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Abstract

This paper examines industrial transformation using an imitation-innovation growth model with a stylised internalisation framework developed to determine the composition of heterogeneous foreign multinationals in a developing host economy. A key feature of the model is the introduction of a dichotomous relationship between domestic and foreign firms, where the latter, each of which consisting of an expert bringing either *standardisation* or *sophisticated* know-how, perceives heterogeneity among the productivity of domestic workers. Productivity is a transformation of ability, hence linking the skills acquisition decision and foreign subsidiaries' operational mode choice along the same ability distribution. Calibrated for Malaysia, the simulations uncover complementarities between labour market and FDI-promoting policies. These complementarities are stronger in an environment with endogenous technological change.

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Keywords: Foreign Experts, Human Capital, Industrial Transformation, Innovation.

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1 Introduction

Over the past thirty years, the global industrial development megatrend has seen the development of two interesting phenomena: (i) uneven industrial transformation performance across middle-income economies; (ii) evolving characteristics of modern foreign multinationals (MNCs), notably their subsidiary operations in developing economies, to be increasingly experts-driven (than the traditional goods-driven mode). These phenomena mainly relate to the role of human capital and foreign expertise in driving the process of industrial transformation, which in itself is often a major policy agenda for policymakers in developing middle-income economies to avoid experiencing a dramatic slowdown in productivity.

First, in terms of industrial transformation, it has been observed that some of the fastest growing economies in the world have appeared to benefit from a particular industrial transformation strategy to move rapidly into high-income. Relying first on imitation-based, low-skill production model premised on imported technologies from abroad, these economies were able to expand their industrial scale quickly through the process of 'learning-by-doing'. In many cases, with the facilitation of strategic industrial policies, these economies were able to reap the benefits of the Marshallian externalities associated with these external learnings to accumulate relatively abundant human capital. These subsequently prepare them for industrial transformation to innovation-driven growth (Günther and Alcorta 2011).

These economies include some of the leading 'latecoming' industrial economies in East Asia, such as Singapore, South Korea, and Taiwan, where human capital and foreign MNCs have often been credited as key factors underpinning their successful transformation in the 1990s (Nelson and Pack 1999). Nevertheless, many other economies in the region, such as neighbouring Thailand and Malaysia, have similarly embarked on outward-oriented policies at about the same time. However, these economies were not able to follow in their footsteps despite the presence of FDI. For instance, Malaysia, despite hosting some of the leading global multinationals and a large share of high-technology exports, has seemingly become an example of an industrialising economy stuck in the middle – possessing the capacity to be an innovation-driven economy yet left outside the doorstep of the global leading industrial innovators' club (Hill et al. 2012).[1]

Many studies have attempted to explain such diverging industrial transformation performances observed across the East Asian economies. The inability of middle-income economies such as Malaysia and Thailand in switching their industrial strategies appear to reflect the failure in developing enough capacity to meet the needs of

[1] Many middle-income economies appear to have experienced the same fate: Based on World Bank data in 2012, there were only 13 out of the 101 middle-income economies in 1960 that successfully moved up to become high-income by 2008. As much as a developing economy can use imitation-based strategy to escape from poverty trap quickly, the same strategy often becomes the major impediment that holds back the economy from switching successfully to innovation-driven. This results in a phenomenon known as the 'middle-income trap'.

fast-evolving international product markets that put more emphasis on innovation and product differentiation (Kharas and Kohli 2011; Felipe et al. 2012). In contributions of a more theoretical nature, the struggle of these middle-income economies may be attributed to the inability in finding the right combination of policies to affect the nonlinear dynamics of human capital in promoting industrial transformation. For instance, Agénor and Canuto (2012), in examining the more general topic of 'middle-income trap' using an overlapping generations model with endogenous occupational choices, show that a middle-income growth trap corresponds to one of the multiple equilibria of the system due to the nonlinearity of the relationship between marginal benefits associated with industrial knowledge and the share of population engaging in innovation. Meanwhile, Eeckhout and Jovanovic (2012), in an occupational switching model, show that openness results in disproportionate occupational switching into managerial jobs in high skill economies, and these tend to leave the middle-income economies worse off as they experience the smallest change in the factor-price ratio. Both of these studies suggest human capital heterogeneity and their allocations as key mechanisms influencing imitation-innovation trade-offs in the process of industrial transformation.[2]

Indeed, the need to better understand the role of human capital in driving industrial transformation extend to instances where one is trying to understand the determination and role of foreign MNCs in a developing host economy. As summarised in studies such as Amsden (2001) and Lall (2013), and implied by Faeth (2009) from her survey of the FDI literature, the FDI phenomenon in developing economies is largely a tale of heterogeneity, and therefore cannot be explained by a single theoretical model. Indeed, there appear to be limited theoretical contributions about the relative importance of different types of FDI in driving innovation from the perspective of a host country, more so within a multi-sectorial growth framework with formal explanation of the '*internalisation*' mechanism within foreign multinationals (Saggi 2002).[3]

To add further complications, the second observed phenomenon mentioned earlier refers to the evolving characteristic of modern foreign enterprises in developing economies due to the rapid changing landscape of global trades. As often documented in the literature on *global talent management*, such as Scullion and Brewster (2001) and McDonnell et al. (2010), as well as business advisory research by organisations such as WEF-BCG (2011) and PricewaterhouseCoopers (2012), a combination of ris-

[2] In recent theoretical contributions, such imitation-innovation trade-offs are modelled in studies such as Benhabib et al. (2014) and Lucas and Moll (2014). These papers are nonetheless based primarily on the Schumpeterian quality ladder framework, with the matching of the overall empirical productivity distribution as an endogenous outcome of searching by heterogeneous agents being the primary emphasis. Such emphasis tends to neglect the role of other cross-cutting factors in the economy. Nonetheless, these contributions do underline the potential role of implicit information and search costs in affecting firms' decisions with respect to the imitation-innovation dynamics.

[3] Existing theoretical contributions on the role and determinants of FDI as a vehicle of international technology transfer have mostly concentrated on studying the determinants of international production choices by foreign MNCs in either international trade theory-motivated framework in the tradition of Helpman (1984) or models with underpinning industrial organisation theories headlined by Markusen (1984).

ing knowledge activity flows, cross-border talent mobility, and fast-improving global transportation and communication technology in recent years have contributed to ever-mobile international firms. Instead of selling goods, the activities of foreign enterprises are increasingly characterised by top quality advisory services and know-how, with the identity of foreign subsidiaries often being assumed by the human capital of the foreign experts representing them. In other words, foreign firms are hosting a greater number of global assignments in more countries than ever, and these growing number of international assignees and foreign expatriates represents "*a far wider range of organisations than the traditional large MNC*" (Scullion et al. 2007). This makes formal modelling of the role of foreign multinationals in promoting industrial transformation an even more difficult task.

Indeed, we may even argue that it may not be a coincidence that there is often mixed empirical evidence with respect to the overall impact of FDI in promoting domestic innovation, when FDI is defined in its traditional context or form.[4] The learning and knowledge conduit role of foreign MNCs is likely to involve some degree of modelling of the incentive mechanism at a more disaggregated level—the foreign experts themselves—since expertise is embodied in experts.[5] In a study, Markusen and Trofimenko (2009) attempt to close this gap by modelling the precise micro-mechanism of how foreign experts transfer knowledge and skills to domestic workers. Their framework is nonetheless limited to micro considerations and not based on a general equilibrium framework, therefore does not allow for the examination of such links within the context of economic growth.

This paper contributes to the literature by incorporating a stylised internalisation framework for foreign MNCs within an endogenous growth model for a particular developing host economy. Specifically, the objectives include: (i) to develop an imitation-innovation model with heterogeneous human capital and foreign MNCs that would account for the two recent trends of industrial development; (ii) to formalise a FDI composition-determination framework based on 'internalisation advantage' that would allow for the examination of how the role of foreign experts would be affected in the presence of asymmetric views on productivity of domestic workers; and (iii) to examine the role of public policies and identify the right combination that minimises cost associated with the imitation-innovation trade-offs while accelerating skills acquisition and innovation expansions. Section 2 reviews relevant literature on FDI to provide further context on modelling the heterogeneity of foreign multinationals. Section 3 presents the model. The dynamic system derived is also presented in this section. Model calibrations are reported in Section 4. In Section 5, the various policy experiments analysed

[4] See Blomström and Sjöholm (1999) for examples of positive spillover, while Haddad and Harrison (1993) and Djankov and Hoekman (2000) are examples with negative effects.

[5] Indeed, almost all of the literature on firm-level innovation technological capabilities building, such as those reviewed in Bell and Figueiredo (2012), premise on an objective to overcome this problem by examining the internal operations of foreign multinationals using mainly non-generalisable case studies. Studies examining incentives at an even more disaggregated level—incentives of foreign experts—remain scarce.

(from individual policies to composite programmes) are illustrated and discussed. Section 6 draws together the policy implications from the analysis and concludes the paper with some final remarks.

2 Contextual Background on FDI Heterogeneity

While macroeconomic studies examining FDI heterogeneity at the disaggregated form of foreign experts are scarce, we can establish some contextual framework based on the literature on heterogeneous foreign MNCs. The most prominent early studies on the motive of foreign MNCs as a driver of FDI flows refer to the eclectic paradigm of Dunning (1977), who introduces the OLI (*Ownership-Location-Internalisation advantages*) 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 determined by the institutional and policy factors of a host economy, in influencing the internalisation decisions made. The different form of entries by MNCs into a particular host economy often reflects the internalisation advantages of firms: a *market-* or *resource-seeking* FDI tends to be driven by market and cost considerations, while an *efficiency-* or *strategic asset-seeking* FDI by technological acquisitions or objectives to strengthen its innovation competitiveness. Typical operational decisions by foreign subsidiaries, which often would reflect those of foreign experts as well, are therefore first motivated by *market-seeking* and *resource-seeking* objectives, with subsequent sequential investment being *efficiency-seeking* or *strategic asset/foreign network-linking* in nature (Dunning and Lundan 2008). While the OLI framework is static in nature, it highlights that there appears to be sequential entry dynamics for foreign subsidiaries. To the extent that these subsidiaries are essentially providing professional expertise, these also reflect sequential entry dynamics for foreign experts.

Of the three main determinants posited by Dunning, the ownership-specific and location-specific advantages have been well-incorporated in many theoretical contributions on FDI, with two major propositions said to drive the different composition of FDI: Vertical FDI driven primarily by factor endowment considerations and Horizontal FDI driven primarily by relative cost and market proximity considerations (Faeth 2009).[6] The former tends to be explained as an equilibrium phenomenon due to factor endowment differences across regions resulting in vertically-integrated firms with geographically fragmented production, while the latter driven mainly by ownership-specific strength, such as Markusen's (1984, 1995, 1998) knowledge capital models. Markusen's contributions essentially explain FDI as an outcome of MNCs capitalising

[6]From this point onwards, the terminologies for FDI of all nature are used interchangeably with MNC despite the difference in strict conceptual definition. For example, Horizontal/Vertical FDI mode also indicates Horizontal/Vertical MNCs.

on their unique intangible assets and proprietary knowledge, and are therefore consistent with the 'foreign expert' approach introduced in this paper.

Consistent with Dunning's explanation, firms are said to opt for Horizontal over Vertical mode as the initial form of entry due to knowledge capital and the know-how advantage over rivals, and the latter tends to be more costly too, irrespective of whether the explicit or implicit costs are referred to (Markusen 1995; Horstmann and Markusen 1996). Empirically, global FDI flows are documented by Brainard (1997) and Markusen and Maskus (2002) to be predominantly driven by Horizontal MNCs. However, their definition of FDI composition is based largely on the *Horstmann-Markusen-Venables* (HMV) interpretation (Horstmann and Markusen 1987, 1992; Markusen and Venables 1999), which tends to ignore the different aspects of factor endowment considerations that leads to a necessary further distinction of vertically-integrated MNC activities–and therefore experts with different quality of know-how.

As documented in international production fragmentation studies such as Athukorala (2005), Athukorala and Hill (2010), the fragmented production process of vertically-integrated MNCs often generates various niches across different value chains that have vastly different resource requirements, with some being more technological- and skill-intensive than others. Besides, the various FDI-targeting rules and ownership stipulations imposed in developing economies often inadvertently result in many nonmandated subsidiaries or investment commitments made by vertically-integrated MNCs, in forms such as technological licensing agreements (Saggi 2002). As MNCs often treat such commitments as nonmandated subsidiaries internally to serve merely as a manufacturing or export platform to a third economy (Hanson et al. 2001), these often result in MNCs that are neither imitation- nor innovation-enhancing (see D'Costa (2002) and Hobday et al. (2004) for examples). To account for these FDI modes, we adopt the description used by Hanson et al. (2001) and group them as 'Platform FDI'.[7]

Indeed, once the basic platform-type of FDIs is further differentiated from vertically-integrated MNCs, we can define a *hierarchy of internalisation decision-making* with regards to FDI mode, and the order of Platform-Horizontal-Vertical matches their respective importance in the host economy's spillover. Due to factors such as agency or information cost, MNCs tend to use basic Platform mode as default 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. While both Horizontal and Vertical MNCs tend to invest in knowledge-intensive industries and are therefore likely to be drawn to destinations with large pool of quality human capital (Borensztein et al. 1998), 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. Horizontal MNC is therefore the more common type observed. However, this mode has limited contributions to promoting innovation

[7] In the literature, common internationalisation modes explored also include direct exporting versus FDI, offshoring, and more complicated vehicles of joint-ventures. These are related but peripheral issues in the context of this paper.

in a developing host economy (Markusen 1998). Indeed, foreign subsidiaries are more inclined to send in foreign experts with sophisticated innovation know-how, the more productive the pool of human capital of a host economy is (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.

Without changing much from the existing interpretations by HMV or Saggi (2002), introducing a third MNC mode within a *hierarchy of internalisation framework* enriches the understanding of their respective impacts on host economy's development agenda. Relating this to multi-sector growth models developed to examine industrial development transitions, such as Funke and Strulik (2000) and Agénor and Dinh (2013), there appear to be different roles played by different types of MNCs, particularly across different production activities of a host economy. Initial entrance by MNCs with platform operations are likely significant only to growth in low-income economies often facing difficulties with access to basic financing and infrastructure. For a middle-income economy with some stocks of human capital, a Horizontal MNC is likely to benefit the host economy in its imitation activities, while a Vertical MNC would tend to be more involved in innovation activities. Furthermore, there appears to be significant but non-linear relationships between FDI and human capital within a host economy (Kottaridi and Stengos 2010), suggesting some degree of interactions between labour market policies and foreign investment liberalisation measures in a host economy. Indeed, given that the productivity of domestic workers in a host economy appears to play some role in determining the strength of linkage effects brought about by foreign MNCs (Javorcik 2004; Liu 2008), there may be potential complementarities between policies promoting FDI and human capital accumulation. For instance, empirical studies such as Blomström and Kokko (2003) and Ciconne and Papaioannou (2009) indicate some degree of interactions between FDI and education policies. Likewise, studies such as Haaland and Wooton (2001) and Olney (2013) suggest that labour market policies are often related to 'foreign investment-attracting' agenda of developing economies. The latter is part of a 'race-to-the-bottom' literature on FDI and globalisation, which posited that, intense FDI policy competition among developing host economies may lead to deterioration of fundamentals such as labour quality, and such phenomenon often result in the failure of many generous direct investment incentives in attracting top quality FDI due to the adverse signalling effects generated (see Oman (2000) and FitzGerald (2001)).

The studies reviewed indicate that FDI is not only an inherently heterogeneous phenomenon, but 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' framework for FDI is not an angle explored in the literature, yet the know-how embodied in foreign experts is the main driving factor of technological learning in a host economy, this paper focuses on modelling FDI in the form of foreign experts instead of tangible capital. The model developed would then be used to provide some generalisations of the role of different foreign subsidiaries in promoting the industrial transformation agenda of a developing economy.

3 The Model

The model host economy studied is populated with households consisting of individuals with different innate abilities. There are five production sectors, with the modelling approach for the domestic production sectors adapted primarily from Agénor and Dinh (2013), notably the production structures of final output and intermediate goods sectors. Knowledge growth in the host economy is assumed to be driven by 'horizontal' expansion of differentiated intermediate goods (IG) in the tradition of Romer (1990). This means the origin of the industrial transformation process is seeded in the production of imitative and innovative blueprints. Productivity in both imitation and innovation sectors benefits from the presence of foreign firms, though there is a largely separate foreign sector determining the different *types* of foreign subsidiary mode operating in the host economy. The focus is on non-pecuniary externalities, which as pointed out in Saggi (2002), are the critical (yet relatively unexplored) impacts of foreign MNCs on the development of a developing host economy.

Drawing on ideas from the contribution of Markusen and Trofimenko (2009), as well as to account for the growing global trends of fluid global expert and enterprise assignment flows as documented in the *global talent management* literature[8], the foreign sector is modelled as consisting of foreign subsidiaries, where each subsidiary unit consists of one foreign expert with specific production process know-how that is only available in the foreign source economy. As a result of foreign firms being effectively experts with specialised human capital, a dichotomous relationship is also introduced between domestic and foreign firms, where foreign experts perceive heterogeneity among productivity—a transformation of ability—of domestic workers and would therefore discriminate among workers more. These therefore allow for the modelling of the incentives affecting the micro-mechanism of how foreign experts impart specific know-how to affect industrial transformation in a host economy. Lastly, a demand feedback channel from the degree of industrial development of a host economy to determining FDI compositions is also introduced through endogenous foreign preferences to capture the significance of international product market dimension, as described in Kharas and Kohli (2011) and Felipe et al. (2012).

[8] For example, see studies mentioned earlier, such as Scullion and Brewster (2001) and McDonnell et al. (2010).

3.1 Domestic Sectors in Host Economy

3.1.1 Households

It is assumed that there is a continuum of dynastic representative households in the economy, growing at an exogenous rate $n > 0$. Given initial number of members, L_0 in each household at time $t = 0$, the size of the representative family at time t is $L_t = \exp(nt)L_0$. Each individual member within a household is assumed to be infinitely lived, and possesses identical ability level, a, though different abilities are assumed at the household level, as in Agénor and Alpaslan (2014). Ability follows a Pareto distribution, indexed by $a \in [a_m, \infty)$, with probability density function $f(a) = \chi a_m^\chi / a^{1+\chi}$ and cumulative distribution function $F(a) = 1 - (a_m/a)^\chi$. χ is the Pareto index, where the larger the value, the smaller the proportion of people with high cognitive ability. The mean ability of the population is given by $\chi a_m/(\chi - 1)$, and $\chi > 2$ and $a_m > 1$. A household with ability a and size L_0 maximises intertemporal utility by solving the optimisation problem of

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

where $\rho > 0$ is the subjective discount rate and $u(c_t^a)$ is the utility function of individual member of a household that depends on each individual member's consumption, c_t^a, assuming a constant relative risk aversion functional form, given by

$$u(c_t^a) = \frac{1 - (c_t^a)^{1/\sigma}}{1 - \frac{1}{\sigma}}, \tag{2}$$

subject to household budget constraint of

$$\dot{W}_t^a = r_t W_t^a + (1 - \tau) Y_t - L_t c_t^a, \tag{3}$$

where $\frac{1}{\sigma} \geq 0$ and σ denotes the constant elasticity of intertemporal substitution, r_t the riskfree market interest rate, Y_t the economy's output of final goods, and $\tau \in (0, 1)$ the tax rate on income. It is assumed that agents do not value leisure, and therefore face no disutility from working or skills acquisition. Each representative household is also assumed to make allocations of consumption equally among its members. Household is not allowed to borrow. Standard transversality condition is assumed.

The solution to the family's dynamic optimisation problem yields the standard Euler equation,

$$\frac{\dot{c}_t^a}{c_t^a} = \sigma(r_t - \rho), \tag{4}$$

which states that per capita consumption expenditure grows over time if and only if the market interest rate exceeds the subjective discount rate. At the aggregate level, the dynamics of household consumption, $C_t = L_t c_t^a$, is then described by

$$\frac{\dot{C}_t}{C_t} = \sigma(r_t - \rho) + n. \tag{5}$$

In terms of skills acquisition, individual members decide whether to acquire skills or enter straight away into the labour force as unskilled workers, taking wages and interest rate as given. Skill acquisition decisions are therefore made to maximise each member's discounted wage income, which is also equivalent to the representative household'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 the worker's ability) or decide to spend first an exogenously given period of time T to acquire skills. The education process occurs during the period of $(t, t+T)$, and a direct cost of $t\acute{c}_t$ is incurred. Post-acquisition of skills, individual enters the labour force at $t+T$ as a skilled worker and earns a wage of $a^\xi w_t^S$, where $\xi > 0$ is a productivity parameter measuring the strength of ability's effect on wages. This would ensure that skilled workers with higher ability levels earn higher wages.[9]

Based on a generalised specification of Dinopoulos and Segerstrom (1999) introduced by Agénor and Dinh (2013), an individual with ability $a \in [a_m, \infty)$ would opt to become a skilled worker if and only if

$$\int_{t+T}^{\infty} \exp[-\rho(s-t)] a^\xi w_s^S ds - t\acute{c}_t \geq \int_{t}^{\infty} \exp[-\rho(s-t)] w_s^U ds, \tag{6}$$

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 that is assumed to be proportional to the skilled wages at $\Gamma \in (0,1)$. The inequality (6) 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 education (discounted wage income working as an unskilled worker). Hence, there exists a threshold level of ability $\hat{a}_t$ such that (6) holds as an equality, expressed as

$$\hat{a}_t = [\exp(\rho T).(w_t^U/(1-\Gamma)w_t^S)]^{1/\xi}. \tag{7}$$

At any time t, $(1-\hat{a}_t)L_t$ individuals either work as skilled workers or are undergoing skills acquisition at any time t. If skills acquisition is assumed to take place instantaneously, as in Eicher and García-Peñalosa (2001)[10], equation (7) can be simplified to

$$\hat{a}_t = [w_t^U/(1-\Gamma)w_t^S]^{1/\xi}. \tag{8}$$

[9]Large ξ indicates strong effect, which implies that individuals with higher innate abilities would face lower cost in acquiring skills. This therefore also indicates the efficiency of skills acquisition.

[10]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 $T = 0$. Knowing that individuals live forever in the model, any training period specified within $(0, T)$ is small with respect to infinity and therefore can be treated as taking place instantaneously.

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

$$L_{U,t} = L_t \int_{a_m}^{\hat{a}_t} f(a)da = L_t a_m^{\chi} \left[-a^{-\chi}\right]_{a_m}^{\hat{a}_t} = L_t \left[1 - (a_m/\hat{a}_t)^{\chi}\right]. \tag{9}$$

Given (9), 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 acquired skills need to be accounted for. This gives the effective supply of skilled labour at time t, $L_{S,t}$, as

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

Equivalently, in relative terms, the shares of unskilled and (effective) skilled labour supply are given by

$$\theta_{U,t} = \frac{L_{U,t}}{L_t} = \left[1 - (a_m/\hat{a}_t)^{\chi}\right], \text{ and } \quad \theta_{S,t} = \frac{L_{S,t}}{L_t} = \frac{\chi a_m^{\chi}}{\chi - 1}(\hat{a}_t)^{1-\chi}. \tag{10}$$

3.1.2 Imitation

In most existing contributions on imitation, innovation, and growth in the tradition of Rustichini and Schmilz (1991), the imitation sector serves as a significant source of growth, and the role of the imitation sector in driving growth has been documented to be especially significant for relatively 'backward' economies playing catch-up to developed peers. A classic example is the 'flying geese paradigm' used to describe the industrial transformation process of developing East Asian economies in the early 1990s (Kojima 2000). As agents in the economy learn from imitation, they would develop the capacities to creatively imitate and subsequently, progress to engage in indigenous innovation. This transition from imitation to innovation is known as the *stepping stone* effect by Perez-Sebastian (2007) and Glass (2010).

The imitation sector produces imitative goods in the form of blueprints that are purchased by firms producing basic intermediate input in the intermediate goods sector. Firms specialised in imitation employ only unskilled labour, in quantity $L_{U,I,t}$. There is no aggregate uncertainty in the research technology of imitative blueprints production, though the production flow, $\dot{M}_t^I$ at any time t is determined by a productivity factor that depends on the economy-wide stock of imitative blueprints at time t, M_t^I, as well as an externality term associated with the size of Vertical MNCs in innovation, $n_{FV,t}M_t^R$. This productivity factor, Φ_t^I is expressed as:

$$\Phi_t^I = (n_{FH,t})^{\psi_1^I}(M_t^I + \psi_2^I n_{FV,t} M_t^R), \tag{11}$$

where $\psi_1^I \geq 0$ and $\psi_2^I \in \mathbb{R}$, which feeds into the aggregate production technology of imitative blueprints of

$$\dot{M}_t^I = \Phi_t^I(\frac{L_{U,I,t}}{L_t}), \tag{12}$$

where it is assumed, in consistent with the 'dilution effect' discussed by Dinopoulos and Segerstrom (1999), that it is the ratio of unskilled workers to total population that affects imitation activities.

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; (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 discussed earlier and 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.[11] 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 (12), 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 and firing costs arising from non-competitive labour market practices). The same additional cost is faced by all firms in the sector. The interior solution for unskilled labour employment in imitation ($L_{U,I,t} > 0$) is given by the following first-order condition:

$$w_t^U = \frac{1}{1 + \Lambda^I} \frac{R_t^I \Phi_t^I}{L_t}. \tag{13}$$

[11] The tradeoff between the size of imitation and innovation is explored in studies such as Walz (1996) and some two-country models reviewed by Saggi (2002). Empirically, as reviewed, there are studies such as Haddad and Harrison (1993) and Djankov and Hoekman (2000) that document negative effects of foreign firms on domestic firms' productivity. However, empirical studies specifically in the area of international production networks, such as Athukorala (2005) and Kam (2013), do find the presence of a positive productivity spillover from leading foreign innovators to the productivity of domestic imitators, notably component part suppliers in the host economy.

3.1.3 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, though the research production flow at any time t is determined by a productivity factor, Φ_t^R, defined as

$$\Phi_t^R = (n_{FV,t})^{\psi_1^R}(M_t^R + \psi_2^R M_t^I), \tag{14}$$

where $\psi_1^R \geq 0$ and $\psi_2^R \geq 0$, which feeds into the aggregate production technology of innovative blueprints:

$$\dot{M}_t^R = \Phi_t^R(\frac{L_{S,R,t}}{L_t}). \tag{15}$$

As in the imitation sector, the production technology of innovative goods captures the key knowledge spillover properties that are often documented in industrial development literature. 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 *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 (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.[12] Likewise, to eliminate scale effects, innovation production is specified as depending on the ratio of skilled workers employed 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 of

$$\Pi_t^R = Q_t^R \dot{M}_t^R - (1 + \Lambda^R) w_t^S L_{S,R,t},$$

subject to (15), 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 $\Lambda^R > \Lambda^I$, the labour market for the innovation sector is more distorted than the labour market for imitation sector, meaning that it is comparatively more expensive to hire skilled workers in innovation than unskilled workers in imitation within the economy. This specification of $\Lambda^R > \Lambda^I$ is consistent with the general

[12] A more accurate modelling approach would be to scale the variable by number of domestic experts, but such top domestic experts is usually very small or 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.

finding documented in Haaland and Wooton (2001).[13]

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

$$w_t^S = \frac{1}{1+\Lambda^R}\frac{Q_t^R \Phi_t^R}{L_t}, \tag{16}$$

which, using (14), can be rewritten as

$$w_t^S = (\frac{1}{1+\Lambda^R})(\frac{Q_t^R}{L_t})(n_{FV,t})^{\psi_1^R}[1+\psi_2^R(\frac{m_t^I}{m_t^R})]M_t^R. \tag{17}$$

3.1.4 Final Output

The final output sector is a perfectly competitive market consists of firms producing final goods. There is a continuum of identical domestic firms involving in the production of 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, $L_{S,Y,i,t}$, unskilled labour, $L_{U,Y,i,t}$, and composite intermediate input, X_t^i.

The production function of individual domestic firm i takes the form of a standard Cobb-Douglas specification:

$$Y_t^i = (L_{S,Y,i,t})^{\beta^S}(L_{U,Y,i,t})^{\beta^U}(X_t^i)^{\gamma}(K_t^i)^{\alpha}[\frac{K_t}{(L_t)^{\iota}}]^{\varrho}, \tag{18}$$

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 economy-wide aggregate stock of private capital, $K_t = \int_0^1 K_t^i di$, asserts a conventional Arrow-Romer type of externality on each individual firm i's production, at a magnitude of ϱ. However, it is subject to a congestion effect of ι due to total population size, L_t.

The composite intermediate input exhibits constant returns to scale with respect to basic and sophisticated intermediate inputs. The composite intermediate inputs required for individual firm's production, X_t^i in (18) is written as

$$X_t^i = [\int_0^{M_t^I}(x_{s,t}^I)^{\eta} ds]^{\nu/\eta} \cdot [\int_0^{M_t^R}(x_{s,t}^R)^{\eta} ds]^{(1-\nu)/\eta}, \tag{19}$$

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

[13] 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 higher degree of labour market rigidities.

intermediates, $\eta \in (0,1)$ and $1/(1-\eta) > 1$ the price elasticity of demand for each intermediate input (in absolute terms).[14]

Faced with competitive markets for private inputs, the optimisation problem of firms in the final output sector is to maximise profits, $\Pi_t^{Y,i}$, with respect to private capital, skilled labour, unskilled labour, and the quantities of all intermediate inputs, taking factor prices and aggregate level of M_t^I, M_t^R, $L_{S,Y,t}$, $L_{U,Y,i,t}$, and L_t at any time t as given:

$$\begin{aligned}\max_{K_t^i, L_t^{S,Y,i}, L_t^{U,Y,i}, x_{s,t}^{I,i}, x_{s,t}^U} \Pi_t^i &= P_t^Y Y_t^i - (1+\Lambda^Y) w_t^S L_{S,Y,i,t} - (1+\Lambda^Y) w_t^U L_{U,Y,i,t} - (r_t+\delta) K_t^i \\ &\quad - \int_0^{M_t^I} P_t^{I,s} x_{s,t}^I ds - \int_0^{M_t^R} P_t^{R,s} x_{s,t}^R ds,\end{aligned}$$

where P_t^Y is the price of final good normalised to unity, $P_t^{I,s}$ ($P_t^{R,s}$) 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. A third labour market distortion parameter Λ^Y is introduced to capture the additional cost faced by firms induced by sector-specific labour market rigidity, and is assumed to affect in the same manner the use of both skilled and unskilled labour in production of final goods.

Given that all firms in final output production are identical and demand the same quantity of each input, profit maximization in a symmetric equilibrium yields

$$r_t = \alpha \frac{Y_t}{K_t} - \delta, \tag{20}$$

$$w_t^S = \frac{\beta^S}{1+\Lambda^Y} \frac{Y_t}{L_{S,Y,t}}, \quad w_t^U = \frac{\beta^U}{1+\Lambda^Y} \frac{Y_t}{L_{U,Y,t}}, \tag{21}$$

$$x_{s,t}^{\varkappa} = \left(\frac{\gamma \nu^{\varkappa} Z_t^{\varkappa}}{P_t^{\varkappa,s}}\right)^{1/(1-\eta)}, \quad s = 1, ...M_t^{\varkappa}, \tag{22}$$

$$Z_t^{\varkappa} = Y_t / \int_0^{M_t^{\varkappa}} (x_{s,t}^{\varkappa})^{\eta} ds, \tag{23}$$

where $\varkappa = I, R$, $\nu^I = \nu$, and $\nu^R = 1-\nu$.

Given that both the technology and demand for all specific intermediate type (either basic or sophisticated) 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

$$X_t = [(M_t^I)^{1/\eta} x_t^I]^{\nu} [(M_t^R)^{1/\eta} x_t^R]^{1-\nu}. \tag{24}$$

[14] Similar to final output elasticities α, β^S, β^U, and γ, the coefficient ν is fixed at a constant value, though it is endogenized in the sensitivity analysis section later using a generalized logistic curve.

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 (18), the aggregate final output Y_t can be written as

$$Y_t = (L_{S,Y,t})^{\beta^S} (L_{U,Y,t})^{\beta^U} (X_t)^{\gamma} (K_t)^{\alpha} [\frac{K_t}{(L_t)^{\iota}}]^{\varrho}. \tag{25}$$

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

$$\dot{K}_t = I_t - \delta K_t, \tag{26}$$

where I_t is the aggregate private investment by the normalised number of firms.

3.1.5 Intermediate Goods

The intermediate goods sector is monopolistically competitive, and consists of two sub-sectors of: (i) intermediate input producers producing basic inputs, based on blueprints produced by the imitation sector; (ii) intermediate input producers producing sophisticated inputs, based on blueprints produced by the innovation sector.

Consider first producers of basic intermediate inputs, $x_t^{I,s}$, $s = 1, ...M_t^I$. Each firm specializes in producing one unit of horizontally-differentiated basic intermediate input. To obtain the rights to produce, each producer pays an imitative blueprint price, R_t^I, in each period to the firm that produced the relevant blueprint in the imitation sector. Each firm produces the one unit of intermediate input to be used in the production of final output, and each of the unit produced uses one unit of the final output.

Faced with a monopolistically competitive market structure, each basic intermediate input firm maximises profits by setting price $P_t^{I,s}$ for good s, given the perceived demand function, (22) for its good. In a symmetric equilibrium, and using also (23), profits are then expressed as

$$\Pi_t^I = (P_t^I - 1)[\gamma \nu Y_t / P_t^I M_t^I (x_t^I)^{\eta}]^{1/(1-\eta)}.$$

The solution yields an optimal price of

$$P_t^{I,s} = \frac{1}{\eta}, \quad \forall s = 1, ...M_t^I. \tag{27}$$

The associated quantity demanded at the equilibrium price, $P_t^I = P_t^{I,s}$ is

$$x_{s,t}^I = (\gamma \eta \nu Z_t^I)^{1/(1-\eta)}, \forall s,$$

which is equal to

$$x_t^I = \gamma \eta \nu (\frac{Y_t}{M_t^I}), \tag{28}$$

in a symmetric equilibrium.

The maximum profit in a current period t is then given by

$$\Pi_t^I = (1-\eta)\gamma\nu(\frac{Y_t}{M_t^I}). \tag{29}$$

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

$$R_t^I = \Pi_t^I. \tag{30}$$

Sub-sector for the production of sophisticated intermediate inputs assumes a similar market structure. Before producing its specialised sophisticated input, each firm must purchase a patented blueprint from the innovation sector. Unlike imitative blueprints, patented blueprints are infinitely-lived. Each sophisticated intermediate input firm sets its price to maximise profits, given the perceived demand function, (22) for its good. In a symmetric equilibrium, and using also (23), profits are then expressed as

$$\Pi_t^R = (P_t^R - 1)[\gamma(1-\nu)Y_t/P_t^R M_t^R (x_t^R)^\eta]^{1/(1-\eta)}.$$

The solution yields an optimal price of

$$P_t^{R,s} = \frac{1}{\eta},\ \forall s = 1, ...M_t^R, \tag{31}$$

with an associated quantity demanded at the equilibrium price, $P_t^R = P_t^{R,s}$ of

$$x_t^R = \gamma\eta(1-\nu)(\frac{Y_t}{M_t^R}). \tag{32}$$

The maximum profit is then given by

$$\Pi_t^R = (1-\eta)\gamma(1-\nu)(\frac{Y_t}{M_t^R}). \tag{33}$$

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 input. The latter is equal to the sum of the profit rate and the rate of capital gain from a change in the patent price over time. This gives

$$r_t = \frac{\Pi_t^R}{Q_t^R} + \frac{\dot{Q}_t^R}{Q_t^R},$$

which can be rearranged to yield

$$\dot{Q}_t^R = r_t Q_t^R - \Pi_t^R. \tag{34}$$

3.2 Foreign Sector

There is a single large source country 'exporting' foreign multinationals (MNCs) to different developing host economies in the world. A developing host economy can have both innovation and imitation sectors or only have an imitation sector, depending on the phase of development it is in, though by implication of the model specified, the presence of Vertical FDI is a necessary condition for innovation sector to exist (conversely, Horizontal FDI is necessary for imitation sector to exist).

In each period of time, for any host economy of interest, investment flows characterised by total number of firms in three different modes of foreign MNCs' subsidiaries are determined for any individual host economy. The three types of FDI modes are *Platform*, *Horizontal*, and *Vertical* FDI.[15] A foreign firm consists of an expert or professional that brings specific know-how into the host economy. Specifically, each foreign firm is one individual and the fixed know-how brought into the host economy is essentially specific processes that are only available in the foreign source country. For example, this means a Vertical MNC would come in the form of an innovation expert bringing *sophisticated* know-how, while a Horizontal MNC would be in the form of an imitation expert bringing *standardisation* know-how. By definition, the FDI composition of a particular host economy in any period t would therefore equal the composition of foreign experts in the economy. As we are interested mostly in the non-pecuniary externalities associated with the presence of foreign experts, we assume no cross-border trade in the model.

Dunning's hypothesis on '*internalisation advantage*' determinant generally seeks to understand how foreign MNCs shape their 'in-house' internal preference with respect to involvement in different production chains of a host economy. To model this, we introduce a specification based on Brambilla et al. (2009) where a foreign subsidiary is allowed to reevaluate its investment mode in each period, and decides on whether to switch and bring in another foreign expert with more advanced specific process know-how: *standardisation* know-how for Horizontal MNC, and *sophisticated* know-how for Vertical MNC. In addition, a critical feature of the model is to introduce a dichotomous relationship between domestic and foreign firms with respect to observing the productivity and ability of workers in host economy. As stated earlier, for domestic firms, only the average productivity of workers matters in production. In the context of foreign firms, first note that upon entry and having decided on the *type* of operation mode in each period, foreign firms are randomly matched to intermediate varieties invested in. However, the individual ability of domestic workers is not fully observable to foreign firms (though they do know the overall distribution of ability in the host economy), and the differences between individual workers are therefore scrutinized more. Specifically, the foreign experts look directly at the distribution of skills and perceive heterogeneity among the productivity of domestic workers. For example,

[15] In addition to the literature reviewed, the classification of FDI is also supported by an empirical estimation exercise implemented. See *Model Calibration* and *Appendix A* in the paper for further details.

for two different skilled workers, foreign experts perceive them as having different productivity, which is a transformation of ability. As a result of preference to be 'matched' to workers with higher productivity, there is therefore an additional layer of discrimination among workers from the perspective of foreign firms, hence resulting in a sorting process for foreign subsidiaries in every time period, akin to those described in Melitz (2003) and Brambilla et al. (2009). Consequently, these would result in different threshold values set for different modes of operation due to an implicit cost uncertainty induced from this different preference for foreign experts.[16]

Lastly, the role of Platform FDI in production of a middle-income host economy with an innovation sector is deemed insignificant and therefore not studied, though they are still modelled as a default base entry mode of foreign MNCs.

3.2.1 Stylised MNCs' Internalisation Framework

In terms of formal model specification to characterise the internalisation process of MNCs for investment in a specific developing host economy of interest, 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.[17]

Specifically, in the first stage, the planner of the foreign source economy determines the allocation of aggregate salary expenditure for experts deployed across all developing host economies. 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

[16] Uncertainty of such nature may broadly be known as some sort of information cost, arising from asymmetry in either demand or supply factors. Such issues are 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.

[17] 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 headquarter. In addition, unlike models treating FDI as capital stock, our main emphasis in this study is on heterogeneous FDI compositions and how such choice is affected by skills distribution of a host economy, the usual returns motive examined is therefore abridged and simplified as a lump-sum salary expenditure paid by foreign planner to the entire pool of foreign experts.

is specified in the second stage. Investment in the host economy is assumed to be in terms of the intermediate variety it is matched to. Collectively, the pool of foreign experts in the specific host economy modelled forms a representative value function over a composite of intermediate varieties, with a further layer of 'shadow investment quality' ascribed to capture the preference of foreign experts to be matched to workers of higher productivity, even among the same variety type that they are matched to.[18]

Specifically, the value function is given by[19]

$$
\begin{aligned}
U_t^F &= \{\left([\int_{s=0}^{\bar{M}^{FP}} (\bar{x}_{s,FP}^0)^{\frac{\sigma^F-1}{\sigma^F}} ds]^{\frac{\sigma^F}{\sigma^F-1}}]^{\frac{\theta^F-1}{\theta^F}} \right) \qquad (35)\\
&\quad +(\int_{j=0}^{N_F} [\int_{s=0}^{M_t^I} \gamma_{1,t}(x_{s,FH,t}^I)^{\frac{\sigma^F-1}{\sigma^F}} ds + \int_{s=0}^{M_t^R} \gamma_{2,t}(x_{s,FV,t}^R)^{\frac{\sigma^F-1}{\sigma^F}} ds]^{\frac{\theta^F-1}{\theta^F}} dj)\}^{\frac{\theta^F}{\theta^F-1}},
\end{aligned}
$$

where the first expression gives some constant variety range, $\bar{M}^{FP}$, over default Platform investment, $\bar{x}_{s,FP}^0$, that is treated as constant throughout all periods; M_t^I, M_t^R denote the imitative and innovative varieties over 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. (2009). $\gamma_{2,t}$ and $\gamma_{1,t}$ represent foreign preferences for investment of Vertical and Horizontal MNC respectively.[20,21]

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.[22]

[18] 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 between the workers employed in the intermediates they are matched to.

[19] The nested utility approach is commonly applied to study the effects of pricing competition on firms' entry and exit decisions. By simplifying the pricing aspect and applying it to examine foreign firms' decisions to maintain or upgrade into different modes of operation, it allows one to study FDI heterogeneity along a production value chain, as well as their respective impacts on the process of industrial transformation within a host economy.

[20] 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 described in Kharas and Kohli (2011) and Felipe et al. (2012). Nevertheless, it is taken as given by the pool of foreign experts when solving for the maximisation problem in every period.

[21] Since not all destinations of host economies have an innovation sector, we can set $x_{s,t}^R = 0$ in the value function for host economies without an innovation sector.

[22] The algebraic derivations follow a standard approach in product differentiation and pricing competition studies with a nested, Dixit-Stiglitz CES value function, notably Allanson and Montagna (2005) and Brambilla et al. (2009). The general expression of the theoretical demand functions, as well as associated shadow investment price indices, are provided in the Appendix.

3.2.2 FDI Compositions in Host Economy

In stage three, for a given number of foreign firms ($N_{F,t}$) entering the host economy of interest in each period t, each firm's dynamic entry decision is modelled as a static decision in opting for investment mode.[23] Upon entry, foreign firms first assume a Platform FDI mode and to simplify matters, no subsequent exit is allowed. Further, in each period t, a firm can opt to stay and operate as Platform FDI (incurring a basic 'doing-business' cost of F_0); incurring additional cost, F_1 on top of F_0 to upgrade into Horizontal FDI mode; or incur $F_0 + F_2$ to operate as a Vertical MNC. All three costs, F_0, F_1, and F_2 are expressed as a fraction of some theoretical baseline price corresponding to the default Platform investment, P_0 (which is normalised to one). Further, $F_2 > F_1 > F_0$ 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 additional bureaucratic or operation costs to operate in the host economy.[24]

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 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, we can express an optimal shadow price of investment (from the perspective of foreign experts) as a function of ϖ, that is,

$$P_{s,t} = \left(\frac{\sigma^F}{\sigma^F - 1}\right)(\varpi_{s,t}), \tag{36}$$

priced at $\sigma^F/(\sigma^F - 1) > 1$ times of $\varpi_{s,t}$.[25]

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.

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

[24] 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 government of the host economy.

[25] 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.

The basic idea is as follows. While a lower value of $\hat{a}_t$ from the labour supply in the household sector 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. As derived later, we would expect the model specification to result in the 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 (alternatively interpretable as needing a larger quantity/pool of skilled workers to offset the higher productivity requirement) than a potential Horizontal MNC.

Further, as an additional novel feature, a second source of asymmetry is introduced. Specifically, when a foreign subsidiary is confronted with the decision to upgrade and bring in experts with top know-how in innovation, the cost associated with the productivity requirement is subject to a parameter ϕ, such that $(1/\varpi)\hat{}(-\phi) > 0$ is now priced by the foreign experts to reflect the increasing difficulties in telling apart and identifying 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. In other words, as the pool of skilled workers gets larger in the host economy, the brightest with the highest productivity would be harder to distinguish from other skilled workers.[26]

The two dichotomous features discussed in the foreign sector characterise the stylised 'internalisation' framework that determines FDI compositions in this model. Equation (36), 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 Platform (π_{FP}), Horizontal (π_{FH}), or Vertical (π_{FV}) operational mode (see Appendix C). 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 $\pi_{FH}(\varpi_{FV}) = \pi_{FV}(\varpi_{FV})$. Then, by introducing a time-invariant structural parameter generalising the degree of pricing competition in the host economy, Lerner Index, LI, the three minimum threshold values for MNCs' internalisation decision in any period t can be expressed as

$$\varpi_{FP,t} = \frac{a_{FP,t}}{\tilde{a}} = \left[\frac{f_{c0}}{\left((\sigma^F - 1)^{\sigma^F - 1}/(\sigma^F)^{\sigma^F - 1} y_t^F\right) P_{F,t}^{\theta^F - 1}} \right]^{1/(1-\sigma^F)}, \tag{37}$$

$$\varpi_{FH,t} = \frac{a_{FH,t}}{\tilde{a}} = \left[\frac{f_{c1}}{\left((\sigma^F - 1)^{\sigma^F - 1}/(\sigma^F)^{\sigma^F - 1} y_t^F\right) P_{F,t}^{\theta^F - 1} [\gamma_{1,t}^{\sigma^F} (LI)^{\sigma^F - \theta^F} - 1]} \right]^{1/(1-\sigma^F)}, \tag{38}$$

[26] In contrast, a positive ϕ means declining cost associated with productivity requirement, which is unlikely to be the case for Vertical FDI.

$$\varpi_{FV,t} = \frac{a_{FV,t}}{\tilde{a}} = \left[\frac{(f_{c2} - f_{c1})}{\left((\sigma^F - 1)^{\sigma^F - 1}/(\sigma^F)^{\sigma^F - 1} y_t^F\right) P_{F,t}^{\theta^F - 1} (LI)^{\sigma^F - \theta^F} [\gamma_{2,t}^{\sigma^F} - \gamma_{1,t}^{\sigma^F}]} \right]^{1/[\phi(1-\sigma^F)]}, \tag{39}$$

where f_{c0}, f_{c1}, f_{c2} are the 'doing-business' costs (in proportion of $P_0 = 1$); 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 shadow 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 $a_{FP} = \tilde{a}/\tilde{a}_{\min} \forall t$, where $\tilde{a}/\tilde{a}_{\min}$ denotes some minimum threshold value of entry by foreign firms (a large value along the ability distribution of host economy). At any time t, the proportion of the three types of foreign firms can be computed as

$$\begin{aligned} n_{FP,t} &= \frac{N_{FP,t}}{N_{F,t}} = [F(1/\varpi_{FH,t}) - F(1/\varpi_{FP,t})] \\ &= [1 - (\frac{a_{FH,t}}{a_{FP}})^{\chi}] , \end{aligned} \tag{40}$$

$$\begin{aligned} n_{FH,t} &= \frac{N_{FH,t}}{N_{F,t}} = [F(1/\varpi_{FV,t}) - F(1/\varpi_{FH,t})] \\ &= [(\frac{a_{FH,t}}{a_{FP}})^{\chi} - (\frac{a_{FV,t}}{a_{FP}})^{\chi}], \end{aligned} \tag{41}$$

$$\begin{aligned} n_{FV,t} &= \frac{N_{FV,t}}{N_{F,t}} = [1 - F(1/\varpi_{FV,t})] \\ &= (\frac{a_{FV,t}}{a_{FP}})^{\chi}, \end{aligned} \tag{42}$$

where a_{FP}, a_{FH}, a_{FV} give the host economy-specific threshold value of entry for Platform, Horizontal, and Vertical MNCs. While $n_{FH,t}$ in (41) is determined by both $a_{FH,t}$ and $a_{FV,t}$, given fixed a_{FP}, (42) shows that the lower the value of a_{FV} (therefore the stricter the entry criteria for Vertical FDI), the smaller share of Vertical MNCs in the host economy. Also, (40) shows that the lower the value of a_{FH} (therefore stricter criteria for Horizontal FDI), the larger the share of Platform MNCs.[27]

Some straightforward algebraic manipulations using (37)-(39) allow us to substitute out y_t^F and $P_{F,t}$, and establish two threshold conditions of

$$a_{FH,t} = \left[\frac{f_{c0}}{f_{c1}} ((LI)^{\sigma^F - \theta^F} (\gamma_{1,t})^{\sigma^F} - 1) \right]^{-1/(1-\sigma^F)} a_{FP}, \tag{43}$$

[27] Indirectly, these imply that the distribution of foreign experts in the host economy is influenced by a Pareto distribution. In the absence of an actual empirical distribution, and given that the element of ability is unobserved in terms of real world data, this is a reasonable assumption.

and

$$a_{FV,t} = \left[\frac{f_{c2} - f_{c1}}{f_{c0}} \frac{1}{(LI)^{\sigma^F - \theta^F}[\gamma_{2,t}^{\sigma^F} - \gamma_{1,t}^{\sigma^F}]}\right]^{1/[\phi(1-\sigma^F)]} a_{FP}^{1/\phi} \tilde{a}^{(\phi-1)/\phi}, \tag{44}$$

respectively.

In addition, a feedback channel on the state of industrial development of a host economy to FDI composition is introduced as taking place via the international product market dimension, as described in Kharas and Kohli (2011) and Felipe et al. (2012). Given that FDI inflows into the Southeast Asian regions are found empirically to be idiosyncratic in nature but follow a Weibull distribution by Gander et al. (2009), and that theoretical models of international trade tend to link spending fraction of a home country on a particular destination country to product ideas drawn randomly from a frontier distribution characterised by Fréchet type of extreme value distribution (see Bernard et al., 2003 for example, who use a Weibull distribution), the two foreign preference parameters $\gamma_1$and γ_2 are modelled using a Weibull distribution, governed by a hazard function of

$$\begin{aligned} \gamma_1 &= [1 - h(\gamma_2; \omega_k, \omega_\lambda)]\gamma_2 \\ &= [1 - (\frac{\omega_k}{\omega_\lambda}(\frac{\gamma_2}{\omega_\lambda})^{\omega_k - 1})]\gamma_2, \end{aligned} \tag{45}$$

where $h(\gamma_2; \omega_k, \omega_\lambda)$ denotes the hazard rate of ${\gamma_2}$[28], 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 preferences to become Q^F, a demand-side feedback channel depending on the state of industrial development of a host economy, and rewrite (43) and (44) as

$$a_{FH,t} = \left[\frac{f_{c0}}{f_{c1}}((LI)^{\sigma^F - \theta^F}(Q_t^F - \Theta_1(Q_t^F)^{\omega_k})^{\sigma^F} - 1)\right]^{-1/(1-\sigma^F)} a_{FP}, \tag{46}$$

and

$$a_{FV,t} = \left[\frac{f_{c2} - f_{c1}}{f_{c0}} \frac{1}{(LI)^{\sigma^F - \theta^F}[(Q_t^F)^{\sigma^F} - (Q_t^F - \Theta_1(Q_t^F)^{\omega_k})^{\sigma^F}]}\right]^{1/[\phi(1-\sigma^F)]} a_{FP}^{1/\phi} \tilde{a}^{(\phi-1)/\phi}, \tag{47}$$

respectively, where $\Theta_1 = (\omega_k/\omega_\lambda)(1/\omega_\lambda)^{\omega_k - 1}$. As not all developing economies host an innovation sector, the foreign source economy therefore evaluates all host economies

[28] 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.

for offshore investment by setting $\dot{Q}^F = \dot{m}_t^I$ in each period.[29,30]

Finally, using (40)-(42), (46), and (47), we can derive the expressions for $n_{FH,t}$ and $n_{FV,t}$ as

$$\begin{aligned} n_{FH,t} &= a_{FP}^{-\chi}(a_{FH,t}{}^{\chi} - n_{FV,t}.a_{FP}^{\chi}) \\ &= \left(\frac{a_{FH,t}}{a_{FP}}\right)^{\chi} - n_{FV,t} \\ &= \left[\frac{f_{c0}}{f_{c1}}((LI)^{\sigma^F-\theta^F}(Q_t^F - \Theta_1(Q_t^F)^{\omega_k})^{\sigma^F} - 1)\right]^{-\chi/(1-\sigma^F)} - n_{FV,t}, \end{aligned} \tag{48}$$

and

$$n_{FV,t} = \left(a_{FP}^{1/\phi}\tilde{a}^{(\phi-1)/\phi}\right)^{\chi}\left[\frac{f_{c2}-f_{c1}}{f_{c0}}\frac{1}{(LI)^{\sigma^F-\theta^F}[(Q_t^F)^{\sigma^F} - (Q_t^F - \Theta_1(Q_t^F)^{\omega_k})^{\sigma^F}]}\right]^{\chi/[\phi(1-\sigma^F)]}, \tag{49}$$

respectively, 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 perceived heterogeneity of productivity among workers, and an assumed one-to-one transformation of productivity from ability (due to persistence), the determination of $n_{FH,t}$ and $n_{FV,t}$ in any period t is mainly 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 (48), 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

3.3.1 Government

Before closing the model, the government's budget is discussed. A balanced budget is maintained, and the government cannot issue bonds to borrow. At each moment of

[29] Alternatively, Q^F can be modelled as depending on the growth rate of m^R (innovative varieties) if we are only interested in host economies with both imitation and innovation sectors. Another approach is to treat Q^F as growing at an exogenous constant rate, which would then remove any feedback channel from industrial transformation of a host economy to the determinant of FDI.

[30] 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) and Günther and Alcorta (2011). It also provides a more general feature given that there are developing host economies that have only imitation production. Note that the industrial composition ratio, $m_t = m_t^I/(m_t^R + m_t^I)$ can be used in an alternative specification, though it comes with a lot more complications. Specifying $\dot{Q}^F$ as being driven by the dynamics of the industrial ratio—hence a complicated expression with the dynamics from both state variables, $\dot{m}_t^I$ and $\dot{m}_t^R$—would make the subsequently derived expressions for $n_{FH,t}$ and $n_{FV,t}$ analytically intractable. The same tractability consideration explains the rationale for using the stationary variable of m_t^I instead of M_t^I.

time t, the government taxes on final output at the rate τ to finance its expenditure G_t. The fixed costs incurred on the foreign firms are treated as a deadweight loss to the economy and therefore not factored into the government budget. The flow budget constraint at time t is therefore simply written as

$$G_t = \tau Y_t. \tag{50}$$

3.3.2 Market Equilibrium Conditions

The market equilibrium conditions to consider are the host economy's market for final goods and the labour markets for both unskilled and skilled workers.

Final Goods Market Equilibrium For the final goods market, as noted earlier, under symmetry, $\int_0^{M_t^I} x_{s,t}^I ds = M_t^I x_t^I$ and $\int_0^{M_t^R} x_{s,t}^R ds = M_t^R x_t^R$. The final goods market-clearing condition is given by

$$Y_t = L_t c_t^a + M_t^I x_t^I + M_t^R x_t^R + I_t + G_t. \tag{51}$$

Using (28), (32), and (50), equation (51) is rewritten as

$$I_t = L_t c_t^a - (1 - \gamma\eta - \tau)Y_t, \tag{52}$$

which represents the private investment level in the economy at any time t.

Labour Markets Equilibrium In order for the market for skilled labour to clear, note that skilled workers are employed in either the production sector for final goods or innovative blueprints. Market equilibrium is

$$L_{S,Y,t} + L_{S,R,t} = L_{S,t},$$

which equals to

$$\theta_{S,Y,t} + \theta_{S,R,t} = \theta_{S,t}, \tag{53}$$

when expressed as a proportion of total population (divided by L_t).

To clear the labour market for unskilled workers, recall that unskilled workers are employed in either the production sector of final goods or imitative blueprints. Market equilibrium is

$$L_{U,Y,t} + L_{U,I,t} = L_{U,t},$$

equivalent to the ratio terms of

$$\theta_{U,Y,t} + \theta_{U,I,t} = \theta_{U,t}, \tag{54}$$

when expressed as a proportion of total population (divided by L_t).

For the foreign sector, in any given period t, the shares of foreign experts or subsidiaries in Platform, Horizontal, and Vertical mode in the host economy should sum up to one, with $n_{FP,t}$ derived residually. This means

$$n_{FP,t} = 1 - n_{FH,t} - n_{FV,t} \ , \ n_{FP,t} \geq 0. \tag{55}$$

3.4 Dynamic System and Steady-state

3.4.1 Dynamic System

Before presenting the overall dynamic system of the economy, to generate endogenous growth, we impose the following knife-edge conditions:

Assumptions: $\beta^S + \beta^U - \varrho\iota = 0$, $(\gamma/\eta) + \alpha + \varrho = 1$.

Specifically, first, define $m_t^I = M_t^I/K_t$ and $m_t^R = M_t^R/K_t$. Using (28) and (32), (24) is written as:

$$X_t = (\gamma\eta\nu^\nu(1-\nu)^{1-\nu})(m_t^I)^{\nu(1-\eta)/\eta}(m_t^R)^{(1-\nu)(1-\eta)/\eta}(\frac{Y_t}{K_t})(K_t)^{1/\eta}.$$

Substituting the expression into (25), and let $\theta_t^{S,Y} = L_t^{S,Y}/L_t$ and $\theta_t^{U,Y} = L_t^{U,Y}/L_t$, gives

$$Y_t = (\theta_t^{S,Y})^{\beta^S}(\theta_t^{U,Y})^{\beta^U} L_t^{\beta^S+\beta^U-\varrho\iota} \tag{56}$$
$$\times \left\{(\gamma\eta\nu^\nu(1-\nu)^{1-\nu})(m_t^I)^{\nu(1-\eta)/\eta}(m_t^R)^{(1-\nu)(1-\eta)/\eta}(\frac{Y_t}{K_t})\right\}^\gamma (K_t)^{(\gamma/\eta)+\alpha+\varrho}.$$

$(L_t)^0 = 1$ 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.

The four differential equations are

$$\frac{\dot{m}_t^R}{m_t^R} = (n_{FV,t})^{\psi_1^R}[1+\psi_2^R(\frac{m_t^I}{m_t^R})](\theta_{S,t}-\theta_{S,Y,t}) - (1-\gamma\eta-\tau)(\frac{Y_t}{K_t}) + z_t^C + \delta, \tag{57}$$

$$\frac{\dot{m}_t^I}{m_t^I} = (n_{FH,t})^{\psi_1^I}[1+\psi_2^I n_{FV,t}(\frac{m_t^R}{m_t^I})](\theta_{U,t}-\theta_{U,Y,t}) - (1-\gamma\eta-\tau)(\frac{Y_t}{K_t}) + z_t^C + \delta, \tag{58}$$

$$\frac{\dot{z}_t^C}{z_t^C} = n + [\sigma\alpha - (1-\gamma\eta-\tau)](\frac{Y_t}{K_t}) + z_t^C - \sigma(\rho+\delta) + \delta, \tag{59}$$

$$\frac{\dot{Q}_t^R}{Q_t^R} = [\alpha(\frac{Y_t}{K_t}) - \delta] - (1-\eta)\gamma(1-\nu)(\frac{Y_t}{K_t})(\frac{1}{Q_t^R})(\frac{1}{m_t^R}), \tag{60}$$

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

$$\frac{Y_t}{K_t} = \frac{\Theta_2}{[(\theta_{S,Y,t})^{\beta^S}(\theta_{U,Y,t})^{\beta^U}]^{-1/(1-\gamma)}}\left\{(m_t^I)^{\nu(1-\eta)/\eta}(m_t^R)^{(1-\nu)(1-\eta)/\eta}\right\}^{\gamma/(1-\gamma)}, \tag{61}$$

$$\theta_{S,Y,t} = \frac{\beta^S(1+\Lambda^R)}{(1+\Lambda^Y)}(\frac{Y_t}{K_t})[Q_t^R(m_t^R)]^{-1}(n_{FV,t})^{-\psi_1^R}[1+\psi_2^R(\frac{m_t^I}{m_t^R})]^{-1}, \tag{62}$$

$$\theta_{U,Y,t} = \frac{\beta^U(1+\Lambda^I)}{(1+\Lambda^Y)(1-\eta)\nu\gamma}(n_{FH,t})^{-\psi_1^I}[1+\psi_2^I n_{FV,t}(\frac{m_t^R}{m_t^I})]^{-1}, \tag{63}$$

$$\theta_{U,t} = 1 - a_m^{\chi}[\frac{\beta^U}{\beta^S(1-\Gamma)}\frac{\theta_{S,Y,t}}{\theta_{U,Y,t}}]^{-\chi/\xi}, \tag{64}$$

$$\theta_{S,t} = \frac{\chi a_m^{\chi}}{\chi-1}[\frac{\beta^U}{\beta^S(1-\Gamma)}\frac{\theta_{S,Y,t}}{\theta_{U,Y,t}}]^{(1-\chi)/\xi}, \tag{65}$$

$$n_{FH,t} = \left[\frac{f_{c0}}{f_{c1}}((LI)^{\sigma-\theta}(w_m m_t^I - \Theta_1(w_m m_t^I)^{\omega_k})^{\sigma^F}-1)\right]^{-\chi/(1-\sigma^F)} - n_{FV,t}, \tag{66}$$

$$\begin{aligned} n_{FV,t} &= \left(a_{FP}^{1/\phi}\tilde{a}^{(\phi-1)/\phi}\right)^{\chi} \\ &\times \left[\frac{f_{c2}-f_{c1}}{f_{c0}}\frac{1}{(LI)^{\sigma^F-\theta^F}[(w_m m_t^I)^{\sigma^F}-(w_m m_t^I-\Theta_1(w_m m_t^I)^{\omega_k})^{\sigma^F}]}\right]^{\chi/[\phi(1-\sigma^F)]}, \end{aligned} \tag{67}$$

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

Finally, to calculate the final output growth rate of the economy at any time t during the transition, first log-differentiates (61) with respect to time. Then, with further substitution of the log-differentiated version of equations (62) and (63), and rearranging of terms, we obtain

$$\begin{aligned} \frac{\dot{Y}_t}{Y_t} &= \frac{\dot{K}_t^P}{K_t^P} + \left[\frac{\gamma\nu(1-\eta)}{(1-\gamma)\eta}(1-\frac{\beta^S}{1-\gamma}-\frac{\beta^S(1+\psi_1^R)(-\chi\omega_k\sigma^F)}{(1-\gamma)[\phi(1-\sigma^F)]})^{-1}\right]\frac{\dot{m}_t^I}{m_t^I} \\ &+(\frac{\beta^U}{1-\gamma})(1-\frac{\beta^S}{1-\gamma})^{-1}\frac{\dot{\theta}_t^{U,Y}}{\theta_t^{U,Y}} \\ &+\{[\frac{\gamma(1-\nu)(1-\eta)}{(1-\gamma)\eta}-\frac{\beta^S}{1-\gamma}](1-\frac{\beta^S}{1-\gamma})^{-1}\}\frac{\dot{m}_t^R}{m_t^R} \\ &-(\frac{\beta^S}{1-\gamma})(1-\frac{\beta^S}{1-\gamma})^{-1}\frac{\dot{Q}_t^R}{Q_t^R} \\ &-[(\frac{\beta^S\psi_2^R}{1-\gamma})(1-\frac{\beta^S}{1-\gamma})^{-1}(1+\psi_2^R\frac{m_t^I}{m_t^R})^{-1}][\frac{m_t^I}{m_t^R}(\frac{\dot{m}_t^I}{m_t^I}-\frac{\dot{m}_t^R}{m_t^R})] \end{aligned} \tag{68}$$

3.4.2 Steady-state

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, (61)-(65), and the two equations determining number of Horizontal MNCs (foreign experts with standardisation know-how) and Vertical MNCs (foreign experts with sophisticated know-how), (48) and (49), 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 grows at the same constant rate as private capital stock in the steady-state, which in turn means that private consumption is also growing at a same constant rate; (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 (57)-(60) 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 not presented analytically, but instead determined numerically.

While the complexity of the model means that saddlepath stability also cannot be established analytically, local stability in the vicinity of computationally derived steady-states can be established for selected configurations of model parameters using numerical techniques such as the relaxation algorithm proposed by Trimborn et al. (2008).[31] Nonetheless, since it cannot be fully established analytically, some configurations of the model may result in the model being locally indeterminate. As explained in Trimborn et al. (2008), this can happen to some high dimensional growth models in which the long-run equilibria give rise to (saddle-point stable) center manifolds, where an unbalanced initial state condition would determine to which particular steady-state level the economy converges. Hence, instead of just identifying some discrete number (for example, a high and a low) of steady-states (in models such as Howitt and Mayer-Foulkes (2005)), the model is likely to have a continuous family of multiple steady-states. This necessitates the use of a computational method solving for a two-point boundary value problem in any policy experiment, so that we are able to ensure that any policy shock applied to the model would always move from one steady-state to another steady-state. Unlike conventional forward shooting methods (see Judd (1998)), finite-horizon discrete time approximation methods (see Fair and Taylor (1983) and Mercenier and Michel (1994) for examples), or the backward integration method (Brunner and Strulik 2002), the relaxation algorithm proposed by Trimborn et al. (2008) is more efficient in dealing with high dimensional systems and therefore allows us to trace out the unique transition dynamics numerically for each

[31] The relaxation algorithm is a specific type of finite-difference method designed to overcome typical problems faced when solving multi-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 minimization procedure of pertubation method when calculating the time path of solutions. See Trimborn et al. (2008) for a full description of the algorithm.

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 later.

Lastly, note that an alternative regime involving smaller version of the system can be derived to characterise those developing host economies that have *only imitation* sector, similar to the one derived in Agénor and Dinh (2013). The outcome of this depends on the interactions of the different threshold values along the ability distribution of the host economy. Specifically, if $a_{FV,t} < \hat{a}_t < a_{FH,t} < a_{FP}$, there is non-zero supply of skilled workers in the economy but no foreign expert operates as a Vertical MNC, therefore all skilled workers can only work in the final output sector. There is only imitation sector in the economy, with non-zero presence of Horizontal MNCs. However, this case is not examined in this study.

4 Model Calibration

To illustrate possible impacts of policies, the model is calibrated for an upper-middle income country with both innovation and imitation sectors, as well as having non-zero presence of multinationals with Vertical FDI mode. Malaysia, a Southeast Asian economy that has successfully positioned itself as part of the global production value chain of foreign MNCs yet remains troubled by challenges of successfully adopting innovation-led growth strategy to attain high-income economy status, is chosen as the studied economy.

On the *household* side, the annual discount rate, ρ, and the elasticity of intertemporal substitution, σ, are set at fairly conventional values of 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, and given that firm-level distribution of skills (hence also include training expenditure) in Malaysia is generally not reported in surveys (Sander and Hanusch 2012), the number of effective skilled labour in the model is defined as the number of workers with tertiary education. The calibration strategies for the remaining household parameters would therefore focus on producing an initial share of skilled workers, θ_S at 0.240, given the other fairly standard production parameters used for other sectors. 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 for human capital development, such as *Pembangunan Sumber Manusia Berhad*, 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, is set at a minimum value that would still satisfy the mathematical properties of $\chi > 2$ and $a_m > 1$.

In the *imitation* sector, for ψ_1^I, the parameter measuring the spillover from the presence of Horizontal MNCs, 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.[32,33]

In the *innovation* sector, for ψ_1^R, based on case studies such as Rasiah (2012), a slightly stronger effect of foreign MNCs' presence on indigenous innovation in comparison to ψ_1^R is to be expected, leading to the setting of $\psi_1^R = 0.40$. The *stepping stone* effect parameter measuring the marginal externality associated with stock of imitative blueprints, ψ_2^R, is set initially to a high value of 9.5 to reflect the historically established industrial base in Malaysia, such as the global electronic and electrical components manufacturing hubs documented by Kharas et al. (2010) in Penang, though sensitivity analysis reported later will further assess the effect of a change in this parameter on the degree of industrial transformation.

In the *final output* sector, the elasticity of production with respect to private capital, α, is set at a fairly standard value of 0.3 (Agénor 2011). The elasticity of output with respect to composite intermediate goods, 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) and Sequeira (2011) for developed economies. By implication of the constant returns-to-scale assumption, that leaves a total of 0.4 between skilled and unskilled labour. Both Agénor and Dinh (2013) and Agénor and Alpaslan (2014) set the elasticity of production with respect to unskilled labour, 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, X_t, as measured by 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 as industrial transformation takes place over time, a specific sub-section on endogenous ν is presented as part of the sensitivity analysis in later sections. Lastly, following Agénor and Dinh (2013), the depreciation rate for private capital, δ, is set at 0.068.

On the three labour market rigidities-induced cost mark-up parameters introduced across the labour-employing sectors, an initial state with the order of innovation, imitation, and final output sector in terms of rigidity is calibrated, in consistent with observations documented in Sander and Hanusch (2012). In the overlapping genera-

[32] As discussed earlier in the sub-section for *Imitation* sector, 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.

[33] Small values for ψ_2^I, irrespective of the sign, are used for the calibration and sensitivity analysis. Large value of ψ_2^I is destabilising to the model, and this is obvious from the equation for m_t^I.

tions model of Agénor and Khazanah team (2012), the cost parameter associated with labour market rigidities 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 workers for the innovation sector.

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 0.61 used by Iacopetta (2010), 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 very well— a highly specialised global electrical and electronic component manufacturing hub, and part of the production network of large foreign MNCs.

Regarding the vastly simplified *government*, the tax rate on final output, τ, is set equal to 0.25, which corresponds to the average effective tax rate on the output of Malaysia used by Agénor and Khazanah team (2012). Table 1 summarises the parameter values for the host economy.

Moving on to the *foreign* sector, in the representative objective function for foreign experts in the host economy, recall that the elasticities of substitution abide by 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 Iacopetta (2010) for substitution parameter in the production side. This is deliberately 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. As stated, the normalisation of $P_0 = 1$ is applied. The calibration for the Lerner Index, LI, is based on the average empirical estimates of profit margin, 0.2544, for Malaysian manufacturing firms in 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 as a percentage of real GDP per capita reported in the 2004, 2006, and 2008 version of World Bank Doing Business Surveys. 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 forty percent of the baseline price, $P_0 = 1$. 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. In terms of the asymmetric cost parameter, $\phi = -1$ is conveniently set to reflect a linear function of $1/\varpi$, with the negative value still allowing us to capture the growing difficulties in identifying the best among the highly skilled workers when the threshold entry value becomes increasingly lower and restrictive.[34]

The total number of foreign experts entering into 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). Indeed, the compositions of inward FDI stock from the United States (U.S.) for different East Asian economies are presented in Figure 1. 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.[35] Based on the estimates, the initial proportion of Platform (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, using the expression for LI, modified from Allanson and Montagna (2005) and stated as (**??**) in the Appendix, 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 (42) would allow us to calculate the threshold value of entry for Vertical FDI, a_{FV}, to equal 3.155. Then, given the values for a_{FV}, a_{FP}, the initial steady-state value for n_{FH}, and other calibrated parameters, the threshold value for Horizontal FDI, a_{FH}, can be calculated by rearranging (41), 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. The parameter values used for the foreign sector are summarised in Table 2.

For the main variables of interest, calibrations for the initial steady-state of labour proportions work as follows. As stated, from data, we know $\theta_S = 0.240$. Further, based on estimated statistics on the percentage share of R&D researchers and technicians 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 the calibrated values for a_m, χ, ξ, β^S, β^U, we can rearrange (65) to calculate for the absolute share of unskilled labour in final output production, $\theta_{U,Y}$, which equals

[34] For the range of parameter values satisfying $\phi < 0$, when a convex increasing function of information cost, $\phi < -1$, is used, the system runs into convergence problems quickly. Alternatively, $\phi > -1$ can be used to reflect a concave increasing function of $1/\varpi$, though those calibrated values experimented make no significant difference to the results obtained.

[35] Ideally, the availability of firm-level enterprise survey data on an annual basis would allow us to adopt the approach of Lim (2015) to distinguish the three types of FDI modes. In the absence of such data, the classification is based largely on Markusen's (1998), as well as those of Brainard (1997) and Braconier et al. (2005), and the financial and operating data of majority-owned nonbank foreign affiliates of U.S. is used to proxy for the composition of MNCs. See Appendix A for further details.

0.0231. Then, rearranging (64), the share of unskilled labour in the population, θ_U, would equal 0.9856. By implication, the proportion of unskilled labour working in the imitation sector can then be calculated as equal to 0.9625.[36]

For the calibration of 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 measuring the degree of innovation expertise in host economy, 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 in the model, 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 of Ψ_t turns out to be 0.3672.[37]

Finally, for the initial steady-state growth rate of final output, a multiplicative constant is introduced to yield both an initial annual growth rate for final output and initial growth rate of private capital stock to equal 4.3 percent per annum, which corresponds to the average growth rate for Malaysia in the period of 2008-13. By implication of the properties of initial steady-state, private consumption growth is also equal to 4.3 percent.

5 Policy Experiments

Similar to the main focus of related studies, namely 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, $\theta_{S,R,t}$.[38]

[36] Following Agénor and Dinh (2013), we introduce inertia in the labour adjustment process to prevent unrealistic jumps in the transition dynamics. The relevant static equations are therefore solved as dynamic equations in their partial adjustment form, though these are merely nuances in numerical simulations that make no material difference to the actual solutions.

[37] In the absence of data on the embodied human capital of experts, we retain the calculated ratio that is based on $n_{FV,t}$ and $\theta_{S,R,t}$. Alternatively, we can also introduce a multiplicative constant to normalise the value to an index, though these will not make material difference to the results examined.

[38] As seen in Figure 1 and consistent with the general finding of the East Asian technological innovation capability-building literature (see, for example, Amsden (2001)), larger shares of Vertical MNCs do not always translate into successful industrial transformation. We therefore argue that it is the relativity of foreign-to-domestic innovation know-how that is the more appropriate indicator.

As we are mostly interested in the long run effects of policy interventions, all policy experiments implemented 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 labour market rigidity-induced 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.[39] Individual policies are first discussed, followed by different variations of composite policy packages. These are then followed by a specific subsection on sensitivity analysis involving endogenous technological change, where the parameter ν is made endogenous to the state of industrial transformation.

5.1 Individual Policies

First, we examine the broad pattern of transition dynamics associated with individual policies. All shocks considered are unanticipated in nature. Absolute deviations of key variables in the baseline economy are examined, with selected sensitivity results concerning parameters relevant to the specific policy considered also discussed. Unless stated otherwise, absolute change specified for policy shock also represents percentage change in most cases, given that policy parameters considered are either in proportion of skilled wage (Γ) or as a fraction of a baseline theoretical investment price normalised to one (f_{c0}, f_{c1}, f_{c2}).

5.1.1 Skills Acquisition Cost

Consider first a permanent reduction in skills acquisition cost, Γ, from 0.25 to 0.18. This represents a reduction of seven percent in skilled wage, and may be thought of as a subsidy scheme designed to reduce either the cost of pursuing advanced education or workplace training expenditure. This is obtained by reallocating spending within the budget, so that the tax rate remains the same and the overall balance remains.

The cost reduction associated with skills acquisition induces more workers to invest in skills. This leads to an expansion in both the proportion of skilled labour employed in the final output and the innovation sectors. At first, the increase in skilled labour supply lowers skilled wages. At the same time, the rise in skilled employment promotes activity in both innovation and final output production, which would raise the marginal product of unskilled workers and consequently, unskilled wages. This nets off some

[39] When solving for the continuous time dynamic problems over the entire infinite time horizon, 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.

of the skills acquisition incentive, resulting in a 'scale-back' pattern for both effective shares of total skilled labour and those employed in innovation, as seen in Figure 4. The respective absolute deviations from initial steady-state are 0.69 and 0.13 percentage points respectively.

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 just a slightly lower level than initial steady-state. This is the same for the proportion of foreign innovation 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. In relative terms, this indicates a small deepening of domestic innovation expertise (relative to foreign 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.

As seen in Figure 4 and Table 4, additional sensitivity analysis on the efficiency parameter of training, ξ, as well as 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 also carried out for this shock. It can be seen that changes in variables are generally more responsive to the shock the higher the efficiency of training is. In terms of the elasticity parameters in the research sectors, 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 largely 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 instead, 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.

5.1.2 Labour Market Reform for Innovation Sector

Next, we consider labour market reform measures applied specifically to the innovation sector to reduce the cost mark-up associated with the hiring of skilled researchers in the domestic innovation sector. In Malaysia's context, this policy may be interpreted as bringing about similar effects to the type of initiatives implemented by the semi-statutory body of *TalentCorp Malaysia* in recent years.[40] Specifically, for the policy

[40] *TalentCorp Malaysia* was established on 1 January 2011 under the Prime Minister's Department of Malaysia to formulate and facilitate initiatives to address the availability of talent in line with the needs of the country's economic transformation.

experiment consists of a permanent reduction in Λ^R from 0.2 to 0.0 (a 100 percent reduction in labour cost mark-up in the innovation sector). Simulation results for the four main variables of interest are presented in Figure 5.

While changes in the industrial composition ratio and effective skilled labour share appear to be largely similar to Figure 4, the policy effects here operate mainly through the skilled labour market reallocation channel. As skilled workers become relatively more expensive in the production of final output and relatively cheaper in the production of innovative blueprints, more skilled labour are employed in the innovation sector. However, similar to the skills acquisition cost cut, there is a secondary effect that mitigates the expansion, resulting in the hump shaped patterns observed for effective skilled labour. 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 of the innovation sector. More specifically, 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.

Even though the 'scale-back' in innovation sector expansion observed earlier (with skills acquisition cost cut) remains in action, it is less significant as the link with the relative wage ratio adjustment is less direct here. The reduction in Λ^R leads to a proportionate decline in the effective hiring cost of skilled labour in innovation, but given that both Λ^Y and Λ^I stay the same, the unskilled wage adjustment mechanism resulting in subsequent disincentive in skills acquisition is less in action here. As such, the expansion in innovation relative to imitation is more effective, therefore resulting in a larger permanent reduction of 3.25 percentage points in the industrial ratio, m. Similar to the results associated with skills acquisition cost cut, the steady-state effect on proportion of foreign experts with sophisticated know-how, n_{FV}, resulting from this labour market 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 in the host economy (Ψ declines from 0.3672 to 0.3119, which indicates 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 from the initial baseline.

Two other sensitivity results are presented in Figure 5, where the transition pattern of shock associated with a larger *stepping stone* effect, $\psi_2^R = 15.5$, is mostly similar to the benchmark case (other than a steeper 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 cross-term of foreign innovation experts and innovative blueprint stock ($n_{FV,t}M_t^R$) is specified as having positive feedback ($\psi_2^I = 0.3$) to imitation (instead of negative tradeoff as in the benchmark calibration), a more favourable outcome is observed for the industrial composition ratio (m declines by 3.3 percentage points) without the corresponding decline in share of Vertical MNCs, $n_{FV,t}$. This suggests that, in terms of domestic labour market and skills expansion policies, slightly favourable industrial transformation outcomes can be achieved when there is positive externality from the overall participation of foreign experts with sophisticated know-how in the innovation sector to the productivity of domestic imitators.

Lastly, the experiment with a simultaneous cut in Λ^Y also yields results with similar transition patterns, with deviations observed in variables generally smaller due to the cut in Λ^Y producing a mitigating effect because of (i) less skilled final output worker reallocating to the innovation sector, and (ii) smaller skills acquisition incentive due to cut in Λ^Y also reduces effective cost of hiring unskilled labour in the final output sector. Nonetheless, the steady-state effect of a rise in effective skilled labour share is actually larger with the additional Λ^Y cut due to the effects of overall skilled labour expansion outweighing that of point (ii) mentioned above.

5.1.3 Foreign Investment Liberalisation Measures

In the model context, 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 specific targeted investment liberalisation or deregulation measure implemented by the host economy.

First, we consider individual effects associated with each of the three fixed costs. 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. Predictably, a cut in the basic cost of F_0 would unambiguously bring about positive effects on both n_{FH} and n_{FV}. Nonetheless, for the add-on cost of F_1 and F_2, by implication of the foreign sector specification, as well as owing to the asymmetric nature of the perceived productivity difference from the perspective of foreign innovation experts, the policy experiments produce some interesting yet seemingly counter-intuitive results that may partly help to explain the phenomenon often observed in real life, where competing host economies offering the best financial incentives often do not end up attracting the best foreign innovation experts with frontier know-how.[41]

[41] These are summarized in studies on FDI policy competition, such as Oman (2000), Blomström (2001), and FitzGerald (2001). In essense, this branch of the literature argues that the quality of the enabling environment of investment (for examples, governance and 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 costly and counterproductive to offer investment incentives if the 'fundamentals' of the potential host economy fail to meet basic requirements. Hence, the impact of regulatory incentives varies by the different type of firms' operations.

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 from the initial 0.40). 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–therefore f_{c2}–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, given the equi-profit condition, $\pi_{FH}(\varpi_{FV}) = \pi_{FV}(\varpi_{FV})$, used to derive threshold value for Vertical MNCs, a_{FV}, the asymmetric productivity term, ϖ_{FV}^{ϕ}, would have to adjust, as seen from (39). 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, consistent with Horstmann and Markusen (1996), the reduction in F_2, without an accompanying cut in F_0, can lead to an adverse signalling type of outcome. Given the asymmetric structure specified for the internalisation decision of a typical foreign innovation expert in Vertical MNC mode, foreign subsidiaries in the host economy 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_{c2} in (39) would result 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 Horizontal operation and instead bringing in experts with standardisation know-how. In the benchmark simulation, n_{FH} increases by 4.4 percentage points while n_{FV} drops by 0.5 percentage points, which is a counter-intuitive result.[42]

The expansion in n_{FH} further creates a secondary effect: it leads to an expansion in imitative goods relative to innovative goods in the host economy due to a rise in productivity of imitation. This results in industrial composition ratio, m, rising by 5.6 percentage points (see Figure 6). 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. As seen in (**??**), 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,

[42]While the simulation result may seem puzzling to some, there are nonetheless non-theoretical studies, specifically those in the 'race-to-the-bottom' literature such as Vogel and Kagan (2004), that have documented similar adverse signalling effects of FDI-promoting policies. In such context, a cut in F_2, without an accompanying F_0 cut, may be viewed adversely by foreign subsidiaries as a signal of shortage in domestic innovation expertise and lower productivity.

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 in the host economy improves, with Ψ 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 (20), aggregate private consumption grows by the same percentage points too.

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 with respect to offering all forms of targeted incentives to attract foreign firms at the global frontier, yet failed to attract many of such foreign firms (Yusuf and Nabeshima 2009).

Simulations on F_1: Next, consider a permanent reduction of F_1, which is also f_{c1}, from 0.33 to 0.30. The same three percent reduction in terms of the baseline theoretical price is maintained, though it is 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 (38), a reduction in f_{c1} 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 (39), given fixed f_{c2}, the reduction in f_{c1} widens the comparative cost gap, $f_{c2} - f_{c1}$. 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 the host economy.

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 most apparent for the case where there is positive feedback from the cross-term of $n_{FV,t}M_t^R$ to the productivity of imitation ($\psi_2^I = 0.3$), as the foreign-to-domestic innovation expertise ratio, Ψ, increases by more in this case. In addition, it can also be seen from Figure 7 that the transition–for both the industrial composition ratio and foreign-domestic innovation expertise ratio–displays more volatilty in this case, since Vertical MNCs are not only driving innovation but also having a positive spillover to imitation, hence more complicated dynamics are observed. Results on steady-state effects for other sensitivity analysis are also presented in Table 4.

Simulations on F_0: Next, consider a permanent reduction of F_0, which is also f_{c0}, from 0.2733 to 0.2433. While the same three percent reduction is maintained, 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, ceteris paribus, this would create incentives for 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 required to be paid every period ($F_0 + F_1$) 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. Specifically, 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. In relative terms, this means domestic innovation expertise deteriorates by 12 percent, indicating a growing reliance on foreign experts (in terms of innovation expertise) in the host economy.

Figure 8 illustrates two other experiments in which the policy of f_{c0} reduction by 0.03 is implemented with $\psi_1^I = 0.7$ and $\psi_2^I = 0.3$. The transition paths observed for the experiment with a higher elasticity with respect to Horizontal multinationals, $\psi_1^I = 0.7$, are largely similar to the benchmark case. For $\psi_2^I = 0.3$, similar to the results observed for the previous F_1 shock, when there is positive feedback from the cross-term of $n_{FV,t}M_t^R$ to the productivity of imitation, the transition path for key variables displays more volatility: Initially, as $n_{FV,t}$ increases and the innovation sector expands, the positive feedback specified means it spills over to improving the productivity of imitators. This additional channel means the unskilled employment in imitation would grow more than the skilled employment in innovation, therefore putting upward pressures to the unskilled-skilled wage ratio and disincentivizes skills acquisition. These effects explain the U-shaped pattern for both effective skilled labour shares in Figure 8. Nevertheless, this secondary effect is eventually dominated by the primary effect of innovation sector expansion, resulting in a modest increase in effective skilled labour share in steady-state.

In terms of other 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.

Lastly, before proceeding to experiments of different composite reform programmes, we examine briefly three different combinations of foreign cost cuts. These are: (i) simultaneous reductions in f_{c0}, f_{c1}, and f_{c2} by 0.03; (ii) a proportionate cost cutting programme tilted towards providing investment incentives for foreign experts with know-how of technological leadership (f_{c0} reduced by 0.01, f_{c1} reduced by 0.03, and f_{c2} reduced by 0.05); and (iii) another proportionate cost cutting programme tilted towards providing basic investment incentives for all foreign MNCs (f_{c0} reduced by 0.05, f_{c1} reduced by 0.03, and f_{c2} reduced by 0.01). The simulation results for the benchmark model are presented in Figure 9. Unsurprisingly, the time paths observed for key variables closely resemble the individual shocks, depending on the dominant foreign cost cut policy in the combined programme. In short, the balanced cost cutting programme in (i) appears to be the relatively more stable and conservative programme that would deliver a lower industrial composition ratio, m (by -1.2 percentage points), higher supply of effective skilled labour, θ_S (by $+0.1$ percentage points), but a negligible impact on aggregate private consumption growth. Predictably for a full-blown foreign investment liberalisation measure, the ratio of foreign-to-domestic innovation expertise increases from 0.3672 to 0.3924 (+6.9 percent from initial value), indicating a growing reliance on foreign experts in innovation activities in the host economy.

The second programme (with f_{c2} cut by 0.05) would result in a higher steady-state final output growth, aggregate private consumption growth, and a reduction in Ψ from 0.3672 to 0.2965 (a relative deepening of domestic innovation expertise by 19.3 percent). However, the results are accomplished through 'reverse transformation' where m increases (by 3.1 percentage points) and θ_S decreases (by 0.2 percentage points). The third programme (with f_{c0} cut by 0.05) produces impressive industrial transformation results, where the industrial composition ratio, m, declines by 4.5 percentage points, the effective skilled labour share, θ_S, increases by 0.4 percentage points, and the share of Vertical FDI increases by 0.5 percentage points, though the transition paths fluctuate the most and it incurs the cost of lowering aggregate private consumption growth (-0.2 percentage points). Likewise, the host economy develops greater reliance on foreign experts in innovation know-how as Ψ rises from 0.3672 to 0.4601.

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 of individual policies 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. The key complementarity between labour and foreign investment liberalisation policies is best illustrated here, since a successful deepening of domestic innovation expertise—relative to foreign expertise—in the host economy would see a reduction in the foreign-to-domestic innovation expertise ratio, Ψ.

Consider three different composite policy reform programmes, which combine the policies of a skills acquisition cost cut (Γ from 0.25 to 0.18), the innovation sector-specific labour market reform (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 skills acquisition cost and innovation sector labour cost mark-up reductions with the first combination of foreign cost cuts discussed previously (simultaneous reduction in f_{c0}, f_{c1}, and f_{c2} by 0.03). *Composite Programme B* combines the proxies for education and labour market policies with the second proportionate cost cutting programme (f_{c0} reduced by 0.01, f_{c1} reduced by 0.03, and f_{c2} reduced by 0.05), while *Composite Programme C* combines the Γ and Λ^R reductions with the third proportionate cost cutting programme tilted towards providing basic investment incentives to all foreigners (f_{c0} reduced by 0.05, f_{c1} reduced by 0.03, and f_{c2} reduced by 0.01).

The results of the three composite policy reform packages implemented in the benchmark model are illustrated in Table 5 and Figure 10. 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_{c0} cut by 0.05 produce positive deviation in the share of Vertical MNC, n_{FV}, in steady-state. At the same time, the skills acquisition-stimulating cost reduction measures 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 occurring 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 towards innovation raises the productivity of labour in that sector, which magnifies the initial effect. Nonetheless, the increase in the supply of skilled labour in final output production 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 humped and U-shaped pattern associated with θ_S and m (as well as Ψ) in Figure 10.

Apart from the labour market adjustments, 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 in Figure 10. 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 foreign innovation experts in the host economy. Overall, while the host economy would experience improvements in both industrial composition (a decline in m) and relative domestic innovation expertise (a decline in Ψ) 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, the *Composite Programme B* results in largely opposite results. The share of foreign experts in the Vertical MNC mode, n_{FV}, would decline in steady-state due to the adverse signalling effects associated with the large f_{c2} cut. This then results in 'reverse transformation' towards imitation, less incentive to acquire skills and work in innovation sector, hence a drop in both effective skilled workers, θ_S, and those employed in the innovation sector, $\theta_{S,R}$. 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. While steady-state effects for other key variables are also documented, we focus on the industrial composition ratio (m) and the foreign-domestic innovation expertise ratio (Ψ), the two key indicators of interest. 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 and labour market 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 in the host economy when compared to *Composite Programme C*. The results from these policy experiments are generally consistent with the consensus views surveyed and documented in Saggi (2002) and Faeth (2009), where evidence on the direct role of FDI in promoting indigenous knowledge activities are mixed, but their indirect impacts on domestic economy tend to be positive if their presence leads to a deepening of innovation expertise among domestic agents.

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 more effective in all three composite programmes. As an illustration, Figure 11 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 findings in Agénor and Dinh (2013) and Agénor and Alpaslan (2014).

In terms of other parameters, when the substitution parameter for intermediate goods production is calibrated at a higher value to indicate greater substitutability between intermediate goods in domestic production, specifically $\eta = 0.54$ as in Funke and Strulik (2000), the effectiveness of *Composite Programme A* and *Composite Programme C* in driving industrial transformation becomes lower, with m declining, and

θ_S and $\theta_{S,R}$ increasing at lower rates. The lower substitutability between intermediates effectively takes away the effectiveness of policies in expanding innovative varieties as it implies that each unit of intermediate input is priced lower. For each gain from expansion of innovative varieties, the associated benefits to improving skills acquisition incentives will also be lower, hence resulting in smaller gains of effective skilled labour and those employed in the innovation sector. In terms of domestic innovation expertise, even though the indicator of Ψ declines more (compared to the benchmark case), this relative deepening is spurious as it is attained when both labour market and FDI-promoting policies become less effective under this scenario.

Meanwhile, when the Lerner Index parameter is calibrated at $LI = 0.25$, hence indicating a greater degree of product market competition in the host economy, it can be noted that more favourable industrial composition outcomes are achieved for the two relatively transformation-friendly composite programmes compared to the benchmark economy. Specifically, the industrial composition ratio, m, would decline by more, while at the same time the gains in effective skilled labour, θ_S, and those employed in the innovation sector, $\theta_{S,R}$, are larger. Greater degree of pricing competition also means the monopolistically priced innovative blueprints would be less attractive, hence less incentives for foreign experts in the Vertical mode to enter. Nonetheless, the fact that the product market has more slackness means, for a given level of expansion in innovation activities, the effectiveness of human capital and labour market policies in promoting a greater level of skills acquisition would become higher. In combination, these two forces naturally lead to greater deepening in relative domestic innovation expertise, as Ψ would decline more under both *Composite Programme A* and *Composite Programme C*.

Lastly, when the shape parameter of the Weibull function is calibrated at $\omega_k = 1.2$, indicating that the changes in foreign preference increases with time (or the foreign preference for investment as a Horizontal MNC (relative to Vertical MNC) in the host economy would decline more rapidly over time), the effectiveness of the composite programmes in reducing m would be marginally lower than the benchmark case. Nevertheless, the effectiveness of the two relatively transformation-friendly composite programmes in promoting skills expansion and the deepening of domestic innovation expertise is higher compared to the benchmark economy. In fact, in other experiments involving calibrations of $\omega_k < 1$ that have been tested, the effectiveness of policies in promoting skills expansion and domestic innovation expertise would decrease the smaller the value of ω_k, and these observations are consistent across all three composite packages. These imply that the implementation of composite reform packages to drive industrial transformation and deepening of domestic innovation expertise would actually be more effective under an environment of fast-evolving international product markets.

For the balanced and generally less volatile *Composite Programme A*, Table 8 illustrates the benefits of the implementation of composite packages. In comparison to the 'sum of parts' from aggregating steady-state effects of all individual policies, the implementation of a composite reform programme clearly exhibits policy complementarity. The decline in the industrial composition ratio, the expansion of effective skilled labour and those employed in the innovation sector, as well as the increase in the share of foreign experts with sophisticated know-how (Vertical MNC) in the host economy, are of larger magnitude compared to when merely summing up effects from all the individual policies implemented in isolation. However, the fact that there is an increase in the number of foreign innovation experts under the composite programme means the relative measure of Ψ declines by less. Likewise, the steady-state positive deviation in aggregate private consumption growth—growing at the same rate as final output in steady-state—is actually slightly lower under the composite programme. This is due to the fixed share of basic inputs in composite intermediate inputs, ν, used in final output production (biased towards imitation-based basic input), therefore leading to less expansionary effects from policies. Nevertheless, as would be seen in the next subsection, when ν is allowed to change over time, the composite policy programme would generate even more complementarity and attain the desired outcome in all indicators examined.

5.3 Endogenous Technological Change and Policy Complementarities

In addition to conventional policy experiments, an interesting policy element to consider is to incorporate some form of 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 such as the industrial composition ratio, m_t, 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 a typical exercise of sensitivity analysis.

The generalised logistic curve is specified as

$$\nu_t = f(m_t) = \nu_m + \frac{(\nu_M - \nu_m)}{[1 + \exp\{-\zeta(m_t - m_I)\}]^{1/\upsilon}}, \quad \nu_t \geq \nu_m, \tag{69}$$

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. As expected, for all three of the composite programmes, endogenising ν_t generates more sensitive results, and 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' overall gains, underlying the significance of endogenous technological change in magnifying the benefits of policy complementarity between the labour market and FDI-promoting policies. In fact, notwithstanding the fact that *Composite Programme C* would come with even more volatility, the model with endogenous ν and $\zeta \geq 2.0$ would allow the composite programme to produce a steady-state increase in aggregate private consumption growth, which has been the shortcoming of this option when implementing the composite programmes in the benchmark model. These greater benefits of policy complementarity in a model where the share of intermediate inputs in production is allowed to change can be seen in Table 8.

6 Concluding Remarks

The main purposes of this paper include: (i) to develop an imitation-innovation model with heterogeneous foreign multinationals that would allow for the internalisation determinant (least modelled formally within a growth framework, out of the trio of *ownership-specific*, *location-specific*, and *internalisation advantages*) to be formally incorporated within the framework of a growth model with imitation, innovation, and heterogeneous labour; (ii) to model foreign MNCs in the disaggregated form of foreign experts as suggested in Markusen and Trofimenko (2009), so that the micro-mechanism of how foreign presence can affect the dynamics of industrial transformation, can be better understood; (iii) to examine the role of public policies, notably human capital and FDI-promoting policies, in driving industrial transformation and the deepening of domestic innovation expertise within a host economy; and (iv) to identify the combination of policies that would deliver the most complementarity amidst the uneven path of policy transition.

Based on the framework of Agénor and Dinh (2013), industrial transformation was measured by changes in an index of industrial structure, defined as the ratio of the variety of imitation- to innovation-based intermediate goods. This idea that is largely Romerian based is further supplemented by a foreign multinationals' sorting framework adapted from Brambilla et al (2009), whose mix of expanding varieties and quality ladder features allow us to model a dichotomous relationship introduced between domestic and foreign firms that would capture the usually stricter preference of foreign experts. Unlike the former, foreign experts have a choice of other investment destinations and therefore perceive heterogeneity among the productivity of domestic workers. Due to persistence, productivity is assumed to be a one-to-one transformation of ability, which then allows us to link the skills acquisition decision and foreign subsidiaries' operational mode choice along the same ability distribution of the workers in the host economy. In addition, asymmetry is introduced specifically for Vertical MNCs to capture the increasingly costly nature for foreign experts to identify the best among the most productive workers. These novel features allow the model to simulate some policy experiment results that are consistent with observations well-documented in the FDI literature, such as the adverse signalling effects arising from FDI policy competition in the 'race-to-the-bottom' literature.

The model was calibrated for Malaysia, an upper-middle income economy with a reasonably developed industrial structure and existing presence of Vertical MNCs. A variety of policy experiments were performed, which helped to enhance the understanding of interactions between the labour market and FDI-promoting policies in driving industrial transformation. 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 dichotomy and asymmetry with respect to foreign experts' perceived productivity of domestic workers, 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 labour market and FDI-promoting policies in promoting industrial transformation, especially if the government of a host economy intends to minimise disruption of industrial transformation while at the same time improving welfare, in the form of increasing aggregate private consumption growth. Specifically, this would allow for the reaping of the benefits of policy complementarities. Furthermore, the knowledge externalities associated with learning in the imitation sector, first introduced in Agénor and Dinh (2013), was found to continue playing a critical role in facilitating industrial transformation and deepening of domestic innovation expertise. Also, results from the sensitivity analysis conducted when endogenous technological change was introduced, support the conventional belief that governments of developing economies should strive to undertake measures in improving the technological diffusion rate within the economy.

By design, the model provides a base framework for future research, notably a *stage-of-development* modelling exercise similar to Chen and Funke (2013) that would allow for *post hoc* examination of historical development paths of selected developing economies moving from pure imitation-based to fully industrialised economy. The key model feature (linking of heterogeneous human capital and FDI along the same ability distribution, with the latter modelled as experts) is a novel contribution. Nevertheless, 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. First, while the major theme of the research emphasizes public policies, the role of the government in the model is minimal in a sense that fiscal policy components are largely treated as exogenous. Second, while the model establishes indirect feedback from the skills channel to FDI composition via the novel feature of interactions along the same ability distribution, 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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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
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
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
Government		
τ	0.25	Effective tax rate on final output

Table 2

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

Table 3

Calibrated Parameter Values: Generalised Logistic Curve for ν

Parameter	Value	Description
ν_M	0.9	Upper bound for ν (asymptotes)
ν_m	0.1	Lower bound for ν (asymptotes)
υ	1.272	Corresponding asymptote value for diffusion
ζ	1.0	Diffusion rate
m_I	0.55	Inflection point for industrial composition ratio

Table 4

Individual Policies: Steady-state Effects

(Absolute deviations from initial steady-state)

Benchmark[43]	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
$\dot{C}/C$	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
$\dot{C}/C$	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
$\dot{C}/C$	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
$\dot{C}/C$	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
$\dot{C}/C$	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

[43] The relevant parameter values for the benchmark economy are $\psi_1^R = 0.4$, $\psi_1^I = 0.35$, $\psi_2^I = 0.3$, and $\psi_2^R = 9.5$. The specific individual policy shocks considered include Γcut from 0.25 to 0.18; Λ^R cut from 0.2 to 0.0; F_0 cut from 0.2733 to 0.2433; F_1 cut from 0.33 to 0.30; and F_2 cut from 0.40 to 0.37.

Table 5

Composite Policy Reform Programmes: Steady-state Effects

(Absolute deviations from initial steady-state)

Benchmark[44]	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
$\dot{C}/C$	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
$\dot{C}/C$	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
$\dot{C}/C$	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
$\dot{C}/C$	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
$\dot{C}/C$	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

[44] The relevant parameter values for the benchmark economy are $\psi_1^R = 0.4$, $\psi_1^I = 0.35$, $\psi_2^I = 0.3$, $\psi_2^R = 9.5$, $\eta = 0.39$, $LI = 0.7456$, and $\omega_k = 1.0$. The composite policy reform programs considered include a combination of: (i) Composite A - Γcut from 0.25 to 0.18, Λ^R cut from 0.2 to 0.0, F_0 cut from 0.2733 to 0.2433, F_1 cut from 0.33 to 0.30, and F_2 cut from 0.40 to 0.37; (ii) Composite B - Γcut

Table 6

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

(Absolute deviations from initial steady-state)

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

from 0.25 to 0.18, Λ^R cut from 0.2 to 0.0, F_0 cut from 0.2733 to 0.2633, F_1 cut from 0.33 to 0.30, and F_2 cut from 0.40 to 0.35; (iii) Composite C - Γcut from 0.25 to 0.18, Λ^R cut from 0.2 to 0.0, F_0 cut from 0.2733 to 0.2233, F_1 cut from 0.33 to 0.30, and F_2 cut from 0.40 to 0.39.

Table 7
Sensitivity Analysis: Endogenous ν with Generalised Logistic Curve
Composite Policy Reform Programmes: Steady-state Effects
(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
$\dot{C}/C$	0.0430	0.0009	0.0022	-0.0007
Ψ	0.3672	-0.0566	-0.1262	-0.0112
ν	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
$\dot{C}/C$	0.0430	0.0011	0.0022	-0.0003
Ψ	0.3672	-0.0670	-0.1271	-0.0310
ν	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
$\dot{C}/C$	0.0430	0.0013	0.0023	0.0002
Ψ	0.3672	-0.0791	-0.1280	-0.0528
ν	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
$\dot{C}/C$	0.0430	0.0017	0.0023	0.0008
Ψ	0.3672	-0.0931	-0.1294	-0.0764
ν	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
$\dot{C}/C$	0.0430	0.0021	0.0023	0.0015
Ψ	0.3672	-0.1090	-0.1309	-0.1010
ν	0.5700	-0.0739	-0.0080	-0.1153

Table 8
Policy Complementarities
Comparison across Composite Programme A
(Absolute deviations)

	m	θ_S	θ_{SR}	$\dot{C}/C$	Ψ
Sum of Parts:[45]					
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 ν)	**-0.0489**	**0.0092**	**0.0089**	**0.0007**	**-0.0477**
Composite A (endogenous ν)					
- $\zeta = 1.0$	**-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**

[45] The specific individual policy shocks considered include Γcut from 0.25 to 0.18; Λ^R cut from 0.2 to 0.0; F_0 cut from 0.2733 to 0.2433; F_1 cut from 0.33 to 0.30; and F_2 cut from 0.40 to 0.37.

Figure 1: Estimated FDI Composition from U.S. to selected East Asian Economies, 1999-2008

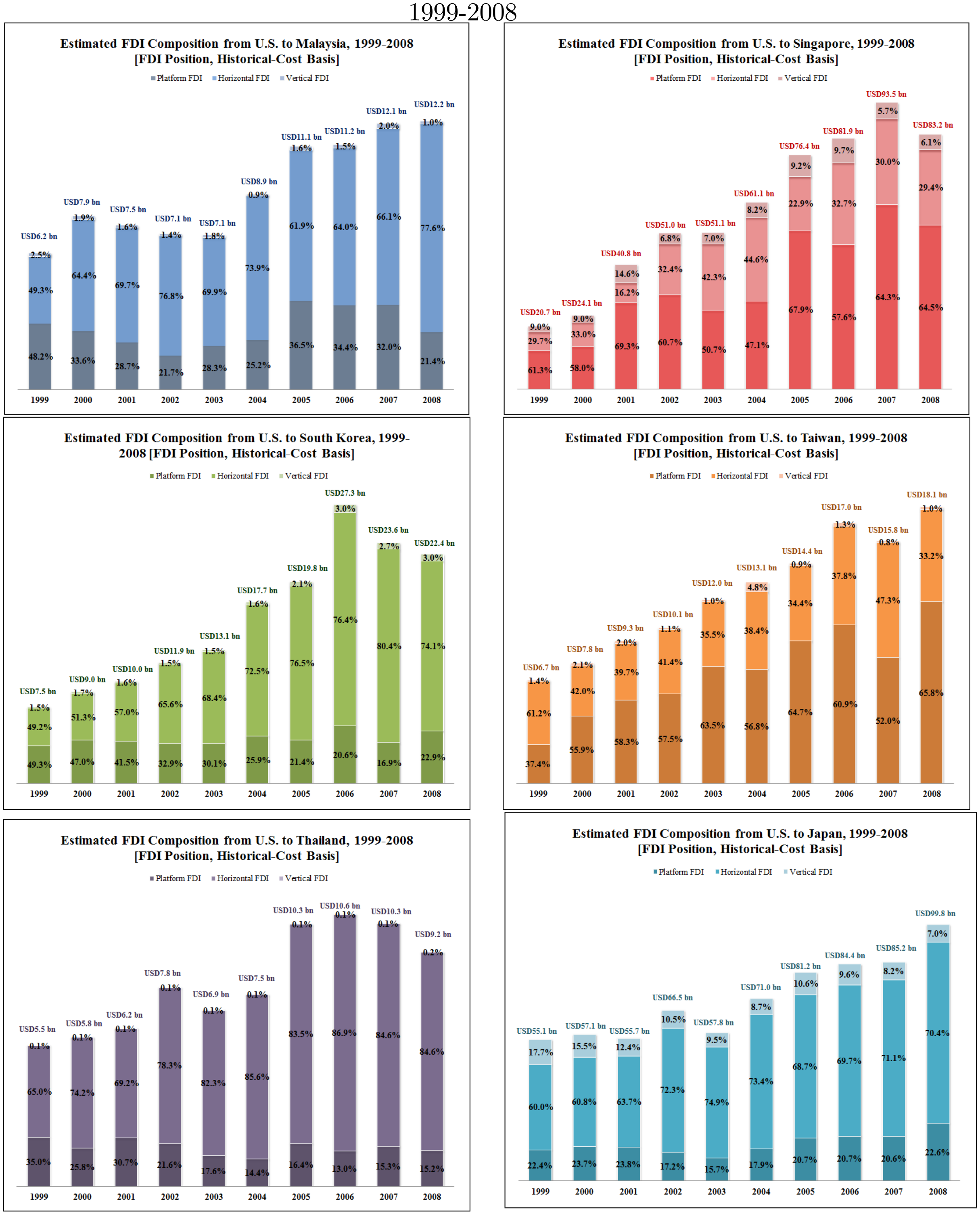


Figure 2
Production and Labour Allocations in Host Economy

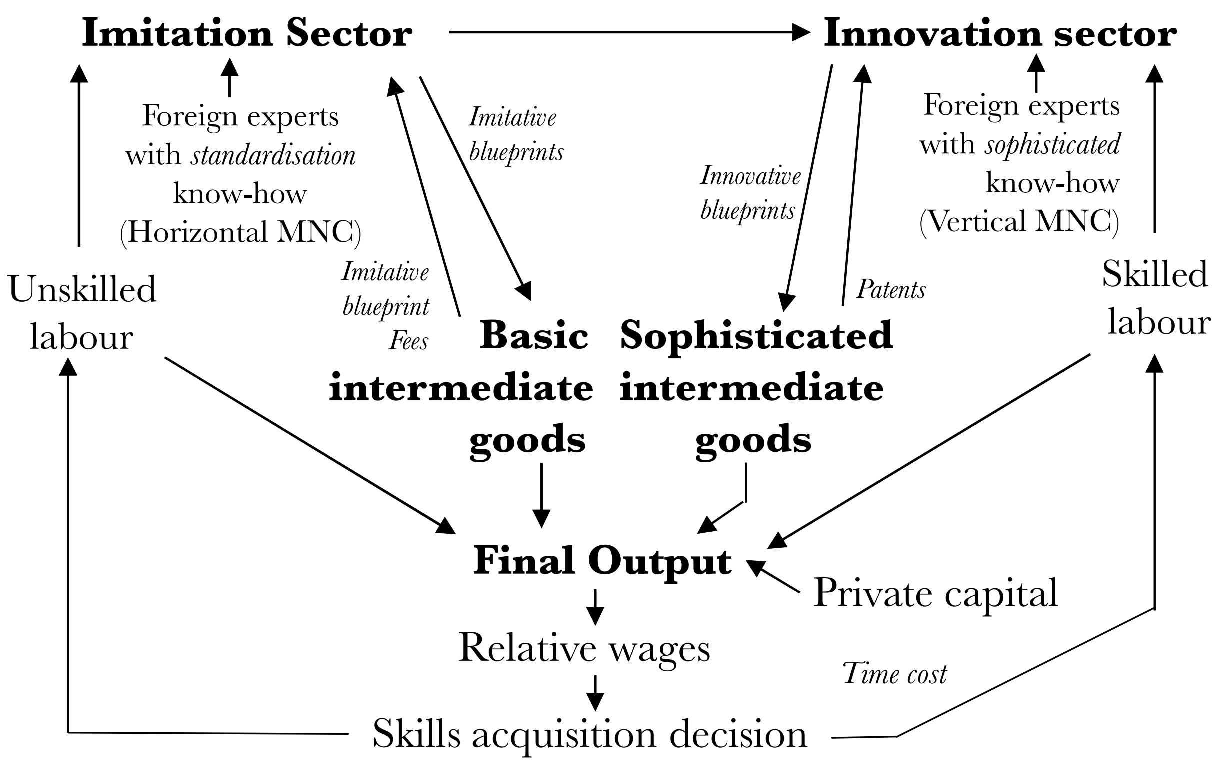


Figure 3
Foreign Sector

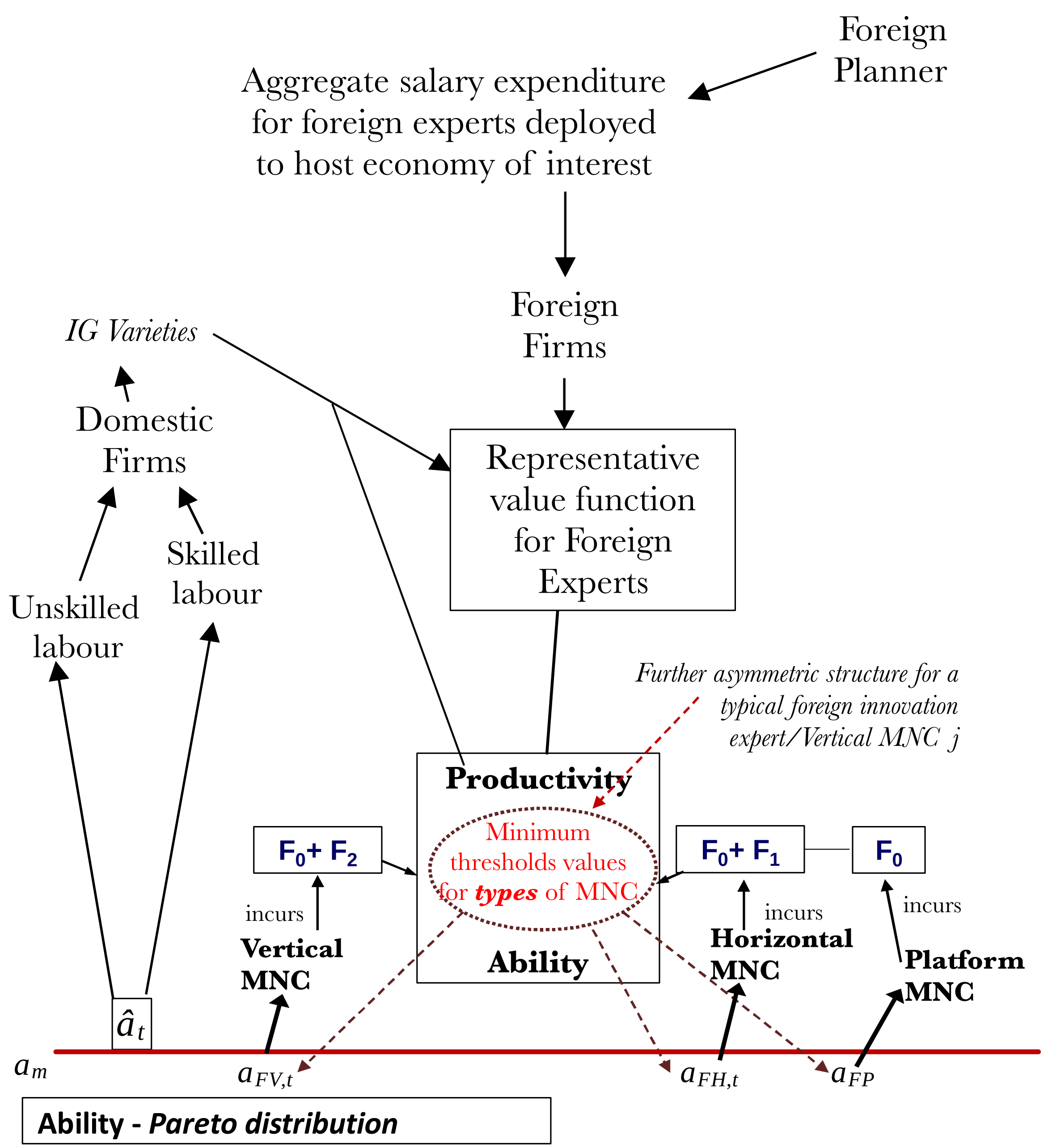


Figure 4
Permanent Cut in Skills Acquisition Cost from 0.25 to 0.18
(Absolute deviations from baseline)

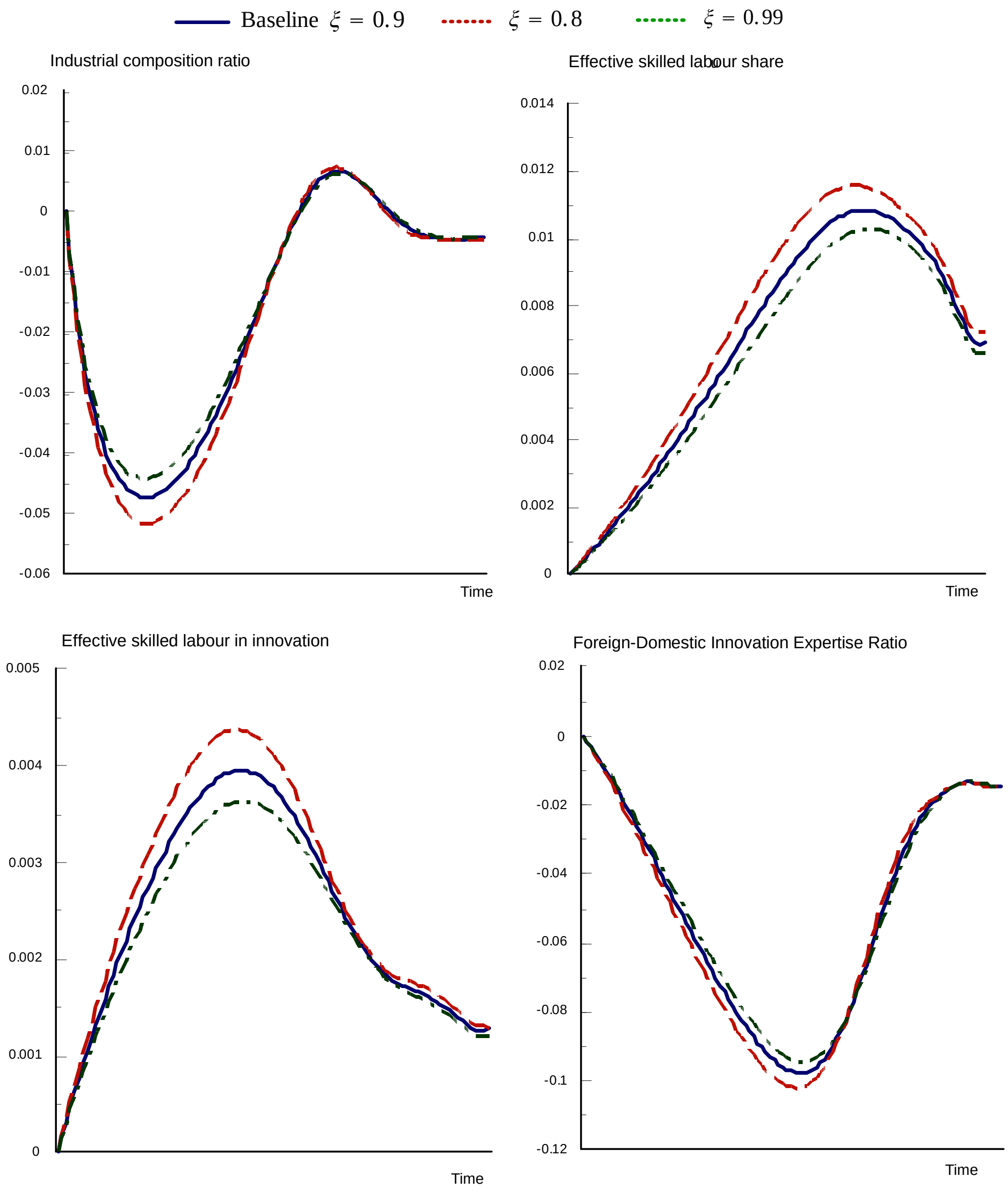


Figure 5

Permanent Cut of Labour Cost Mark-Up in Innovation Sector,

Λ^R from 0.2 to 0.0

(Absolute deviations from baseline)

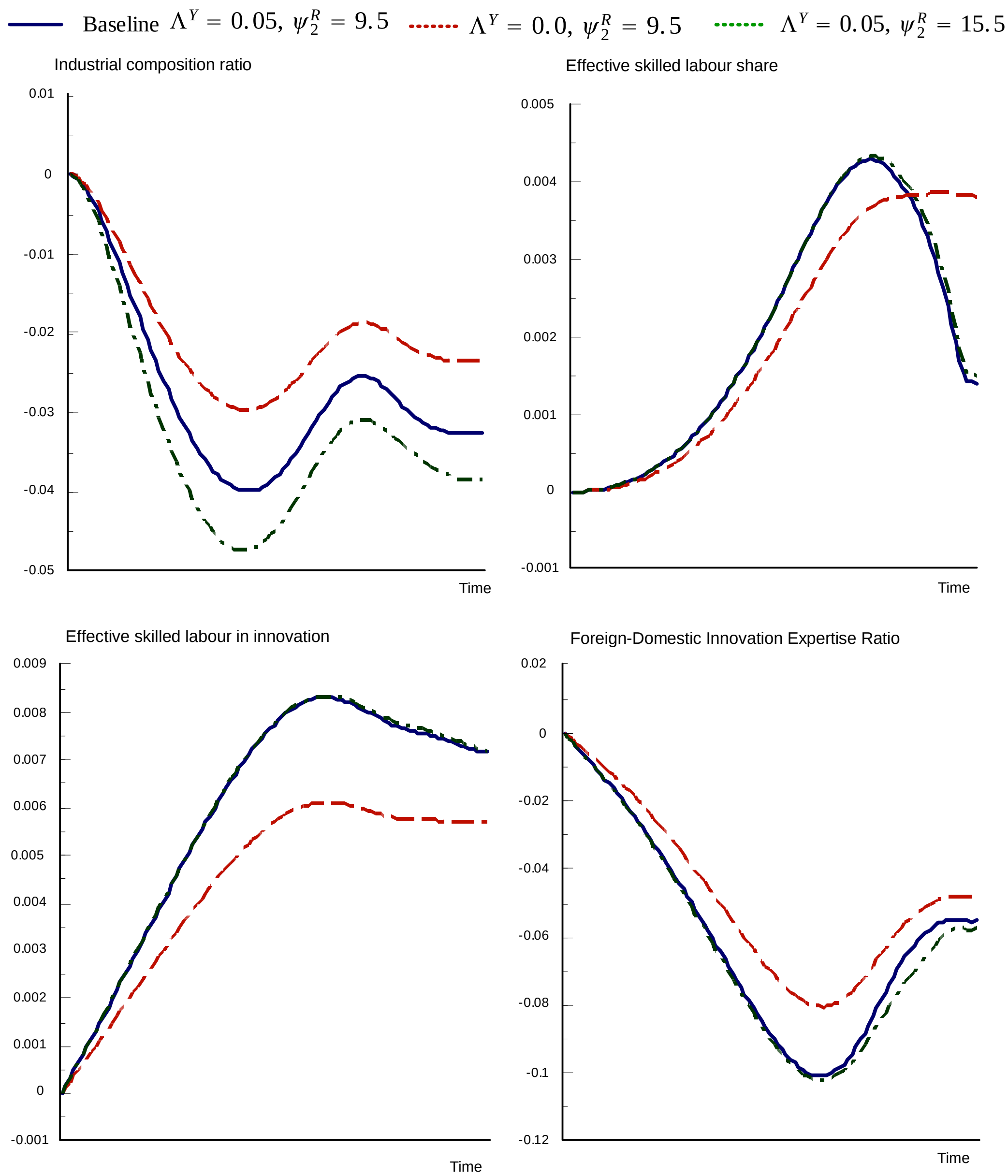


Figure 6

Permanent Cut of F2 by 0.03

(Absolute deviations from baseline)

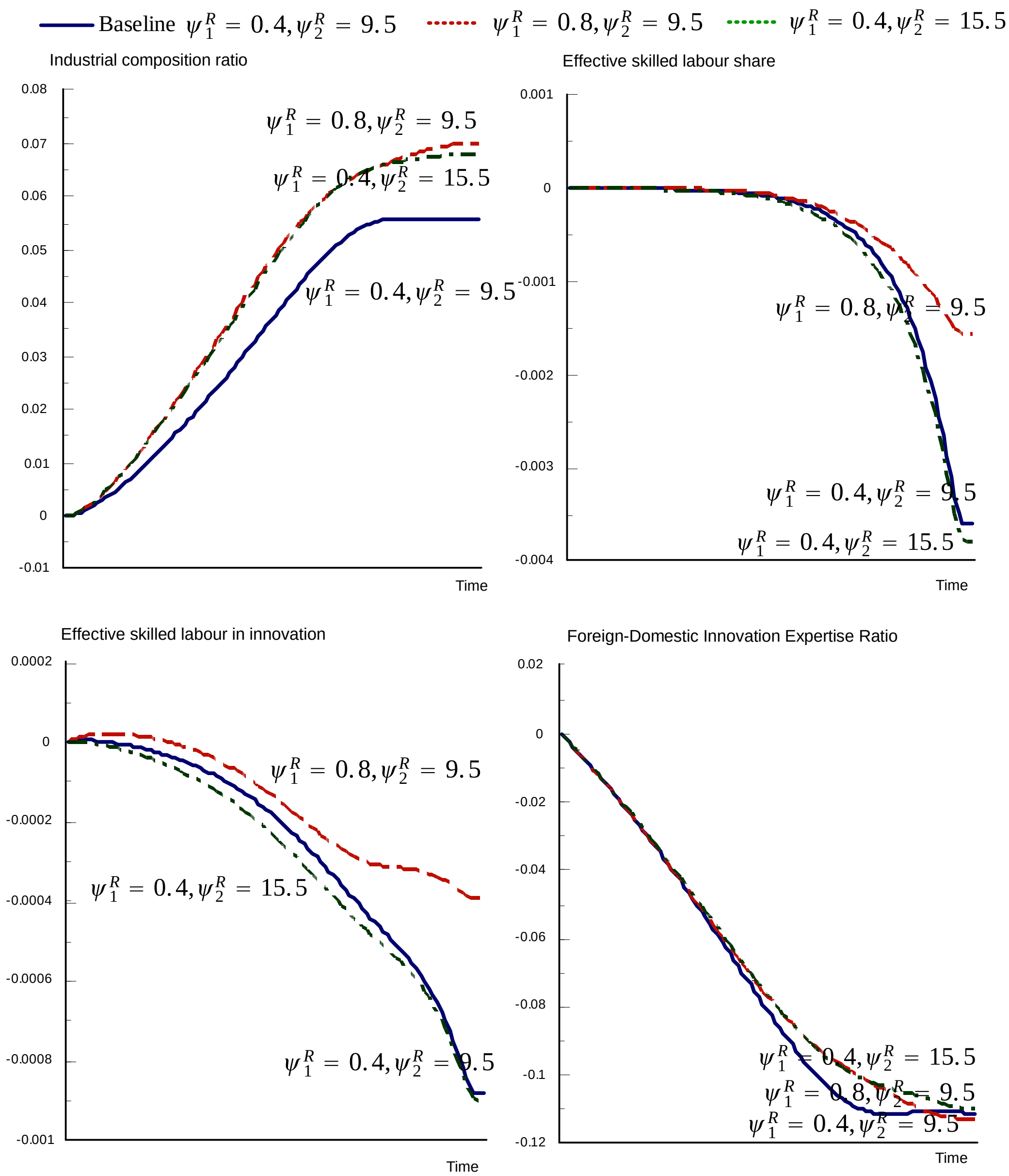


Figure 7

Permanent Cut of F1 by 0.03

(Absolute deviations from baseline)

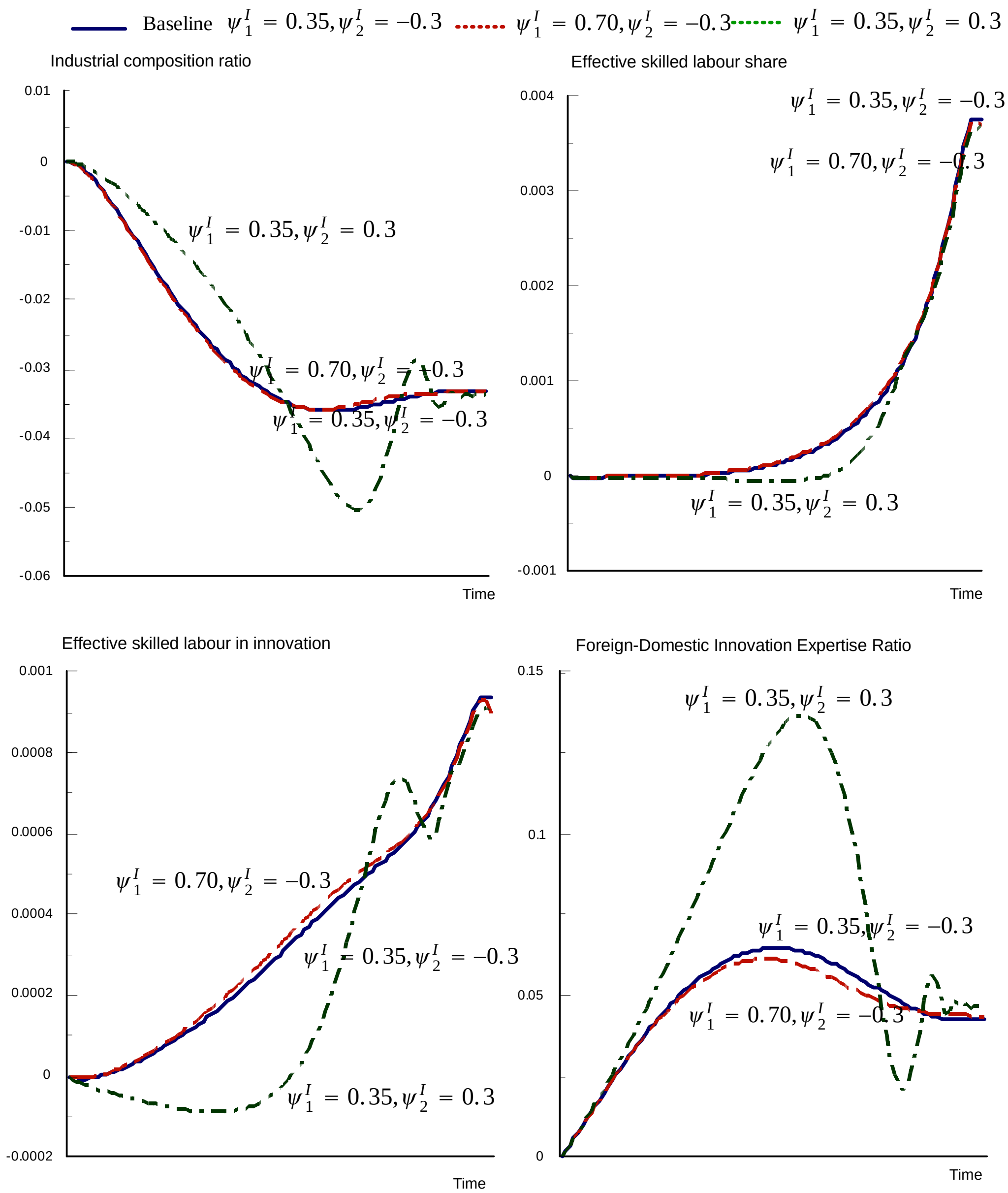


Figure 8

Permanent Cut of F_0 by 0.03

(Absolute deviations from baseline)

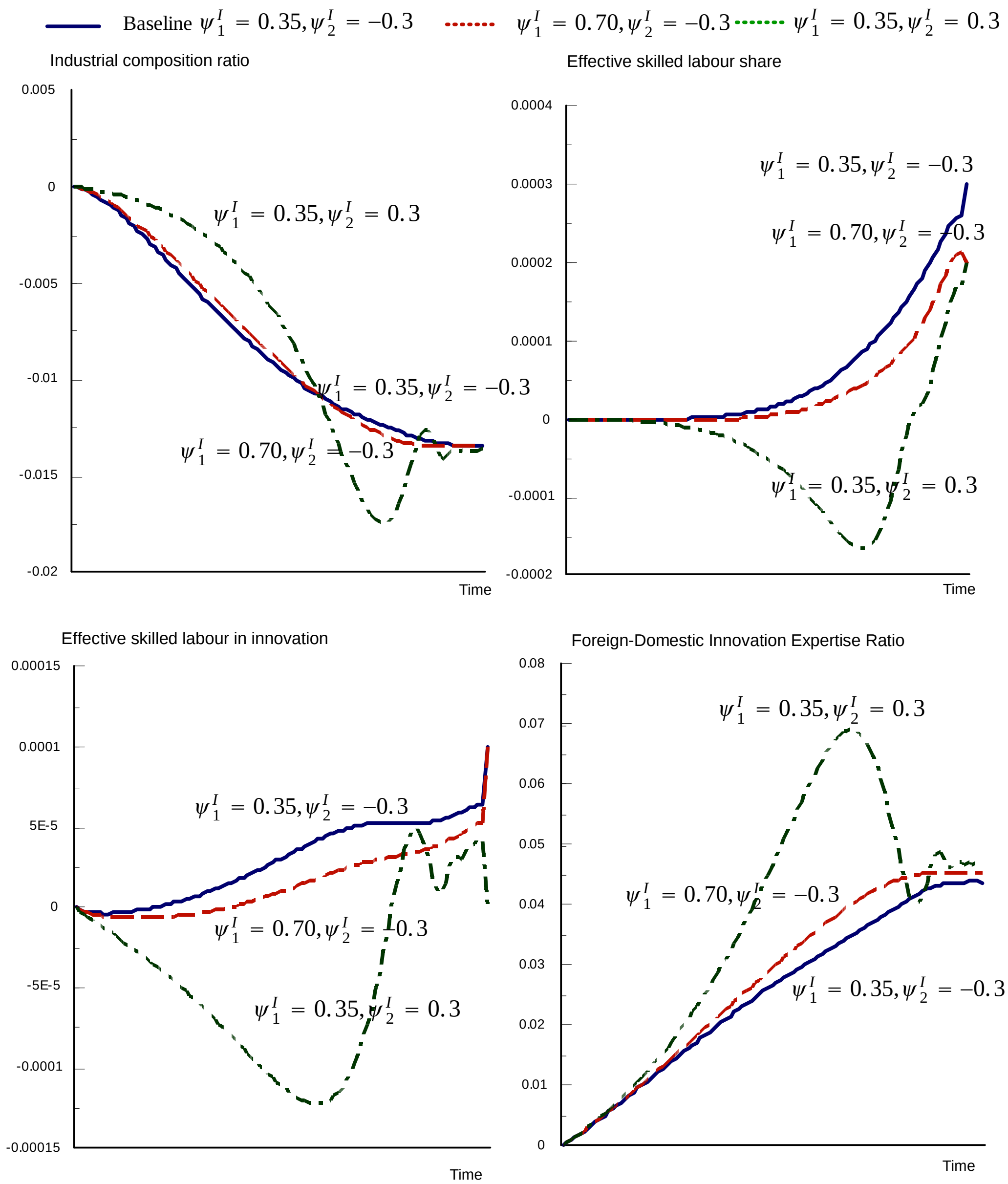


Figure 9
Different Combination of Foreign Cost Cut,
Benchmark Calibration
(Absolute deviations from baseline)

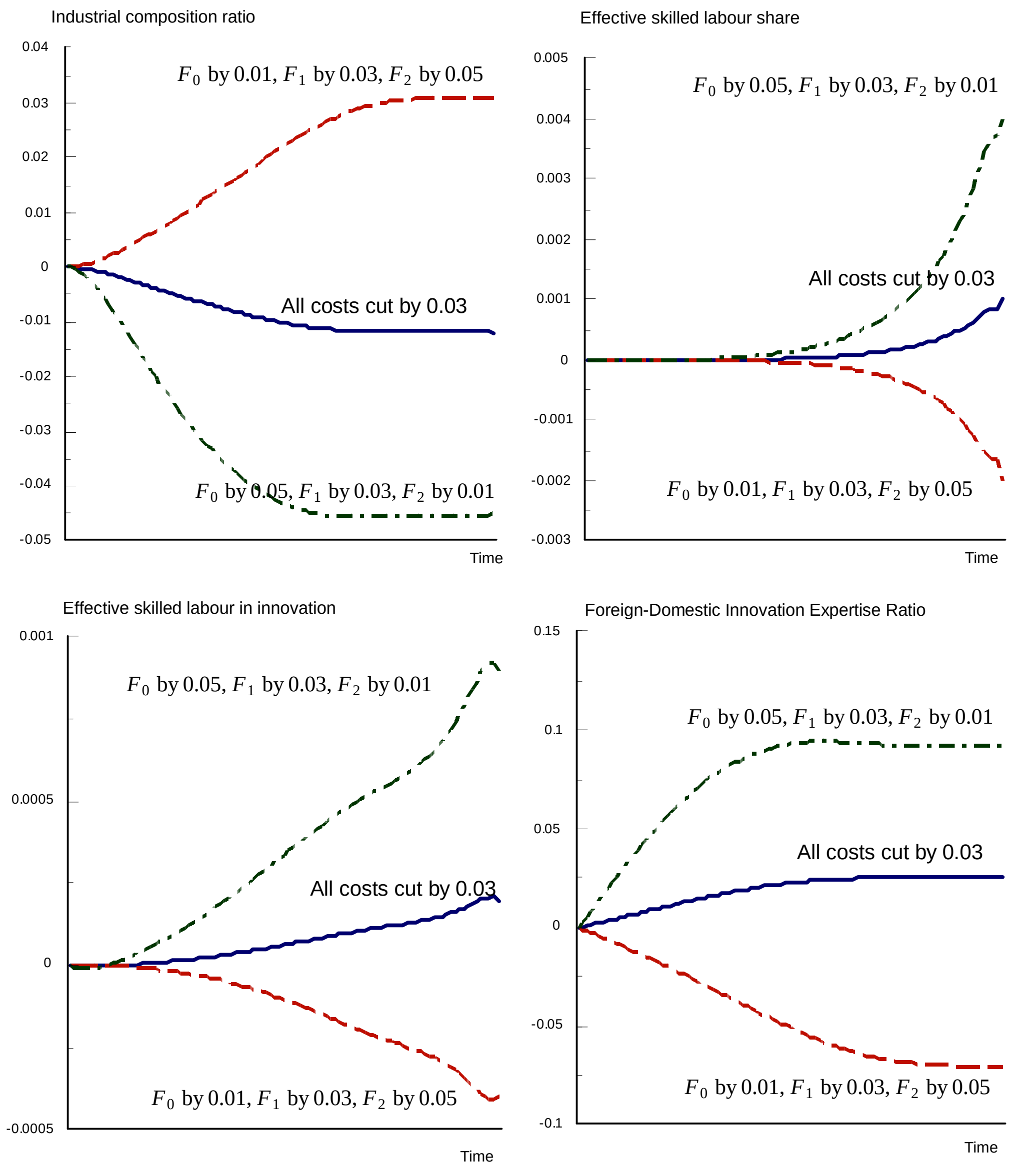


Figure 10
Composite Policy Reform Packages,
Benchmark Calibration
(Absolute deviations from baseline)

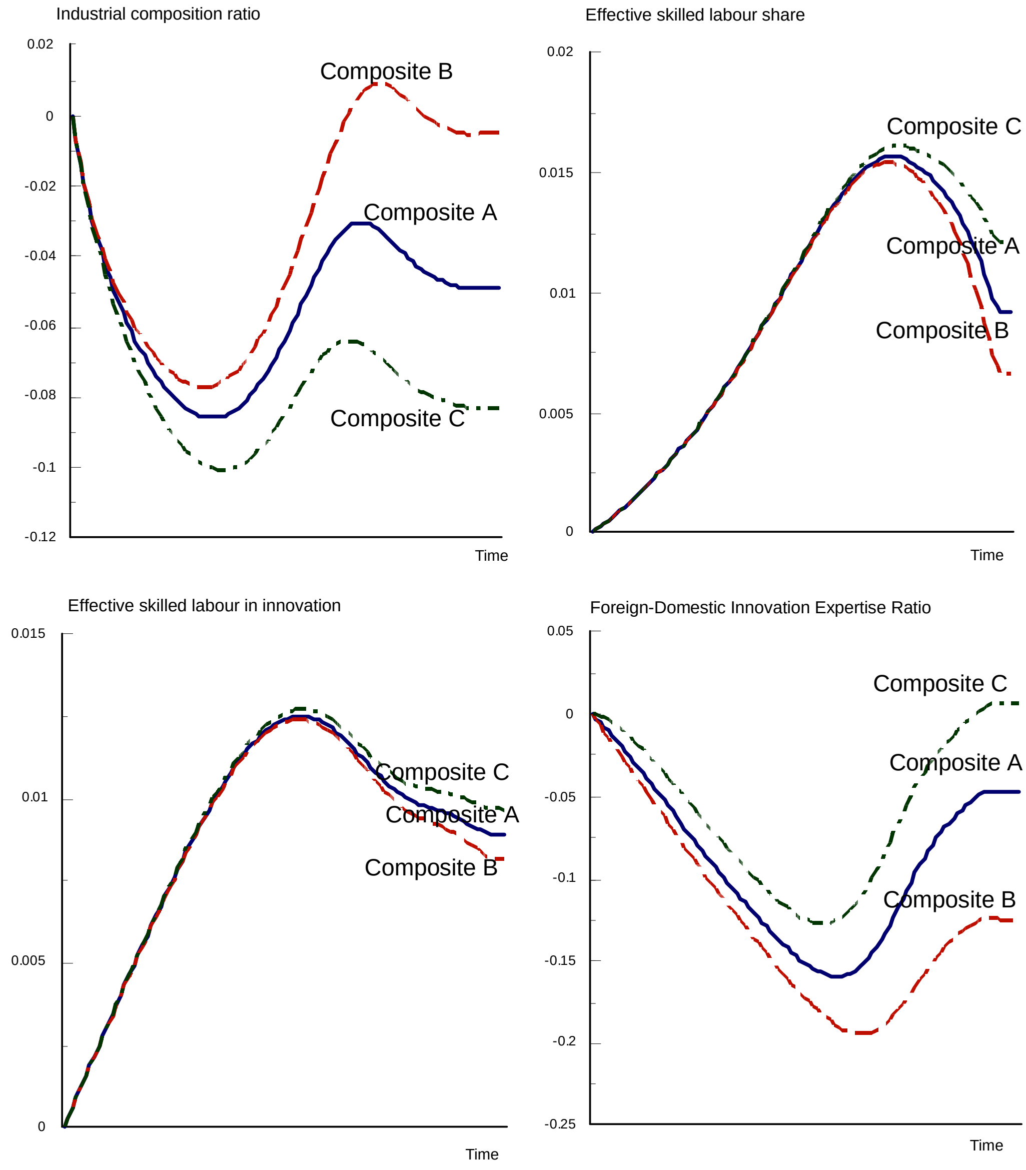
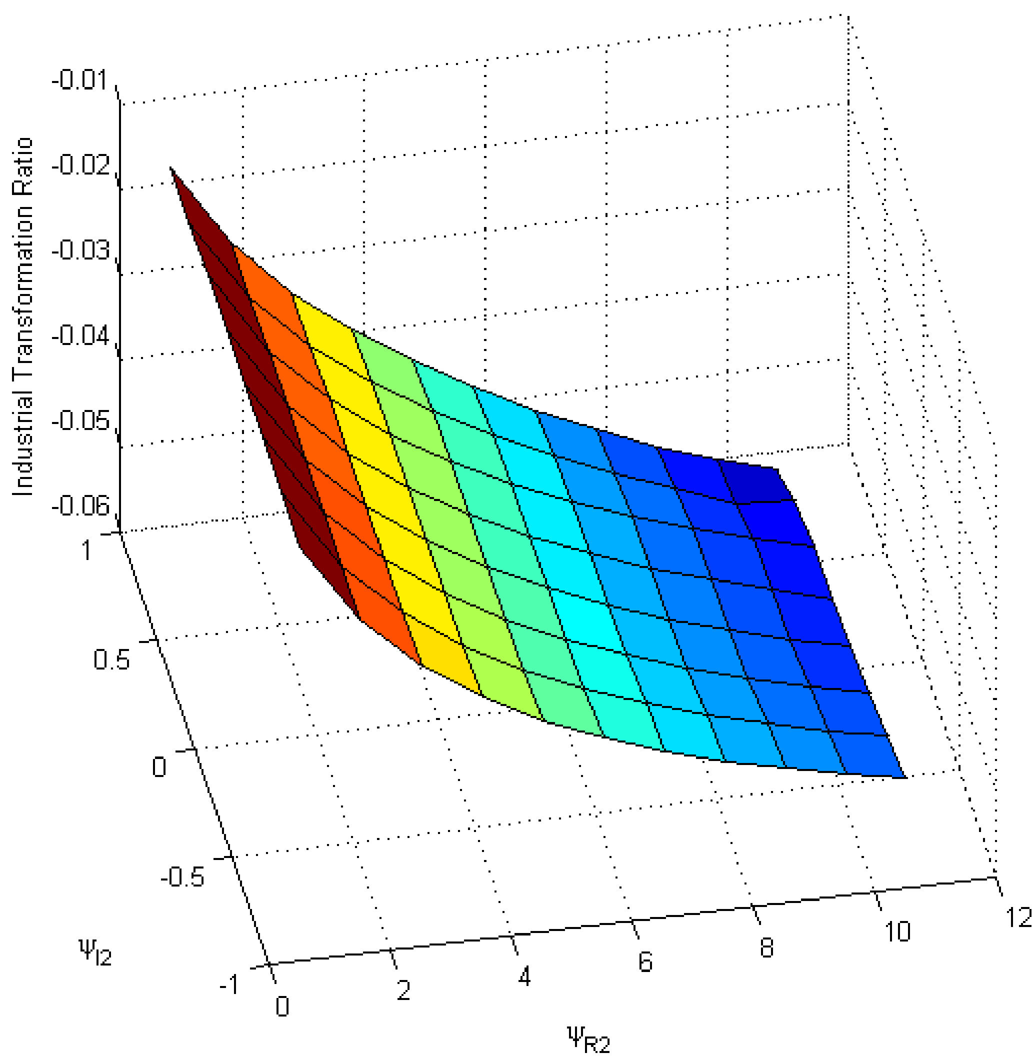


Figure 11
Industrial Composition Ratio
Composite Policy Reform Programme A
(Absolute deviations from baseline)



Note: ψ_2^I is the elasticity of imitative blueprint with respect to the cross-term of foreign innovation experts
and stock of innovative blueprint, and ψ_2^R is the elasticity of innovative blueprint with respect to
imitative-to-innovation blueprint ratio measuring the stepping stone effect