	C/C	0.0005	0.0026	-0.0014
n_{FV}	0.0164	0.0006	-0.0035	0.0035	n_{FV}	0.0003	-0.0028	0.0025
Ψ	0.3672	-0.0493	-0.1259	-0.0001	Ψ	-0.0557	-0.1085	-0.0200

Figure 3: Composite Programme A - Industrial Composition Ratio [Abs Devs from Baseline]



5.3 Endogenous Technical Change, Policy Complementarities

In addition, we consider endogenous change in the industrial production structure. As pointed out by Agénor and Dinh (2013), as the process of industrial transformation gradually takes place over time, the share of basic inputs in composite intermediate inputs, ν, is expected to change. Nonetheless, endogenising a production parameter and linking it to a non-linear variable using a standard S-curve within a high-dimension system could easily pose a convergence problem. To overcome this problem, a generalised logistic curve is used to model ν endogenously to the change in the industrial composition ratio, m_t, with the critical parameter on rate of technological diffusion gradually increased in typical fashion of sensitivity analysis.

The generalised logistic curve is specified as

$$\nu_t = f(m_t) = \nu_m + \frac{(\nu_M - \nu_m)}{[1 + \exp\{-\zeta(m_t - m_I)\}]^{1/\upsilon}}, \quad \nu_t \geq \nu_m, \tag{55}$$

where $\nu_m, \nu_M \in (0, 1)$ represents the lower and upper bounds (asymptotes) of ν_t respectively, ζ is the technological diffusion rate, $\upsilon > 0$ is the corresponding asymptote value for diffusion, and m_I is the inflection point for the industrial composition ratio. For the purposes of this particular sensitivity analysis, the calibrations of $\nu_m = 0.1$, $\nu_M = 0.9$, and $m_I = 0.55$ are applied, all of which are reasonable values for a typical S-curve. The parameter ζ is set at 1.0 to 5.0, which indicates a sensitivity analysis of diffusion rates ranging from 100 to 500 percent, and the parameter υ is calibrated to maintain initial steady-state values at $\nu_t = 0.57$, $m_t = 0.5836$, and $\Psi_t = 0.3672$ for the different cases of ζ.

The three composite policy reform programmes are examined again, with steady-state effects for the key variables of interest presented in Table 7. For all composite programmes, endogenising ν_t generates more sensitive results. The higher the diffusion rate, ζ considered, the greater the steady-state effects documented. The additional gains amplify the policy complementarity effects. For example, at the highest ζ value examined ($\zeta = 5.0$), *Composite*

Programme A would lead ν_t to decline from 0.57 to 0.496. This would result in an impressive reduction of -7.8 percentage points in the industrial composition ratio (in comparison, in the benchmark model with fixed ν, m declines by 4.9 percentage points), and expansion of θ_S and $\theta_{S,R}$ by 1.95 and 1.82 percentage points respectively. In terms of the deepening of domestic innovation expertise, the foreign-domestic innovation expertise ratio, Ψ decreases more significantly too despite both $\theta_{S,R}$ and n_{FV} having increased. At the same time, the steady-state effect on aggregate private consumption growth would be higher too, growing by 0.21 percentage points. The final output growth rate increases from 4.3 to 4.5 percentage points. These indicate 'across-the-board' gains, underlying the significance of endogenous technological change in magnifying the benefits of policy complementarity between human capital and FDI-promoting policies. These greater benefits of policy complementarity are summarised in Table 8.

Table 7
Sensitivity Analysis: Endogenous v with Generalised Logistic Curve
Composite Programmes: (Absolute deviations from initial steady-state)

	Initial values	Composite A	Composite B	Composite C
	100% diffusion rate, $\zeta = 1.0$			
m	0.5836	-0.0535	-0.0054	-0.0902
θ_S	0.2400	0.0105	0.0068	0.0143
θ_{SR}	0.0446	0.0101	0.0083	0.0118
C/C	0.0430	0.0009	0.0022	-0.0007
Ψ	0.3672	-0.0566	-0.1262	-0.0112
v	0.5700	-0.0097	-0.0010	-0.0164
	200% diffusion rate, $\zeta = 2.0$			
m	0.5836	-0.0585	-0.0060	-0.0978
θ_S	0.2400	0.0121	0.0070	0.0169
θ_{SR}	0.0446	0.0116	0.0085	0.0142
C/C	0.0430	0.0011	0.0022	-0.0003
Ψ	0.3672	-0.0670	-0.1271	-0.0310
v	0.5700	-0.0215	-0.0021	-0.0361
	300% diffusion rate, $\zeta = 3.0$			
m	0.5836	-0.0643	-0.0067	-0.1059
θ_S	0.2400	0.0141	0.0072	0.0200
θ_{SR}	0.0446	0.0134	0.0086	0.0171
C/C	0.0430	0.0013	0.0023	0.0002
Ψ	0.3672	-0.0791	-0.1280	-0.0528
v	0.5700	-0.0358	-0.0035	-0.0592
	400% diffusion rate, $\zeta = 4.0$			
m	0.5836	-0.0709	-0.0076	-0.1141
θ_S	0.2400	0.0165	0.0075	0.0238
θ_{SR}	0.0446	0.0155	0.0089	0.0205
C/C	0.0430	0.0017	0.0023	0.0008
Ψ	0.3672	-0.0931	-0.1294	-0.0764
v	0.5700	-0.0532	-0.0055	-0.0859
	500% diffusion rate, $\zeta = 5.0$			
m	0.5836	-0.0780	-0.0087	-0.1217
θ_S	0.2400	0.0195	0.0078	0.0280
θ_{SR}	0.0446	0.0182	0.0092	0.0243
C/C	0.0430	0.0021	0.0023	0.0015
Ψ	0.3672	-0.1090	-0.1309	-0.1010
v	0.5700	-0.0739	-0.0080	-0.1153

Table 8
Policy Complementarities - Composite Programme A
(Absolute deviations)

	m	θ_S	θ_{SR}	C/C	Ψ
Sum of Parts:					
Γcut	-0.0043	0.0069	0.0013	0.0003	-0.0145
Λ^R cut	-0.0325	0.0014	0.0072	0.0009	-0.0553
F_0 cut	-0.0134	0.0003	0.0001	-0.0002	0.0439
F_1 cut	-0.0333	0.0038	0.0009	-0.0022	0.0431
F_2 cut	0.0560	-0.0036	-0.0009	0.0022	-0.1109
Aggregate effects	**-0.0275**	**0.0087**	**0.0086**	**0.0011**	**-0.0937**
Composite A (fixed v)	**-0.0489**	**0.0092**	**0.0089**	**0.0007**	**-0.0477**
Composite A (endogenous v)					
- $\zeta = 1.0$	**-0.0535**	**0.0105**	**0.0101**	**0.0009**	**-0.0566**
- $\zeta = 2.0$	**-0.0585**	**0.0121**	**0.0116**	**0.0011**	**-0.0670**
- $\zeta = 3.0$	**-0.0643**	**0.0141**	**0.0134**	**0.0013**	**-0.0791**
- $\zeta = 4.0$	**-0.0709**	**0.0165**	**0.0155**	**0.0017**	**-0.0931**
- $\zeta = 5.0$	**-0.0780**	**0.0195**	**0.0182**	**0.0021**	**-0.1090**

6 Concluding Remarks

This paper develops an imitation-innovation model with heterogeneous labour and foreign MNCs to examine industrial transformation for a developing host economy. With FDI modelled at the disaggregated level of foreign experts, we formalise a MNC composition-determination framework that explains Dunning's 'internalisation advantage' (1977) as being driven by the presence of asymmetric views on productivity of domestic workers. As productivity is a transformation of ability, the skills acquisition decision and foreign subsidiaries' operational mode choice are determined along the same ability distribution in the model. This, coupled with the modelling of an additional asymmetry between Vertical MNCs and other MNCs, enable the model to be calibrated and analysed. The calibrated analysis produces policy experiment results that are consistent with some well-documented stylised facts in the FDI literature.

We examine the transitional dynamics of various policies. The results showed that the implementation of foreign investment liberalisation measures in a typical developing host economy would not be a matter of straightforward provision of investment incentives. Indeed, in the presence of asymmetries, our results find that an investment liberalisation measure that is balanced and targeting all types of foreign firms is more innovation- and skills acquisition-promoting than disproportionate ones biased towards selected types of foreign firms. Overall, the results showed the importance of combining human capital and FDI-promoting policies in promoting industrial transformation, especially if the government of a host economy intends to minimise disruption of industrial transformation. Furthermore, results from the sensitivity analysis conducted with endogenous technological change support the conventional belief that governments of developing economies should strive to undertake measures in improving the technological diffusion rate within the economy.

There remain limitations that future research can address. For this reasonably complicated high-dimensional model, some policy elements are not pursued, largely as a self-contained measure to ease computational burden, but are obviously aspects for extensions. For instance, the role of fiscal policy in the model is minimal. Second, while the model establishes indirect feedback from the skills channel to FDI composition, a direct feedback channel of human capital to FDI is not modelled. For future research, notably in a model with Lucas type of disembodied human capital and more traditional modelling of FDI as capital, this would obviously be worth examining.

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