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Logistics, Trade and Production Networks: An Empirical Investigation

Prabir De* and Amrita Saha**

Abstract: Logistics services contribute to not only expansion in trade and production networks within or across countries but also help to build countries' productive capacities. With production processes and tasks in production increasingly fragmented across borders, time-sensitive logistics services along with information and communication technology can be the key to facilitate production networks. The analysis in this study provides a synoptic view of the role of logistics in promoting such production networks across borders. It undertakes a case study of two products: India's export of yarn to Bangladesh and India's import of air-conditioning equipment from Thailand. It is observed that improvements in logistics services can significantly increase trade volumes through production networks across borders. Also, there exists such a long-run relationship between trade and logistics performance that the causal link can be in both directions. In terms of policy, this paper suggests that efficient performance in logistics contributes positively to trade, which, in turn, promotes production networks across borders. A regional logistics sector policy focusing on narrowing logistics gaps is thereby important to facilitate trade and production networks in Asia and the Pacific.

Key words: Logistics, Logistics Performance, Production network, Trade, Asia and Pacific

JEL codes: F2, F10

1. Introduction

Logistics is an important determinant in sustaining a country's (or a region's) competitive advantage.[1] Its contribution to growth, economic integration and poverty reduction has been well recognised. Improvements in logistics services help countries to produce more sophisticated products and encourage

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a more dynamic export (import) diversification process. This in turn contributes to improvements in an economy's growth and development. In the last decade, there were noticeable developments in logistics services on account of technological achievements; however, there is evidence of a rising gap between the LDCs and the developing economies in terms of quality, particularly in Asia and the Pacific region.[2]

Logistics services involve the process of planning, implementing, and controlling the efficient and cost effective flow and storage of raw materials, in-process inventory, finished goods and related information from the point of origin to the point of consumption (destination) to meet customer's requirements.[3] With production processes and tasks in production increasingly fragmented across national borders, time-sensitive logistics services along with information and communication technology is the key to facilitate cross-border production networks.[4] In other words, logistics services play a catalytic role ensuring just-in-time delivery of goods and services, either as inputs to production process or as final outputs. Logistics services perform a critical role as a mechanism to integrate and coordinate activities that are increasingly fragmented across geographically dispersed stages of production in the global economy. Efficiency in logistics services is, therefore, an important factor contributing to not only the expansion in trade and production networks within or across countries but also building their productive capacities in networked countries (Kimura 2012). Efficiency in logistics services is also dependent to a large extent on 'Behind the Border' measures of government policy and regulation that are driven by efficiency and equity concerns. The need of a regional logistics sector policy to facilitate the trade and production networks across the borders in Asia is thus felt important.[5]

Rapid advances and innovations in communication and transportation facilitate the establishment of services links that combine the fragmented production blocks and lead to subdivision of tasks and reorganisation in producing economies of scale (Ando and Kimura 2009). This process of fragmentation in production enables countries to specialise according to their comparative advantages. The costs of fragmentation include the associated services link costs. While several studies have dealt with the subject of production fragmentation in context of East Asia, none so far have attempted to explore the empirical links between logistics services and production networks.[6]

In this study, our objective is to empirically explore the role of logistics in enhancing production networks. We take up the case for logistics services, the demand for which originates primarily from trade in goods. Two case studies are undertaken: (i) India's export of textile yarn to Bangladesh, and (ii) India's import of air conditioning equipment from Thailand. Here, yarn and air conditioning equipment are selected owing to a steady rise in trade in these two products, which has been facilitated by regional and bilateral FTAs.[7] While Bangladesh buys yarn from India, India buys air conditioning equipment from Thailand. We argue that there is an increasing evidence of vertical (or horizontal) production networks emerging between these countries. It is thereby important to assess such development, which could then help countries to undertake policy reforms in order to facilitate gains from production networks, for instance, by improvements in logistics services.

The remaining part of the study is organised as follows: Section 2 presents the data and methodology. Section 3 discusses some stylised facts on India's trade with Bangladesh and Thailand in yarn and air conditioning equipment, and overall trends in intra-industry trade between them. Section 4 undertakes an assessment of logistics in Asia – Pacific countries including Bangladesh, India and Thailand. Section 5 presents the major analytical findings, and finally the Section 6 concludes.

2. Data and Methodology

The objective of this study is to explore the role of logistics services efficiency in enhancing trade and production networks. We aim to understand how changes in logistics efficiency affect changes in import demand in sectors that generate production networks. The Constant Elasticity of Substitution (CES) function has been used extensively to represent demand side of the economy. Substituting scarce factors of production by relatively more abundant ones is a key element of economic efficiency and a driving force of economic growth. A measure of that force is the elasticity of substitution between capital and labour which is the central parameter in production functions, and in particular CES ones. Thus, the common feature translates into a constant elasticity of trade with respect to trade cost.[8] Motivating by above, we make an attempt to estimate the relation between logistics performance and trade flows controlling for other variables. The following CES equation is considered.[9]

$$U_i = \left(\sum_j \lambda_j x^{1/\theta} \right)^{\theta} \quad \text{.......... (1)}$$

where, *i* and *j* are importing and exporting countries, respectively, θ = σ / (1- σ). We treat λ is a quality shifter specific to exporter *j*, or, in other words, it represents the number of unique varieties being produced by exporter *j*.

We write the import demand for a product as follows:

$$q_{ij} = E_i \left(\frac{\lambda_j}{p_j} \right)^{\sigma} t_{ij}^{-\sigma} \quad \text{.......... (2)}$$

where q_{ij} is value of import of *i* from *j*, *t* is trade cost component which captures logistics efficiency, *E* is real expenditures on a product (expenditures divided by the price level), which we do not observe but proxy it by country's GDP.[10] Similarly, λ/*p* are not really observable due to poor quality of measures of *p*, and also contaminated by quality differences.[11] We want prices net of quality differences and quality itself, but we cannot observe those. We want to control for a demand shifter that is exporter specific – India is different from Thailand, certainly in its size and probably in the quality of the products it makes so we want to sweep that out. Therefore, we have to omit those things we cannot observe. We undertake this as follows:

First, we take log and use a vector of importer and exporter fixed effects. We get equations (3) and (4) below:

$$\ln q_{ij} = \ln E_i + \sigma \ln\left(\frac{\lambda_j}{p_j}\right) - \sigma \ln t_{ij} \quad \text{...(3)}$$

$$\ln q_{ij} = A_i + A_j - \sigma \ln t_{ij} \quad \text{..(4)}$$

Second, we replace t_{ij} by z_{ij}, which is logistics performance index (LPI). We write the trade cost vector as follows:

$$\ln q_{ij} = A_i + A_j - \sigma \ln z_{ij} \quad \text{... (5)}$$

Since our purpose is to assess the impact of LPI on trade over time, we consider two cross-section years, namely, 2000 and 2010. We rewrite the equation (2) as follows:

$$\frac{q_{ij\,2010}}{q_{ij\,2000}} = \frac{E_{i\,2010}\left(\frac{\lambda_{j\,2010}}{p_{j\,2010}}\right)^{\sigma} z_{ij\,2010}^{-\sigma}}{E_{i\,2000}\left(\frac{\lambda_{j\,2000}}{p_{j\,2000}}\right)^{\sigma} z_{ij\,2000}^{-\sigma}} \quad \text{.................................(6)}$$

By taking log, we get

$$\ln\frac{q_{ij\,2010}}{q_{ij\,2000}} = \ln\left(\frac{E_{i\,2010}}{E_{i\,2000}}\right) + \sigma \ln\left(\frac{\frac{\lambda_{j\,2010}}{p_{j\,2010}}}{\frac{\lambda_{j\,2000}}{p_{j\,2000}}}\right) - \sigma \ln\left(\frac{z_{ij\,2010}}{z_{ij\,2000}}\right) \quad \text{....................(7)}$$

We incorporate importer and exporter fixed effects to take care expenditures or the quality or the price parameters, and rewrite it as follows:

$$\ln \frac{q_{ij2010}}{q_{ij2000}} = A_i + A_j - \sigma \ln \left(\frac{z_{ij2010}}{z_{ij2000}} \right) \quad \text{.............................. (8)}$$

Now, controlling for other exogenous variables, we rewrite the equation (8) as follows:

$$\ln \frac{q_{ij2010}}{q_{ij2000}} = A_i + A_j - \sigma \ln \left(\frac{z_{ij2010}}{z_{ij2000}} \right) - \sigma \ln X'_{ij} + \varepsilon_{ij} \quad \text{................................(9)}$$

where, i and j are importing and exporting countries. We use country dummy (=1 when i is importer (exporter), and 0 otherwise). The parameters to be estimated are denoted by σ, and ε_{ij} is the error term.

We use data for 2000 and 2010, and consider bilateral data for all the variables for individual partners. We empirically estimate this relation on Bangladesh's import of yarn from India and import of air conditioning equipment by India from Thailand. The usual caveat is that one needs to combine the supplier of inputs with users of the product in a backward linkage framework. Although supply chains can be more than 1 and it may be at several stages, here we consider only the stage of yarn supply to Bangladesh's ready-made garment producers or India's import of air conditioning equipment from Thailand and do not go backward to find the supply chain (if it exists) for yarn or air conditioner production.

We aim to answer the following research questions in this study.

- How do we measure logistics performance?
- Does logistics performance play a catalytic role in expanding the merchandise trade flow and facilitating production networks in South and Southeast Asia?
- What is the causality between logistics performance and trade? How it moves and in which way?

We deal with the aforesaid research questions in following ways.

One, whether the trade between two or more economies will rise and be facilitated towards fragmentation will depend on potential of intra-industry trade (IIT) between them. Following Mikic and Gilbert (2007), we attempt to assess the magnitude and emerging trend of cross-border production network at a disaggregated trade level. We analyse whether trade leads to generate production networks and vertical trade between the two countries by primarily looking at the intensity of intra-industry trade. Here, data is sourced from COMTRADE.

Two, to measure logistics performance across countries, we generate an index out of a selected set of indicators. The methodology to measure logistics performance follows multi-dimensional factor analysis (or popularly called principal component analysis). The logistics services cover indicators which are critical to production networks and the supply chain. Here, data is sourced from WDI.

Three, a panel data regression is carried out with Equation (9) as baseline to understand the relationship between logistics performance with merchandise trade flow that leads to generate production networks across borders. The co-integration technique is also used to assess the causality between logistics performance and trade.

3. India's Trade with Bangladesh and Thailand

While examining India's trade with Bangladesh and Thailand, we need to acknowledge the fact that India's bilateral trade with Bangladesh and Thailand is in part influenced by its FTAs such as SAFTA in case of Bangladesh, and India-Thai EHS and India-ASEAN FTA in case of Thailand.[12] Distributions of India's exports to Bangladesh and imports from Thailand are skewed towards selected products. Of these the more prominent ones consist of export of yarn to Bangladesh and import of air-conditioning equipment (ACE) from Thailand.

Table 1: India's Import of ACE from Thailand and Export of Yarn to Bangladesh

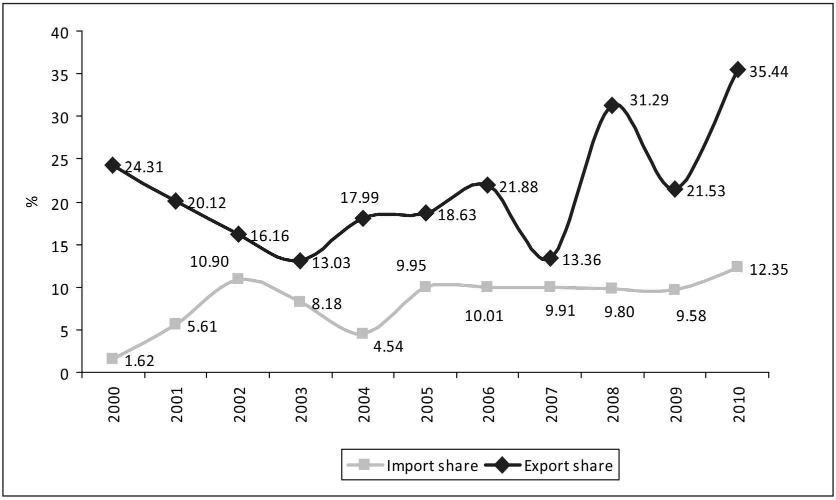
Year	India's Import of ACE from Thailand	India's Total Import from Thailand	India's Export of Yarn to Bangladesh	India's Total Export to Bangladesh
(US$ million)				
2000	5.42	335.38	209.12	860.33
2001	22.71	404.38	201.36	1000.63
2002	42.50	390.02	183.00	1132.54
2003	45.11	551.54	208.34	1599.55
2004	35.31	777.38	292.38	1624.82
2005	112.00	1125.16	308.49	1656.05
2006	161.30	1612.10	358.13	1636.98
2007	214.17	2162.16	346.59	2594.56
2008	251.67	2567.24	805.60	2574.66
2009	257.12	2683.95	469.66	2181.10
2010	470.61	3810.14	1070.86	3021.79
CAGR (%)	56.25	27.51	17.74	13.39

Source: Calculated based on COMTRADE.
Note: For corresponding HS codes, please refer Appendix 2.

India's import of ACE from Thailand has witnessed a massive growth of 56.25 per cent in the last decade, indicating rise in India's import demand from Thailand. In 2010, India imported US$ 470.61 million worth ACE from Thailand, which was 12.35 per cent of India's total imports from Thailand (Table 1, Figure 1). Incidentally, ACE are part of India-Thailand Early Harvest Scheme (EHS), where India has offered tariff concessions and reduced the customs duty to zero. As a result, India's import of ACE has increased sharply since 2004 (Figure 1).

Table 1 clearly shows that in 2010, export of yarn to Bangladesh alone accounted for about 35 per cent of India's total exports to Bangladesh. In the same year, India exported over US$ 1 billion worth textile goods including yarn to Bangladesh. Over time, Bangladesh's dependence on India as a source of yarn has increased. India's export of yarn to Bangladesh was 24.31 per cent of her total exports in 2000, which rose to 35.44 per cent by 2010.

Figure 1: Trends in Trade Share: India's Export of Yarn to Bangladesh and India's Import of ACE from Thailand



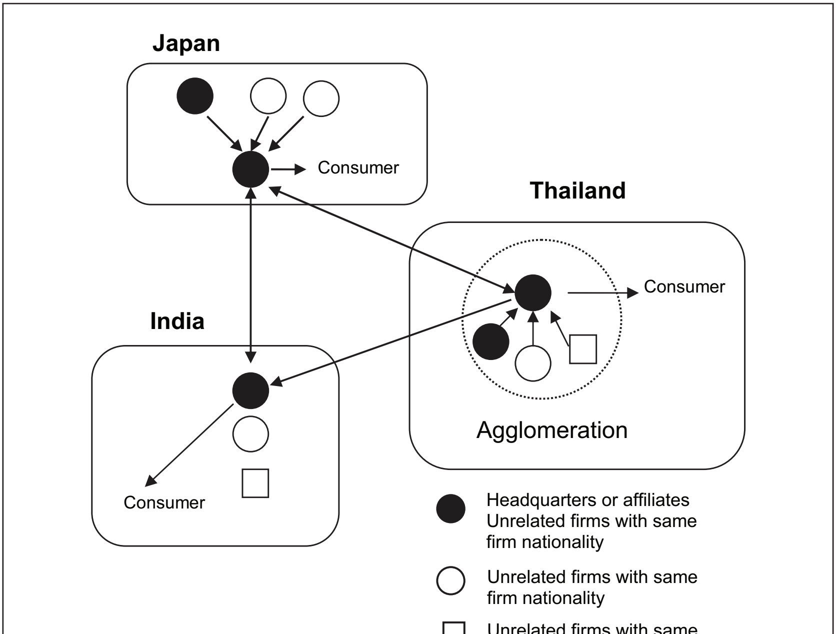
Source: Authors' calculation.

We now study these disaggregated trade flows in terms of intermediates, capital and consumption goods using the Broad Economic Categories (BEC) classification.[13] India's total imports of 'Transport Equipment and Parts and Accessories thereof' from Thailand amounted to US$ 482 million in 2010. Matched with the corresponding HS codes for ACE, we get similar figures for ACE imports, such that it is observed that more than 97 per cent of total transport equipment imported from Thailand comprised ACE in 2010. In terms of the BEC, these can be classified under intermediate goods used in manufacturing capital or consumption goods. These may be used in producing several consumption goods classified under BEC-522, i.e., the non-industrial transport equipment and capital goods under BEC-521, i.e., the industrial transport equipment. In the same year, India exported US$ 2.2 billion worth of industrial transport equipment and US$ 0.8 billion worth of non-industrial transport equipment to the world. These evidence the possible emergng production networks involving India and Thailand.

Production structures of firms involved in producing parts of ACE and further processing show quite many units involved in the manufacturing process.[14] We also observe that India's imports of ACE from Thailand seem to be primarily driven by Japanese MNEs, such that there is evidence of an early stage of production network involving Japan, Thailand and India as illustrated in Figure 2. We observe a more complicated division of labour wherein more than two countries are involved with a sophisticated combination of intra-firm and inter-firm transactions being developed (Figure 2). In such a scenario, improved trade facilitation and time-sensitive logistics services are critical for development of cross-border production networks.

In terms of the BEC, India's total exports of 'Processed Industrial Supplies' (which also consist of yarn exports) to Bangladesh was US$ 1.5 billion in 2010. Matched with the corresponding HS codes, it is observed

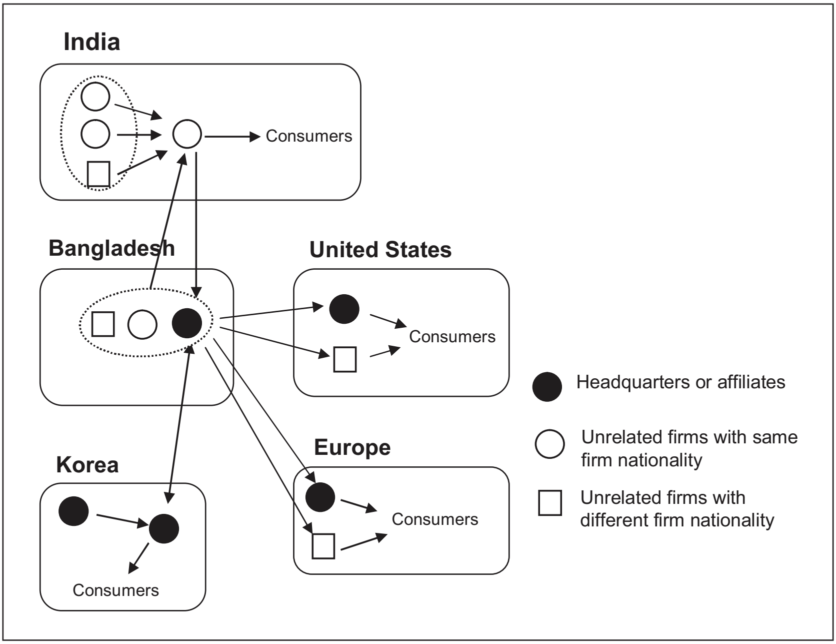
Figure 2: Illustration of Production Networks in India-Thailand Trade in ACE



Source: Drawn by authors based on Ando and Kimura (2009).

that exports of yarn comprise a significant share of these supplies. In terms of the BEC, these can be classified under consumption goods in which the intermediates used are classified as 'Primary Industrial Supplies'. In the same year, India imported US$ 24 billion worth of Primary Industrial Supplies from the world, of which US$ 91 million was from Bangladesh. Figure 3 illustrates observable production networks between India and Bangladesh particularly in textile and clothing.

Figure 3: Illustration of Production Networks in India-Bangladesh Trade in Textile and Clothing



Source: Drawn by authors based on Ando and Kimura (2009).

The pattern of division of labour appears simplistic, not only in case of India-Bangladesh but also with the other trading partners of Bangladesh. In terms of production structures of Indian firms involved in yarn manufacture, it is observed that maximum firms were involved in spinning, weaving and finishing of textiles. Overall, it appears to be a scenario of cross-border production sharing. This textile and clothing group comprises yarn (cotton and polyester) as well as fabric (mainly denim), which are almost exclusively exported by India to Bangladesh through road (by trucks to be precise).[15] Therefore, we argue that logistics performance is crucially important to facilitate the production networks involving India and Bangladesh.

Intra-Industry Trade and Vertical Fragmentation of Production

Since trade in this era of globalisation is dominated by intra-industry trade,[16] it is essential to look at the intra-industry trade potential between India and Bangladesh in yarn. Intra-industry trade (IIT) index is a popular method to identify the scope for production network between India and Bangladesh, and India and Thailand. IIT is observed when a country simultaneously imports and exports similar types of products within the same 'industry' or 'sector'. There are two types of intra-industry trade: horizontal intra-industry trade and vertical intra-industry trade (Greenaway *et al*. 1995). Horizontal intra-industry trade refers to the simultaneous exports and imports of goods classified in the same sector and at the same stage of processing. This is usually based on product differentiation. Vertical intra-industry trade refers to the simultaneous exports and imports of goods classified in the same sector but which are at different stages of processing. This is normally based on the "fragmentation" of the production process into different stages, each performed at different locations by taking advantage of the local conditions. It is widely discussed in literature that the IIT is a measure of the degree to which trade in a particular sector represents intra-industry trade (based on scale economies and/or market structure). By engaging in IIT, a country can reduce the number of similar goods it produces, and benefit from scale economies. Higher IIT ratios suggest that these sources of gains are being exploited. The IIT index measures the degree of overlap between imports and exports in the same commodity category, with a value of 1 indicating pure intra-industry trade and a value of 0 indicating pure inter-industry trade.[17]

Table 2 presents the common set of traded goods between India and Bangladesh for which we observe relatively higher IIT index scores.[18] The estimated scores indicate that IIT index levels are higher in manufactured

Table 2: Intra-Industry Trade Index (2007): Common Set of Products at 6-digit HS

HS Code	Product	IIT India	IIT Bangladesh
230220	Rice bran oil	0.935	0.836
721550	Bars & rods other than free-cutting steel not further worked than cold formed/cold finished	0.923	0.421
850720	Other lead-acid accumulators	0.922	0.557
600622	Other knitted or crocheted fabrics of cotton, dyed	0.771	0.929
960719	Other slide fasteners	0.770	0.719
610510	Men's/boys' shirts of cotton	0.758	0.819
621790	Parts of garments/ clothing accessories	0.729	0.463
848390	Parts of transmission shafts, cranks, bearing housings, gears or clutch	0.703	0.778
854419	Winding wires of other metals / substances	0.505	0.633
620319	Suits of other textile materials	0.486	0.704
521211	Other unbleached woven fabrics of cotton weighing not more than 200 G/M2	0.417	0.770

Source: Authors' calculation.

Note: IIT index was calculated for bilateral trade between India and Bangladesh.

Table 3: IIT in Textile and Clothing Sector, 2010 (Exporter: India, Importer: Bangladesh)

HS code	Product	IIT
5608	Knotted netting of twine, etc, fishing and other n...	0.14
5208	Woven cotton fabric, >85% cotton, < 200g/m2	0.20
5211	Woven fabric, <85% cotton with manmade fibre,>200g...	0.24
5408	Woven fabric of artificial filament, monofilament ...	0.32
5210	Woven cotton, <85% cotton with manmade fibre,<200g...	0.33
5402	Synthetic filament yarn (not sewing thread) not ret...	0.41
5403	Artificial filament yarn (except sewing), not reta...	0.42
5204	Cotton sewing thread	0.48

Source: Calculated using TradeSift, University of Sussex.

products than in primary products, reflecting the greater role of economies of scale in the production of those products. The IIT scores suggest that there are production-sharing opportunities in a static sense in 11 products with varying potentials. The range of such potentials varies from textile and clothing sector (most concentration) to iron and steel (least concentration), whereas electrical machinery and equipment, and mechanical appliances occupy the middle portion (medium concentration) of the value chain. The index scores also indicate that there are only two sectors in which intra-industry trade is accounted for a moderate share between India and Bangladesh, viz. textile and clothing, and electrical machinery and mechanical appliances sectors at the 6-digit HS level. In other sectors, intra-industry trade is accounted for either low or negligible share. In category of textile and clothing, cotton sewing thread (HS 5204), artificial filament yarn (HS 5403) and synthetic filament yarn (HS 5402) have witnessed relatively higher IIT scores, indicating potential of further intra-industry trade between India and Bangladesh (Table 3). On the other, in case of India's import of ACE from Thailand, we find a relatively higher and rising IIT index score in air, vacuum pumps, compressors, ventilating fans, etc. (HS 8414), which increased from 0.344 in 2000 to 0.409 in 2010 with a peak of 0.590 in 2007 (Table 4). In sharp contrast, IIT index scores of air conditioning equipment, machinery (HS 8415) and compression-ignition engines (diesel, etc.) (HS 8408) show trade in these two products has been inter-industry type. Therefore, we select yarn exports from India to Bangladesh and ACE imports by India from Thailand in this study to explore the links between trade and logistics performance.

To identify the vertical IIT, the indices at a high disaggregated level (HS 6) are compared with those at a low disaggregated level (HS 2). IIT indices that are low at HS 6 and high at HS 2 are a necessary, although not sufficient condition, for the existence of vertical trade because they suggest that the countries trade different products in the same sector. The usual caveat is that when the IIT index is observed to be low at HS 6 but high at HS 2, one should check on case-by-case basis whether the different products are differentiated as final products or as parts and components versus final products. However, the usual caveat is that there might be aggregation bias. Table 5 presents the vertical IIT potential between India and Bangladesh, while the same between India and Thailand is presented in Table 6. Textile and clothing sector alone offers huge vertical trade opportunities between the two countries, more importantly in the Wadding, felt, and the nonwoven yarns (HS 56). However, the vertical IIT potential in case of ACE at the present seems to be not very high as compared to other sectors between India and Thailand.

Table 4: IIT in Air Conditioning Equipment (Importer: India, Exporter: Thailand)

Year	Compression-ignition engines (diesel, etc), (HS 8408)	Air, vacuum pumps, compressors, ventilating fans, etc. (HS 8414)	Air conditioning equipment, machinery (HS 8415)
2000	0.548	0.344	0.031
2001	0.007	0.214	0.013
2002	0.017	0.145	0.020
2003	0.044	0.247	0.031
2004	0.173	0.061	0.051
2005	0.019	0.205	0.064
2006	0.002	0.276	0.013
2007	0.008	0.590	0.003
2008	0.029	0.563	0.003
2009	0.036	0.448	0.001
2010	0.023	0.409	0.008

Source: Calculated using TradeSift, University of Sussex.

How do we then facilitate vertical IIT between the two countries? What are the policies needed? Our analysis indicates that a number of product categories and sectors exhibit an increasing share of IIT having higher economies of scale between India and Bangladesh, and these are the sectors where we have the potential for growth in bilateral trade between the two countries through IIT. Kimura and Kobayashi (2009) present a graphical link between production blocks emerged due to vertical IIT and the connected service links, which have been facilitating the fragmentation. Nonetheless, improved service links between India and Bangladesh; and India and Thailand are important to strengthen the production networks. More importantly, reduction in service link cost to connect production blocks would pave the way for activating production networks. One way to look at the service links is to measure the performance of logistics services of countries engaged in cross-border production networks.

Table 5: Vertical IIT Potentials between India and Bangladesh*

Reporter	Partner	HS2	Commodity (HS2)	IIT (HS2)	IIT** (HS6)	Potential (HS2-HS6)
India	Bangladesh	03	Fish, crustacean, mollusc, and others	0.970	0.787	0.183
India	Bangladesh	09	Coffee, tea, MATN, and spices	0.801	0.560	0.241
Bangladesh	India	03	Fish, crustacean, mollusc, and others	0.200	0.003	0.197
Bangladesh	India	08	Edible fruits and nuts	0.180	0.001	0.179
Bangladesh	India	14	Vegetable plaiting materials	0.770	0.012	0.758
Bangladesh	India	19	PREP. of cereal, flour, starch, and milk	0.160	0.012	0.149
Bangladesh	India	25	Salt, sulphur, earth, stone, and plastering materials	0.830	0.140	0.691
Bangladesh	India	31	Fertilisers	0.950	0.194	0.756
Bangladesh	India	33	Essential oils, resinoids, perfumery, and cosmetics	0.800	0.476	0.324
Bangladesh	India	39	Plastics and articles thereof	0.440	0.326	0.114
Bangladesh	India	53	Other vegetable textile fibres	0.020	0.000	0.020
Bangladesh	India	54	Man-made filaments	0.330	0.019	0.311
Bangladesh	India	55	Man-made staple fibres	0.530	0.288	0.242
Bangladesh	India	56	Wadding, felt, and nonwoven yarns	0.690	0.041	0.650
Bangladesh	India	63	Other made-up textile articles	0.310	0.235	0.075
Bangladesh	India	84	Nuclear reactors, boilers, parts	0.980	0.277	0.703
Bangladesh	India	87	Vehicles of railway, tramway roll-stock	0.080	0.051	0.029

Source: Authors' calculation.

Notes: *IIT indices are calculated for bilateral trade between India and Bangladesh at H2 nomenclature.
**Average of multiple products at HS 6

Table 6: Vertical IIT Potentials between India and Thailand*

Reporter	Partner	HS2	Commodity (HS2)	IIT (HS2)	IIT** (HS6)	Potential (HS2 - HS6)
India	Thailand	84	Nuclear reactors, boilers, machinery, etc.	0.33	0.20	0.13
India	Thailand	48	Paper & paperboard, articles of pulp, paper and board...	0.99	0.13	0.86
India	Thailand	15	Animal, vegetable fats and oils, cleavage products,...	0.98	0.11	0.87
India	Thailand	64	Footwear, gaiters and the like, parts thereof	0.97	0.11	0.86
India	Thailand	51	Wool, animal hair,horsehair yarn and fabric there...	0.97	0.05	0.92
India	Thailand	87	Vehicles other than railway, tramway	0.97	0.21	0.76

Source: Authors' calculation.

Notes: *IIT indices are calculated for bilateral trade between India and Thailand at H2 nomenclature.
**Average of multiple products at HS 6.

4. Measuring Logistics Performance

Here, we briefly summarise the methodology and data sources for constructing logistics performance index (LPI) covering 20 Asia-Pacific countries, and the results. There are several aspects of logistics which complement each other, such as telecommunication, transport, financial infrastructure and human resource quality. While these indicators are correlated among themselves in some cases, none of them will capture the overall logistics performance adequately. A country may have a very good network of roads but poor telecommunication infrastructure, for example. Therefore, the statistical technique of principal component analysis (PCA) is helpful in constructing a unique single index that captures the variance or information contained in different variables capturing different aspects of infrastructure. PCA finds linear combinations of the original variables to construct the principal components or factors with a variance greater than any single original variable.

$$LPI_{it} = \sum W_{jt} X_{jit} \quad \text{..........(10)}$$

where LPI_{it}= Logistics Performance Index of the i-th country (20 countries) in t-th time (namely, 2000 to 2010), W_{jt} = weight of the j-th aspect of logistics in t-th time, and X_{jit} = value of the j-th aspect of logistics for the i-th country in t-th time point. Each of the 11 variables is normalised for the size of the economy so that it is not affected by the scale. Here, W_{jt} are estimated with the help of PCA. The aspects of logistics covered in the construction of the composite index and their measurements are as follows:

Transportation: There could be several aspects of transport infrastructure such as availability of and quality of roads, railways, air transport and ports. In view of the availability of comparable indicators, we have employed following five indicators for capturing the availability and quality of transport infrastructure: (i) Air transport is captured with the help of passengers carried per 1000 population and air freight taken per 1000 population, (ii) Road infrastructure is captured by the length of roads network per 100 sq. km. of surface area, and percentage share of paved roads, (iii) Railway infrastructure is captured through length of railway lines per 100 sq. km. of surface area, (iv) Port infrastructure is captured by container port traffic per 10,000 population; and (v) ICT services are captured with the help of internet users per 100 population, mobile cellular subscriptions taken per 100 population and telephone lines per population.

Information and Communication Technology: The availability of ICT infrastructure is captured with the help of teledensity, and density of internet users. Total number of telephones lines per 1000 inhabitants is a measure of teledensity. Number of internet users per 1000 inhabitants is used to capture IT penetration in logistics.

Financial Services: Domestic credit provided to the private sector (logistics service providers) by the banking sector (as percent of GDP) is employed as a measure of availability of financial infrastructure.

Human Resource Quality: We take adult literacy rate as a common indicator to represent human resource quality.

Table 7: LPI Scores and Ranks

Sr. No	Country	2000		2005		2010	
		Score	Rank	Score	Rank	Score	Rank
1	Australia	5.143	6	5.334	6	5.487	6
2	Bangladesh	1.269	17	1.476	17	2.130	17
3	Cambodia	1.014	20	1.204	20	2.081	19
4	China	2.489	9	3.383	9	4.213	9
5	Hong Kong	8.299	2	9.730	2	10.418	1
6	India	1.776	14	1.993	13	2.882	13
7	Indonesia	2.168	11	2.310	11	3.665	10
8	Japan	5.463	5	5.495	5	6.080	5
9	Korea	5.923	3	5.929	3	7.011	3
10	Lao PDR	1.223	19	1.276	19	2.121	18
11	Malaysia	3.699	7	4.410	7	5.255	7
12	Mongolia	1.545	15	1.730	15	2.313	15
13	Myanmar	1.234	18	1.312	18	1.543	20
14	New Zealand	5.843	4	5.895	4	6.454	4
15	Pakistan	1.312	16	1.603	16	2.289	16
16	Philippines	1.865	12	2.121	12	3.150	12
17	Singapore	10.082	1	10.121	1	10.402	2
18	Sri Lanka	2.354	10	2.523	10	3.571	11
19	Thailand	3.314	8	3.736	8	4.498	8
20	Vietnam	1.821	13	1.867	14	2.843	14
	Spearman rank correlation coefficient	0.992* (2000-2005)		0.995* (2005-2010)		0.985* (2000-2010)	

Source: Authors' calculation.
Note: *Significant at 1 per cent

The data sources include various issues of *World Development Indicators* of The World Bank. Appendix 4 provides the detailed list of these variables, while Appendix 5 presents the factor loadings, estimated through PCA. Weights are found to be robust as factor loadings for each year explain about 58 to 65 percent of the observation.

The LPI scores and ranks for the 20 countries for the years 2000, 2005 and 2010 are computed following the methodology outlined above, and are summarised in Table 7. The patterns that emerge from the Table 7 are on expected lines, and some important observations are as follows:

First, the Asia and Pacific comprise a heterogeneous group characterised by wide gaps in logistics performance. Relatively richer economies occupy the top positions in LPI, whereas the LDCs are at the bottom. For example, Myanmar, Cambodia, Lao PDR and Bangladesh occupy the bottom ranks in logistics performance. Other developing countries occupy the middle portion of the ladder. Given the estimated ranks, LDCs and land-locked countries across the world suffer more due to logistics inadequacy. As Spearman rank correlation coefficients indicate, there is still high degree of stickiness in their ranks. In general, the rankings in logistics attainment seem to relate to their levels of development.

Second, among the 20 Asia-Pacific countries, four countries have successfully improved their ranks between 2000 and 2010, while the rest of the three countries decelerated. There was no change in ranks among top nine countries between 2000 and 2010. India, Indonesia, Cambodia and Lao PDR are the countries which have improved their ranks in logistics services during 2000 and 2010. On the other, Myanmar has witnessed a sharp fall in logistics, compared to other countries during 2000 and 2010. The logistics gap between the relatively developed and the least developed countries in Asia and the Pacific region seems to have widened than narrowed between 2000 and 2010.

5. Does Improvement in Logistics Services Lead to Higher Trade in Production-Networked Goods?

This section begins by exploring whether or not improvement in logistics performance leads to rise in trade in production-networked goods across borders with reference to Equation (9). We consider India's export of yarn and import of ACE as dependent variables interchangeably, and LPI, for both partner and reporter countries, as independent variable. We also include a set of control variables such as exchange rate (er), population (pop), manufacturing value added (mva), GDP and per capita consumption of electricity (pce) to represent external and internal factors those influence trade in production-networked goods across borders. This panel data model considers a set of 19 Asia-Pacific countries and a period of 11 years (2000 to 2010).[19] Data has been sourced from WDI.

The panel being considered has a strong correlation between GDP and trade. Thus, it will create a definite problem if both of these variables are taken together. However, even if we do not take population, it might well influence the result through a fixed-effect regression, where country size and strength are important determinants. Hence, the regressions reported here try to avoid the obvious multicollinearity problem. Also, the data structure shows non-linearity so that double log regressions give better results than non-transformed variable-based regressions. Variables being in natural logarithms, estimated coefficients show CES elasticity. The elasticity is useful both as an indicator of the effect of trade barriers on trade volumes. The estimated baseline results are presented in Table 8.

Table 8: Baseline Regression (OLS): Fixed Effect Model

Variable	Traditional	FEM	Traditional	FEM
	India's Export of Yarn		India's Import of ACE	
	ln_export	ln_export	ln_import	ln_import
ln_lpi_r	1.130* (0.632)	0.266* (0.213)	-2.634*** (0.993)	0.146* (0.151)
ln_lpi_p	-1.079 (0.936)	0.778* (0.661)	2.260*** (0.682)	0.860* (0.668)
ln_er	-0.321*** (0.0756)	-1.191 (1.904)	-0.00188 (0.0719)	-1.715 (2.17)
ln_pce	-1.612*** (0.277)	-0.217* (1.412)	-0.933*** (0.219)	-0.145 (1.172)
ln_mva	0.194 (0.225)	1.918 (1.689)	6.942*** (0.274)	2.542 (2.982)
ln_gdp	1.442*** (0.136)	0.215 (1.327)	0.859*** (0.113)	0.226 (0.915)
Observations	209	209	209	209
R-squared	0.358	0.952	0.844	0.937
Country effect	No	Yes	No	Yes
Year effect	No	Yes	No	Yes

Source: Authors' calculation.
Notes: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The model performs well as most of the variables do have expected signs. Estimated models explain about 36- 96 per cent of the variations in direction of trade flows. The most interesting result is the strong influence that changes in LPI, both reporter and partner, had on changes in trade: higher the logistics performance, higher the trade in production-networked goods. The other important point to note is that in all regressions the classical linear regression is dominated by fixed-effect model. Hence, the ordinary regression results reported in Table 8 are not statistically tenable, particularly when regressor is India's export of yarn.[20] The robustness gets improved in case of fixed-effect model, which explain about 95 per cent of the variations in observation in case of export of yarn and 94 per cent in case of import of ACE. Baseline regressions suggest logistics performance and trade in production-networked goods are positively associated and that improvement of logistics would lead to an increase in trade, other things being equal. Coefficients of LPI have positive signs in FEM for both reporting country as well as partner country. In other words, controlling for country fixed-effects, the estimated elasticities indicate that a 10 per cent improvement in logistics performance in India increases her export of yarn to Bangladesh by about 3 per cent, whereas the improvement of logistics by same margin in Bangladesh increases India's export of yarn to there by almost 8 per cent. Marginal return from logistics improvement is thus appeared to be much higher in Bangladesh than India. In case of India's import of ACE from Thailand, estimated elasticities indicate 10 per cent improvement in India's logistics may lead to rise in India's import by 9 per cent, whereas 10 per cent improvement in logistics in Thailand may lead to rise in Thailand's export of ACE to India by about 1.5 per cent. Therefore, improvement of logistics services is essential as it would generate trade creation effect on goods that are linked to production networks across borders.

The reason the cross-country regressions technique was chosen for this study was because it was the methodology used by many research papers to gain generalisations in the results. Thus, although it is true that few of the country-specific policies and variables (some of them do not vary much over time) may lead to movements in trade and logistics, the cross-country regression generalises the result, focusing on some important accepted variables that are significant determinants. This in itself is important. Also, the fact can be established that country specific variables, together with the commonly accepted variables, are indeed important catalysts in this analysis.

Robustness Checks

The relationships described above cannot be interpreted as causal until the possibility of endogeneity has been ruled out in the baseline regressions. To address this issue, a dynamic GMM estimator (system-GMM) – also known as Arellano-Bover/Blundell-Bond linear dynamic panel-data estimation – was used to analyse changes across countries and over time.[21] The estimator also effectively deals with reverse causality by including lagged dependent variables to account for the persistence of the inequality and/or trade openness indicators.[22]

One of the main advantages of the system-GMM estimator is that it does not require any external instruments other than the variables already included in the dataset. It uses lagged levels and differences between two periods as instruments for current values of the endogenous variable, together with external instruments. More importantly, the estimator does not use lagged levels or differences by itself for the estimation, but instead employs them as instruments to explain variations in infrastructure development. This approach ensures that all information will be used efficiently, and that focus is placed on the impact of regressors (such as trade) on logistics, and not vice versa.

Also, the Arellano-Bover estimates presented in Table 9 remove the weak instrumental variables and poor efficiency problems since they utilise more moment conditions. Table 9 provides system-GMM estimates when the dependent variable is Indian export of yarn and India's import of ACE interchangeably. The Wald chi square statistics indicate the estimated results are robust and statistically significant. To test the appropriateness of the instruments used, the Sargan J-statistics of over-identifying restrictions in Table 9 is used. The Sragan J- statistics show that the applied instruments are valid. The Arellano-Bond (AB) tests for serial correlation support the model specification. If the model is well specified, we expect to reject the null of no autocorrelation of the first order (AB1), and to not reject the hypothesis of no autocorrelation of the second order (AB2). It is apparent that past export determines, to a smaller extent, the present level of export (first period lagged export is statistically significant), but logistics performance has strong influence on the export or yarn or import of ACE over time. In support of the previous findings (Table 8), system-GMM estimates suggest persistence of export (import), since the initial level of export (import) appears to be an important instrument that matters in the evolution of production-networked trade over space and time. Thus, the results of system-GMM support the static panel result. Therefore, we conclude that improvement in logistics performance significantly increases the production-networked trade across borders. However, to ascertain the causation between logistics performance and trade, we need to look at the causality.

Table 9: Arellano-Bover Dynamic Panel-data Estimation (System GMM)

DV = ln_export	**Coefficient**	**SE**	**DV = ln_ import**	**Coefficient**	**SE**
ln_export L1.	0.239*	0.069	ln_import L1.	0.107*	0.030
ln_export L2.	0.044	0.083	Ln_import L2.	0.015	0.060
ln_lpi_p	0.980***	0.346	ln_lpi_r	0.584**	0.357
ln_lpi_r	0.654**	0.264	ln_lpi_p	0.168	0.021
ln_er	-0.257	0.242	ln_er	-0.109	0.118
ln_pce	-1.044**	0.434	ln_pce	0.500	0.758
ln_mva	0.095	0.601	ln_mva	0.836	0.846
ln_gdp	1.533***	0.173	ln_gdp	1.812**	0.395
Wald chi2 (Prob > chi2)	2112.95 (0.00)			2956.59 (0.00)	
Sargan test, chi2 (Prob> chi2)	2.71 (0.342)			1.63 (0.265)	
Arellano-Bond (AB) test 1, Prob > z	0.004			0.003	
Arellano-Bond (AB) test 2, Prob > z	0.893			0.675	
Instruments	60			60	
Observations	171			171	

Source: Authors' calculation.
Notes: Dynamic panel counts White period instrument weighting matrix, White period standard errors and co-variance (d.f. corrected). The estimation uses orthogonal deviation. L1 and L2 equal lags 1 and 2, respectively. SE stands for standard errors. *** p<0.01, ** p<0.05, * p<0.1

Table 10: Im, Pesaran and Shin (IPS) Panel Unit Root Test (Period: 2000-2010)

Variable	Level	1st Difference
Export of yarn	4.3469	
Import of ace	4.1241	
lpi_p	-0.878	-8.3574
lpi_r	-1.2862	
gdp	11.1182	
mva	0.1723	-8.3376
pce	1.7857	
er	3.1842	

Source: Authors' calculation.

Cointegration and Causality

Table 10 presents the results of the Im, Pesaran and Shin (IPS) panel unit root test at level. IPS test is usually applied for heterogeneous panel to test the series for the presence of a unit root.[23] We found that the null hypothesis of having panel unit root is generally rejected in all but two variables at level form and various lag lengths. The results of the panel unit root tests confirm that the two variables are non-stationary at level. Table 10 also presents the results of the tests at first difference for IPS test. It was observed that for all the series the null hypothesis of unit root test is now rejected at 95 per cent critical value (1 per cent level). Hence, based on IPS test, there is strong evidence that all the series are integrated of order one, denoted I (1).

Next, we test for cointegration using the four panel cointegration tests developed by Westerlund (2007) (Appendix 7).[24] The underlying idea is to test for the absence of cointegration by determining whether the individual panel members are error correcting. This is to investigate whether long-run steady state or cointegration exist among the variables. Since the variables are found to be integrated in the same order I (1), we continue with the panel cointegration tests carried out for constant plus time trend. The postulated relationship between the variables allow for a linear time trend. The results are in Table 11. Results strongly reject the hypothesis that the series are not cointegrated, thereby showing existence of a long-run relationship among the relevant variables.

Table 11: Westerlund Panel Cointegration Test (Period: 2000-2010)

(a) Export of Yarn

Statistic	Value	z-value	P-value
gdp (partner)			
Gt	-4.963	-14.149	0
Ga	-21.352	-6.195	0
Pt	-18.876	-11.259	0
Pa	-85.544	-55.89	0
mva (1st diff)			
Gt	-11.421	-49.2	0
Ga	-23.013	-7.284	0
Pt	-33.568	-28.372	0
Pa	-34.816	-18.872	0
er			
Gt	-6.299	-21.399	0
Ga	-13.448	-1.016	0
Pt	25.939	40.94	0
Pa	5.263	10.374	0
lpi_p (1st diff)			
Gt	-12.438	-54.722	0
Ga	-21.123	-6.045	0
Pt	-0.59	10.039	0
Pa	-2.456	4.741	0
lpi _r			
Gt	-4.587	-12.108	0
Ga	-26.657	-9.671	0
Pt	-8.86	0.407	0
Pa	19.693	-7.837	0

Source: Authors' calculation.

(b) Import of ACE

Statistic	Value	z-value	P-value
gdp (partner)			
Gt	-6.076	-20.189	0
Ga	-24.845	-8.484	0
Pt	-20.045	-12.621	0
Pa	-24.635	-11.443	0
mva (1st diff)			
Gt	-2.128	1.235	0.892
Ga	280.156	191.38	1

Table: 11 continued...

Table: 11 continued...

Pt	-9.967	-0.882	0.189
Pa	-28.718	14.423	0
er			
Gt	-4.728	12.872	0
Ga	1.556	8.816	1
Pt	-13.451	-4.94	0
Pa	-20.965	-8.765	0
lpi_p (1st diff)			
Gt	-2.477	-0.656	0.256
Ga	-118.824	-70.068	0
Pt	-8.297	1.063	0.856
Pa	-15.949	-5.105	0
lpi_r			
Gt	-5.87	-19.071	0
Ga	-130.242	-77.55	0
Pt	-11.751	-2.961	0
Pa	-23.23	-10.42	0

Source: Authors' calculation.

Table 12: Panel Granger Causality Test between Trade and LPI

Variables	F-Test				Null Hypothesis		Result
	A (X causes Y)		B (Y causes X)		A (X causes Y)	B (Y causes X)	Granger Causality
	F-Statistic	F-Critical	F-Statistic	F-Critical			
Export of yarn and lpi_p	0.759	0.09	0.782	0.08	Reject	Reject	Bidirectional
Export of yarn and lpi_r	0.970	0	0.961	0	Reject	Reject	Bidirectional
Import of ace and lpi_p	0	62.2	0	52.6	Do Not Reject	Do Not Reject	No Causality
Import of ace and lpi_r	0.772	0.08	0.605	0.27	Reject	Reject	Bidirectional

Source: Authors' calculation.

Finally, we test for causality based on the Granger causality framework.[25] By estimating an equation in which Y is regressed on lagged values of Y and lagged values of an additional variable X, we can evaluate the null hypothesis that X does not Granger cause Y. If one or more of the lagged values of X is significant, we are able to reject the null hypothesis that X does not Granger cause Y. The test results presented in Table 12 indicate a two-way causality between LPI and trade. Improvement in logistics in trading partners would cause the higher trade in yarn and vice versa, whereas the improvement of same in importing country (trade partner) causes positively to higher trade in air-conditioning equipments.

6. Summary and Implications

Logistics services are an important factor that contribute to not only expansion in trade and production networks within or across countries but also help to build their productive capacities. With production processes and tasks in production increasingly fragmented across national borders, time-sensitive logistics services along with information and communication technology can be the key to facilitate production networks across borders. The analysis in this study provides a synoptic view of the role of logistics in promoting such production networks across borders. It undertakes a case study of two products: India's export of yarn to Bangladesh and India's import of air-conditioning equipment from Thailand. Both Bangladesh and Thailand are India's FTA partners, and trade in yarn and air-conditioning equipment has been growing rapidly. The existing production networks between India and Bangladesh in textile and clothing show that the pattern of division of labour is simplistic and appears to be cross-border production sharing type. However, the production networks between Thailand and India appear to be more complicated division of labour where more than two countries are involved and sophisticated combination of intra-firm and inter-firm transactions have developed.

India's yarn exports to Bangladesh and India's imports of ACE from Thailand were then studied from the point of view of intra-industry trade (IIT) potential. The IIT scores indicate intra-industry trade accounted for a moderate share between India and Bangladesh in textile and clothing sector. Within textile and clothing, India's export of cotton sewing thread (HS 5204), artificial filament yarn (HS 5403) and synthetic filament yarn (HS 5402) to Bangladesh have witnessed relatively higher IIT scores, indicating potential of further intra-industry trade between the two countries. On the other hand, in case of India's import of ACE from Thailand, we find a relatively higher and rising IIT index score in case of air, vacuum pumps, compressors, ventilating fans, etc. (HS 8414). The study has then analysed the vertical IIT. According to the index scores, the textile and clothing sector offers huge vertical IIT opportunities between the two countries, more importantly in the Wadding, felt, and the nonwoven yarns (HS 56). However, the vertical IIT potential in case of ACE at the present seems to be not very high, as compared to other sectors between Thailand and India.

How do we then facilitate vertical IIT between the two countries? What are the policies needed? Our analysis indicates that a number of product categories and sectors exhibit an increasing share of IIT with higher economies of scale between India and Bangladesh. Also, these are the sectors where we observe the potential for growth of bilateral trade between the two countries through IIT. In order to realise the potential, both the countries should undertake further trade liberalisation, such as removing non-tariff barriers, effective action for reducing trade costs by improving trade facilitation both 'at border' and 'behind the border', and improvement of logistics services. More importantly, reduction in service link costs to connect production blocks would pave the way for facilitating production networks.

The estimated LPI scores in this study indicate that the Asia and Pacific comprise a heterogeneous group characterised by wide gaps in logistics performance. Relatively richer economies occupy the top positions in LPI, whereas the bottom positions are occupied by the LDCs. For example, Myanmar, Cambodia, Lao PDR and Bangladesh occupy the bottom positions in logistics performance. Other developing countries occupy the middle portion of the ladder. Given the estimated ranks, LDCs and land-locked countries suffer more due to logistics inadequacy and inefficiency. The logistics gap between the relatively developed and the least developed countries in Asia and the Pacific region seems to have widened between 2000 and 2010.

The point that we emphasise is that logistics appear as a complementary factor in standard literature. We, however, look at the individual causalities in an integrated framework and discuss the role of logistics in promoting trade-induced production fragmentation across borders in an open economy framework. In the panel regressions detailed in this discussion paper, logistics performance is found to affect trade. The system-GMM estimates are robustness checks that suggest persistence of export (import) as the initial level of export (import) appears to be an important instrument that matters in the evolution of production-networked trade over space and time. The results of system-GMM do not reject the static panel data modeling results. Therefore, we conclude that improvement in logistics services significantly increase the trade in production networks across borders.

The final part of the study deals with cointegration and causality. It shows existence of a long-run relationship between trade and logistics performance. The Granger causality tests indicate a two-way causality between LPI and trade. The improvement in logistics in trading partners would Granger cause the higher trade in yarn and vice versa, whereas the improvement in logistics in importing country (here, India) causes positively to higher trade in air-conditioning equipment. The causal link, therefore, moves in both directions.

In terms of policy, this study suggests that efficient performance in logistics contributes positively to trade which can in turn promote cross-border production networks in Asia and the Pacific countries. Hence, the countries should pay greater attention to improvements in logistics, both trade infrastructure and human capital. Logistics improvement is shown to unambiguously increase trade. Therefore, we emphasise a logistics sector policy to facilitate trade and production networks across borders in Asia and the Pacific, which has the potential to reduce the high logistics gaps. The resource requirements for bridging the gaps are substantial. The process of regional economic integration has to contribute to narrowing these gaps by providing resources for improvements in logistics performance.

Endnotes

1 Refer, for example, World Bank (2012), Planning Commission (2011), to mention a few.

2 Based on a worldwide survey of operators on the ground - such as global freight forwarders and express carriers - the Logistics Performance Index (LPI) of The World Bank measures the logistics "friendliness" of 155 countries. It helps countries identify the challenges and opportunities they face in their trade logistics performance and what they can do to improve. Refer, for example, World Bank (2012). Appendix 1 presents the global ranks of selected Asia-Pacific countries for the year 2012. The contrast is while Singapore and Hong Kong occupy the first and second global rank in LPI, countries like Mongolia, Myanmar, Cambodia, and Lao PDR fall in the bottom group in LPI, thus showing wide intra-regional variations in logistics performance.

3 There is no clear consensus on definition of logistics. In literature, it overlaps in many cases with transportation even though there is a clear difference between the two. In most ASEAN and South Asian countries, there is still a lack of understanding of what makes up logistics and how a logistics policy should be developed. Logistics development policy frequently becomes just a transport investment infrastructure plan, but logistics is much more than just transport infrastructure, and developing a national logistics policy requires a holistic approach that encompasses traders, service providers, infrastructure, and rules and regulations. Refer, for example, Hollweg and Wong (2009), Sourdin and Pomfret (2012).

4 This is what Baldwin termed as "the 2nd unbundling". The 2nd unbundling is the international division of labour in terms of production processes and tasks. Refer Baldwin (2011).

5 This is also not to deny that framing a regional logistics sector policy has been slow in South and Southeast Asia, compared to national logistics sector policy adopted by several developing countries in recent years, Refer, for example, Findlay (2009), Sourdin and Pomfret (2009).

6 A vast number of studies on production fragmentation in context of East Asia was done by Kimura alone (refer, for example, Kimura and Ando 2005).

7 Preferential tariff reductions were given under, for example, SAFTA in case of India – Bangladesh trade, and ASEAN-India FTA and India-Thailand FTA in case of India – Thailand trade.

8 Refer, for example, Bergstrand (1985), Feenstra (2004).

9 The CES production function was first developed by Arrow *et al* (1961).

10 The reason is that if all goods are consumed as a constant fraction of GDP and price levels do not vary, but we do not see the expenditure shares or the price levels. In particular, the main way that international production sharing shows up here is that E varies a lot across countries as a function of what they are producing – a country makes lot of cars it demands an unusually large amount of car parts and components.

11 For example, a high price for a product may reflect higher production costs, or it may just reflect quality differences.

12 SAFTA was implemented among eight South Asian countries on 1 July 2006, whereas India-Thai Early Harvest Scheme (EHS) was implemented on 1 March 2004, and India-ASEAN FTA came in force on 1 January 2010.

13 Refer Appendix 2 for the BEC Codes and corresponding BEC-HS correspondences. Details on this methodology can be accessed at: http://www.icrier.org/pdf/amrita_saha.

pdf. A limitation of this consists of the fact that a single intermediate maybe an input for several final goods. It only traces the evidence of possibilities of production networks. This can be useful when supported by surveys with firms involved in these networks.

14 Refer Appendix 2 for matched data on Indian Industry.

15 There are some shipments from India's western part to Bangladesh by ocean.

16 Intra-industry trade produces extra gains from international trade, over and above those from comparative advantage, because intra-industry trade allows countries to benefit from larger market and economies of scale. Refer, for example, Krugman and Obstfeld (2000).

17 Before calculating IIT, data coordinates at HS nomenclature H2 were matched for both the countries. The traditional way to measure the degree of intra-industry trade is the Grubel-Lloyd Index (G-L Index). For further details of IIT, please refer, Mikic and Gilbert (2007, p.76).

18 Appendix 3 presents the calculated IIT scores.

19 We took all the countries listed in Table 7 except Brunei. Due to data limitation, we had to exclude Brunei.

20 Selection of model, whether a random-effect or a fixed-effect regression, was done based on Hausman test.

21 First introduced by Arellano and Bond (1991).

22 Following Arellano and Bover (1995), and Blundell and Bond (1998), a system-GMM was taken in place of a difference-GMM. Arellano and Bover (1995) and Blundell and Bond (1998) revealed a potential weakness of the difference-GMM estimator. They showed that lagged levels can be poor instruments for first-differenced variables, particularly if the variables are persistent. In their modification of the estimator, they suggested the inclusion of lagged levels along lagged differences. In contrast to the original difference- GMM, they termed this the expanded estimator system-GMM.

23 Appendix 6 presents the basic equations of IPS.

24 Appendix 7 presents the basic equations of Westerlund.

25 The usual caveat is that we intentionally ignore running any further panel regression at this point. Ideally, one may carry a panel regression (e.g. FMOLS) since the variables in questions are cointegrated. Since our interest is to investigate the causal direction, we concentrate only on Granger causality. Refer Appendix 8 for a briefed note on Granger causality model.

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Appendix 1

World Bank LPI, 2012

Country	LPI Rank	LPI Score	Customs	Infra-structure	Inter-national shipments	Logistics compe-tence	Tracking & tracing	Time-lines
Australia	18	3.73	3.60	3.83	3.40	3.75	3.79	4.05
Bangladesh	*	*	*	*	*	*	*	*
Cambodia	101	2.56	2.30	2.20	2.61	2.50	2.77	2.95
China	26	3.52	3.25	3.61	3.46	3.47	3.52	3.80
Hong Kong	2	4.12	3.97	4.12	4.18	4.08	4.09	4.28
Japan	8	3.93	3.72	4.11	3.61	3.97	4.03	4.21
India	46	3.08	2.77	2.87	2.98	3.14	3.09	3.58
Indonesia	59	2.94	2.53	2.54	2.97	2.85	3.12	3.61
Korea	21	3.70	3.42	3.74	3.67	3.65	3.68	4.02
Lao PDR	109	2.50	2.38	2.40	2.40	2.49	2.49	2.82
Malaysia	29	3.49	3.28	3.43	3.40	3.45	3.54	3.86
Mongolia	140	2.25	1.98	2.22	2.13	1.88	2.29	2.99
Myanmar	129	2.37	2.24	2.10	2.47	2.42	2.34	2.59
New Zealand	31	3.42	3.47	3.42	3.27	3.25	3.58	3.55
Pakistan	71	2.83	2.85	2.69	2.86	2.77	2.61	3.14
Philippines	52	3.02	2.62	2.80	2.97	3.14	3.30	3.30
Singapore	1	4.13	4.10	4.15	3.99	4.07	4.07	4.39
Thailand	38	3.18	2.96	3.08	3.21	2.98	3.18	3.63
Vietnam	53	3.00	2.65	2.68	3.14	2.68	3.16	3.64
Sri Lanka	81	2.75	2.58	2.50	3.00	2.80	2.65	2.90

Note: * Data not available

Source: The World Bank, Washington, D.C.

Appendix 2

HS Codes Considered for Calculating the Export of Yarn to Bangladesh

HS code	Product Description	HS code	Product Description
5205	Cotton yarn (other than sewing)	5603	Nonwovens, whether or not impregnate
5201	Cotton, not carded or combed.	5202	Cotton waste (including yarn waste)
5208	Woven fabrics of cotton, containing...	5607	Twine, cordage, ropes and cables,
5509	Yarn (other than sewing thread)	5107	Yarn of combed wool, not put up for
6006	Other knitted or crocheted fabrics.	5508	Sewing thread of man-made staple fibres
5407	Woven fabrics of synthetic filament	5007	Woven fabrics of silk or of silk
5209	Woven fabrics of cotton, containing...	5404	Synthetic monofilament of 67
5402	Synthetic filament yarn (other than...	5003	Silk waste (including cocoons)
5510	Yarn (other than sewing thread) of...	5604	Rubber thread and cord, textile
5504	Artificial staple fibres, not carde...	5002	Raw silk (not thrown)
6001	Pile fabrics, including long pile	5403	Artificial filament yarn (other than...
5512	Woven fabrics of synthetic staple...	5505	Waste (including noils, yarn waste...
5212	Other woven fabrics of cotton.	5606	Gimped yarn, and strip and the like
5515	Other woven fabrics of synthetic...	5601	Wadding of textile materials and...
5206	Cotton yarn (other than sewing thread)	5406	Man-made filament yarn (other than...
5408	Woven fabrics of artificial filament	5609	Articles of yarn, strip or the like
5503	Synthetic staple fibres, not carded...	5516	Woven fabrics of artificial staple
5112	Woven fabrics of combed wool or of ...	5608	Knotted netting of twine, cordage
5513	Woven fabrics of synthetic staple...	5305	Coconut, abaca (Manila hemp or Musa..
5211	Woven fabrics of cotton, containing...	5514	Woven fabrics of synthetic staple
5605	Metallised yarn, whether or not gim	5602	Felt, whether or not impregnated
5903	Textile fabrics impregnated, coated...	5306	Flax yarn
5210	Woven fabrics of cotton, containing...	5005	Yarn spun from silk waste, not put...
5806	Narrow woven fabrics, other than go...	5109	Yarn of wool or of fine animal hair
5401	Sewing thread of man-made filaments	5308	Yarn of other vegetable textile fibres
5309	Woven fabrics of flax	5111	Woven fabrics of carded wool or of...
5501	Synthetic filament tow	5507	Artificial staple fibres, carded...
5207	Cotton yarn (other than sewing thread)	5103	Waste of wool or of fine or coarse
5204	Cotton sewing thread, whether or not...	5502	Artificial filament tow
5203	Cotton, carded or combed.		

Appendix 2 continued...

Appendix 2 continued...

HS Codes Considered for Calculating the Import of ACE from Thailand

HS code	Product Description
8415	Air conditioning machines, comprising
8408	Compression-ignition internal combustion
8414	Air or vacuum pumps, air or other

BEC Codes

BEC	Good	Description
53	Primary/Semi Processed	Transport equipment and parts and accessories thereof
51	Final	Passenger Motor Cars

BEC	Good	Description
22	Final	Processed Industrial Supplies
21	Primary/Semi Processed	Primary Industrial Supplies

Appendix 2 continued...

Appendix 2 continued...

Production structure of Indian firms in Yarn Manufacture & Air Conditioning Equipment

Commodity	Number of factories				Value of Output in Rupees Lakhs				Net Value Added in Rupees Lakhs			
	2004	2006	2007	2009	2004	2006	2007	2009	2004	2006	2007	2009
Yarn*	11342	11942	11425	13417	11108327	14460645	15951148	20594695	1387909	2756030	3602741	2747245
Air Conditioning Equipment**	4050	4047	4149	4481	3238332	5378400	6836824	9611648	671973	1181872	1472233	2437654

For 2004-2007: NIC-1998 3 digit codes matched with corresponding ISIC Revision 2 codes and HS-1996 4-Digit Codes. *Includes 171 (Spinning, Weaving & Finishing of Textiles), 172 (Manufacture of other Textiles), 243 (Manufacture of Man-made Fibers). **Includes 291 (Manufacture of General Purpose Machinery) further disaggregated to 2911 (Manufacture of engines and turbines, except aircraft, vehicle and cycle engines), 2912 (Manufacture of pumps, compressors, taps and valves), 2919 (Manufacture of other general purpose machinery).

For 2008 onwards: NIC-2008 3 digit codes matched with corresponding ISIC Revision 2 codes and HS 1996 4-digit codes. *Includes 131 (Spinning, Weaving & Finishing of Textiles), 139 (Manufacture of other Textiles), 203 (Manufacture of Man-made Fibers). **Includes 281 (Manufacture of General Purpose Machinery) further disaggregated to 2911 (Manufacture of engines and turbines, except aircraft, vehicle and cycle engines), 2912 (Manufacture of pumps, compressors, taps and valves) , 2919 (Manufacture of other general purpose machinery.

Source: Authors' calculation.

Appendix 3

Calculated IIT Scores
(Exporter: India, Importer: Bangladesh)

Year	Product	Product Name	IIT Score
2001	5609	Articles of yarn strip, twine, cordage, rope, nes	0.99
2004	5202	Cotton waste, including yarn waste and garnetted s...	0.93
2000	5601	Textile wadding and articles, textile flock, dust,...	0.91
2000	5602	Textile felt	0.89
2007	5608	Knotted netting of twine, etc, fishing and other n...	0.89
2003	5202	Cotton waste, including yarn waste and garnetted s...	0.84
2007	5601	Textile wadding and articles, textile flock, dust,...	0.81
2003	5204	Cotton sewing thread	0.75
2008	5608	Knotted netting of twine, etc, fishing and other n...	0.71
2009	5403	Artificial filament yarn (except sewing), not reta...	0.67
2003	5603	Nonwovens textiles except felt	0.65
2004	5608	Knotted netting of twine, etc, fishing and other n...	0.65
2006	5512	Woven fabric with >85% synthetic staple fibres	0.65
2000	5401	Sewing thread of manmade filaments	0.64
2005	5505	Waste, noils, garnetted stock of manmade fibres	0.59
2001	5103	Waste of wool or animal hair, except garnetted sto...	0.58
2004	5103	Waste of wool or animal hair, except garnetted sto...	0.53
2007	5007	Woven fabric of silk or of silk waste	0.51
2009	5404	Synth monofilament >67dtex <1mm, strip, straw<5mm	0.49
2010	5204	Cotton sewing thread	0.48
2006	5606	Chenille, loop whale, gimped (except metallised) y...	0.45
2001	5608	Knotted netting of twine, etc, fishing and other n...	0.45
2004	5505	Waste, noils, garnetted stock of manmade fibres	0.45
2005	5602	Textile felt	0.44
2005	6001	Pile fabric, knit or crochet	0.43
2010	5403	Artificial filament yarn (except sewing), not reta...	0.42
2007	5210	Woven cotton, <85% cotton with manmade fibre,<200g...	0.41
2010	5402	Synthetic filament yarn(not sewing thread) not ret...	0.41
2008	5202	Cotton waste, including yarn waste and garnetted s...	0.41
2007	5202	Cotton waste, including yarn waste and garnetted s...	0.41
2007	5208	Woven cotton fabric, >85% cotton, < 200g/m2	0.40

Appendix 3 continued...

Appendix 3 continued...

2008	5210	Woven cotton, <85% cotton with manmade fibre,<200g...	0.38
2008	5007	Woven fabric of silk or of silk waste	0.37
2002	5407	Woven synthetic filament yarn, monofilament >67dte...	0.36
2003	5607	Twine, cordage, rope and cable	0.34
2006	5601	Textile wadding and articles, textile flock, dust,...	0.33
2010	5210	Woven cotton, <85% cotton with manmade fibre,<200g...	0.33
2010	5408	Woven fabric of artificial filament, monofilament ...	0.32
2009	5609	Articles of yarn strip, twine, cordage, rope, nes	0.31
2003	5309	Woven fibres of flax	0.30
2005	5103	Waste of wool or animal hair, except garnetted sto...	0.30
2006	5406	Manmade filament yarn except sewing, for retail sa...	0.28
2009	5204	Cotton sewing thread	0.27
2007	5512	Woven fabric with >85% synthetic staple fibres	0.24
2010	5211	Woven fabric, <85% cotton with manmade fibre,>200g...	0.24
2002	5201	Cotton, not carded or combed	0.22
2008	5602	Textile felt	0.20
2010	5208	Woven cotton fabric, >85% cotton, < 200g/m2	0.20
2009	5608	Knotted netting of twine, etc, fishing and other n...	0.20
2006	5007	Woven fabric of silk or of silk waste	0.18
2004	5513	Woven fabric >85% synth + cotton, <170g/m2 unbl/bl...	0.18
2008	5204	Cotton sewing thread	0.17
2007	5513	Woven fabric >85% synth + cotton, <170g/m2 unbl/bl...	0.16
2005	5202	Cotton waste, including yarn waste and garnetted s...	0.15
2008	5607	Twine, cordage, rope and cable	0.14
2005	5003	Silk waste	0.14
2008	5601	Textile wadding and articles, textile flock, dust,...	0.14
2010	5608	Knotted netting of twine, etc, fishing and other n...	0.14
2009	5601	Textile wadding and articles, textile flock, dust,...	0.11
2009	5607	Twine, cordage, rope and cable	0.11
2003	5408	Woven fabric of artificial filament, monofilament ...	0.11
2005	5211	Woven fabric, <85% cotton with manmade fibre,>200g...	0.11
2009	5806	Narrow woven fabric, except labels, etc, bolducs	0.11
2008	5512	Woven fabric with >85% synthetic staple fibres	0.10
2008	5505	Waste, noils, garnetted stock of manmade fibres	0.10
2009	5402	Synthetic filament yarn (not sewing thread) not ret...	0.10

Source: Authors' calculation.

Appendix 4

List of Logistics Performance Indicators

Sr. No.	Category	Indicator	Data Source
1	Transport services	Air transport, freight (million ton-km), taken per 1000 population	World Development Indicators (WDI), World Bank
2		Air transport, passengers carried, taken per 1000 population	
3		Container port traffic (TEU: 20 foot equivalent units), taken per 1000 population	
4		Rail lines (total route-km), taken per 100 sq. km. of area	
5		Roads, paved, taken as % of total roads	
6		Roads, total network (km), taken per 100 sq. km of area	
7	ICT services	Internet users, taken per 100 population	
8		Mobile cellular subscriptions, taken per 100 population	
9		Telephone lines, taken per 100 population	
10	Financial services	Domestic credit to private sector, taken as % of GDP	
11	Human resource quality	Literacy rate, adult total (% of people ages 15 and above)	

Appendix 5

PCA Weights

Indicators	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Air freight transport	0.324	0.327	0.322	0.319	0.324	0.324	0.324	0.345	0.333	0.335	0.353
Air passengers transport	0.341	0.339	0.343	0.331	0.344	0.348	0.348	0.366	0.349	0.348	0.331
Container port traffic	0.312	0.320	0.323	0.320	0.318	0.315	0.315	0.325	0.310	0.309	0.318
Rail lines	0.044	0.296	0.281	0.272	0.274	0.267	0.270	0.278	0.264	0.272	0.013
Roads, paved	0.281	0.270	0.272	0.277	0.277	0.279	0.280	0.360	0.277	0.280	0.279
Roads, total network	0.292	0.252	0.244	0.236	0.241	0.237	0.238	0.243	0.237	0.228	0.278
Internet users	0.327	0.308	0.317	0.333	0.330	0.326	0.320	0.332	0.321	0.324	0.346
Mobile cellular subscriptions	0.380	0.354	0.359	0.361	0.355	0.357	0.359	0.370	0.348	0.342	0.350
Telephone lines	0.363	0.336	0.338	0.339	0.334	0.337	0.340	0.354	0.341	0.334	0.334
Domestic credit to private sector	0.292	0.284	0.279	0.286	0.281	0.281	0.278	0.275	0.292	0.294	0.318
Literacy rate	0.219	0.195	0.201	0.205	0.203	0.205	0.208	0.224	0.209	0.217	0.233
Eigen value	6.381	7.139	7.029	6.987	7.046	6.941	6.943	6.512	6.960	6.831	7.037
Proportion explained (%)	58.000	64.900	63.900	63.520	64.050	63.100	63.120	59.200	63.270	62.100	63.980

Source: Authors' calculation.

Appendix 6

Im, Pesarn, and Shin (IPS) Unit Root Test

Im, Pesaran and Shin (IPS) proposed a test for the presence of unit roots in panels, and begin by specifying a separate ADF regression for each cross-section with individual effects and no time trend:

$$\Delta y_{it} = \alpha_i + \rho_i y_{i,t-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{i,t-j} + \varepsilon_{it}$$

where $i = 1, \ldots, N$ and $t = 1, \ldots, T$

IPS use separate unit root tests for the N cross-section units. Their test is based on the Augmented Dickey-fuller (ADF) statistics averaged across groups. After estimating the separate ADF regressions, the average of the t-statistics for p_1 from the individual ADF regressions, $t_{iT_i}(p_i)$:

$$\bar{t}_{NT} = \frac{1}{N} \sum_{i=1}^{N} t_{iT}(p_i \beta_i)$$

The t-bar is then standardised and it is shown that the standardised *t-bar* statistic converges to the standard normal distribution as N and T $\rightarrow \infty$. IPS (1997) showed that *t-bar* test has better performance when N and T are small.

Appendix 7

Cointegration Test of Westerlund

The underlying idea in Westerlund (2007) is to test for the absence of cointegration by determining whether the individual panel members are error correcting. Consider the following error-correction model:

$$
\begin{aligned}
D.y_{it} = {} & c_i + a_{i1}*D.y_{it-1} + a_{i2}*D.y_{it-2} + \dots + a_{ip}*D.y_{it-p} \\
& + b_{i0}*D.x_{it} + b_{i1}*D.x_{it-1} + \dots + b_{ip}*D.x_{it-p} \\
& + a_i\left(y_{it-1} - b_i*x_{it-1}\right) + u_{it}
\end{aligned}
$$

where, a_i provides an estimate of the speed of error-correction towards the long run equilibrium $y_{it} = -(b_i/a_i) * x_{it}$ for that series i. The Ga and Gt test statistics test H0: $a_i = 0$ for all i versus H1: $a_i < 0$ for at least one i. These statistics start from a weighted average of the individually estimated a_i's and their t-ratio's, respectively. The Pa and Pt test statistics pool information over all the cross-sectional units to test H0: $a_i = 0$ for all i versus H1: $a_i < 0$ for all i. Rejection of H0 should, therefore, be taken as rejection of cointegration for the panel as a whole.

Appendix 8

Granger Causality

Testing causality, in the Granger sense, involves using F-tests to test whether lagged information on a variable Y provides any statistically significant information about a variable X in the presence of lagged X. If not, then "Y does not Granger-cause X." Refer, Granger (1969) which was popularised by Sims (1972). There are many ways in which to implement a test of Granger causality. One particularly simple approach uses the autoregressive specification of a bivariate vector autoregression. Assume a particular autoregressive lag length p, and estimate the following unrestricted equation by ordinary least squares (OLS):

$$x_t = c_1 + \sum_{i=1}^{p} \alpha_i x_{t-i} + \sum_{i=1}^{p} \beta_i y_{t-i} + u_t$$

$$H_0: \beta_1 = \beta_2 = \ldots = \beta_p = 0$$

Conduct an F-test of the null hypothesis by estimating the following restricted equation also by OLS:

$$x_t = c_t + \sum_{i=1}^{p} \gamma_i x_{t-i} + e_t$$

Compare their respective sum of squared residuals.

$$RSS_1 = \sum_{t=1}^{T} \hat{u}_t^2 \qquad RSS_0 = \sum_{t=1}^{T} \hat{e}_t^2$$

If the test statistic

$$S_1 = \frac{(RSS_0 - RSS_1)/p}{RSS_1/(T - 2p - 1)} \sim F_{p,\, T-2p-1}$$

is greater than the specified critical value, then reject the null hypothesis that Y does not Granger-cause X.

It is worth noting that with lagged dependent variables, as in Granger-causality regressions, the test is valid only asymptotically. An asymptotically equivalent test is given by

$$S_1 = \frac{T(RSS_0 - RSS_1)}{RSS_1} \sim \chi^2(p)$$

Another caveat is that Granger-causality tests are very sensitive to the choice of lag length and to the methods employed in dealing with any non-stationarity of the time series.

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