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Hub-and-Spokes Free-Trade Agreements in the Presence of Technology Spillovers: An Application to the Western Hemisphere

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Hub-and-Spokes Free-Trade-Agreements in the Presence of Technology Spillovers: An Application to the Western Hemisphere[1]

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Hub and Spokes Free-Trade-Agreements in the Presence of Technology Spillovers: An application to the Western Hemisphere

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Contents:

Abstract: *Hub and Spokes FTAs in the Presence of Technology Spillovers: An application to the Western Hemisphere.* — Using a comparative-static general equilibrium model and in the context of the western hemisphere, this paper compares the economic effects of a "hub-and-spokes (HAS)" type of bilateral trade configuration (with Chile being the hub) with those of a more comprehensive regional FTA (namely, the FTAA). The model is augmented to account for the possibility of technology spillovers and its effective assimilation among participating economies. In particular, absorptive capacity, governance factor, proximity and socio-institutional congruence conjointly determine an economy's capacity to capture the technology that is transmitted from developed spoke US to other regions.

Key Words: Hub and Spokes, Free Trade Areas, Technology transfer, Absorption, Governance, Welfare, Preference Dilution.
***JEL no*:** D58, F16, O4

Hub and Spokes FTAs in the Presence of Technology Spillovers: An application to the Western Hemisphere

I. Introduction

The recent proliferation of bilateral agreements has created a number of "hub-and-spokes" types of trade relationship: i.e., one economy becomes a "hub" by establishing bilateral agreements with a number of other nations (the "spokes"). This has been especially noticeable in the Western Hemisphere. Mexico and Chile, in particular, have adopted very ambitious and aggressive bilateral liberalization agendas, forming Free Trade Areas (FTAs) with virtually every region in the hemisphere, and effectively becoming the hubs in the region.[3] This paper investigates the economic implications of a hub-and-spokes (henceforth, HAS) configuration from the viewpoints of both the hub and the spokes and quantifies those implications using an augmented version of a widely used computable general equilibrium (CGE) modelling framework.

In its simplest form, a HAS configuration shares many of the characteristics of a simple free trade agreement with respect to their effects on non-member as well as member countries. However, it is different from a more comprehensive regional agreement (say the Free Trade Area of the Americas (FTAA)) in that trade barriers remain between spokes. Among other effects, this may lead to a disproportionately larger share of the hub in the trade flows among the different partners. Section II of this paper presents a conceptual framework for understanding different economic effects of a HAS.

To the extent that HAS affects the international flows of goods and services and that some technological spillovers are associated with international trade flows, it is

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[3] Mexico has, for instance, established FTAs with the United States, Canada, Colombia, Venezuela, Bolivia, Chile, Costa Rica, Nicaragua, Honduras, Guatemala, El Salvador, and Uruguay. Talks are also underway for an FTA with Mercosur. Chile has preferential trade relationship with Colombia, Ecuador, Mercosur, CACM, Canada, Mexico, and United States.

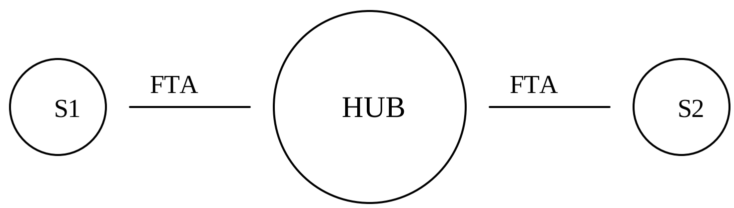
argued that the existence of HAS may affect the cross country flows of technology. Sectors with high import contents of relatively technologically sophisticated goods may harness the benefits of technologically superior inputs used in the production process (see Navaretti and Tarr 2000; Coe, et al. 1997; Coe and Helpman 1995). In the spillover mechanism in this paper, traded intermediates ferry the current state-of-the-art embedded in the foreign intermediate imported into the developing country hubs. In this context, Schiff and Winters (2003), Blyde (2004) has evidenced robust empirical support for such trade-related technology diffusion—both directly from the industrialised nation and indirectly via intra-regional trade in Latin American countries. Such a mechanism is detailed in Section III.

Section IV presents the empirical implementation of such trade-mediated technology transfer in the context of the trade liberalization process in the Western Hemisphere. Using a version of the Global Trade Analysis Project (GTAP) multi-region CGE model (Hertel 1997) and the database (version 5.4), we perform two kinds of trade liberalization experiments namely, a HAS configuration (with Chile being the hub and US and Mercosur, among the other Western Hemisphere economies, being the spokes); and subsequently, the implementation of a comprehensive regional trade liberalization (FTAA) in which trade is liberalized between two spokes. Also, we simulate separately and then, simultaneously the technology spillover shocks in the hi-tech sector and trace the ensuing changes in productivity in the client sectors and regions. Sections V and VI document the policy simulations in terms of the effects of different types of trade liberalization and technology shocks on production, welfare and growth. Section VII concludes.

II. Hub and Spoke: Conceptual Considerations

Figure 1 illustrates the concept of hub-and-spokes arrangement that we are interested in: the central hub establishes two different bilateral FTAs with the two spokes (S1 and S2) while those spokes retain their MFN barriers on each other's goods.

Figure 1 - *Basic Hub and Spokes Structure: A Stylized Model*



The HAS configuration has numerous economic implications, many of which are similar to those found in the standard literature on preferential or discriminatory trade policy (e.g., trade diversion and trade creation). From the viewpoint of the hub, the system is beneficial since it provides preferential access to the market of each spoke. The hub also provides free access to each spoke so that effectively it moves closer to a unilateral free trade regime, which means that the potential adverse terms of trade impact of trade diversion is limited. At the same time, the degree of competition will also be more intense in the hub's market which may hurt domestic firms but benefit consumers. In a more dynamic dimension, the hub can become a more attractive location for foreign investment given its better market access (and potentially higher income), which may lead to an agglomeration of economic activities.

While each spoke has free trade with the hub, the discriminatory nature of the FTA moves it away from free trade with other spokes. Spoke to spoke trade would suffer as trade is diverted towards the hub: it is relatively more advantageous to import from the hub, as it is to export to the hub's market. Each spoke loses from being discriminated against in all the different FTAs from which it is excluded. Even the market access gains from the FTA with the hub would be diluted since the hub is giving the same (if not more favourable) preference to all the other spokes. After all, preference to everybody may be equivalent to no preference at all. The net impact on the different countries depends on the magnitude of each of the effects summarized in Table 1.[4]

Table 1 - *Effects of Hub and Spokes configuration on producer and consumers in different market*

		Markets		
		Hub	**S1**	**S2**
	Hub	More competition from S1 and S2	Improved preferential access to S1	Improved preferential access to S2
Producers	**S1**	Dilluted preferential access to Hub	More competition from Hub	Discriminated against in S2
	S2	Dilluted preferential access to Hub	Discriminated against in S1	More competition from Hub
Consumers		Better availability of goods from S1 and S2	Better availability of goods from Hub (potential trade diversion)	Better availability of goods from Hub (potential trade diversion)

The table suggests that hub producers and consumers tend to be better off than their respective spoke counterpart. One could also tentatively extrapolate from the table that if S1 is a larger and more developed country (say the United States) than S2 (say Mercosur), then S2 will likely be much more worse off than S1 from the HAS configuration, since it is at a disadvantage relative to the hub (say Mexico) in catering to the large S1 market. From this type of analysis, it can be conjectured that, from the point of view of developing countries in the Western Hemisphere, trade liberalization under

[4] Of course, this discussion abstracts away from the important issue of "rules of origin". Incorporating that issue in the analysis would likely exacerbate the adverse impact of the configuration on the spokes.

FTAA is more attractive than being a spoke in a Chile (or Mexico)-centered hub and spoke scenarios.

This analysis can be used to address an interesting general question: *having achieved the status of being a hemispheric hub, would Mexico or Chile have any incentive to pursue full-fledged regional trade liberalization*? In this stylized model, the move from HAS to the FTAA would be achieved in the form of a bilateral liberalization among the disjointed spokes. Of course, removing the barriers between S1 and S2 may not necessarily be an accurate representation of a full-fledged regional FTA.[5]

In a simple comparative static simulation, the possible impact of such trade liberalization under HAS configuration is likely to be negative, since the intra-spoke liberalization would lead to some dilution of the preferences that the hub enjoys in each of the spokes. In fact, following up with the logic presented above, moving from a HAS to a regional FTA ends up hurting the hub since it might be the case that almost all the benefits of being a hub are dissipated. Therefore, the optimism about the accumulation of preferences gathered under PTAs might be shadowed by the preference dilution effect.

However, incorporating a mechanism of hysteresis or persistence via technology spillovers could leave room for altering such conclusion. Because it trade more with the developed spoke (S1), the hub will be more likely to benefit from the trade induced productivity gains. And if that causes a persistent technological advantage, the adverse effects of moving to a more comprehensive FTA will be limited since the hub will remain the more efficient supplier (compared to S2) into developed spoke's market. In that sense, being a hub produces some kind of "first mover advantage" in a purely dynamic

[5] This point is especially relevant in the presence of complex rules of origin: product from S1 using input from S2 may not be allowed duty free in the hub market. We do not consider this issue here.

framework. The hub may still want to pursue the regional FTA, especially if that leads to increased income and thus larger export markets in the spokes for its products. In the paper, we do not model R&D and technology creation aspects and hence, we abstract away from the dynamics involved.[6]

III. Mechanism for Trade-induced Technology Transfer: Theoretical Premise

Developing countries generally depend on foreign technologies originating in their more developed counterparts. The "embodiment hypothesis" contends that technical knowledge generated at the sources of inventions transmits via traded intermediates to the destinations through bilateral trade linkages (see Dietzenbacher 2000; Eaton and Kortum 1996; Keller 1999, 2001; World Bank 1999). The recipient's growth and development depend not only on the extent and nature of the technology that is available to them, but also on their capabilities for effectively absorbing and adopting the diffused technology.[7] Different factors affect the capacity of a given economy to capture the benefits of technological innovation. Investment in human capital or skill acquisition, for instance, can help develop technological or social capability to absorb innovation (see Abramovitz 1997; Nelson 1990; Cohen and Levinthal 1989, 1990; Das 2000, 2002). The effective assimilation depends, *inter alia*, on the skill intensity of the labor force which helps unlocking the potential of technology to induce productivity growth. We refer to this factor as education-related 'absorption capacity (**AC**).'

[6] This does not undermine our purpose since our primary interest is to trace the technology driven growth in the context of FTA and possible configurations of such agreements. However, even in a comparative static framework a mechanism for Baldwin (1996) type capital accumulation effect enables us to trace the dynamic gains due to technology spillovers following trade liberalization. See Itakura (2003).

[7] International trade facilitates propagation of superior 'technologies' embodied in goods. The nexus between domestic growth and the growth rate of the trading partners has been discussed at length—see Connolly 1997; De Ferranti et al. 2003. With proliferation of trade agreements, economic growth in a country becomes closely related to developments abroad. Arora and Vamvakidis (2004) have found a strong positive relationship between long-run growth in the U.S. and rest of the world via spillover effects.

Not only **AC**, but also distance (geographical or socio-cultural) limits the extent of knowledge diffusion and widening of the technology frontier.[8] Krugman (1991, 1995), Deardorff (2001), Keller (2001) have also shown that such 'unobserved' factors do affect trade, international transaction and economic development. For example, cultural affinity determines the degree of social cohesion and acceptance of 'new' technology. It is through the familiarity with another country's institutional factors like legal side, habits and languages that one geographically closer country becomes culturally similar. We incorporate such effect via the exogenously specified 'adjacency parameter (**AP**).' It is a composite measure of cross-sectional variation in relative distance, and hence in cultural affinity of countries, to their trade partners[9].

In the same vein, Schiff and Wang (2002, 2004) discuss, in the context of Latin American and Caribbean countries, the role of governance and institutional quality along with education in appropriating the latest state-of-the-art diffused through intermediates for achieving growth. Also, cultural or institutional homogeneity is closely related to geographical proximity (Linneman 1966; Rauch 2001; Groot et al. 2004). We incorporate the institutional factors via a parameter reflecting the index of governance (**GP**). Typically, it is argued that technology transmitted from the source of technology creation will deliver the potential benefits to the recipients if the level of governance quality of origin vis-à-vis client is (nearly) similar, if not identical. We specify a *binary* governance

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[8] According to Keller (2001), the estimated *geographic half-life* of spillovers is only 1200 kilometers i.e., the distance at which half of the diffused technology spillovers have tendency to disappear.

[9] In the context of geographical barrier for technology transmission one could model the role of technical efficiency in trade facilitation via its effects on reduction in transaction costs (for example, owing to customs automization, e-commerce type commerical innovations)-see Hertel et al. 2001.However, this issue is beyond the scope of the paper.

parameter as comparative measure of institutional quality indicator between two trade partners.

Conjointly, binary source and destination-specific **AP** and **GP** determine the institutional-structural congruence index (**SC**), which together with the absorption capacity (**AC**) determine the technology capture parameter (**CAP**) which encapsulates the role of structural congruence, adjacency and skill-intensity to appropriate the potential benefits of trade-induced technology transfer. Together with trade volume, these indexes determine the 'productive efficiency' parameter.

In a multi-sectoral, multi-regional framework such technological spillovers can be conveniently traced and have been modeled by many authors (Sjoholm 1996; Das 2000; van Meijl and van Tongeren [henceforth, MT] 1998). MT, for instance, incorporate the essential elements of '**AC**' and 'structural similarity (**SS**)' factors (proxied by land-labor ratios) in determining the local usability of foreign technologies. However, features such as cultural similarity, governance and geographical (adjacency) parameters have so far being ignored in the existing modeling efforts.

In the present paper, *firstly*, we specify the technology spillover equations by incorporating the nexus between **AC** and institutional and structural characteristics. *Second*, the '**AC**' factor is destination-specific only.[10] The '**SC**' factor (depending on **AP** and **GP** components) retains its 'binary' affix, though. *Thirdly*, unlike MT (1998) and Das (2000) we incorporate the role of adjacency variable in the line of gravity models

[10] It is argued that domestic usability of the transmitted foreign technology depends on the *recipient's* capability to utilize the diffused technology. Quite reasonably, we assume that if a laggard region 'C' is good at absorbing technology from developed region 'A', it will (to a first approximation) be equally good at absorbing technology from another region 'B' which (from C's point of view) is structurally-institutionally similar to 'A'. Also, another region 'D' who is geographically and institutional structure-wise 'adjacent' to 'C', will also be able to reap the technological benefits (*indirectly*) from not only 'A' and 'B' but also *directly* from 'C' if they integrate via trade. Thus, the AC factor is made destination-specific.

and also, governance variable representing the degree of social cohesion and acceptance for effective absorption of transferred technology.

IV. Database, Model and Simulation Design

Database: Sectoral and Regional Aggregation

We use a version of the comparative static GTAP model tailored to suit our purpose. Version 5.4 of the GTAP database distinguishes 78 regions and 57 sectors and provides us with the splits of labor payments between the skill and unskilled categories (Dimaranan and Mc Dougall 2003). It represents the state of the world economy in 1997. A reduced dimension 9×7 aggregation of the database is used to calibrate the model. Choice of regional dimension is motivated by our primary emphasis on the trade-growth nexus under HAS vis-à-vis FTAA structure in the Western Hemisphere. In terms of the sectoral aggregation, we consider seven composite clusters of commodity types. Table 2 presents the regional and sectoral aggregations. Table 3 shows the sectoral composition. High-technology products are supposedly intensive in sophisticated technology and trade in such products is a primary conduit for technological spillover across borders.

Table 2 - *Sectoral and Regional Aggregations used for the implementation*

Version 5.4 Sectors with Identifier	Version 5.4 Regions with Identifier
1. AGR [agriculture]	1.USA [United States]
2. NRE [natural resources]	2. CAN [Canada]
3. FOOD [food and food products]	3. MEX [MEXICO]
4. LMNFCS [Light manufacturing]	4. CAmCar [Central American and Caribbean]
5. HMNFCS [Heavy manufacturing]	5. Andean [Andean Pact]
6. HITECH [High Technology Products]	6. Chile [Chile]
7. SVC [Services and activities, NES]	7. MERCOSUR [Argentina, Brazil, Uruguay, Paraguay]
	8. RestLA [Rest of Latin America]
	9. Rest of the World [ROW]

Source: GTAP database.

Table 3- *Sectoral Composition*

Sectoral Aggregation	GTAP Sectors
Agriculture	Paddy rice, Wheat, Cereal grains nec, Vegetables, fruit, nuts, Oil seeds, Sugar cane, sugar beet, Plant-based fibers, Crops nec, Bovine cattle, sheep and goats, horses, Animal products, Raw milk Wool silk-worm cocoons, Bovine cattle, sheep and goat, horse meat prods
Natural Resources	Forestry, Fishing, Coal, Oil, Gas, Minerals nec, Petroleum, coal products
Food manufacturing	Meat products nec, Vegetable oils and fats, Dairy products, Processed rice, Sugar, Food products nec, Beverages and tobacco products
Light manufactures	Textiles, Wearing apparel, Leather products, Wood products Metal products, Motor vehicles and parts, Transport equipment nec,
High-tech manufactures	Electronic equipment, Machinery and equipment nec, Manufactures nec
Heavy manufactures	Paper products, publishing, Chemical, rubber, plastic products, Mineral products nec, Ferrous metals, Metals nec
Services	Electricity, Gas manufacture, distribution, Water, Construction Trade, transport, Financial, business, recreational services, Public admin and defence, education, health, Dwellings & Svces

Source: GTAP database and aggregations by authors

GTAP Implementation: Methodology and Parameters

To account for the technology spillover mechanism under HAS vis-à-vis FTAA schemes, a comparative static CGE, GTAP model is customized with equations appended in line with our theory. The economic model includes equations as documented in previous sections and also, some additional coefficients and additional parameters for AC, GP and SC.[11] In our model, we assume one unique source of innovation 'i' in source ‘r’ (i.e., USA). Technological change is treated exogenously as a total factor productivity (TFP) improvement in the high technology sector. Such a technological innovation entails induced productivity enhancements in other sectors especially manufactures.

[11] Structural equations, coefficients and parameters of the model encoded in TABLO language are not reported here for space limitations. TABLO code has been modified to make necessary adjustments for incorporating the theory. Accordingly, parameters file and set declaration have been changed.

Spillover Equations: Modifications to Theory

Technology embodied in intermediate inputs spills over to *all* other sectors and affects their TFPs. That is, following an exogenous technological improvement, all other sectors in the source region, and all sectors in other regions experience *endogenous* Hicks-Neutral TFP improvement. The embodiment index is defined in terms of input-specific trade intensity. We adopt two different specifications for the technology transmission equation: the *trade-induced spillover* between destination regions and the source of technological change, and endogenous *domestic spillover* to the sectors in the source itself from the sector experiencing *exogenous* technological change.

Embodiment Index, Spillover Equation and Productivity Shock

The amount of trade-induced knowledge spillover from a source sector in the source region to a particular sector in the client regions depends on the input-specific trade intensity of production of that sector. Hence the embodiment index is defined in terms of trade intensities for different specific material inputs; i.e., source and using sector-specific trade-embodiment index. We define this index [E_{ijrs}] as the flow of imported intermediate produced in sector 'i' in source region 'r' that is exported to firms in sector 'j' in recipient region 's' [F_{irjs}] per unit of composite intermediate input of 'i' used by sector 'j' in destination 's' [M_{ijs}]. The latter—M_{ijs}—is a simple aggregate of nominal values and is the total (i.e., domestically sourced as well as composite imported inputs) usage of intermediate input 'i' by sector 'j' in region's'. Thus, it is expressed as

$$E_{irjs} = F_{irjs}/M_{ijs} \qquad (1)$$

where F_{irjs} is the imports of 'i' from source 'r' used by sector 'j' in recipient 's'.

For governance parameter (GP), it is measured in the following way:

$$GP_{rs} = \min [1, GP_s/GP_r] \quad (2)$$

According to (2), if destination's' has higher GP_s than that of source 'r' i.e., GP_r, then it is conducive structure for's' to effectively utilize the transferred technology. Otherwise, if the client region lags in institutional quality behind the source [i.e., $GP_s<GP_r$], then it poses hindrance in's' for absorbing the technology even with higher AC. Here, $0 \le GP_{rs} \le 1$.

It is to be noted that the definition for the spillover coefficient bears an additional subscript for source sector 'i' so that we write it as

$$\gamma_{ijrs}\left(E_{ijrs}, \theta_s\right) = E_{ijrs}^{1-\theta_s} \quad (3)$$

where γ_{ijrs} is the spillover coefficient between 'i' in source 'r' and 'j' in destination 's' and θ_s is "capture parameter". θ_s is the product of the recipient-specific AC-index, AC_s (where $0 \le AC_s \le 1$) and the *binary institutional-structural congruence* index SC_{rs} (where $0 \le SC_{rs} \le 1$); it measures the efficiency with which the knowledge embodied in bilateral trade flows from source 'r' is *captured* by the recipients 's' so that:

$$\theta_s = AC_s . SC_{rs} \quad (4)$$

Now, SC_{rs} depends on binary governance parameter (GP_{rs}) and binary adjacency parameter (AP_{rs}). Thus, we can write

$$SC_{rs} = GP_{rs} . AP_{rs}. \quad (4a)$$

Therefore, with 'r' being unique source it follows that:

$$\theta_s = AC_s . GP_{rs} . AP_{rs} \quad (4b)$$

The actual productivity level from the potential streams of 'latest technology' depends on $\theta_s \in [0,1]$ with $\theta_s=1$ implying full appropriation of the foreign technology. For the destination region 's', θ_s and E_{rs} jointly determine the value of the *'Spillover Coefficient'* $\gamma_s(E_{rs}, \theta_s)$. More specifically,

$$\gamma_s(E_{rs}, \theta_s) = E_{rs}^{1-\theta_s} \ , \ 0 \leq \theta_s \leq 1 \qquad (5)$$

It is to be noted that trade intensity is treated as a *binary* variable indexed both for the recipient sector 'j' in a given region's' and for the source sector 'i' and region 'r. Except the information on the aggregate imports of the composite intermediate good used by any given sector in a region i.e., $F_{ij\bullet s}$, the regional composition of imports for individual using sectors in s is not known. Without any data accommodating this degree of disaggregation in the database, we make a pro-rata *assumption* that an imported input is proportionally distributed across all user sectors.[12] If F_{irjs} indicates usage in region 's' by industry j of imported intermediate i from source r,

$$F_{irjs}/F_{ij\bullet s} = F_{ir\bullet s}/F_{i\bullet\bullet s} \qquad (6)$$

where $F_{i\bullet\bullet s}$ is the aggregate imports of tradeable commodity 'i' in region 's' from all source regions evaluated at importer's market prices. In equation (6), the left-hand ratio is the quantity share of source r in the imports of i by sector j in its total imports of 'i' whereas the right-hand ratio is the market share of source 'r' in the aggregate imports of tradeable 'i' in region 's'. $F_{ij\bullet s}$ is the value of purchases of imported intermediates i by sector j in any region s and $F_{ir\bullet s}$ is the value of imports of tradeable good i from r to client s. We assume that the share of imported input 'i' from origin of innovation 'r' in receiving region's' (the *right-hand ratio*, the coefficient) holds for all industries 'j' in's' using imported input 'i'.

[12] This particular assumption is driven by limitations of data availability. However, in the literature on embodied international technology diffusion, this is a common assumption. See OECD (2000), *Science and Technology Indicators Scoreboard*.

In the source region, the benefits of a technological change (exogenous) in a particular sector is reaped *directly* by the other sectors via the usage of locally produced intermediate inputs embodying advanced technology and *indirectly* via the *changes in price relativities* of imported intermediates. Thus, the latest technology embodied in the intermediate inputs experiencing technological progress diffuses to other sectors using that material inputs sourced *domestically*. Hence, the exogenous TFP improvement endogenises the TFP improvement in the receiving sectors via a *domestic* spillover effect. Therefore, the sectoral embodiment index [E_{ijr}] for the sectors in the source is given by

$$E_{ijr} = D_{ijr}/M_{jr} \qquad (i \neq j) \qquad (7)$$

where D_{ijr} is the quantity of domestic tradeable commodity 'i' used by firms in sector 'j' of source region 'r' and M_{jr} is the domestic production of 'j' in 'r'. However, for the source country the relevant capture parameter is defined in terms of absorption capacity (AC_r) and its own institutional governance factor (GP_r) with geographical adjacency parameter set to *unity* i.e., $AP_r = 1$ because within its own market adjacency factor is assumed to be perfect. For source 'r', the measure of *governance parameter (GP_r)* is assumed to be unity and GPr $\in$ [0, 1]. i.e., compared to itself, it is absolutely socially-institutionally congruent. Thus, we assume that the higher is AC and GP in 'r', the higher will be the domestic spillover such that the spillover coefficient (where i and j ($i \neq j$) are the innovating sector and the receiving sectors respectively) is written as

$$g_{ijr}(E_{ijr}, q_r) = E_{ijr}^{1-\alpha_r} \qquad (8)$$

$\alpha_r \in [0, 1]$ is source region's capture-parameter. θ_r has one-to-one correspondence with α_r.

Following our discussion above, the productivity transmission equation for the recipient regions can be written as

$$\text{ava}(j, s) = E_{ijrs}^{1-q_s}.\text{ava}(i, r) \qquad (9)$$

where ava (i,r) and ava(j,s) are respectively the percentage changes in TFP levels in source and destinations [i≠j, r≠s]. For source region ‘r’, the transmission equation is given by

$$\text{ava}(j, r) = E_{ijr}^{1-a_r}.\text{ava}(i, r) \qquad (10)$$

Parameter Settings:

In our augmented theoretical model, we have three sets of parameters in addition to the standard GTAP model parameters. These are skill-induced *AC* index, governance parameter *GP* and proximity parameter ***AP***. As regards the absorption capacity parameter, we calculate the skill-unskilled labor payment shares for all the regions as of 1997 and use those skill-intensity ratios as proxying AC. As per our calculation, α_r proxying AC_{USA} is the highest of all the regions. Calculated AC-values are such that $AC_{USA}>AC_{MERCOSUR}>AC_{CHILE}>AC_{MEX}>AC_{RESTLA}>AC_{CAMCAR}$. However, for highly composite regions the figures are surprisingly high. For example, Canada trails little behind Mercosur whereas within the same group the differences are small and show similar intensity implying that they have more or less similar pattern of skill-intensity. Thus, from the AC-index it is obvious that the developing Americas in Western Hemisphere have low skill-intensity compared to the US but *amongst themselves* they exhibit broadly similar pattern of intensity.

For **GP**, we proceed in several steps: (i) we use the World Bank's most recent and comprehensive data on six dimensional governance indicator made available by

Kauffman et al. (2003) and Kauffman (2004).[13] These values at much disaggregated level are bounded between -2.5 and + 2.5; (ii) on the basis of these disaggregated observations at regional level for each category, we construct a simple average, *composite governance indicator* for each GTAP region as representative for *overall* institutional-structural feature. Typically, as the six aspects are *'by virtue of inherent commonality'* interrelated, the indicators are interrelated as well. Thus, composite indicator as simple arithmetic average of the estimates of score on each separate ones is a reasonable proxy for *overall attribute* of governance. For *composite regions*, we calculate such aggregate values by mapping the component GTAP regions with regions in Kauffman et al. (2003) dataset. Having constructed such individual country/region-wise indexes, we transform via Equation (2) to find *binary indexes* of the concerned regions with unique source. The values are bounded between '0' (extremely low degree of governance) and *unity* (i.e., like the value for USA vis-à-vis Canada with almost perfect governance). We consider absolute magnitude of the indexes as we make *relative scaling* for binary comparison with respect to USA as the benchmark. Based on these findings, we infer that USA and Canada are more institutionally (structurally) homogeneous as opposed to other Latin American countries. From our calculation, as expected, we see that *excepting* Chile, Andean and Central Americas, for other developing spokes the values are low with Mexico having the lowest binary GP index of all.

Regarding binary adjacency parameter (**AP**), we do not have measures of geographical barriers for the composite regions especially for the group of countries lumped in them. In the literature, the most widely used comprehensive proxy measuring

[13] These indicators for perceived institutional quality are: Voice and accountability, Political stability, Government effectiveness, Regulatory quality, Rule of law, and Control of corruption. The values of such parameters for AC, AP and GP are not reported here for want of space.

such variable is the *ad valorem* transportation and insurance costs—ratio of *c.i.f* trade to *f.o.b* values or the *c.i.f* margin (Frankel 1997). Therefore, we assign some 'reasonable' values based on stylized evidences on transport margins present in the GTAP dataset. In particular, we consider as *fob vis-à-vis cif margin* the value of transportation services associated with the shipment of a tradable commodity (margin services) 'i' from 'r' to recipient 's'. We find ratios of such bilateral values *aggregated* across all commodities relative to total value of international transportation services across all goods as well as all routes. This ratio enables us to capture the relative importance of physical distance between two trading nations. The calculated share of transport cost summed across all traded goods in imports of margin commodity is relatively low for Canada whereas for the Latin American countries this value is higher and of the same order within the group; however, the inter-regional differences are not significantly large. *Assuming* that the *lower* is such value; the *higher* is the degree of adjacency (i.e., proximity) between nations and the *higher* is the scope of socio-institutional homogeneity and hence, the *higher* is the extent or scope of regional integration facilitating knowledge capture, we assign higher values for Canada whereas for the rest seven we choose relatively lower, same magnitude within the same group of regions.

Accordingly, the specific values for all these parameters are included in the model implementation. The model is solved using customized windows program Gempack.[14]

In what follows, we describe the policy experiments. We consider two generic types of shocks viz., **[1]** trade policy shocks related to trade liberalization episode under

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[14] This is developed by Ken R. Pearson and colleagues at the Centre of Policy Studies/IMPACT, Monash University, Australia based on GEMPACK software suite. See Harrison and Pearson (1996) for GEMPACK simulation software.

HAS vis-à-vis FTAA and **[2]** technology shocks related to TFP augmentation in high-technology sector in USA.

Trade liberalization Scenarios

Two kinds of trade liberalization experiments are investigated. First, Hub-and-spokes: we consider a simple 3-player HAS configuration, with Chile being the hub and the US and Mercosur being the spokes. That is, two separate FTAs are simultaneously established: Chile-U.S. FTA and Chile-Mercosur FTA.[15] Second, FTAA: following the establishment of the HAS system, we simulate the implementation of the regional trade liberalization in FTAA in which trade is liberalized between the spokes economies.[16]

Technology Shocks

Under a mechanism of trade-induced technology spillover between regions, we want to investigate whether hub (Chile) is going to deliver the potential spillover benefits and resultant productivity growth to the other relatively laggard developing spoke/s when it gets spillover from USA—the advanced spoke. To offer comparative enumeration of the potential impact of trade-induced productivity under HAS-type and FTAA with no-TFP shock scenario, we consider the following experiments:

Pure Productivity Shock: Only productivity shock in the US spilling over to other regions *without* any HAS or FTAA configuration.

TFP shock in the presence of both HAS and FTAA: In this situation, we combine trade policy scenarios above with TFP shock *simultaneously* under each HAS and intra-

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[15] In terms of the actual policy experiment, we assume that each arrangement consists of an *immediate* (i.e., no phasing-in), *complete* (i.e., no excluded sectors and no partial liberalization) and *preferential* (i.e., no liberalization with non-members) removal of the relevant tariffs and any quantifiable non-tariff barriers.

[16] In particular, using the updated database from the previous experiment, we simulate trade liberalization between the spokes—US and Mercosur—to have full-fledged liberalization among the three players.

spoke liberalization. In this scenario, we conjecture that Mercosur gains *directly* in FTAA phase but *indirectly* in HAS phase via Chile—the reason being by simultaneously establishing FTA with the US, Chile gets a head start directly whereas Mercosur does not. Thus, we run a simulation with one such sequential HAS configuration i.e., *TFP shock under sequential HAS and FTAA* where in the first sequence Chile forms FTA with USA and then with Mercosur. In the next phase of trade liberalization with FTAA, Mercosur will be able to reap gains later out of this technology spillover from the US.[17]

Among several empirical studies estimating TFP indexes across regions, relatively few provide industry specific TFP indexes. To the best of our knowledge, amongst the recent studies only Keller (1997, 1999) calculated a TFP index by industry for 8 OECD countries. Keller (2001) also modeled the role of growth of R&D stock and geographical variables in extending the knowledge frontier. We match Keller's (1999) ISIC [revision 2] sectors with the GSC1 sectors in our current implementation. From the figures, it is evident that the industries included in the hi-tech and heavy manufacturing clusters experienced rapid technological change and hence, higher average annual TFP growth during 1970-91—around 3.4% is the average growth in such sectors. We consider hi-tech sector as the source of innovation. According to Keller (1997, 1999), the average annual growth in multifactor productivity in the composite hi-tech sector was 3.2% during 1970-1991. Since we do not have data for the base period 1997 being simulated, we use linear extrapolation method to extrapolate growth rates over 6 years encompassing the simulated period. Thus, the extrapolated growth rate of 4

[17] On the contrary, in a *reverse sequence* where at first Chile forms FTA with Mercosur and then with the US, the technological benefits will be harnessed by Mercosur at later stage only when USA liberalizes trade with her. Blyde (2004) shows empirical supports for such direct and indirect trade-related technology flows.

(approximation to 3.86%) is used as the TFP shock[18]. In particular, we shock the Hicks-Neutral technological coefficient in USA in hi-tech sector by 4% in 1997. In what follows, we document the major simulation results. The closure is the standard GTAP macroeconomic closure (see Hertel 1997; McDougall 2003 for GTAP version 6.2).

V. Illustrative Trade Policy Simulations

Chile-US-Mercosur HAS configuration and subsequently US-Mercosur FTA

The simulation results show that the HAS configuration does indeed divert trade away from non-participating regions to the participating ones. As was argued earlier, the discriminatory nature of the FTA with the hub also moves each spoke away from free trade with other spokes. Spoke to spoke trade would suffer as trade is diverted towards the hub: it is relatively more advantageous to import from the hub, as it is to export to the hub's market. As Table 4 shows, while Chile (the hub)'s exports to the United States and to Mercosur expand by 15 percent, and 68 percent respectively, the trade between the two spokes decline slightly. Chile's export to other non participating regions also drops due to export diversion. At the same time, Chile's imports from those two economies increase by 43 percent and 45 percent respectively. Chile's imports from other regions experience double digit drops in all cases. In this particular case, more trade seems to be created than diverted so that Chile's total import and total export rise by 8 percent and 7 percent respectively.

[18] According to Keller (1999, 2001) the rate of growth of R&D stock in USA is 7.4% of which 90% is originating in manufacturing comprising hi-tech and heavy manufacturing. That is, the growth of R&D in manufactures especially in two sectors heavy manufacturing and hi-tech. is 0.90×7.4%= 6.4% (approximately). Simple average of the TFP indexes in these 2 sectors is also 3.2%

Table 4 - *Simulated impact of a hub-and-spokes configuration on bilateral trade flows (percent changes)*

Source	Destination: 1 US	2 Canada	3 Mexico	4 CAmCar	5 Andean	6 Chile	7 Mercosur	8 RestLA
1 US	0.00	-0.08	-0.11	-0.13	-0.15	43.47	-0.21	-0.08
2 Canada	0.00	0.00	0.00	0.00	0.00	-13.13	0.00	0.00
3 Mexico	0.12	0.16	0.00	0.04	0.05	-17.17	-0.11	0.00
4 CAmCar	-0.01	0.09	0.00	0.02	0.00	-11.24	0.00	0.46
5 Andean	0.12	0.19	0.11	0.06	0.15	-14.18	0.21	0.00
6 Chile	14.96	-3.18	-1.73	-2.22	-1.77	0.00	68.55	-1.47
7 Mercosur	-0.70	-0.63	-0.58	-0.74	-0.57	45.07	-1.01	-0.41
8 RestLA	0.25	0.00	0.00	0.00	0.00	-11.11	0.00	0.00

Source: Simulated effects of reciprocal, bilateral FTA between Chile and USA, Mercosur.

The change in relative prices and trade flows are associated with improved terms of trade (prices of export relative to prices of import) as well as regional welfare. In fact, Table 5 shows that Chile's terms of trade improves by as much as 0.62 percent driven principally by preferential market access and increased demand for Chilean goods (at the expense of other regions) in the two large spoke-markets. Chilean welfare improves by the equivalent of more than $100 million, while US and Mercosur experience improvements by $322 million and $258 million respectively. Rest-of-the world (ROW) aggregate loses the equivalent of $570 million.

Table 5 - *Simulated impact of a hub-and-spokes configuration on Welfare and Terms-of-trade*

Region	Terms of Trade (percent)	Equivalent variation ($ million)	Trade balance ($ million)	Real value of exports (percent)	Real value of imports (percent)
1 US	0.03	322	-43.32	0.08	0.1
2 Canada	-0.02	-45	22.77	0	-0.03
3 Mexico	-0.04	-46	23.48	-0.01	-0.08
4 CAmCar	-0.02	-15	14.75	0	-0.04
5 Andean	-0.07	-51	17.03	-0.03	-0.13
6 Chile	0.62	108	-343.1	5.87	7.7
7 Mercosur	0.14	258	-224.79	0.66	0.81

Source: Simulations by the authors.

With the HAS network of FTAs present, we simulate a (admittedly hypothetical) preferential trade liberalization between US and Mercosur.[19] As shown in table 6, Chile's export to Mercosur declined by 8 percent. Interestingly, there is very little change to Chile's export to US suggesting limited preference dilution in the US market due to already low MFN tariffs. Following the reciprocal and preferential trade liberalization between the US and Mercosur, their bilateral trade increase substantially.

Table 6 - *Simulated impact of a hypothetical US-Mercosur (spoke-to-spoke) liberalization following the HAS experiment on bilateral trade flows among modeled economies (percent changes)*

	Destination							
Source	1 US	2 Canada	3 Mexico	4 CAmCar	5 Andean	6 Chile	7 Mercosur	8 RestLA
1 US	0.00	-0.49	-0.53	-0.97	-1.27	-1.97	60.28	-2.27
2 Canada	0.09	0.00	0.32	-0.12	-0.21	-0.64	-8.45	0.00
3 Mexico	0.19	0.70	0.00	0.04	-0.22	-0.95	-11.70	0.00
4 CAmCar	-0.32	0.46	0.46	0.22	0.00	-0.63	-5.38	-1.37
5 Andean	-0.09	0.29	0.65	0.16	0.04	-0.69	-4.44	-1.69
6 Chile	0.03	0.94	1.26	1.52	0.85	0.00	-8.09	0.00
7 Mercosur	34.76	2.39	3.64	3.24	2.95	1.94	-8.76	1.76
8 RestLA	0.24	0.93	0.00	0.00	0.00	0.00	-1.87	0.00

Source: Simulations by the authors.

As argued earlier, spoke to spoke trade liberalization can hurt the hub in a static framework since some of the benefits of being a hub might be dissipated: intra-spoke liberalization lead to some dilution of the preferential market access that Chile enjoys in each of the two large spokes. Table 7 shows that Chile's terms of trade decline by 0.24 percent following US-Mercosur liberalization due to the decrease in the degree of preference that Chile enjoys in those markets.

[19] Of course, removing the barriers between the spokes may not necessarily be an accurate representation of a full fledged regional FTA or FTAA. This point is especially relevant in the presence of complex rules of origin: product from one spoke using input from a second spoke may not be allowed duty free in the hub market. This is not studied here and it is in our research agenda.

Table 7 - *Simulated impact of a hypothetical US-Mercosur (spoke-to-spoke) liberalization following the HAS experiment*

Region	Terms of Trade (percent)	Equivalent variation ($ million)	Trade balance ($ million)	Real value of exports (percent)	Real value of imports (percent)
1 US	0.28	3026	-889.11	0.62	0.87
2 Canada	-0.14	-308	170.38	0.02	-0.19
3 Mexico	-0.15	-127	95.12	0.02	-0.23
4 CAmCar	-0.12	-79	67.03	0.06	-0.15
5 Andean	-0.08	-55	36.53	-0.01	-0.16
6 Chile	-0.24	-65	19.9	-0.15	-0.44
7 Mercosur	-0.49	-285	-2274.33	5.04	5.4

Source: Simulations by the authors.

This led to a decline of $65 million in Chile's welfare. Not all the welfare gains from the previous HAS liberalization are dissipated because Chile still enjoys advantageous access to Mercosur and the US relative to the other regions. While USA seems to gain from an FTA with Mercosur, in terms of trade (0.28 percent) and welfare ($3 billion), this later ends up being hurt by its own liberalization—largely driven by the preferential removal of relatively high barrier on manufacturing goods.

VI. Technology Transmission and Trade Liberalization Experiments

Pure TFP Shock

In this section, we consider macroeconomic repercussions following TFP escalation *per se*. Because technological change is more predominant in the manufacturing sectors, we confine our discussion mainly for hi-tech, heavy manufacturing and light manufacturing and for the regions US, Canada, Chile, Mexico and Mercosur.[20] After the TFP improvement in hi-tech in the US and the associated endogenous TFP changes in all other sectors (both domestically and abroad), the

[20] Due to limitations of space, we report only selected most important ones.

economy-wide indexes of TFP register an improvement in all the regions. However, the magnitude of the index differs markedly across the regions (row 1, Table 8).

Table 8- *Simulated regional effects of 4% TFP shock in the Hi-tech sector in the US on selected macroeconomic variables (percent changes).*

Percentage change in:	USA	Canada	Chile	Mercosur	Mexico
1. Region-wide index of TFP growth	3.8	2.1	1	0.2	1.5
2. Real GDP at Factor Cost	3.8	2.1	1	0.2	1.5
3. Region-wide index of Real Value-added	3.8	2.1	1	0.2	1.5

Source: Simulations by the authors.

US, being the source of innovation, experiences the highest overall technological progress compared to the regions experiencing a lower TFP improvement than US; more importantly, amongst the recipients, Canada receives higher doses of technology transmission than the other regions. Being neutral in nature, the TFP change translates into an equivalent increase in real GDP at factor cost in the regions.

As is evident from Table 9, the capture of transmitted technology depends on the magnitudes of the economy-wide and sectoral embodiment indexes and spillover coefficients in the destinations vis-à-vis USA. Since the policy shock is injected in the base period 1997 we quote the base-period values of such indexes. The aggregate spillover index gives us an average *overall* magnitude of technology appropriated by all user sectors in the source as well as client regions via intermediate inputs. Table 9 shows that the aggregate embodiment index in the USA $[E_{ir}]$ is higher than those in the destinations $[E_{irs}(s \neq r)]$ - compare figures in column 2. Since the capture-parameter (q_r) in USA is higher than q_s in all the regions (column 4), from Equations (6) and (7) it is clear that USA reaps the maximum spillover (g_{ir}) (column 3). Looking at congruency parameter (column 8), we infer that much of the spillover capture can be attributed to the 'right' constellations of appropriate socio-institutional factors (i.e., GP and AP) aided by absorption index.

Table 9 - *Values of economy-wide embodiment-indexes, spillover coefficients, parameters for governance, adjacency, capture and congruence* [(a)]

GTAP Regions (1)	Embodiment Index (E_{irs}/E_{ir}) (2)	Spillover Coefficient (γ_{irs}/γ_{ir}) (3)	Capture-Parameter (θ_r) (4)	AC (5)	GP_{rs} (6)	AP_{rs} (7)	$SC_{rs} = AP_{rs} \times GP_{rs}$ (8)
1. USA	0.70	0.84	0.71	0.71	1.00	1.00	1.00
2. CAN	0.33	0.48	0.38	0.40	1.00	0.95	0.95
3. Chile	0.14	0.21	0.25	0.41	0.70	0.85	0.60
4. Mexico	0.35	0.37	0.04	0.38	0.10	0.90	0.09
5. Mercosur	0.03	0.04	0.08	0.43	0.22	0.80	0.18
6. Rest of LA	0.21	0.26	0.16	0.38	0.50	0.85	0.43

Source: authors' simulations; (a) Values shown relate to the base period pre-shock levels.

The higher value of those parameters and hence, of the capture parameter $[q_r]$ magnifies value of the embodiment index; thus, enabling Canada, Mexico and Chile to record a much higher rate of TFP improvement than Mercosur. Higher volume of trade flows from USA inflates aggregate embodiment indexes in Canada and Mexico. Despite having higher θ_r in Chile than Mexico, higher embodiment index and spillover coefficient in Mexico translate into relatively higher TFP and welfare gains there (Table 10). Note that ordering of the spillover coefficient in column 3 of Table 9 matches the ordering of the real GDP in row 2 of Table 8.

Regarding post-simulation trade scenario, Table 10 shows that *aggregate* volume of exports increases in the principal beneficiaries of TFP changes namely, Canada and Mexico, while for Mercosur, it declines slightly. Imports increase for all regions. Because the changes in price relativities across regions induce changes in regional terms-of-trade (TOT), the pattern of inter-regional competition is disturbed. The preceding discussion shows that the TFP shock erodes competitiveness of Chile and Mercosur (due to lower capture) whereas USA, Canada and Mexico become more competitive. A much larger rise in the volume of exports from USA, Mexico and Canada and relatively smaller order of magnitude of fall in the volume of exports from Mercosur and others translate into a rise in the volume of trade in hi-tech and manufactured products.

Table 10- *Simulated regional effects on aggregate performance*

Change in:	USA	Canada	Chile	Mercosur	Mexico
1. Terms-of-trade	-0.81	0.22	0.03	0.26	0.33
2. Aggregate export price index	-1.93	-1.38	-1.23	-0.99	-1.33
3. Aggregate import price index	-1.13	-1.60	-1.26	-1.24	-1.65
4. Real value of exports	4.32	2.69	0.92	-0.31	2.20
5. Real value of imports	1.52	2.55	0.93	0.73	2.22
6. Regional Household Income	3.97	2.38	1.07	0.30	1.82
7. Change in trade balance (in US $ million)	16298.71	1013.66	12.08	-570.59	429.03
8. Welfare (EV) (in million US $)	286816.2	13495.7	750.1	2590.9	6248.5

Source: Simulation by authors. Note: First 6 rows report results in Percentage changes. Reported welfare and trade balance changes in rows 7 and 8 are in levels and in million $.

The next couple of sections give comparative enumeration of combined simulated effects of trade liberalization scenarios.

TFP with-HAS and FTAA, no HAS sequencing

In the presence of the TFP shock, we simulate a one-shot emergence of a HAS (i.e., Chile *simultaneously* forms FTA with USA and with Mercosur). The results reported in Table 11 show that the TOT movement preserves the same ranking and order of magnitude except for Chile and Mercosur who register relatively higher improvement in terms of trade due to preferential market access and resultant rise in trade. Thus, welfare increases considerably contributed by predominantly technical change (see rows 6 and 7 in Table 11). Also, these countries are able to register positive trade balance due to trade creation except Mercosur whose exportable become relatively dearer compared to the price of the importable. Following the establishment of the HAS, we look at the case in which a more comprehensive regional FTAA is achieved by freeing trade between the spokes.

Table 11- *Simulated regional effects on aggregate performance without sequencing*

Regions	USA		Chile		Mercosur		Mexico		Canada	
Type of configuration→:	Joint HAS (1)	FTAA (2)	Joint HAS (1)	FTAA (2)	Joint HAS (1)	FTAA (2)	Joint HAS (1)	FTAA (2)	Joint HAS (1)	FTAA (2)
Changes in↓:										
1. Terms-of-trade	-0.78	-0.55	0.25	-0.2	0.36	-0.72	0.29	0.2	0.21	0.11
2. Aggregate export price index	-1.92	-1.75	-1.02	-1.73	-0.89	-2.18	-1.36	-1.38	-1.39	-1.42
3. Aggregate import price index	-1.15	-1.21	-1.27	-1.54	-1.24	-1.47	-1.65	-1.58	-1.6	-1.52
4. Regional Household Income	3.98	4	1.21	1.3	0.27	0.21	1.81	1.81	2.37	2.34
5. Change in trade balance (in million US $)	16303.95	16318.99	160.19	36.65	-563.8	204.74	414.53	392.28	1003.1	959.34
6. Welfare (EV) (in million US $)	287121.3	294994.5	846.66	913.64	2768.6	2058.26	6206.47	6239.38	13454.5	13457.2
7. Contribution of TFP to EV(in million US $)	294897.2	300239.8	750.27	874.55	2015.34	2686.23	5252.98	5335.39	11249.7	11433.1

Source: Authors' simulation of impact of 4% TFP Shock plus joint HAS and FTAA. Note: First 4 rows report results in Percentage changes. Welfare and trade balance changes in rows 5, 6 and 7 are reported in levels.

In this FTAA scenario, TOTs fall in these two regions whereas other considered regions maintain the same sign. This is due to the fact that in the FTAA scenario, USA and Canada, the biggest benefactors of trade-induced technology flows and having higher parameters of such capture, are able to appropriate the benefits of market accesses in these two regions. Although, export diversion occurs between two spokes, it is not substantial and the presence of technology transfer makes the welfare to improve.

TFP with-HAS and FTAA, with sequencing

In this scenario, Chile moves first to form FTA with US and then, with Mercosur. Compared to pure trade policy scenario, due to trade-induced technology spillover the effects are magnified. For example, all the regions experience welfare increase (rows 7 and 8, Table 12)—contributed predominantly by TFP improvement. However, in sequence 1, Chile and USA perform better due to preference accumulation effect via market access in their respective markets. In the first phase, substantial accrual of gains to

Chile is caused by reciprocal removal of trade barriers and concomitant higher doses of technology flows (compare row 7 with rows 8 and 9, Table 12). This is direct effect.

Table 12 - *Simulated regional effects on aggregate trade performance with sequencing*

Regions	USA (1)			Chile (2)			Mercosur (3)		
Type of configuration→:	Chile-US HAS	Chile-Mercosur HAS	FTAA	Chile-US HAS	Chile-Mercosur HAS	FTAA	Chile-US HAS	Chile-Mercosur HAS	FTAA
Changes in↓:									
1. Terms-of-trade	-0.77	-0.81	-0.54	-0.2	0.46	-0.2	0.21	0.41	-0.76
2. Aggregate export price index	-1.91	-1.96	-1.77	-1.51	-0.88	-1.77	-1.05	-0.85	-2.26
3. Aggregate import price index	-1.15	-1.17	-1.24	-1.3	-1.33	-1.57	-1.26	-1.25	-1.5
4. Regional Household Income	3.98	3.97	4	1.02	1.61	1.33	0.25	0.29	0.21
5. Expand (Capital, r)	0.53	0.54	0.57	0.77	0.79	0.82	0.49	0.51	0.53
6. Change in trade balance	16300.68	16344.06	16383.35	105.65	111.07	36.99	-565.51	-572.54	233.87
7. Welfare (EV)	287205.3	292110.7	300366	715.26	1123.27	932.67	2513.15	2906.44	2077.91
8. Contribution of TFP to EV	294897.6	300279.8	305584.6	759.39	885.9	892.42	2014.91	2072.01	2756.25
9. Contribution of Allocative Efficiency to EV	-37.15	-53.77	132.33	10.06	131.97	80.48	229.31	353.43	446.59

Source: Authors' simulation. Note: First 5 rows report results in Percentage changes. Trade balance and Welfare changes in rows 6, 7, 8 and 9 are reported in levels.

However, in the second phase when Chile joins Mercosur, the latter gains in terms of welfare and TOT due to indirect spillover of technological benefits via traded intermediates sourced from Chile after trade liberalization under HAS network. But, Mercosur being relatively laggard in capturing the spillover benefits (due to non-access and low constellation of capture-parameters) suffers from deterioration of trade balance (row 6, Table 12). Under full-fledged FTAA scenario, however, it improves its trade balance, even higher than Chile (compare columns 2 and 3, row 6 in Table 12). Comparing the respective FTAA columns with the two sequential HAS networked liberalization episodes for each of the reported regions, we can infer that FTAA has been welfare-augmenting and trade creating for most of them especially USA and Mercosur. In fact, in a paper of latest vintage by Blyde (2004) the empirical results are in conformity with our findings.

For Chile as hub, although it accumulates preferences under two HAS sequences, this preference gets diluted in FTAA scenario where the welfare increase is moderate and lowered to $933 million from $1123 million. Moreover, due to upsurge in trade under HAS and FTAA configuration, there is enhancement of production efficiency resulting in regional income gains (row 4, Tables 11 and 12). However, this increase in income creates further gain via increase in gross investment and capital accumulation (row 5, Table 12) and hence, results in 'trade-induced investment-led growth' (*á la* Baldwin 1996). In each case, compared to HAS sequences the FTAA scenario gives much augmentation of capital goods leading to efficiency gains. Thus, even in a static CGE framework quasi-dynamic effects are generated owing primarily to trade-led technology spillover. Below Table 13 reports the sectoral performances behind such growth effect.

Table 13- *Simulated impact on sectoral TFP, output and spillover coefficient by sectors*[*]

Regions	**Sectors**	**Spillover Coefficients (Base period)**	**Sectoral TFP Growth (Percentage changes)**	**Sectoral Output (Percentage changes)**
(1)	(2)	(3)	(4)	(5)
USA	LMnfcs	0.94	3.78	4.09
	HMnfcs	0.94	3.74	3.95
	HiTech	0.91	4	4.06
CAN	LMnfcs	0.57	2.26	2.4
	HMnfcs	0.54	2.17	2.27
	HiTech	0.67	2.67	2.88
Chile	LMnfcs	0.3	1.18	1.23
	HMnfcs	0.27	1.08	1.02
	HiTech	0.34	1.36	0.91
Mercosur	LMnfcs	0.03	0.1	0.16
	HMnfcs	0.03	0.11	0.12
	HiTech	0.1	0.39	0.08
Mexico	LMnfcs	0.2	0.81	0.49
	HMnfcs	0.52	2.09	1.86
	HiTech	0.58	2.32	2.47

*Figures in columns 4 and 5 are in percentage changes following TFP shock.

From the values of *sectoral* spillover coefficients (column 3, Table 13), it is evident that in USA sectoral TFP growth is highest in all four sectors as compared to other regions (column 4, Table 13). The highest value of capture parameter magnifies the values of spillovers there and hence resulted in higher TFP growth. Similar considerations apply for Canada, Chile and Mexico. However, for the relatively laggard regions Mercosur and Mexico with lower magnitude of θ_r, the resultant sectoral TFP growth is of very low magnitude. TFP improvement resulted in higher percentage increases in output in all the regions (column 5, Table 13). Cost-saving and consequential decline in supply prices is largely attributed to a decline in the price of composite value-added and its constituents following TFP shock. However, compared to HAS sequences, in FTAA scenario Mercosur registers much larger fall in prices compared to Chile, due to direct and indirect transmitted productivity gains, thereby grabbing market access at the expense of Chile as Hub. From Table 14, we infer that as changes in relative price in all three sectors in Canada, Mercosur and Chile vis-à-vis USA is much higher, following the shock the regional aggregate exports from USA to all the destination regions in all three sectors increase. For USA and Canada, the percentage increase in the quantity index of exports is governed by the relative changes in the market prices of the tradeables imported from one source to another. For Chile, after FTAA formation it loses market access not only to other spoke but also to other markets due to preference dilution; also, compared to Mercosur, we see very little percentage rise in exports of other developing regions as destinations (columns 2, 4 and 5, Table 14).

Table 14- *Simulated effect on aggregate regional exports of commodities under FTAA (% changes)*

GTAP Sectors	Regions				
	USA (1)	Chile (2)	Canada (3)	Mexico (4)	Mercosur (5)
1. Hitech	6.81	-9.9	3.57	3.39	4.56
2. Heavy Mnfcs	3.96	1.63	2.72	2.28	6.33
3. Light Mnfcs	6.17	1.86	2.57	0.88	21.79

Source: Authors' simulation results of 4% TFP shock.

VII. Concluding Remarks

In this paper, we investigate the economic implications of hub-and-spokes configuration and compare it with a broader type of regional liberalization in which free trade is established among spokes. We argue that such configuration is likely to alter trade pattern disproportionately in favour of the hub, since from the point of view of each spoke, it becomes more advantageous to import from the hub, as it is to export to the hub's market. We confirm this result in a simulation exercise scenario in which Chile becomes the hub, and the United States and Mercosur are the spokes. This type of results would be even stronger if the spokes are small developing countries. Even the preferential market access that a given spoke gains from the FTA with the hub would likely be diluted by the fact that the hub is also giving the same (if not more favourable) preference to all the other spokes.

This argument relates to the debate of whether a Free Trade Area of the Americas would be superior to a series of criss-crossing bilateral FTA among the potential FTAA members. In fact, having achieved the status of being a hemispheric hub, countries like Mexico or Chile may no longer have any incentive to pursue strenuous full fledged FTAA-type regional trade negotiations. In our simulations, we show that the move from HAS to the FTAA (proxied by a bilateral liberalization among the disjointed spokes) is likely to hurt the hub, due to the dilution of the preference that it enjoys in each of the spokes.

Given that the HAS configuration definitely affect the pattern of trade among all concerned economies, we argue that it could also affect the flow of technological innovation (embodied in traded intermediates). We augment the standard modelling framework to capture this possibility. Following the technology shock, we calibrate: (i) regional disparities in capturing transmitted productivity gains; (ii) the impact on global trade; (iii) welfare impact. The model results show that technological innovations in the hi-tech sector result in a significant increase in manufacturing production. Also, results show that sectors that use hi-tech products intensively register higher output growth especially in USA experiencing much higher benefits of TFP change. It is quite likely to consider multiplicity of sources of technology creation. In this context, modelling skill formation, appropriateness of technology and indigenous R&D capabilities will impart valuable insights for enunciating policy insights for fostering absorptive capacity. Also, more refined specification of technology capture, socio-institutional factors and adoption will give much richer dynamics. However, given the limited scope of the study, the present attempt is a starting point.

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