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ABSTRACT

Nexus between income inequality and technology capture is explored in a global CGE model to explore the ricochet effect of technology transmission and its capture. In particular, the model shows that exogenous technology shock from developed North, vehicled via trade, transmits to developing Souths and induces productivity growth. This spillover capture, aided by human capital based adoptive capability, better governance and institution, causes increase in income and welfare and subsequently, leads to decline in income inequality. Dynamism of Southern Engines of Growth—India and China— caused them to emerge as 'core' South. Thus, triangular innovation diffusion between dynamic and peripheral South is also simulated to show how the backward or peripheral South could catch up via South-South Cooperation in a declining North-South trends in trade. This accrual of benefits could lead to sustained productivity growth and consequential relief of incidence of poverty in low-income countries.

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Keywords: Spillover, Human capital, Governance, Hub-and-Spokes, Innovation and Absorptive Capacity, Gini, Poverty Gap.

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"The emphasis on human capital, especially the development of skill and productive ability spread across the population, contributes to shifting the focus of analysis from a "hard" view of development to a more" people-friendly" approach. ..[the] process of development is not separable from the expansion of human capabilities for its intrinsic as well as instrumental importance ."

—Amartya K. Sen, in Development Thinking at the beginning of the 21st Century, pp. 20-22: 1997.[1]

"Innovation depends significantly on overall conditions in the economy, governance, education, and infrastructure. Such framework conditions are particularly problematic in developing countries, but experience shows not only that proactive innovation policies are possible and effective but also that they help create an environment for broader reforms."

--World Bank, p.2: 2010.

1. A Brief Overview:

The relationship between long-term sustained productivity growth and egalitarian distribution is contingent, *inter alia*, on human capital formation, structural reforms, and trade reforms in conjunction with sound macroeconomic policies. Quite pertinently, it has been remarked: 'trade liberalization ought to be simple choice for poverty-fighting politicians', *but* we need 'in economic terms, the technological prowess, intellectual firepower, and rapid rates of economic growth' for poverty alleviation (*The Economist*, December 18, 2004). For the 'infant' economies, the role of knowledge-capital and its propagation is important for reducing poverty and income inequality. Kosempel (2007) has shown that persistent disparities in income levels across nations could be attributed to the knowledge deficiencies and inability to learn the foreign technologies. Trade is an important conduit for North-South technology diffusion (Keller 2004, Coe and Helpman 1995, Bayoumi et al. 1999, Lucas 2009a). In this context, the dynamism of information and communication technology (ICT) is significant for facilitating diffusion. As global technological system is undergoing rapid transformation and innovation is at the core of economic progress of developing world, an 'organic and evolutionary perspective' beyond traditional policy focus is necessary (World Bank 2010).[2]

For economic growth to be pro-poor, it is imperative that the poor should have access to cutting-edge technologies, better socio-institutional set up and appropriate macroeconomic fundamentals. Thus, local conditions matter for turning the trade opportunities into growth effects. In this context, we emphasize the role of *socio-institutional factors*: human capital based *absorptive capacity*, *governance*, R&D and *social acceptance* parameters. Especially Goals 2 and 8 of MDG targets emphasize the predominant roles of access to new technologies via global partnership (i.e., educative effect of trade), universal primary education, boosting ICT investment, technology transmission, promoting e-Government, and good business environment, etc.[3] In fact, lack of capacity

[1] Suntory and Toyota International Centre for Economics and Related Disciplines (STICERD). London School of Economics and Political Science. Discussion Paper No: DEDPS/2, March 1997.

[2] Following this report, we adopt the definition of innovation as technology or practices new to an economy, but not in absolute sense.

[3] Goals 8A and 8F emphasize good governance, poverty reduction and technological access via global partnership (p. vii). Large disparities exist in use of ICT and diffusion of climate mitigation technologies (pp. 72-77, United Nations 2010.).

to absorb and innovate has been syndromes adversely affecting Africa's growth performances (Onyeiwu, March 2011). On the same token, empowering people by education facilitates human development. On the aspect of diffusion and social acceptance of novel technologies, governance and socio-institutional features make the climate favorable. Often, bad governance leads to flagrancy and misuse of resources. For example, in the context of Latin America, most of the countries except Chile have *not* been so successful in reducing poverty primarily because of corrupt political system siphoning off resources, lack of quality education, infrastructure, and governance.[4] As pointed out by Sachs et al. (2004), in the context of tropical Sub-Saharan Africa, achieving poverty reduction entails *removing* these obstacles.

As Meier and Stiglitz (p.5, 2002) put it, 'the *preconditions* [of absorptive capacity] must be in place for the acceptance and implementation of ideas.' Also, for the emerging Southern engines (e.g., especially India and China) better technological capability and skill has led to splitting the value-chain into separate 'production blocks' and trade in intermediates. As technological change affects it, it is important to have a cursory look at the extent of 'fragmentation' of production process.

In this multipolar world, there is still a gap in understanding how North-South and South-South learning and knowledge exchange (i.e., triangular diffusion) works to reduce the income gap. This paper spells out a mechanism whereby closing the technological gap could reduce poverty *via* synergies and complementarities between North-South and South-South spillover and its capture. In particular, we show that given the initial income distribution, *with* proper constellation of socio-institutional factors, innovative and absorptive capacity (AC), the scope of trade-mediated innovation dissemination facilitates reduction of initial income inequality.[5] A reduced-dimension version of a global Computable General Equilibrium (CGE) model Global trade analysis project (GTAP) (Hertel ed. 1997), with 78 regions × 57 sectors, is spelt out and tailored in Section 3 for studying the multi-sectoral, multi-regional linkages. Section 2 reviews the literature and presents stylized evidences. Section 4 documents the implementation methodology. Section 5 analyzes the results. Section 6 summarizes.

2. Trade, Technology and Inequality: A Bird's Eye (Re-) view

Over several decades, researchers have contributed to offer insights about proximate determinants of within-country and cross-country differences in productivity (TFP) and income levels. Emphasis varied across wide range of factors such as, technology, human capital, as well as culture, climate, institutions, and geography (Acemoglu and Dell 2010). Of late, an ambitious sets of new 'Kaldor'-style stylized facts presented by Jones and Romer (2010) offered the interactions between increased market integration and *four state variables*, namely: ideas, human capital, population and

[4] *International Herald Tribune*, 26 May 2005, p. 6

[5] According to Lucas (2009, p.1), 'flow of ideas is the main force for the reduction of income inequality, and for the convergence of incomes to a common, growing level.'

institutions that play role in explaining wide cross-country variation in growth rates and TFP, and their 'distance from the technology frontier'.[6] The most important among these facts are globalization's pervasive impact, large income (and growth) differences, flows of goods and technology, rise in human capital, and stable relative wages across skill categories (p. 225). Hsieh and Klenow (2010) has also shown the importance of education, technology, and institutions for explanations of income differences. Quoting Lucas (2009a, p.1): "a study of economic growth in the *world as a whole* must be a study of the diffusion of the industrial revolution across economies, a study of the cross-country flows of production-related knowledge from the successful economies to the unsuccessful ones."

Since our interest is to explore the role of trade (and other behind-the-border factors) in reducing inequality, we explore trade in technology-based sectors based on comprehensive data in GTAP Version 6 time-series trade data for the period 1965-2004. Share of high-technology exports in manufacturing exports are higher for advanced and semi-industrialized nations (Das 2002&2008). Based on technology content of different sectors, we consider broadly defined sectors with common characteristics and technology-intensivity of clusters.[7] These broad clusters include light manufactures, heavy manufactures, and hi-tech products (Table 1).[8]

Table 1: Average annual growth rates for global trade in technology clusters, 1965-2004

Technology Clusters	Average Annual Growth Rates (%)
Information and communication technology	12
Consumer goods	9.1
Biotechnology Cluster	6.1
Nanotechnology Cluster	10.4
Transport Equipment	11.2
Fabrication	9.1

Source: Author's Calculations based on time-series trade data from the GTAP database Version 6.

From the table, it is evident that global trade in technology-intensive products registered considerable growth and hi-technology sector registered the highest growth rate. Also, localisation of foreign technology depends on indigenous invention potential and own R&D-effort for building technology infrastructure. Technology achievement differs across nations because of uneven diffusion, inequalities in access to innovation, as well as in education and skills. According to UN Human Development Report (2001, p.2), "the 20th Century's unprecedented gains in advancing human development and eradicating poverty came largely from technological breakthroughs." Following the report, we use Technology achievement Index (**TAI**) (Table 2) of each region and compare between source and the host nations to derive a bilateral technological congruence (**TC**) parameter (see next section). This index, focusing on achievements in creation, diffusion, and development of human capability, is a broad measure of technology capability and captures disparities in human development.

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[6] This paper offers insights about the relationship between technology and nurturing human capability (p.6).
[7] According to OECD (2000), technology is broadly defined as direct and indirect R&D embodiment of various types of intermediate inputs and capital goods.
[8] Average annual growth rates are calculated using Ordinary Least Squares method.

Table 2. Technology Achievement Index for selected GTAP regions*

Regions	Index values
Bangladesh	0.04
Canada	0.59
China	0.30
EU	0.51
HongKong SAR-Taiwan Province of China	0.46
India	0.20
Japan	0.70
MERCOSUR	0.34
Other South Asia	0.12
Rest-of-the-World	0.25
South America	0.32
South East Asia	0.36
Sri Lanka	0.20
United States	0.73

Source: Human Development Report 2001, Table A2.1
*For Composite regions, the index is calculated by computing the group average.

From the Table, it is evident that the index values are much higher for developed regions like USA, Canada, Japan and EU. For the developing regions, we see relatively higher values for 'dynamic adopters' in East and South Asia and some bloc of South American countries. [9] However, for some high performing economies, the values of such index are relatively low compared to industrialized nations. This is because in those countries there are *within-country* differences with enclave-led growth.[10]

ICT-related activities has generated spillover effects in the form of *outsourcing of materials and services* and *splintering* of industrial activity (Gordon and Gupta, 2004).[11] In this context, we consider realignment of production and increasing tradability of services due to innovations that has led to expanding global trade in intermediates and outsourcing, especially in China and India-both diversifying, upscaling its production and exports (Santos-Paulion 2010b). There has been substantial production fragmentation via FDI undertaken by U.S. and Japanese IT firms, supporting that technology diffusion *causes* offshore outsourcing (Bonham and Gangnes 2004).

For a given final goods sector j in a region r, we define OS_SM (j, r) as the quantitative measure of service and material outsourcing intensity—based on Amiti and Wei (2004)—as a share of

[9] According to Human Development Report (p. 47, 2001), Technological Achievement is important for human development and the Index correlates with the Human Development Index.

[10] For example, in case of India, Bangalore is technological hub, the centre of outsourcing activities and software technology development, but this is not spread in other regions uniformly because of low adult literacy rate, low tertiary enrolment rate and uneven diffusion of technology. Thus, although a state like Bangalore has high achievement index India's overall index is not that high, but India is ahead of others in IT area.

[11] IT products include SITC (revision 2 and 3) classification categories 75, 76 and 776. These are automatic data processing instruments such as computers, calculators, photocopy machines, etc. and also, electronic components including semiconductors, electronic tubes and valves, telecommunications and radio equipment.

total inputs. We calculate extent of outsourced material or services for an industry j, OS_SM (j, r) according to the formula below:

$$OS\_SM_{jr} = \sum_{i} \left[\frac{a_{ijr}}{a_{jr}}\right] \times \left[\frac{G_{ir} + P_{ir} + a_{ir}}{Y_{ir} + M_{ir} - X_{ir}}\right] \qquad (1)$$

where for any region 'r',

a_{ijr}: use of intermediate input 'i' in final user sector 'j',

a_{jr}: total *all intermediate inputs* (*summed across all 'i'*) used for production in sector 'j',

G_{ir}: government consumption of import of traded commodity 'i',

P_{ir}: private household's consumption of import 'i',

a_{ir}: for each i^{th} intermediate input, total intermediate use of ‘i’ by all user sectors 'j' (*summed across 'j'*),

Y_{ir}: production/output of i^{th} traded commodity,

M_{ir}: imports of i^{th} traded commodity, and

X_{ir}: exports of i from r.

The first bracketed term, share of i^{th} intermediate input in overall intermediate input usage for an industry j, gives intermediate input intensity for industry of use ‘j’. Without having information for imports of each input by each industry from source region to destination regions, the second term is used to calculate the import share by usage, which is applied to each i^{th} industry.[12] These two terms together give outsourcing intensity of material/services ‘i’ for a typical industry of use ‘j’ in a region ‘r’. By aggregating over all the intermediate inputs (i.e., summing across all i’s) used in a particular final goods sector ‘j’, we derive the *average outsourcing intensity ratio* for each j^{th} sector of use, for five broad categories of manufactures: light and heavy manufactures, hi-technology intensive products, textile and clothing, capital goods and also for one service industry composite (Table 2).

Table 3: Outsourcing of materials and services for selected sectors across regions (%)

	Developed Regions				Developing Regions				
Sectors	USA	Canada	Japan	EU	India	China	South-East Asia	Mercosur	South America
Light Manufactures	10.9	20.8	9.9	21.9	9.9	12.6	28.4	6.9	18.6
Heavy Manufactures	14.9	34.6	8.9	28.3	14.2	12.7	36.3	10.3	23.9
Hi-Technology Products	17.1	50.1	8.1	29.9	14.6	18.2	55.8	14.02	35.7
Services	5.8	15.6	5.2	13.1	8.8	11.8	27.7	6.2	17.4
Capital Goods	11.5	22.3	4.9	21.5	11.6	9.6	34.9	9.2	24.2

Source: Author's calculation using GTAP Version 6 Database

The calculations show that the developed and emerging economies of Asia are the recipients of outsourcing. Dividing the world economy into four-speed world (poor, struggling, affluent, and converging), OECD (2010) has shown that the economic centre of gravity has shifted to these emerging

[12] In Amiti and Wei (2004), a pro-rata assumption is made and economy-wide import share is applied for computing such import share. Since in the GTAP database, we have data on foreign and intermediate inputs used in sectors of usage, this ad hoc assumption is not applied. Thus, ours specification and calculation supposedly contains more accurate data.

economies. More and more developing economies are engaged in innovative partnerships in areas of mutual learning and knowledge for facing development challenges. This realignment of regional growth has altered the macroeconomic context and development policy must take into account such shift of the global economic heft. Fragmentation of production process has enabled division of production networks according to comparative advantage and led to the emergence of China and India as the centers of such activities. In fact, service sector's share being largest (54%), "India's experience proffers an unparalleled paradigm of the role of technological progress, and the transmission channels through which macroeconomic fundamentals can explain [her] success" (Santos-Paulino and Wan p. 264, 2010b). In case of China, such shifts have been induced via 'informatization' and radical gradualism to service sector following Indian experience (World Bank 2007a&b). During 2000s, they have grown about 3 to 4 times the OECD average while some developing nations in Africa and Latin America underperformed (OECD 2010). China and India has done rapid intensification of R&D spending as percent of GDP (about 1.7-2%). Both of these nations' stellar performance in technology, innovation, advanced labor force, domestic factors, and trade highlights the opportunities of positive spillovers for others and thus, challenge the conventional wisdom focusing on advanced economies as tour-de-force. In fact, IMF (January 2011) has offered insightful evidences on profound impact of Brazil-Russia-India-China (BRIC) on the low-income countries (LICs) via international economic ties or, South-South trade (19% of global trade). In particular, the report finds substantial support for growth spillovers via closer BRIC (particularly India and China) -LIC ties encompassing mostly trade, financing, FDI, technology for overcoming infrastructural bottlenecks, improving productivity, and sustained growth (p.p. 28-30).[13] Comprising more than 40% of the global population, trajectories of GDP growth rate in theirs has established themselves as Southern giants (that is, China and India being the first two in the Southern bloc).

According to Bonham and Gangnes (2004), East Asia's share of global IT production has grown to 26% compared to 5% twenty years ago, almost at par with the US at 28%, establishing herself as leading exporter of such products. For the Newly Industrialized Economies, the compound annual growth rate of IT production during 1985-2000 was almost 14% whereas for Japan it is 6%. In case of East Asia, sustained economic growth has led to reduction of poverty in this highly dynamic developing region—number of people living below $2 a day have fallen to 34% from 50% at 1999 level (World Bank 2004). In that bloc, China has emerged as 'a major hub for regional production and trade networks' (World Bank 2004a). The impact of India's growing exports of IT-related services has been enormous (Kobrin, 1999). According to the report, in this region, industrial production achieved 5-10% gains due primarily to India's export potential especially in hi-tech sectors and IT-related service activities. Pakistan and Sri Lanka did not perform as well like the Indian sub-continent. As opposed to

[13] In post-crisis period, BRIC's contribution to LIC growth divergences has increased. Trade channel is the dominant with 60% of the impact transmission.

these regions, Nepal, Bhutan, and Bangladesh showed poor performances due to political instability, infrastructural deficiencies, and heightened external market competition. Having immense innovation potential, unleashing it via entrepreneurial competition, creating and diffusing innovation, and fostering inclusive innovation by promoting adaptive capacity and grassroots efforts could decline poverty (World Bank 2007a). According to OECD (2010), "Software technology is gaining prominence in national strategies for the development of information and communication technology. There has been a surge in regional and bilateral co-operation in software development in recent years, especially in e-governance and e-learning. Most technical capacity, however, remains concentrated in China, India and a few South-East Asian countries." As India and China have increasingly participated in global trade by technical upgrading, product diversification and expanding trade capabilities, their roles in boosting long run economic growth of the LICs in post-crisis period is substantial. According to Santos-Paulino and Wan (p.2, 2010a), 'rapid growth in China and India is a key driver behind the expected convergence of per capita incomes at the national level and internationally.' Under globalization, the prospect of forming Free Trade Agreement (FTA) in these regions calls for the analysis of a development strategy for technical and industrial cooperation between these countries. Based on this sui generis cases, India can be conceived as a *'hub*' region in South Asia which can potentially transfer benefits to neighboring nations serving as '*spokes*' to her; thus, in a Free Trade Agreement (SAFTA) *Hub-and-Spokes* (HAS, heretofore) type of trade arrangements could potentially be a conduit for growth propagation in poor nations in South Asia. Analogously, China's meteoric rise has established herself as a *hemispheric hub*. Thus, South-South and triangular knowledge transfer could create an opportunity for learning partnership between the 'new' growth-drivers and the relatively backward economies. Nonetheless, there are several preconditions--for example, structural and institutional reforms, infrastructure strengthening, foreign direct investment, improving governance, basic education, human capital, health, intellectual property rights, to name a few.

Any service or material outsourcing by relocating least efficient parts of production to cheaper locations can have positive productivity benefits, in the sense that it can provide inputs to other user firms at lower prices and results in fall in final goods prices. [14] *Without* any human capital augmentation and technological spillover for long–run growth, it leads to welfare loss as displaced workers in developing nations consume less, and face decline in standard of living than before. This creates incidence of poverty. For formulating an effective development strategy, the *triads* of growth, inequality and poverty are all important (Bourguignon 2004). According to World Development Report (2005), lower diffusion barriers, organizational innovation, and better investment climate in China helped to bring 400 million people out of poverty net. Many researchers have highlighted the nexus between trade, growth and poverty (Berg and Krueger 2003; Dollar and Kraay 2002; World Bank's Development

[14] Amiti and Wei (2004, pp. 36-58) in IMF working paper & in Finance and Development, IMF (pp. 38-39). Scope for India, China and its trading partners to benefit from fragmentation is enormous via sophisticated high tech products.

Policy Group's Global Economic Prospects 2004a; World Development Report, various issues; Robinson and Lofgren 2005, Winters et al. 2004). There are empirical evidences that trade helps nations to embark on a higher growth path (Frankel and Romer 1999; Helpman 2004, Lucas 2009a). However, given the income distribution, growth is beneficial for reduction of income poverty; but if growth leads to a worsening of the distribution, then poverty accentuates (Deininger and Squire 1996). According to Ravallion (1995, 2001, 2004), sensitivity of poverty to economic growth depends on *initial* income inequalities.

Gini Coefficient is the most widely used aggregate measure of income inequality with salient characteristics.[15] Although it captures overall income distribution aspect, it reflects the extent of poverty in a nation. According to Sen (1973), his poverty index is "essentially a *translation* of the Gini coefficient from the measurement of inequality to that of poverty." Ravallion (1994) also finds that rankings of inequality and poverty indices are similar and they move in unison with each other. By drawing on a relationship of poverty-growth-inequality triangle, Bourguignon (2003) showed that changes in income distribution could be attributed to growth effect (given unchanged *relative* income distribution) and distributional effect (given unchanged mean income). It can be envisaged that if an economy has egalitarian distribution then the fruits of economic growth, whatever be the source, permeates through social osmosis into the overall fabric of the society if it is targeted well by public policy. On the contrary, if a society has inegalitarian income distribution, there will be imperfection in absorbing the fruits of economic growth as every dollar generated due to growth bypasses the poor segment of the society. Yitzhaki (2002) decomposed inequality index into components reflective of extent of inequality among poor and rich classes so that it provides, like poverty indices, necessary information about *within* and *between-groups* inequality. In this work, within each cohort, 'skilled' are assumed to be 'non-poor' or relatively affluent whereas the 'unskilled' are assumed to be 'poor' or relatively less affluent. Within these cohorts, there are substantial income differences that are reflected in national Gini measures. Computed Gini across skill-unskill labor categories for the GTAP non-composite regions show that across almost all regions, compared to Gini index for skilled labor force, the Gini coefficient is lower for the unskilled.[16] This implies that *within-group* income inequality is

[15] Poverty gap (PG) is 'the mean shortfall from the poverty line expressed as a percentage of the poverty line. This measure reflects the depth of poverty as well as its incidence (World Bank 2008, p.348)'. We adopt the standard definition of Gini following World Bank (1998/99, p. 236), "Gini index measures the extent to which the distribution of income among individuals or households within an economy deviates from a perfectly equal distribution. ... [A] Gini index of zero would represent perfect equality and an index of 100 would imply perfect inequality." However, as this paper does neither develop a new measure of Gini index and Poverty, nor does it offer a critique of such family of measures in the literature, for parsimony, I do not elaborate on various aspects (see Sen 1973 and 1995).

[16] See Das (2008) for the computed indices, which are not reported for space limitations. Alternatively, for computing the Ginis, we have also taken percentage of people below national poverty line and 50% of median income for developed nations as proxy of proportion of people below poverty line. This measure is not accurate. However, because GTAP database has skilled income payment share we adopt tertiary education enrolment level as proxy of skilled.

higher for skilled.[17] As such, there are considerable heterogeneities across these two groups and so, we could expect considerable heterogeneity in the impacts of trade on inequality and poverty (Ravallion 2004).[18] Compared to the case of *initial* high-income inequality for relatively equal income distribution (i.e., relatively lower Gini for unskilled), economic growth has larger effect on poverty alleviation.

Technology can ameliorate the problems of bad governance, economic distance factors, productivity and enable a nation to move ahead. This depends also in '*scaling up'* of the successes so that it reaches the relatively less skilled segments, and thus can have a dampening effect on inequality. According to Dyke (2001), "Poverty can be eliminated within the next 50 years if a broad range of technology—not only information technology—is used as a tool to spark and enhance a comprehensive development strategy that encompasses economic, political, social, and environmental elements. Technology is not a solution in itself, but it has enormous potential to speed poverty reduction (p. 17)."

However, according to Sen (p.9, 1995) "the theory of inequality evaluation has close links with that of assessment of poverty, and the choice of space becomes a central concern… If poverty is seen as the deprivation of some minimum fulfillment of elementary capabilities, it becomes easier to understand why poverty has both an absolute and a relative aspect. These considerations are important in dealing with poverty in any country (rich or poor). Thus, Sen (1995) calls for an 'explicit consideration of the relation between deprivations in' income and the capability to enjoy the fruits of economic growth. As argued by Sen (1993, 2004), combination of failure of entitlements (i.e., lack of resources) and capability failure (i.e., inability to transform commodity characteristics into useful functioning) leads to poverty. In this paper, we adopt this broader connotation of poverty— economic 'unfreedom' (Sen 1998). The empowerment via investing in technology and socio-institutional fundamentals confers freedom as a means to the end of emancipating people from economic unfreedom or poverty. Access to knowledge-capital broadens the initial entitlements conducive for growth, whereas the important *functioning* of being able to reduce incidence of poverty depend on the TAP parameters for knowledge-absorption. These factors expand the 'capabilities' and convert 'expanded set of entitlements' or access to technological improvement to well-defined action by dint of enhanced productivity. However, even with accessibility to foreign technology *without* 'right' combination of AC, SC, GP and TC parameters there is scope of *capability failure*, which might translate into failure of achievement of important functioning resulting in increase in poverty gap.[19] In other words, the essential idea here is not, as such,

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[17] According to Yitzhaki (2002), it is an increasing function of poverty line. If the cutoff poverty line is below the overall mean income then, between -group inequality will rise with the poverty line because then, proportion of people living below poverty line will have income lower than mean income of the whole group. Thus, those who are above poverty line will have higher average income, much higher than the cutoff line of poverty.

[18] The Gini values across skill categories are discussed in detail in other paper (Das 2008). As this article has a different focus, we do not report it here for space constraints.

[19] Given the primary emphasis of the paper, viz., impact of innovation capture on inequality and subsequently on reduction of economic gap, it is to be noted that we consider here poverty gap (PG, see sections 3 and 4 below) and hence, we do not consider poverty and inequality synonymously. As has been mentioned by Deaton and Dreze (2002), inequality's reflection can be found in poverty measurement and PG can give equally good measure like head-count ratio.

about the role of income transfer, per se, between wealthy and non-wealthy; rather, it focuses on the role of socio-economic factors and institutional arrangements in developing capabilities so as to achieve arrays of alternative functioning opportunities e.g., innovating efficiency by harnessing the fruits of technical progress.[20] Technology or income gains, *per se*, might be necessary for expansion of opportunities and achieving technical efficiency; however, 'freeing' up the constraints or limited capture via quality social arrangements and promulgating absorptive capacity is quasi-sufficient to proffer higher degrees of freedom to ward off deprivation—technological as well as human capital-wise—and hence, poverty. With knowledge-capital (either indigenous or acquired capabilities), the gap will shrink as the capability expansion will make the innovation system efficient with relatively better opportunity space. The recipient nations with favourable initial conditions (quality education, innovative capabilities and other socio-institutional factors) will be in a better position to accumulate capabilities for uptaking ideas and innovation, reducing morbidity, and achieving better human capital than the stagnating ones. However, degree of such innovation-diffusion and dampening of poverty gap is conditional on the virtuous circle of technology, poverty and inequality[21] In fact, acknowledging country-specific idiosyncrasies, Fosu (January 2011) presents recent global evidences to show that although economic growth and income inequality both matter, initially favourable income distribution matters for growth to be effective in poverty reduction and thus, lends support to my thesis.

3. Technology Spillover, Capture and Poverty Gap: Rationale and a Model

3.1 Underlying Theoretical Premise

In this paper, we construct an empirical general equilibrium model (a modified version of a global trade (CGE) model) to highlight the role of skill, governance, structural congruence between advanced source and relatively backward nations for assimilating the technology.

According to the UN (2010, p. ix) MDG Gap Task Force Report, after the crisis as there are huge gaps in meeting the MDG 8 commitments, 'improved access to new technologies has become increasingly pressing'. Different factors affect the capacity to capture the benefits of technological innovation. Effective assimilation depends on the skill intensity of the labor force--i.e., absorption capacity (**AC**). It depends on education and schooling years (Barro and Lee, 1996; Cohen and Levinthal, 1989, 1990; Nelson, 1990). Investment in human capital, for instance, can help developing technological capability. Although lack of formal education might not pose serious obstacles for

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In case of India, the study finds that in 1990s an increase in inequality does not accompany unprecedented improvement in poverty gap with divergences in social progress parameters across regions. According to Sen (1995), income gap and head-count are inadequate measure of poverty as income transfer/gain does not give true picture of aggregate poverty as it ignores inequality in income distribution among the poor. In Sen's formulation (p. 104, ibid.), aggregate poverty measure is function of income gap, head-count as well as Gini coefficient of inequality. This justifies the rationale in this paper.

[20] For example, in case of green revolution, gene revolution, or any emerging technologies the capability to adopt and adjust (via public-private joint venture of R&D) leads to fall in micronutrient deficiencies of the laggard nations, improvement in their human capability via nourishment and better health, and productive efficiency gains. Thus, it 'frees' the individuals from the lack of capability to use technology.

[21] Bussolo and O'connor (2002) discussed this in the context of India, China as well as others for emerging technologies.

embracing 'new' ideas, knowledge deficiency is surely a handicap, in general, for procurement, absorption, and effective dissemination of technology.[22] Rather than standing on the shoulders of the giants, education or cognitive skills (in the broad sense) reinforce the other facets—like social learning, networking, institutions, and quality government—conducive for overcoming the backwardness. In a similar vein, it is pertinent to note that: "the backwardness of individuals as economic agents is an unfortunate cause and result of poverty. Schooling and training are commonly advocated as means of raising creative capacity and inspiring achievement." (Meier and Stiglitz, 2002, p.4). [23] In African growth context, Onyeiwu (p. 4, March 2011) presents both arguments—for and against—of developing AC and TAI. In particular, it has been shown that because of lack of adequate technological innovation and absorptive capacity the African firms produce low-end products and experience slow growth. Paus (2005) mentions that: "the absolute number of skilled and educated workers in a developing country is one factor that ceteris paribus influences the amount of high-tech FDI a developing country can attract." Chen (2008) has found that the primary motive of location of R&D centres in China has been the supply of 'best talents.' Not only that, several recent research, viz., Lucas (2009a&b), Jones and Romer (2010), Hsieh and Klenow (2010), amongst others, have mentioned the importance of this linkage.

Technology and human development are intimately related via enhancement of human capabilities, reinforcing each other in a virtuous circle. Domestic invention and foreign-sourced technological spillovers depend, *inter alia*, on a country's institutional setting like political stability and good governance (Groot et al. 2004; De Ferranti, et al. 2003, Coe, Helpman and Hoffmaister 1997, 2008; Dasgupta 2009). Being familiar with another country's institutional factors like legal side protecting intellectual property rights (IPRs), habits and even languages that one geographically closer country becomes culturally congruent and socially cohesive. The role of governance and institutional quality along with education in appropriating the diffused spillovers can not be underestimated. In fact, broadening the connotation Dasgupta (p.3, 2009) argues that "that a natural place to look for the worth of social capital in macroeconomic statistics is "total factor productivity" (TFP). But that implies that TFP is an amalgam of technology and institutions." Typically, in countries with low income level and

[22] Recently, while explaining an 'educational puzzle' in case of Germany, importance has been ascribed to 'a combination of schooling and apprenticeship' as a 'reliable supplier and shaper of the sort of labour German businesses need to make goods of high quality.' Moreover, it recognizes that 'the best long-run predictor of a country's economic growth rate is the performance of its children in comparative tests in science, maths, and so forth (The Economist, p.64, February 2011). Hanushek and Woessmann (2008) has presented evidences supporting complementarity between cognitive skill as well as quantity and quality of schooling institutions are important for closing the economic gap.

[23] Absorptions of 'ideas' or innovations (in Schumpeterian sense of entrepreneurship) require some basic level of education. In case of low-value added segments, like assembly jobs in a vertically integrated production structure, higher human capital content might not be essential as unskilled workers can perform the routine, mechanical job by sheer learning-by-doing. However, without a 'basic' level of educational background via schooling, making effective use of even that knowledge imparted via on-the-job training and its successful implementation is quite difficult. In other words, a certain threshold level of formal education enables one to be receptive to new vintage technology in the first place and then, the higher is the extent of educational attainment via formal schooling, the higher is the scope for accessing sophisticated and scientific ideas embedded in technology and improving further (Lucas 2009a, Jones and Romer 2010).

higher extent of poverty, the issue of bad quality governance is important to consider. We incorporate the institutional factors via a parameter reflecting the index of governance (**GP**). Typically, it is argued that technology transmitted from the source will deliver the potential benefits to the recipients if the level of governance quality of origin vis-à-vis client is (almost) similar, if not identical. Also, better GP can enhance integration, facilitate trade flows, and makes it structurally homogeneous.

Not only hindrance in acquisition of AC and TC, but also *socio-cultural distance* limits the extent of knowledge diffusion and widening of the existing technology frontier. For cultural affinity that determines the degree of social cohesion and acceptance of 'new' technology in a region, it is assumed to depend on overall quality of human resource development. We incorporate such effect via exogenously specified 'social acceptance (**SA**) parameter'--a composite measure representing quality of life. This measure also captures the effect of human capital, via human resource development and improvement in living standard, on reduction in deprivation. Conjointly, source and destination-specific **TC** and **GP** determine the binary institutional-structural congruence index (SC) which together with the absorption capacity (AC) and social acceptance (SA) parameters determines the *amalgam* technology appropriation parameter (**TAP**)--encapsulating the role of SC, TC and AC in harnessing the benefits of technology transfer. The magnitude of such *composite index* confers some objective measure of proximity (unity identifying almost proximate regions, while zero indicating maximum incongruity).

State-of-the-art technologies of recent vintages, invented in the developed countries (DCs), are *embodied* in the commodities produced using the new 'ideas.' The spillover to the destinations happens via bilateral trade linkages.[24] Sustained growth and development depends on indigenous innovation potentials and on their capabilities to assimilate advanced technologies, and this is especially true for the low-income nations (Pack and Westphal 1986; World Bank 2007&2010; Das 2008). Current vintage technologies such as bio-nanotechnology and ICT require expertise for utilisation (Jones and Romer 2010).[25]

3.2 A Model

An exogenous technological improvement in unique sector of source induces spillover effects to all other sectors in the source and destinations via traded intermediates. This is facilitated by increasing fragmentation of production technology in separate production blocks involving trade in middle products enriched in technological contents (Jones 2000). Lucas (2009a&b) has formally modeled the role of knowledge (ideas), its 'social and reciprocal' character and emphasized the importance of trade-led diffusion of ideas for endogenous technological progress and economic growth.

[24] Thus, international trade in commodities facilitates propagation of superior 'technologies' embodied in those traded goods and services (Eaton and Kortum, 1996; Keller, 1998, 2001, 2004; World Development Report, World Bank, 1999 for empirical evidences).

[25] In this paper, we consider emerging technology like ICT as it is a general-purpose technology (GPT) with pervasiveness. The ability to use such modern technology requires a threshold level of skill even for basic functioning.

As specified in equation (2), trade-induced knowledge spillover to a particular sector in the client regions depends on input-specific trade intensity via fragmented technology. Unlike several studies offering aggregated mechanism for say, FDI and factor market effects and skill formation, ours offer an aggregative mechanism for technology capture (via factors determining macroeconomic channel) while technology transmission is modeled via micro-transmission mechanism underlying sectoral productivity spillovers.[26] Hence the embodiment index is defined in terms of trade intensities for different specific material inputs--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 intermediates used by sector 'j' in 's' [M_{ijs}]. Thus,

$$E_{irjs} = F_{irjs}/M_{ijs} \qquad (2)$$

where F_{irjs} is the imports of 'i' from source 'r' used by sector 'j' in recipient 's'. M_{ijs} is the value of purchases of traded intermediate i by firms in industry j of region r. For governance parameter (**GP_{rs}**), it is measured by the following function:

$$GP_{rs} = min\ [1, GP_s/GP_r] \qquad (3)$$

According to (3), if destination's' has higher GP_s than that of source 'r' i.e., GP_r, then it is conducive governance structure for's' to effectively utilize the transferred technology. Otherwise, a backward client region lags in institutional quality [i.e., $GP_s<GP_r$], and faces hindrance for absorbing the technology even with higher AC ($0 \leq GP_{rs} \leq 1$).

Analogously, for *technological congruence* factor (**TC_{rs}**), measuring proximity or closeness between the source and the client regions 'r' and 's', is defined as below:

$$TC_{rs} = min\ [1, TC_s/TC_r] \qquad (4)$$

Here, $TC_{rs} \in [0, 1]$ with zero, representing distancing away from the invention frontier of the inventor and unity implying otherwise. For Social acceptance (SA_s) indexes, it is given by:

$$SA_s = \min[1, \frac{SAs}{SAthreshold}] \qquad (5)$$

This implies that a larger magnitude of social acceptance (via human development) than the threshold level is conducive for AC. It binds the value within unit interval and captures the notion that, depending upon technology, up to a certain limit the low level of human development obstacles

[26] The model developed here considers the spillover mechanism at the sectoral level emphasizing micro-level mechanisms via trade in intermediates and its impact on productivity. However, the capture parameters like AC, TAI, TC, and GP are done at the aggregate level because of paucity of data at the sectoral level for all global regions in a multi-regional world trade model. Parsimony of data in a multi-regional setup for all sectors limits our analysis in the current paper. Sector-specific absorption and other parameters could be considered for further extension. Given the current focus and primary emphasis, it does not undermine our purpose. In fact, Das (2010) has outlined such a micro-transmission channel, which awaits implementation in a large-scale general equilibrium framework. I thank a referee for helpful feedback.

acceptance, but beyond the minimum level, it facilitates adoption. The threshold level of social acceptance proxied by human development index (HDI) measures standard of living and quality of life. This provides the basis for improvement in social status and poverty alleviation.

The definition for the spillover coefficient is given by:

$$\gamma_{ijrs}\left(E_{ijrs},\theta_s\right)=E_{ijrs}^{1-\theta_s} \qquad (6)$$

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

$$\theta_s = AC_s.SA_s.SC_{rs} \qquad (7)$$

whereas

$$SC_{rs} = GP_{rs}.\ TC_{rs} \qquad (8)$$

The actual productivity level from the potential streams of 'current vintage technology' depends on $\theta_s \in [0,1]$ with $\theta_s=1$ implying full assimilation of technology.[27] For destination region's', θ_s and E_{rs} jointly determine the value of the '*Spillover Coefficient*' $\gamma_s(E_{rs}, \theta_s)$ such that:

$$\gamma_s(0)=0,\ \gamma_s(1)=1,\ \gamma_s' = (1-\theta_s)\, E_{rs}^{-\theta_s} > 0,\ \gamma_s'' = -\theta_s(1-\theta_s)/E_{rs}^{1+\theta s} < 0.$$

where primes indicate the first (′) and the second (″) derivatives with respect to E_{rs}.

More specifically,

$$\gamma_s\left(E_{rs},\theta_s\right)=E_{rs}^{1-\theta_s}\ ,\ 0 \le \theta_s \le 1 \qquad (9)$$

In the source region, the benefit of a technological change in a sector is reaped *directly* by the other sectors via the usage of *locally* produced intermediates embodying superior technology and *indirectly* via imported intermediates. Exogenous TFP improvement in 'r' has a *domestic* spillover effect in the receiving sectors via so that:

$$E_{ijr} = D_{ijr}/M_{jr} \qquad (i \neq j) \qquad (10)$$

where D_{ijr} is the quantity of domestic tradeable commodity 'i' used by firms in sector 'j' of source 'r' and M_{jr} is the domestic production of 'j' in 'r'. The spillover coefficient for source is:

$$\gamma_{ijr}(E_{ijr},\theta_r)=E_{ijr}^{1-\alpha_r} \qquad (11)$$

where $\alpha_r \in [0, 1]$ is the human capital and social acceptance based capture-parameter for source 'r'.

[27] As mentioned before, Dasgupta (2009) and Kauffman (2004) provide overview of such indicators of socio-economic and political stability. In fact, corruption and bad governance create a pernicious cycle of syndromes inhibiting growth and social distrust causing the economic system to collapse under infernal regime. The composite capture-parameter encapsulates such factors. As we do not explicitly model these factors and the focus is more on assimilation aspect, we set aside detailed overview on such issues.

Generically, TFP transmission equation can be written as:

$$\text{ava(j, s)} = E_{ijrs}^{1-\theta_s}\,.\text{ava (i, r)} \qquad (12)$$

where ava (i,r) and ava (j,s) are respectively the percentage changes in TFP levels in source and destinations [i≠j are the innovating sector and the receiving sectors respectively, and r≠s]. In our model,θ, is the capture parameter composite of AC, SS, TC and GP [θ∈ (0, 1)].

Following our discussion, spillover coefficient and technology appropriation parameter are crucially dependent on these structural factors. Starting with an existing level of income inequality, one can reduce inequality and hence, incidence of poverty provided some factors counter the inequality-inducing effect of general-purpose technology like ICT. The factors that work *against* the inequality convergence effect are lack of human capital, bad governance, lack of innovation capability, and inept institutional structure. Fostering technology could induce structural change, impact on income inequality and lead to higher incidence of poverty with more unequal income distribution—the inequity in distribution even with higher average level of income sends more people in poverty.

Unlike previous studies, we incorporate the aspect of geographical dispersion of productivity spillovers and its repercussions on poverty gap elimination. Poverty is a multidimensional concept and human development index (HDI) is a 'conglomerative' index of relative human deprivation, as argued Anand and Sen (1997). In our formulation, we consider Human Development Index (HDI) as a proxy for social acceptance of foreign technology, embracing a wider perspective of poverty.[28] However, we focus on the role of Capture-parameter as a facilitator in such mechanism. Higher capture implies higher spillover coefficient and hence, higher TFP and labor productivity. Thus, higher trade-mediated technology flows and induced-productivity escalation depend on higher values of spillover coefficient and θ whereas θ-values depend on constellation of AC, SS, TC and GP. Higher θ means lower Gini values and vice versa. Therefore, trade can facilitate inequality convergence if these factors are appropriately functioning so that with perfect capture [i.e., θ = 1], inequality is non-existent [G = 0] whereas with abysmally low knowledge harness [i.e., θ = 0], inequality is extremely high [G = 1], causing extreme poverty. In particular, we postulate an inverse logistic relationship[29] between $G_{initial} \in [0, 1]$ and θ∈[0, 1] such that when θ rises from 0 to 1, $G_{initial}$ falls from 1 to 0. Therefore, we write, for any region 's', generically:

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[28] Human Poverty Index is an alternate measure of income poverty and it is deprivational index (Anand and Sen 1997). It includes three components viz., survival deprivation, educational and knowledge deprivation, and economic deprivation.

[29] One could have an inverse linear specification where $G_{convert} = 1 - F(G_{initial}, \theta)$. However, this is not strong specification. Alternatively, another nonlinear specification is Cobb-Douglas: $G_{convert} = G_{initial}^{[1-\gamma s(Ers,\, \theta s)]}$ where no spillover implying $\gamma_s = 0$ means $G_{convert} = 1$ (that is, perfect inequality) and $\gamma_s = 1$ implies $G_{convert} = G_{initial}$ (that is, initial inequality prevails) without any magnification of inequality.

$$\mathbf{G}_{\text{convert}}(\mathbf{r}) = \mathbf{G}_{\text{initial}}(\mathbf{r}) * \frac{\mathbf{e}^{-\mathbf{g}\gamma(\mathbf{r}).\eta(\mathbf{r})}}{\mathbf{Y}_{\text{initial}}(\mathbf{r}).\mathbf{e}^{-\mathbf{g}\gamma(\mathbf{r}).\eta(\mathbf{r})} + 1} \qquad (13)$$

where

g: average proportional rate of decrease of Gini coefficient due to growth in trade dependency ratio (trade as a percentage of GDP).

γ (s): regional spillover coefficient parameter.

η(s): poverty elasticity with respect to trade liberalization;

$Y_{initial}$ (s): initial poverty threshold income level, normalized to *unity* (benchmark) for each 's'.

Given $\gamma'_s = (1-\theta_s)\, E_{rs}^{-\theta_s} > 0$, we can use equation (11) to infer that

$$\frac{\partial \mathbf{G}_{\text{convert}}(\mathbf{s})}{\partial \theta_s} = \left[\frac{\mathbf{G}_{\text{initial}}(\mathbf{s}) * \eta(\mathbf{s})}{\mathbf{Y}_{\text{initial}}(\mathbf{s}).\mathbf{e}^{-\mathbf{g}\gamma(\mathbf{s})} + 1}\right] \times (-\mathbf{g})\mathbf{e}^{-\mathbf{g}\gamma(\mathbf{s})} \times \gamma'(\mathbf{s}) < 0 \qquad (14)$$

Thus, from a policy perspective, for a nation with an existing level of inequality or poverty, she could surpass the 'inequality trap' and achieve growth if there is appropriate constellation of factors like literacy, education, social capital, governance, democracy, economic freedom, infrastructure, etc. These factors determine the capture (θ). Thus, trade and technology can have dampening effect on Gini via growth, trade, technology nexus (Hertel and Reimer 2004, Dollar and Kraay 2002, Cline 2004, McCulloch, Winters, and Cirera 2001; Winters et al. 2004).

Unlike prior research focusing *only* on the nexus between Gini coefficients and economic growth vis-à-vis trade, our study contributes by extending the extant research via incorporating the distributional impact of technology spillovers. Following Bourguignon (2004), for small mean income changes and changes in distribution of relative income, change in poverty is a function of growth in mean income and change in relative income distribution. Poverty gap is another signaling indicator of income inequality gap.[30] According to Chen and Ravallion (2004), 'poverty gap [measures] the mean distance below the poverty line as a proportion of the poverty line. It reflects inequality among the poor (assuming that non-poor or rich has zero gaps). Thus, according to Bourguignon (2004), changes in growth and inequality in (relative) distribution generate changes in poverty depending on initial inequality. In our model, we postulate that the higher is the value of the technology appropriation parameter (contingent on the constellation of parameters for AC, GP, TC and SC), the higher will be the rate of appropriation of technology and hence, the higher will be labor productivity leading to lower inequality (i.e., lower Gini coefficient). The crucial role ascribed to technology appropriation parameter determines the effect on poverty gap and income distribution. The initial poverty gap in a region 'r', being dependent on technology capture, is reduced by the spillover; given transformed Gini indexes

[30] Chen and Ravallion (2004, World Bank Research Observer) defines Poverty Gap, PG = [1 – ratio of mean income of the poor to the poverty line] × Head count ratio.

($G_{convert}$), the higher is the absorption capability measured by capture parameter, the lower is the inequality gap.

Let PG_r: poverty gap in *any* region 'r'.

$G_{convert}$ (r): transformed Gini values due to spillover effect (as before from equation 13).

μ(r): mean absolute income of a nation 'r' as ratio of income to poverty line of $1.08 a day (see Chen and Ravallion 2004).To show the mechanism, for any r, we define:

$$PG_r = G_{convert}(r) - \mu(r) \times \ln(\theta_r) \qquad (15)$$

Thus, *given* $G_{convert}$ (r) and μ(r), $\partial(PG_r)/\partial\theta_r = -\frac{\mu_r}{\theta_r}$, where θ, μ > 0. This means that for given income μ(r) when capture parameter augments the spillover, the poverty gap diminishes.

However, for binary relation between two regions—source and destinations—'r' and 's', the Gap in Gini for any destination region 's' when 'r' is unique ('r' being unique source region) is,

$$PG(s) = G_{convert}(r) - \mu(s) \times \ln(\theta_r/\theta_{rs}) \qquad (16)$$

Hence, using (14), given $\frac{\partial G_{convert}(s)}{\partial\theta_s} < 0$, we write also $\partial(PG_s)/\partial\theta_{rs} < 0$.

On this basis, for all 'r' we implement a linear specification of (15) where capture parameter enters linearly in the equation such that[31]

PG (r) = $G_{convert}$ (r) – Initial Poverty Gap **(r) × θ_r.**

The upshot is that: higher capture-parameter translates into higher technological spillover; also, per capita income of recipients rise due to induced productivity escalation. This, in turn, translates into reduced income and productivity gap, which transforms into fall in poverty *gap*.

4. Methodology, Framework, and Simulation Design for implementation

For our analysis of technology, trade and inequality, particular focus is given on the emerging economies India and China, as they comprise almost 33% of the population of the world. The headcount fraction of population in poverty ($2) is at 53.7% for China and 86.2% for India (Cline, 2004). We explore the possibility (or impossibility) of reduction in income poverty in these major economic heavyweights via trade with their major trading partner the US (i.e., developed North). Implications of policy reforms on reducing inequality and poverty are important for these two countries as they are important trade partners of the US. Scope of a hub-and-spoke three-player configurations between USA vis-à-vis India and China in global trade policy scenario is an important factor (a la Fugazza and Robert-Nicoud 2006). We consider two generic types of shocks viz., **[1]** trade policy shocks related to trade

[31] This is motivated by the fact that we do not have data for μ(r) for GTAP composite regions. However, given the primary focus of our research this linear (instead of log-linear) specification suits our purpose to support our conjecture. The derivative, as in equation (15), is negative implying capture-parameters' dampening effect on the poverty gap.

liberalization episode under Hub-and-Spokes (HAS) vis-à-vis FTA between India and China, multilateral trade liberalization between USA and other regions, and **[2]** technology shocks related to TFP in high-technology sector in USA.

4.1 Database

In the context of analysis of trade and poverty, use of such CGE models is also practiced—see Cline (2004), Hertel and Reimer (2004). However, in discussing the poverty impact of trade policy the computable general equilibrium (CGE) literature on South Asia (India, Sri Lanka, or Bangladesh) and South East Asia is not so proliferating. That also motivates us to focus on emerging economic heavyweights, namely, India and China.[32] Multi-regional, multi-sectoral CGE models score over other analytical tools for modeling global trade policy issues (Hertel 1997).Literatures abound with models that focuses on the trade policy issues especially in the context of Europe, North America, and South America (see Bhagwati 1993, Francois and Sheills 1994). Unlike, partial equilibrium models and Social Accounting Matrix (SAM) and Input-Output models, CGE approach is far more sophisticated in tracing the intersectoral and inter-regional linkages. It accounts for repercussions in other regions and sectors in response to an exogenous policy shock. In particular, Global Trade Analysis Project's (GTAP) Version 6 global database and the modified CGE trade model is used for undertaking the research (Hertel ed. 1997; Dimaranan and McDougall, 2003).[33] A reduced dimension 14×12 aggregation of the database is used for calibration. Choice of regional dimension is motivated by our primary emphasis on the trade-growth-poverty nexus. We consider twelve commodity types. Each trading region engages in trade with other regions. High-technology products are supposedly intensive in sophisticated technology and trade in such products is a primary conduit for technological spillover across borders. Following Armington (1969) specification, products are differentiated by geographical regions of origin. Table 4 presents the regional and sectoral aggregations. Table 5 shows the sectoral composition.

[32] As mentioned in sections 2 and 3 above, performance of India and China, despite idiosyncratic features, receives special attention in present study as they are most populous and emerging growth engines or giants.

[33] GTAP 6 is the latest release of the database based solely on the beta release of Version 5.4 database. However, Version 6 extends the beta release to more regions with same number of sectors and those regions are not subject of analysis in the present research and hence, it does not undermine our purpose.

Table 4 - Sectoral and Regional Aggregations used for the implementation

Version 5.4 Sectors with Identifier	Version 5.4 Regions with Identifier
1. Pdr [Paddy, Rice]	1.USA [United States]
2. Wht [Wheat]	2. CAN [Canada]
3. Gro [Grains]	3. Ind [India]
4. LMNFCS [Light manufacturing]	4. Chn [China]
5. HMNFCS [Heavy manufacturing]	5. Jpn [Japan]
6. HITECH [High Technology Products]	6. Sam [Latin American Countries]
7. V_F [Vegetable, Fruits, etc.]	7. MERCOSUR [Argentina, Brazil, Uruguay, Paraguay]
8. Osd [Oilseeds]	8. Sea [South East Asia]
9. Extract [Natural Resources]	9. Osa [Other South Asia]
10. Food [Food and Agriculture]	10. Slk [Sri Lanka]
11. TexClt [Textile and Clothing]	11. HTW [Hong Kong and Taiwan]
12. SVC [Services and activities, NES]	12. Bgd [Bangladesh]
	13. EUFTA [European Union]
	14. Rest of the World [ROW]

Source: Author's aggregation based on GTAP V5.4/6 database.

Table 5- Sectoral Composition

Sectoral Aggregation	GTAP Sectors
Paddy	Paddy rice,
Wheat	Wheat,
Grains	Cereal grains nec,
V_F	Vegetables, fruit, nuts,
OSD	Oil seeds,
Food	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, Meat products nec, Vegetable oils and fats, Dairy products, Processed rice, Sugar, Food products nec, Beverages and tobacco products
Extract	Forestry, Fishing, Coal, Oil, Gas, Minerals nec, Petroleum, coal products
TexClt	Textiles, Wearing apparel
Light manufactures	Leather products, Wood products, Paper products, publishing,
High-tech manufactures	Electronic equipment, Machinery and equipment nec, Manufactures nec
Heavy manufactures	Metal products, Motor vehicles and parts, Transport equipment nec, 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 author

The GEMPACK software suite developed at the Centre of Policy Studies, Monash University, Melbourne, Australia is used to conduct simulations (Harrison and Pearson 1996).

4.2 Parameters Settings:

In keeping with the theory, our augmented theoretical model incorporates four sets of parameters in addition to the standard GTAP model parameters. These are skill-induced *AC* index, governance parameter *GP*, social acceptance parameter *SA*, and technological proximity parameter *TC*. For AC, we calculate the regional skill-unskilled labor payment shares and use those regional skill-intensity ratios, as proxying AC. Calculation shows that α_r proxying AC_{USA} and AC_{HTW} is the highest of all the regions. Calculated AC-values are such that $AC_{USA} > AC_{HTW}$ $AC_{EUFTA} > AC_{JAPAN} > AC_{MERCOSUR} > AC_{SAM} > AC_{CAN} > AC_{CHINA} > AC_{INDIA} > AC_{SOUTHASIA}$. However, for composite regions such as Hong Kong-Taiwan, South East Asia or South America the figures are high. Canada falls behind EU and Mercosur whereas intra-group differences are small and show similar intensity implying more or less similar pattern of skill-intensity.

Regarding binary structural congruence parameter (**SC**), we consider two constituents: TC and GP. For **GP**, we use the World Bank's most recent and comprehensive data on six dimensional governance indicators (Kauffman et al. (2003) and Kauffman (2004)).[34] These values at much disaggregated level are bounded between -2.5 and + 2.5. However, based on these disaggregated observations for each regional category, we construct a simple average, *composite governance indicator* for each GTAP region. Typically, as the six aspects are, *'by virtue of inherent commonality*', interrelated, the indicators suit our purpose. 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. Then, we transform via Equation (3) to find *binary indexes* of the concerned regions with unique source. We consider absolute magnitude of the indexes as we make *relative scaling* for binary comparison with respect to USA as the benchmark. The values are bounded between '0' (extremely low degree of governance) and *unity* (i.e., like the value for USA vis-à-vis Canada and EU with high-quality governance). Based on these findings, we infer that USA, EU, Japan and Canada are more institutionally homogeneous as opposed to low-income countries. However, for South Asia and East Asia, these values are not as low. In case of India and Sri Lanka as compared to Bangladesh and other South Asian countries, the magnitude of GP parameter is higher -0.65 and 0.69 respectively.[35] In case of China, the value of this binary parameter is lower (0.32) compared to Hong Kong – Taiwan composite region (0.74). This is owing to the government's ineffectiveness in providing better institutional variables like property rights or governance.

The values of TAI measure are taken from Human Development Report (2001) and R&D figures are taken from Human Development Report (2003). For those regions where such values are missing, in conformity with the same pattern of values of R&D expenditure share in GNP, we proxy the

[34] These indicators for perceived institutional quality are: Voice and accountability, Political stability, Government effectiveness, Regulatory quality, Rule of law, and Control of corruption. Although basic calculations and data sources are presented, the values of such parameters for AC, SA, TC and GP are not reported here for want of space.

[35] By calculating the composite values of GP indices from its estimates of score of each of the 6 components, we get figures for Bangladesh and Sri Lanka as more negative compared to that in India. This implies better governance in India compared to those South Asian nations. But, taking absolute magnitude gives erroneous perceptions about this parameter. To avoid this inconsistency, we make adjustments by calculating regional averages of 6 indices (6.49) and then, take the difference of each of the countries GP values to compute the relative difference/distance from regional average of South Asia. This gives consistent measure of GP values of South Asian nations.

share values of hi- and medium- technology exports as indicators of technological achievement. We get higher values for USA, Canada, Japan and EU whereas for the rest we get relatively lower or same magnitude within a group (via Equation (9)). For **SA**, we consider human development index (Human Development Report, 2003). We take East and South East Asia's composite human development index for threshold values.[36] The model is solved using customized windows program Gempack.[37] We consider simultaneously generic types of shocks viz., technology shocks related to TFP augmentation in high-technology sector in USA and trade policy shocks under Hub and Spokes configuration.[38]

5. Scenarios and Results.

5.1 Technology Spillover Scenario: Pure TFP Shock

In this scenario, we consider exogenous total factor productivity augmentation in the Hi-technology sector in the USA that is transmitted to other regions. Under such a scenario, pure productivity shock spills over to the other laggard regions. 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, 1998, 2001) calculated a TFP index by industry for 8 OECD countries. We match Keller's (1998) 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, 1998), the average annual growth in multifactor productivity in the composite hi-tech sector was 3.2% during 1970-1991. We use linear extrapolation method to extrapolate growth rates over 6 years encompassing the simulated period[39]. In particular, we shock the Hicks-Neutral technological coefficient in USA in hi-tech sector by 4%. The closure is the standard GTAP macroeconomic closure (Hertel 1997). Two major spokes are India and China.

In this section, we consider macroeconomic repercussions. Because technological change is occurring in the manufacturing sectors, we confine our discussion mainly for hi-tech, heavy manufacturing and light manufacturing. 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 economy-

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[36] The reason behind choosing East and South East Asia as borderline case of threshold level is that these regions, over last two decades have embarked on a path of human resource–led development path and achieved remarkably high growth cycles. This miracular performance sets them as a reference region (World Bank 1998/99).

[37] 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.

[38] We could consider trade reform scenarios with different configurations. However, given the focus that is not reported.

[39] According to Keller (1997, 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%

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 6).

Table 6- *Simulated regional effects of 4% TFP shock in the Hi-tech sector in the US on selected macroeconomic variables (percent changes).*

Percentage change in:	US	Canada	EU	China	South America	India	Mercosur	Bangla-desh	Sri Lanka
1. Region-wide index of TFP growth	3.6	2.2	0.76	0.11	1.65	0.10	0.30	0.12	0.16
2. Real GDP at Factor Cost	3.6	2.2	0.76	0.11	1.65	0.10	0.30	0.12	0.16

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 the US; more importantly, amongst the recipients, Canada, EU and South America (including Mexico under NAFTA) receive 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. However, the discrepancies in TFP growth performances across regions can be attributed to differences in magnitudes of capture parameter and its constituents. The higher value of those parameters and hence, of the capture parameter [θ_r] magnifies value of the embodiment index; thus, enabling Canada, South America and EU to record a much higher rate of TFP improvement than other regions in South Asia and China. Higher volume of trade flows under NAFTA from USA inflates aggregate embodiment indexes in Canada and Mexico. Despite having higher θ_r in Mercosur than South America, higher embodiment index and spillover coefficient in South America translate into relatively higher TFP and welfare gains there (Table 7).

In case of India, China, Bangladesh and Sri Lanka the growth in TFP induced by spillover is of lower order of magnitude. This is owing to the fact that these countries, unlike those in NAFTA and EUFTA and Latin American regions, relatively speaking, do not have much trade with USA although liberal trade reform measures have been taking place in recent times. Moreover, due to lower values of trade-embodiment indexes the magnitude of spillover coefficient is much lower for these nations as compared to EU, Canada and South America. In addition, the values of the capture parameter are relatively lower in these countries compared to Japan, Canada, EU and Hong Kong, Taiwan. These lower values translate into lower regional TFP indexes for India, China and other South and East Asian regions in our model. Comparing the values we can infer that these regions are socio-institutionally much less congruent to the US and hence the transmitted benefits are not captured in its fullest potential as is found in case of more institutionally homogeneous regions like Canada or EU. Regarding post-simulation trade scenario, *aggregate* volume of exports increases in the principal beneficiaries of TFP changes, while for USA, it increases slightly. Real value of Imports increase for all regions except India and Mercosur. 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 countries and regions (namely, Mercosur, China , India, Sri Lanka and Bangladesh) for which export prices have fallen more than the aggregate import prices, have been able to improve their trade balance. The next section gives comparative enumeration of combined simulated effects of trade liberalization scenarios.

5.2 Analysis of Results for combinations of TFP shock and trade policy configurations:

To offer a comparative enumeration of technology invention policy, we consider two generic types of trade liberalization scenarios in the presence of spillover: firstly, HAS configuration of trade reform where the Hub, USA liberalizes trade with spokes India and China simultaneously (non-sequential) and subsequently, we simulate intra-spoke liberalization. In our case, we consider regional Sino-Indian free trade between India and China with technology transmission from USA to the spokes. That is, *firstly* two separate FTAs are simultaneously established: China-U.S. FTA and India-US FTA. Second, FTA between China and India: following the establishment of the HAS system, we simulate the implementation of the regional trade liberalization in which trade is liberalized between the spokes.[40]

In this scenario, we conjecture that China and India gain *directly* in HAS and FTA phase but other developing regions like Mercosur, South East Asia and Latin America gain *indirectly* in multilateral trade liberalization phase via USA vis-à-vis other economies—the reason being by simultaneously establishing FTA with the US, these regions get a head start directly. In the next phase of trade liberalization with FTA between India and China, Mercosur and other developing regions will be able to reap gains (indirectly) later out of this technology spillover from the US.[41] In the presence of the TFP shock, we simulate a one-shot emergence of a HAS (i.e., USA *simultaneously* forms FTA with India and with China). The results reported in Table 7 show that the TOT movement preserves the same ranking and order of magnitude except for China and USA 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 7). Also, China and India are able to register positive trade balance due to trade creation except Canada, and USA 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 Indo-China FTA is achieved by freeing trade between the spokes.

Table 7- *Simulated regional effects on aggregate performance without sequencing*

Regions	USA		China		India		South America		Canada	
Type of configuration→:	Joint HAS (1)	Indo-China FTA (2)	Joint HAS (1)	Indo-China FTA (2)	Joint HAS (1)	Indo-China FTA (2)	Joint HAS (1)	Indo-China FTA (2)	Joint HAS (1)	Indo-China FTA (2)

40 In particular, using the updated database from the previous experiment, we simulate trade liberalization between the spokes—India and China—to have full-fledged liberalization among the three players.

41 On the contrary, in a *reverse sequence* where at first China forms FTA with USA and then with India, the technological benefits will be harnessed by China at later stage only when USA liberalizes trade with her.

Changes in↓:										
1. Terms-of-trade	0.64	0.19	0.92	0.24	0.07	-0.27	-0.16	0.14	-0.32	0.15
2. Aggregate export price index	-1.06	-1.35	-0.79	-1.35	-1.56	-1.80	-1.62	-1.37	-1.66	-1.30
3. Aggregate import price index	-1.69	-1.54	-1.69	-1.59	-1.62	-1.53	-1.47	-1.50	-1.34	-1.45
4. Regional Household Income	4.06	3.97	0.74	0.30	0.21	0.20	1.81	1.89	2.31	2.48
5. Change in trade balance (in million US $)	-44010.22	-38978.11	-374.9	2370.9	581.33	882.83	179.36	-327.09	-1011.20	-1246.50
6. Welfare (EV) (in million US $)	293090.9	295569.9	5702.7	2322.3	773.62	721.39	13381.02	14032.1	13111.5	14199.4
7. Contribution of TFP to EV(in million US $)	285401.7	292745.3	1000.1	1246.1	503.58	710.30	12267.8	12158.7	11923.47	11926.1

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 FTA scenario, TOTs fall in India whereas other considered regions maintain the same sign. This is due to the fact that in the 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. However, under HAS and Sino-Indian intra-spoke liberalization scenarios the productivity mechanism and induced spillover reduces income inequality by small order of magnitude. These are in Table 8.

Table 8 **Values of original (Base Case) and ex post (Post-Simulation) Gini Coefficients under HAS and Indo-China FTA Scenarios**

		HAS	FTA Indo-China
Regions	**Initial Gini Coefficient**	**Gini Converted via Equation 13**	**Gini Converted via Equation 13**
1. India	0.325	0.3249	0.3248
2. US	0.408	0.405	0.405
3. CHN	0.447	0.4469	0.4468

Comparing rows 1 and 3, Table 8 we see that relative to initial Gini coefficients, *ex post* Gini values decrease under both HAS and intra-spoke FTA scenarios; also, as compared to HAS configurations, in Indo-China FTA scheme the fall in income inequality is a bit more. This is due to indirect spillover under full-fledged liberalization between India and China—two structurally and socio-institutionally more homogeneous Asian countries. Comparing India and China, we see that regional income and welfare changes are much higher in case of China. In case of South Asian bloc, India is ahead of Sri Lanka and Bangladesh because of higher doses of spillover values from USA into India as compared to other countries in that region of neighborhood.

Thus, we now analyze the effect of such productivity benefits and associated factors for income inequality as formalized above. When constellation of socio-institutional parameters like governance, social acceptance, human development and absorption capacity are optimal such that spillover coefficient and capture is higher, then, we see that Gini measure of inequality deflates from its original high value. Higher capture and resultant progress parameters in developed countries like USA, Canada, EU, and Japan translate into much reduced poverty gap from its initial endowment (compare columns in Table 9). In fact, in case of the source of technology creation, USA, the gap goes down considerably because of highest embodiment and technology capture.

However, the experiences differ across the recipients depending upon their variability in assimilation and capture of technology transmitted from the US. In less developed countries, the gap is reduced but much less than USA's richer trade-partners, viz., Japan, Canada, EUFTA, HTW. For India and China, it differs with relatively more gap reduction in case of former than the latter. Bangladesh and other South Asian nations lag behind India and China although they manage to reduce the gap a bit due to induced transmission benefits. Thus, comparative evaluation of regional performances exhibit that technology spillover with adequate capture is necessary for elimination of inequality and gap. In other words, the regions like India, China, South East Asia, Hong Kong, Mercosur have been able to reduce their original poverty gap and Gini coefficient owing to higher 'progress' and 'capture' of transmitted state-of-the-art from developed regions like USA, EU, Japan and Canada--either directly, or indirectly.

Table 9- *Values of Original and ex post Poverty Gap and Capture Parameters across Regions*

Regions	Capture Parameter	Aggregate Spillover	Poverty Gap (Original)	Poverty Gap (Ex post)	Gini Converted
US	0.71	0.82	0.31	-0.02	0.20
Canada	0.32	0.51	0.31	0.06	0.16
Japan	0.48	0.10	0.36	0.01	0.18
EUFTA	0.47	0.18	0.31	0.01	
HTW	0.33	0.19	0.36	0.06	0.18
India	0.03	0.02	0.72	0.14	0.16
China	0.03	0.03	0.42	0.21	0.22
South-East Asia	0.04	0.09	0.36	0.19	0.20
Bangladesh	0.002	0.02	0.67	0.17	0.17
Sri Lanka	0.05	0.04	0.67	0.18	0.21
MERCOSUR	0.08	0.07	0.40	0.23	0.27
South America	0.01	0.38	0.40	0.25	0.25

Now, the increase in income (row 4, Table 7) creates further gain via increase in gross investment and capital accumulation and hence, results in ‘trade-induced investment-led growth’. 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 10 reports the sectoral performances behind such growth effect. From the values of *sectoral* spillover coefficients (column 3, Table 10), it is evident that in USA sectoral TFP growth is highest in all three sectors as compared to other regions (column 4, Table 10). The highest value of capture parameter magnifies the values of spillovers there and hence resulted in higher TFP growth. Similar considerations apply for Canada, EU and South America. However, for the relatively laggard regions China and India with lower magnitude of θ_r, the resultant sectoral TFP growth is of very low magnitude (column 5, Table 10). 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 full-fledged FTA scenario India registers much larger fall in prices compared to China, due to direct and indirect transmitted productivity gains, thereby grabbing market access at the expense of China.

Table 10- *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	0.91	3.65	3.45
	HMnfcs	0.91	3.63	2.92
	HiTech	0.88	4.00	2.48
CAN	LMnfcs	0.63	2.48	2.44
	HMnfcs	0.59	2.34	2.23
	HiTech	0.66	2.62	2.15
China	LMnfcs	0.02	0.10	0.95
	HMnfcs	0.03	0.13	0.39
	HiTech	0.04	0.22	0.25
India	LMnfcs	0.02	0.12	0.82
	HMnfcs	0.02	0.12	0.13
	HiTech	0.05	0.32	0.11
South America	LMnfcs	0.47	1.85	2.05
	HMnfcs	0.48	1.90	1.74
	HiTech	0.50	1.99	2.15
Mercosur	LMnfcs	0.04	0.16	0.68
	HMnfcs	0.08	0.32	0.64
	HiTech	0.14	0.56	0.43

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

6. Conclusion and Policy Insights

Of late, with the rise to prominence of endogenous growth theory the role of international trade and foreign direct investment (henceforth, FDI) in facilitating trans-border technology flows and consequential rise in productivity has been of immense research interest. This paper addresses the effect of international trade and liberalized regime under trade policy configurations between USA and especially developing regions like India, South America, China, and other Asian nations on intra-national and international disparities in income inequality. We consider the dynamism of the high technology clusters viz., ICT in inducing productivity escalation and economic growth. By simulating an augmented version of a global CGE model, we find considerable welfare gains in each recipient.

In particular, the paper models a mechanism of income inequality reduction and elimination of poverty gap facilitated by technology appropriation. Higher constellation of social acceptance, institutional congruence, and better institutional variables aid technology assimilation, thus, leading to inequality convergence. Thus, income inequality falls with trade flows, provided capture parameters and its constituents are appropriate to harness the opportunities let open via global trade. Reduction in income poverty leads to poverty alleviation. In our model, we find that incidence of fall in inequality with global trade openness needs to be aided by the associated factors such as better governance, human capital, human development, social acceptance and socio-institutional congruence with developed nation with high per capita income. Followings are the prospective policy insights from the analysis:

a) Concomitant flows of technological benefits due to trade liberalization under FTA and role of technology policies help in achieving higher economic growth. In addition, government as well as private entrepreneurs effort for unleashing innovation potentials and promoting R&D efforts enable poverty reduction and economic development. In other words, government's role in designing and implementing appropriate domestic reforms by adopting a pragmatic approach is necessary for developing adaptive capacity.
b) There are income distributional impacts and benefits especially the effects under different trade policy and technology policy. A balanced outcome of the public-private actors enable realizing the innovation potential via promoting skill formation, education, quality institutions.
c) Educational attainment and other socio-institutional parameters have prominent role in harnessing the productivity benefits and hence, in enhancing technology capture to reduce income inequality and poverty of relatively laggard trading nations.
d) Public policy for promoting innovation and enabling factors like education, R&D, and good institutions is crucial for realizing potential growth and the Government's role is to prepare the ground as a 'gardener' (World Bank 2010). Role of industrialization, innovation, trade as well as domestic policies are all instrumental for inclusive growth. Tale of two nations—China and India— offers valuable lessons of innovation for other laggard nations to grow.

References:

Acemoglu, D. and Melissa Dell (2010). Productivity Differences Between and Within Countries. American Economic Journal: Macroeconomics, Vol 2 (1), pp.169-188.

Amiti, M., and S-J Wei (October 2004). "Fear of Service Outsourcing: Is it Justified?" IMF Working Paper, Research Department, WP/04/186. pp. 1-42.

Anand, Sudhir and Amartya Sen (1997). "Concepts of Human Development and Poverty: A Multidimensional Perspective." In Poverty and Human Development, Human Development Papers. Human Development Report Office. The United Nations Development Programme, NY, USA.

Barro, R. J. and J. W. Lee (1996). "International Measures of Schooling Years and Schooling Quality." Papers and Proceedings of American Economic Review. 86 (2), pp. 218-223.

Bayoumi, T., D. T. Coe, and E. Helpman (1999). R&D Spillovers and Global Growth. *Journal of International Economics* 47 (2):399-428.

Berg, A., and A. Krueger (2003). "Trade, Growth, and Poverty—A Selective Survey," Annual World Bank Conference on Development Economics 2003, World Bank.

Bhagwati, J. (1993), Regionalism and Multilateralism: An Overview, J. de Melo and A. Panagariya (eds), New Dimensions in Regional Integration (NY: Cambridge University Press).

Bonham, Carl and Byron Gangnes (Oct 26, 2004). "Fragmentation and East Asia's Information Technology Trade." Working Paper 04-9, University of Hawaii.

Bourguignon, Francois (March 2004). "The Poverty-Growth-Inequality Triangle." Working Paper No. 125, Indian council for Research on International Economic Relations, New Delhi, India.

-----------------(2003). "The Growth Elasticity of Poverty Reduction: Explaining Heterogeneity across Countries and Time Periods." In T. Eicher and S. Turnovsky, eds. Inequality and Growth: Theory and Policy Implications. Cambridge: MIT Press.

Bussolo, Maurizio and David O'Connor (2002). "Technology and Poverty: Mapping the Connections." In Jorge Braga de Macedo and Tadao Chino (eds.), Technology and Poverty Reduction in Asia and the Pacific. Development Centre Seminars, OECD.

Cline, W. R. (2004). "Trade Policy and Global Poverty." Centre for Global Development, Institute for International Economics. Washington DC, USA.

Chen, S., and M. Ravallion. (2004). "How Have the World's Poorest Fared since the Early 1980s?" The World Bank Research Observer, 19 (2), World Bank, pp. 141-169.

Chen, Y-C. (2008). "Why do multinational corporations locate their advanced R&D centres in Beijing?" Journal of Development Studies, 44 (5). Pp. 622-44.

Coe, D., and E. Helpman (1995). International R&D Spillovers. *European Economic Review* 39 (5): 859-87.

Coe, D. T., E. Helpman, and A. W. Hoffmaister (1997). North-South R&D Spillovers. *The*

Economic Journal 107 (January): 134-49.

Coe, D. T., E. Helpman and A. Hoffmaister (2008). International R&D Spillovers and Institutions. IMF Working Paper WP/08/104. Pp. 1-35.

Cohen, W. M., and D. A. Levinthal (1989). Innovation and Learning: The Two Faces of R&D. *The Economic Journal* 99(September): 569-596.

———and ————(1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly* 35(1): 128-52.

Das, Gouranga G. (2002). "Trade, Technology and Human Capital: Stylised Facts and Quantitative Evidence"—*The World Economy*, Volume 25, Issue 2, Blackwell Publishers, Oxford (U.K.) & Boston (U.S.A.).

Das, Gouranga G. (March 2008). "Does Trade and Technology transmission facilitate convergence? The tole of technology adoption in reducing the inequality of nations"—Journal of Economic Policy Reform, Volume 11, Issue 1, pp.67-92.

Das, Gouranga G. (2010). "How to Reap the Induced Technological Bonus? A Mechanism and Illustrative Implementation. Modern Economy (Scientific Research), Vol 1 (2), pp. 80-88.

Dasgupta, P (2009). 'A Matter of Trust: Social Capital and Economic Development.' Annual Bank Conference on Development Economics (ABCDE), World Bank, Seoul, June 2009. pp. 1-47.

De Ferranti, D., G. E. Perry, I. S. Gill, J. L. Guasch, W. F. Maloney, C. S. Paramo, and N. Schady (2003b). *Closing the Gap in Education and Technology*. The World Bank, Washington.

Deaton, Angus., and Jean Dreze (Sept 7, 2002). Poverty and Inequality in India: A Re-examination. Economic and Political Weekly pp. 3729-3748

Deininger, K., and L. Squire (1996). "A New Dataset measuring Income Inequality," The World Bank Economic Review 10 (3), pp. 565-591.

Dimaranan, B., and R. A. A. Mc Dougall (eds.) (2003). *Global Trade, Assistance, and Protection: The GTAP 5 Database*, Center for Global Trade Analysis, Purdue University, USA.

Dollar, David and A. Kraay (2002). "*Growth is Good for the Poor*." Journal of Economic Growth, 7, pp. 195-225.

Dyke, Nancy Berg (2001) in Aspen Institute Conference Report on International Peace, Security and Prosperity (2001), "Attacking Global Poverty: Technology for Economic and Social Uplift." August 18-20, 2000, Aspen, Colorado.

Eaton, J. and S. Kortum (1996). Trade in Ideas: Patenting and Productivity in the OECD. *Journal of International Economics* 40: 251-278.

Fosu, A. (January 2011). Growth, Inequality, and Poverty Reduction in Developing Countries: Recent Global Evidence. UNU-WIDER Working Paper 2011/01.

Francois, J. F. and C. R. Shiells (1994), " AGE Models of North American Free Trade' in J. F. Francois and C. R. Shiells, (eds) Modeling Trade Policy, Applied General Equilibrium Assessments of

North American Free Trade, (Cambridge: Cambridge University Press).

Frankel, J. A., and D. Romer. (1999). "Does Trade Cause Growth?" American Economic Review (June), pp. 379-399.

Fugazza, Marco., and Frederic Robert-Nicoud (June, 2006). "Can South-South Trade Liberalization Stimulate North-South Trade?" CEPR Discussion Paper No. 5699. Centre for Economic Policy Research, London: U.K.

Gordon, James and Poonam Gupta (2004). Understanding India's Services Revolution. IMF Working Paper, WP/04/171.

Groot, H. L. F. de., G-J Linders, P. Rietvelda, and U. Subramanian (2004). The Institutional Determinants of Bilateral Trade Patterns. *Kyklos* 57 (February):103-124.

Hanushek, Eric A., and L. Woesmann (2008). *Journal of Economic Literature*, 46 (3), pp. 607-668.

Harrison, W. J. and K. R. Pearson (1996) "Computing Solutions for Large General Equilibrium Models Using GEMPACK." *Computational Economics*, 9: pp. 83-127.

Helpman, E. (2004). "The Mystery of Economic Growth." Harvard University Press.

Hertel, T. W., ed. (1997). Global Trade Analysis: Modeling and Applications. Cambridge, MA, Cambridge University Press.

Hertel, T. W., and J. J. Reimer (November 2004). "Predicting the Poverty Impact of Trade Reform." World Bank Policy Research Working Paper 3444, World Bank.

Hsieh Chang-Tai and Peter J. Klenow (2010). Development Accounting. American Economic Journal: Macroeconomics, Vol 2 (1), pp. 207—223.

International Monetary Fund (January 12, 2011). New Growth Drivers for Low-income Countries: The Role of BRICs. Prepared by the Strategy, Policy, and Review Department. Pp. 1-63.

Jones, C. I. and Paul M. Romer (2010). The New Kaldor Facts: Ideas, Institutions, Population, and Human Capital. American Economic Journal: Macroeconomics, Vol 2 (1), pp. 224—245.

Jones, R. W. (2000). Globalization and the Theory of Input Trade. MIT Press.

Kaufmann, D. A. Kraay, and M. Mastruzzi (2003). Governance Matters III: Governance Indicators for 1996–2002. World Bank Policy Research Working Paper 3106. Dataset at: **www.worldbank.org/wbi/governance/govdata2002/.**

Kaufmann, D (2004). Governance Redux: The Empirical Challenge. Chapter in Global Competitiveness Report 2003-2004, World Economic Forum.

Keller, W. (1997). Trade and the Transmission of Technology. NBER Working Paper, 6113, Cambridge, MA, July, 1-33 + Appendix.

_____ (1998). Are International R&D Spillovers Trade Related? Analyzing Spillovers among Randomly matched trade partners. *European Economic Review* 42:1469-81.

_____ (2001). The Geography and Channels of Diffusion at the World's Technology Frontier. NBER Working Paper, 8150, Cambridge, MA, 1-28 + Appendix.

_____ (2004). .International Technology Diffusion. *Journal of Economic Literature Vol. XLII (September 2004):752-782*.

Kobrin, Stephen J. (1999). Development after Industrialization: Poor Countries in an Electronically Integrated Global Economy. In 'The Globalization of Multinational Enterprise Activity and Economic Development' by Neil Hood and Stephen Young (Eds.). London: Macmillan, 1999.

Kosempel, Stephen (November 2007). "Interaction between knowledge and technology: a contribution to the theory of development." Canadian Journal of Economics, 40 (4), pp. 1237-1260.

Lucas, R. E. Jr. (2009a). Trade and the diffusion of the Industrial Revolution. *American Economic Journal: Macroeconomics*. Vol 1(1). pp.1-25.

Lucas, R. E. Jr. (2009b). Ideas and Growth. *Economica.* Vol 76 (1). Pp.1-19.

McCulloch, N., L. Alan Winters, and X. Cirera (2001). "Trade Liberalization and Poverty: A Handbook." CEPR and Department for International Development., U.K.

Meier, G. M. and J. E. Stiglitz (2002). Frontiers of Development Economics: the future in perspective. World Bank, Oxford University Press.

Nelson, R.R. (1990). On Technological Capabilities and their Acquisition. In R.E. Evenson and G. Ranis (eds.), *Science and Technology*: *Lessons for Development Policy*, Westview Press.

Onyeiwu, Steve (March 2011). Does lack of Innovation and Absorptive Capacity Retard Economic Growth in Africa? UNU-WIDER Working Paper No. 2011/19. ISSN 1798-7237.

OECD (2000). *Science, Technology and Industry Scoreboard of Indicators*, Paris.

OECD (2010). *Perspectives on Global Development 2010: Shifting Wealth*, Paris.

Pack, H., and L. E. Westphal (1986). "Industrial Strategy and Technological Change: Theory versus Reality." Journal of Development Economics, 87, pp. 87-128.

Paus, E. (2005). Foreign Investment, Development and Globalization. New York: Palgrave Macmillan.

Ravallion, M. (1994). Poverty Comparisons. Harwood Academic Books.

------------(1995). "Growth and Poverty: Evidence for Developing Countries in the 1980s." Economics Letters, 48, pp. 411-417.

------------(2001). "Growth, Inequality and Poverty: Looking Beyond Averages." World Development. 29(11), pp. 1803-1815.

------------(2004). "Looking Beyond Averages in the Trade and Poverty Debate." World Bank Policy Research Working Paper 3461. Washington D.C.: World Bank.

Robinson, S., and H. Lofgren (2005). " Macro Models and Poverty Analysis: Theoretical Tensions and Empirical Practice. Development Policy Review, 23 (3), pp. 267-283.

Sachs et al. (2004). "Ending Africa's Poverty Trap." Brookings Institution.

Santos-Paulino, Amelia U. and Guanghua Wan (2010a). Southern Engines of Global Growth. Oxford University Press.

Santos-Paulino, Amelia U. and Guanghua Wan (2010b). The Rise of China and India: Impacts, Prospects and Implications. Palgrave, Macmillan.

Sen, A. (1973). "On Economic Inequality", Oxford and Clarendon Press.

Sen, A. (1993). "Capability and Well-being", in The Quality of Life, (eds.) Martha Nussbaum and A. Sen. Oxford: Clarendon Press.

Sen, A. (1995). " Inequality Reexamined", Oxford University Press.

Sen, A. (2004). "Development as Freedom", Oxford University Press.

The Economist, December 18, 2004. London, U.K.

UNDP. *Human Development Report 2003: Millenium Development Goals: A Compact among Nations to end Human Poverty.* New York, Oxford University Press.

---------- *Human Development Report 2001:* New York, Oxford University Press.

United Nations (October 2010). Millennium Development Goal 8, The Global Partnership for Development at a Critical Juncture. MDG Gap Task Force Report 2010.

Winters, A. L., N. McCulloch, and A. McKay (March 2004). "Trade Liberalization and Poverty: The Evidence So Far." Journal of Economic Literature, Volume XLII, Number 1, pp. 72—115.

World Bank (1998/1999). *Knowledge for Development. World Development Report 1998/9*, New York, Oxford University Press.

World Bank (2000). *Attacking Poverty. World Development Report 2000/2001*, New York, Oxford University Press.

World Bank (2004a). *Global Economic Prospects 2004: Realizing the Development Promise of the Doha Agenda.* Washington D.C.: World Bank.

World Bank (2004b). *World Development Indicators.* World Bank.

World Bank (2005). *A Better Investment Climate for Everyone. World Development Report 2005*, New York, Oxford University Press.

World Bank (2007a). *Unleashing India's Innovation: towards Sustainable and Inclusive Growth.* The World Bank, Washington DC.

World Bank (2007b). *China's Information Revolution: Managing the Economic and Social Transformation.* The World Bank, Washington DC.

World Bank (2008). *Agriculture for Development. World Development Report 2008*, New York, Oxford University Press.

World Bank (2010). Innovation Policy: A Guide for Developing Countries. The World Bank, Washington DC.

Yitzhaki, Shlomo (2002). "Do we need a Separate Poverty Measurement?" European Journal of Political Economy, 18, pp. 61-85.