Productivity Spillovers and Absorptive Capacity: An analysis in a Heterogeneous firm CGE model

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ABSTRACT:

Globalization and the transmission of technology have been discussed in the growth and development literature. Trade and Foreign Direct Investment (FDI) are the two major channels through which spillover of benefits—embodied and disembodied—occur between the source and the host nations. In this paper, we consider the technological spillover to the domestic firms in the host nations via FDI. As countries pass through stages of industrialization and undergo structural transformation to develop, the importance of technology policies and development of technological capabilities can no way be underestimated. Considering the facts that capital goods of differentiated varieties (quality and technology embodiment) originating from different sources (typically industrialized and newly industrializing nations) are vehicles of superior technology flows, in this paper, we consider technology spillover, and explore the factors facilitating (or, bottlenecking) the capture of the benefits. Considerable heterogeneities of MNEs production via FDI exist across countries and sectors. This depends on the heterogeneities of firms. A Global Computable General Equilibrium (CGE) model with Version 9 of the Global Trade Analysis Project's [GTAP] database is calibrated for this purpose. The model consists of thirteen regions and twelve sectors. Technological change in the sources occurs exogenously and it induces endogenous productivity spillovers to other sectors and regions via intermediate input. Following the technology shock/s, we calibrate: (i) the impact on global production; (ii) trade patterns in the industries/sectors; (iii) welfare consequences of technological changes; and (iv) regional disparities in capturing transmitted productivity gains. The results offer valuable insights into the role of technology adoption and productivity benefits via FDI and Trade.

1. Introduction

Globalization and the transmission of technology have been discussed in the growth and development literature. Trade and Foreign Direct Investment (FDI) are the two major channels through which spillover of benefits—embodied and disembodied—occur between the source and the host nations. In this paper, we consider the technological spillover to the domestic firms in the host nations via FDI. In other words, the domestic firms and host nations attempt to attract FDI for reducing the technology gap via technological progress. Aftermath of economic crisis has experienced a dramatic shift of production organization across the globe. This is called 'second unbundling' of vertical slicing of value-chain. International competiveness and productivity differences across countries at different income levels call for attention especially under globalization. As countries pass through stages of industrialization and undergo structural transformation to develop, the importance of technology policies and development of technological capabilities can no way be underestimated. Foreign ownership of capital and international capital movements are important areas for work on technology transfer. Role of FDI and MNCs are important, as are the roles of the associated concern about the 'ownership of capital' and the capital flows. These are long-run issues. Other than that, the aspect of technology creation, R&D, knowledge-capital by concerted effort in investment in human capital needs to be explored.

FDI and trade facilitate knowledge transfer and technology flows, more so with vertical or horizontal integration and supply chain or fragmentation via production networks or, Global Value-Chains (GVC). The level of technological knowledge and the vintages impart features of heterogeneity giving rise to wide range of varieties. Considering the facts that capital goods of differentiated varieties (quality and technology embodiment) originating from different sources (typically industrialized and newly industrializing nations) are vehicles of superior technology flows, and given the fact that fragmentation of value-chain via MNE has given rise to cross-border investments, in this paper, we consider FDI-related technology spillovers, and explore the factors facilitating (or, bottlenecking) the capture of the benefits, and investigate under what circumstances are the spillover effects are most effective. Following the technology shock/s, we calibrate: (i) the impact on global production; (ii) trade patterns in the industries/sectors; (iii) welfare consequences of technological changes; and (iv) regional disparities in capturing transmitted productivity gains. What is the relative efficacy of FDI versus trade in transferring technology to industries where there are large gaps between foreign and domestic firms? Does technology gap across industries—scientific and Non-scientific firms— matter for effective spillover capture? How, and why? What interesting differences could emerge? By addressing these research questions, the results offer valuable insights into the role of technology adoption and productivity benefits via FDI and Trade.

In this context, this paper examines the impact of a potential Trans Pacific Partnership (TPP) Agreement on FDI and productivity spillovers using a Global Computable General Equilibrium (CGE) model. Specifically, we use the Global Trade Analysis Project (GTAP) Model. There are two parts to our analysis. In the first part we obtain the productivity change in response to the RCEP policies such as tariff liberalization and reductions in FDI using the FDI model of GTAP, i.e. GTAP-FDI, which was developed by Lakatos and Fukui (2014). In the second part, we implement the resulting productivity change as a policy shock and analyze the effects of this policy shock using the firm heterogeneity model of GTAP, i.e. GTAP-HET which was developed by Akgul, Villoria, and Hertel (2016). The GTAP-HET model is a useful platform to investigate the productivity spillover effects as it incorporates the trade-induced productivity changes as well as extensive margin effects. In particular, GTAP firm-heterogeneity model (i) traces out self-selection of firms into domestic and export markets based on productivity differences across firms, (ii) captures trade growth along the extensive margin, and (iii) incorporates consumer love-of-variety, and (iv) accounts for fixed costs in domestic and export markets.

While it may be argued that TPP is not relevant any more given that the USA has withdrawn from it in January 2017, we argue that it is still a relevant question from a policy research perspective on three counts; first, TPP is still strongly progressing among the non-US members of TPP with possibilities of China joining in the group, potentially; second, even for the USA, it is important to analyze the potential effects of

TPP from a counterfactual perspective, i.e., what if TPP had gone forward without any obstacle that we saw in January 2017; third, to study the effects of FDI and spillovers in addition to firm heterogeneity and trade liberalization, TPP is a very relevant agreement, since it touches on all these different topics at once.

The rationale to link GTAP-FDI and GTAP-HET models for this analysis is that FDI and trade liberalization causes productivity thresholds to change within- and across sectors. That depends on firm-level heterogeneities in terms of productivity spillover via trade and/or, technology shocks. Firm heterogeneity in productivities could be explained not only in terms of trade-FDI liberalization, but also in the light of technological changes and spillover of such productivity-enhancing policy changes.

2. Background:

Firms are broadly considered as: Scientific Firms and Non-Scientific Firms. Drugs, ICT products, Electronics, etc. fall under the former while the latter include Steel, Textiles, Metal products, Motor Vehicles, etc. Considering the heterogeneous firm types in terms of inherently divergent features, production involving Multinational enterprises (MNEs) varies across sectors in a country (i.e, share of multinational production or FDI in one sector, say Biotechnology, differs from the other, say Automobile, in India or China), and also it differs across countries in a sector (i.e, share of MNEs production in a particular sector like automobile or biosimilars differs across say India and China). Thus, considerable heterogeneities of MNEs production via FDI exist across countries and sectors. As new technologies enter via FDI, there are new varieties (e.g., new generic type Drugs) partially or, totally replacing the old types (endogenous obsolescence). This depends on the heterogeneities of firms and hence, the contingent productivity differences. Foreign R&D capital stock from countries with higher endowments, and hence, comparative advantage in knowledge-intensive goods affects productivity of the host firms. However, differences in productivity across firms (in a nation) and across nations (for a particular firm) are important characteristics of such technology spillovers. In this paper, we consider these aspects and the factors responsible for such heterogeneities.

For the sectors such as manufacturing or capital goods, or even generic medicines, these are intrinsically heterogeneous. Coexistence of old and new varieties will create product varieties. Thus, firm heterogeneity is important because some firms will be able to absorb the FDI and some will not. Contagion effect of FDI is crucial for spillover (Borensztein, Gregorio, and Lee 1998). Sufficient threshold of human capital contributing to host sector and nation vis-à-vis that of origin is important for adoption and catch-up process. FDI in the sectors with knowledge-intensity (or Technology intensive) will lead to product varieties and diversification –endogenous obsolescence of old generics and creation of new varieties.

3. Database

As mentioned in the preceding Sections, despite uncertainties surrounding implementation of TPP, it could be a pertinent scenario and hence, our database will reflect on TPP-based adjustments.

However, alternatively, we could aggregate the model to sixteen RCEP regions (Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei, Vietnam, Laos, Myanmar, Cambodia, China, Japan, South Korea, India, Australia, New Zealand), four non-RCEP regions (USA, EU, Rest of Asia, Rest of the World) and eleven sectors (Grains, Crops, Processed Food, Textiles and Wearing Apparel, Extraction, Electronic Equipment, Machinery and Equipment, Motor Vehicles and Parts, Communications, Other Manufacturing, Services) using the GTAP Version 9 data base (Aguiar, Narayanan, and McDougall, 2016).

We treat the manufacturing sector as monopolistically competitive with heterogeneous firms, while we retain the perfectly competitive structure as well as the Armington assumption in the rest of the sectors. In what follows, we describe a mechanism of introducing productivity spillover via linking GTAP-based FDI model (GTAP-FDI, henceforth) and GTAP firm heterogeneity (GTAP-HET) model.

4. Modeling Productivity Changes and Spillovers

We consider two steps productivity effects, viz., due to pure trade and FDI liberalization induced changes in thresholds, and second, pure technology shocks occurring exogenously but transmitted semi-endogenously to recipients.

FDI and trade liberalization causes productivity thresholds to change within- and across sectors. That depends on firm-level heterogeneities in terms of productivity spillover via trade and/or, technology shocks. Firm heterogeneity in productivities could be explained not only in terms of trade-FDI liberalization, but also in the light of technological changes and spillover of such productivity-enhancing policy changes. However, that means with no Tech Shock liberalization causing more trade in final products and intermediates (capital goods) to induce productivity spillover via FDI and/or, trade.

We first use the GTAP-FDI model to simulate total tariff liberalization and reduced restrictions on FDI amongst the RCEP countries. Magnitudes of shocks are driven from the literature. This simulation in the GTAP-FDI model yields the effect of tariff liberalization and reduced FDI restrictions on productivity. In order to obtain the percentage change in the productivity, the *technical shifter variable "ao(i,r)"* in the GTAP-FDI model is endogenized in the closure. We then use the productivity changes generated in the simulation as an input to the GTAP-HET model. Given our plans to link GTAP-FDI and GTAP-HET to incorporate FDI liberalization mechanism, as mentioned "ao (i,r)" endogenized in FDI-model, is fed as exogenous shock component of the 'SAME' variables in GTAP_HET. Therefore, the simulation in the second step is composed of the productivity changes obtained in the first step, which are the effects of tariff liberalization and reductions in FDI restrictions.

4.1 Description of the GTAP-FDI Model

This model was developed by Ciuriak and Xiao (2014) –we employ the same model without any changes and the description in this section is based on this paper. This model has domestic and foreign investors for each sector and region, while GTAP neither distinguishes between domestic and foreign investors, nor does it allocate investment to each sector in each region. To disaggregate the original GTAP investment-related variables, the authors construct the following matrices on a sectoral and regional level: Gross operating surplus, GOS(j,r); Rates of return, ROR(j,r); Depreciation rate, D(j,r) and Growth rates of capital stocks, K_Gk(j,r). The GOS matrix for 2011 is the same as VFM("Capital",j,r) in GTAP 9 Data Base. Below, we describe the steps to estimate the other three matrices for the same year. The data for ROR, depreciation, and growth of the capital stock by sector-region are obtained from company-specific data, based on Capital IQ.

Apart from the GTAP 9 Data Base, the data sources we rely on include 1) the Foreign Affiliate Sales (FAS) matrix, 2) the FDI stock matrix, and 3) the FDI restrictiveness index. The first two matrices can be found in GTAP research papers (Lakatos et al., 2011; Fukui and Lakatos, 2012). The data used to construct the last matrix are drawn from UNCTAD and OECD data on FDI restrictiveness. Dividing FAS by total domestic sales of products gives us the penetration rates of foreign firms. Total FDI for each country as a ratio of capital stock in that country is regressed against the penetration rates of foreign firms, so as to predict the foreign share of capital stock. The reason we pursue this regression is because FAS data provide better information about the operations of foreign affiliates than data on international flow of funds (Fukui and Lakatos, 2012). For the investment matrix, we assume that firms owned by domestic and foreign investors have the same depreciation rate.

Next, we apply the concept of a "phantom tax" to break down the gross operating surplus of a given region-sector into gross operating surplus for domestic and foreign owned capital. A phantom tax restricts entry of FDI, but does not result in the collection of revenue. Intuitively, the phantom tax restricts the entry of FDI notwithstanding higher returns to foreign capital. With the removal of the phantom tax, foreign capital has an incentive to take advantage of the higher returns by increasing investment, thus expanding the FDI stock.

We start with the FDI restrictiveness matrix, then quantify the effect on FDI of the restrictions — that is, we determine by how much the share of FDI in the region-sector capital stock would increase if we remove all barriers. We then use these results to estimate the phantom tax applying to FDI in each region-sector. We assume that the phantom tax creates a wedge between the RORs of domestic versus foreign-owned capital; this allows us to then derive the gross operating surplus matrix ($GOS_{j,r}^{s}$), using a gravity-like econometric specification.

In the model, we derive the expression linking a change in the level of the phantom tax (τ^{row}) to a change in FDI, consistent with the calculation where the change in FDI was linked to a change in the FDI restrictiveness index. In the MONASH investment function, the growth rate of capital (and hence the level of investment) is determined by investors' willingness to supply increased capital to industry ***j*** in region ***r*** ($K\_G_{j,r}$), which in turn depends on changes in the expected ROR for capital in that sector and region. Assuming that investors are cautious, any shock to the ROR in a given sector and region is, however, eliminated only gradually. This results in similar treatment of investment as in models that incorporate costs of adjustment that are positively related to the level of investment in a given year. The MONASH model, however, instead of relying on increasing adjustment costs as the mechanism to limit investment, incorporates investor perceptions of risk for this purpose. Thus, following the MONASH model, we assume that investors are willing to support capital growth in industry ***j*** in region ***r*** in year ***t*** to move above the historically normal rate of capital growth for this sector-region, only if they expect the ROR to be above the sector-region's historically normal level (see Dixon and Rimmer, 1998, for a discussion). In the model, we have a shift variable to productivity that assumes transmission of FDI into productivity, which is the input going into the firm heterogeneity model.

4.2 Firm Heterogeneity Model (GTAP-HET)

Even though productivity change is endogenously determined by compositional changes in the GTAP-HET model, there is also an exogenous variable that allows for exogenous productivity changes. The endogenous part of the productivity change is trade-induced as in the Melitz model, where tariff liberalization leads more productive firms to expand to export markets and less productive firms to contract or exit the market. This compositional change in favor of more productive firms increases the overall productivity of the industry. The overall productivity change in the GTAP-HET model corresponds to the "ao(i,r)" variable in the standard GTAP model. On the other hand, the exogenous part of the productivity change allows for exogenous shocks to productivity such as the isolated effect of FDI on productivity. The exogenous productivity shock is required in our simulation because the GTAP-HET model does not incorporate the FDI mechanisms. The productivity change resulting from FDI is therefore captured separately in the FDI model and will be incorporated in the GTAP-HET model as an additional shock.

Technological change in the sources occurs exogenously with the assumption that it will induce endogenous productivity spillovers to other client sectors and regions via intermediate input embodying such technological development. Such technological innovation entails productivity growth in other sectors especially food manufacturing and other agricultural products. In GTAP-HET, endogenous shock component causing productivity thresholds to change (compositional changes in the model) could alter thanks to: (i) trade policy shocks (e.g., tariff cut) in HET model itself; and (ii) productivity changes or spillovers in HET. Rationale for (ii): trade in intermediates and high technology content of imports, and digitization of production activities causes sophisticated/tech-enriched imported inputs to furthering compositional changes via changes in productivity thresholds. Advancements in telecommunications, trade costs (TFA, ITA agreements) there are both price and cost responses to trade liberalizations, at intensive margin (of surviving firms) and entry-exit (extensive margin).

Intersectoral and interregional input-output linkages causes productivity shocks to ripple across the economies. Even without any explicit mechanisms of such technology flows across donor-recipient pairs, by considering the extant equations and relevant "ao(ir)" pairs.

In HET model, trade-induced changes in productivity thresholds to enter markets, denoted as aost (i,r,s), results in the overall industry productivity to change, reflected in changes in ao (i,r).

We can think of simulations in two cases:

Case a: Without inter-regional explicit transmission mechanism, productivity thresholds change in domestic and export markets causing average productivity to change in respective markets and this, in turn, alters average productivity for whole industry: - Shocks in the fixed set-up costs, avafe(ir) ≥ 0, results in the productivity threshold aost(i,r,s) to change. Similarly shocks in fixed trading costs avafs (i,r,s) results in causing in the productivity threshold. This will cause endogenous changes in ao(ir) generically, Regions (r) and Sectors (i). 'i' could be "ele" or, "cmn".

ao(j,r)

= SHRSMD(j,r,r) * aos(j,r,r)

+ sum(s,REG, [1 - DELTA(r,s)] * SHRSMD(j,r,s) * aos(j,r,s))

+ [MARKUP(j,r) - 1] * sum(s,REG, SHRSMD(j,r,s) * [ns(j,r,s) - nt(j,r)])

+ aosec(j) + aoreg(r) + aoall(j,r)

Case b: With some transmission mechanism:

Here trade-induced transmission of technology shocks occurs via imported intermediates used in final goods production (VIFM). Digitization-led productivity escalation (advanced telecommunication or ICT-led GPT) causes improvement in productivity of imported intermediates and firms experience such benefits via trade and FDI.

One way would be to think it is "share of foreign-sourced intermediate input/s in final good production". The 'scaling' of such input-intensity depends on extent of 'capture' of ao(ir). This can be specified as product of 'given productivity distribution for 'threshold productivity level' or 'shape parameter'.

5. Scenarios and Simulations

On top of endogenous ao (j,r) generated from GTAP-FDI model, we can consider three generic technological advances and its transmission:

1. Aggregate industry level intersectoral spillover from source to destination where the aggregate change in source is endogenously brought about by firm level technical change occurring for changes in fixed entry cost for either or both domestic and international markets, but confined only to firm level reflected in aggregate sectoral level.

2. Firm to firm technology flows affecting aggregate productivity in both source and destinations from Source i, r.

Variable to shock Exogenous: those who enter export market can cause technology transmission in other nations. However, productivity changes in the source causing thresholds to change can be triggered by technical progress reducing fixed costs in either domestic or foreign or both markets. For example, if it becomes less costly to enter then average productivity of firms improve via improved productivity thresholds.

That happens in source. While diffusing in host, it affects threshold while the average firm productivity becomes endogenous in recipients.

[FULL PAPER STILL IN PREPARATION]

6. Analysis of Simulation Results: Macroeconomic, Industry, and Firm-level Effects

7. Concluding Remarks:

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