Title

REGIONAL INTEGRATION AND PRODUCTIVITY GROWTH IN SOUTH ASIA

Authors

Amirul Islam
Department of Economics
School of Economics & Finance
Curtin Business School
Curtin University
Email: amiruli@yahoo.com

Ruhul Salim
Department of Economics
School of Economics & Finance
Curtin Business School
Curtin University
Ruhul.Salim@cbs.curtin.edu.au

Harry Bloch
Department of Economics
School of Economics & Finance
Curtin Business School
Curtin University
Harry.Bloch@cbs.curtin.edu.au

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Abstract

Understanding the role of regional integration in productivity growth remains a key question in formulating trade policies. Applying both the stochastic frontier analysis (SFA) and the data envelopment analysis (DEA) methodologies on a panel data from the South Asian countries, the study finds an eroding effect of the free trade agreement on productivity. Most of the countries in South Asia have suffered from a total factor productivity decline in the past three decades. The regional free trade agreement implemented in 2006 could not come to the rescue, as it failed to expedite investment. There are, however, substantial variations in technical inefficiencies among the South Asian countries, suggesting the possibilities of productivity improvement for the lagging countries through cross-border resource flows.

Key Words: South Asia, Regional Integration, Productivity Growth.
Regional Integration and Productivity Growth in South Asia

4.1 Introduction

The standard of living of a country depends on its per capita income growth, and it is widely believed that long-term sustainable growth is not possible without continued productivity growth. Observed cross-country variations in income have been attributed to productivity differentials in the literature (Easterly and Levine, 2001). Productivity growth tends to be associated with high growth episodes, both across countries and over time (Dowling and Summers, 1998). This means that the performance of rapidly growing economies depends more on productivity growth than on mere factor accumulations. As labour productivity growth in South Asia during the last decade fell below the long-run trend (Ark and Timmer, 2003), it has been an important issue for the policy makers of the region to explain the contributing factors of the productivity growth. Since trade creates important channels through which productivity is affected, and regional integration can change the existing trade patterns, a pertinent question is then, what empirical evidence we do have to support or refute the claim that the discriminatory trade policy can enhance productivity in South Asia.

Literature on openness reveals at least two channels through which openness can affect productivity, and these are trade and investment. Increased trade can foster a competitive environment whereby resources are attracted into more productive sectors of the economy. The dynamic effects of trade can be associated with the demise of inefficient firms and the expansion of incumbent efficient firms. This creates opportunity for reaping the benefit of large scale production. In a liberalized economy private investment is encouraged, and this, especially the foreign direct investment, increases productivity by transplanting new technology into the host economy. However, Grossman and Helpman (1991 and 1994) show that sustained increases in productivity depend on the post-trade composition of the production structure. If trade leads to specialization in sectors where the opportunities for learning by doing are prevalent, then long-term productivity growth is promising, while productivity might fall if countries
specialize in products that require low levels of skills. Moreover, non-economic factors like a congenial production atmosphere are also required for economic forces to work in the desired direction (Bandara and Karunaratne, 2010).

The productivity issue in South Asia, in the context of overall liberalization, has been investigated with subsets of manufacturing firms for selected countries (as in Mukim, 2011 for Sri Lanka and India; in Salim, 2003 for Bangladesh; and in Khanal and Shrestha, 2008 for Nepal), or for a selected set of agricultural commodities (as in Rahman and Salim, 2012; and in Selim, 2012 for rice production in Bangladesh). There are many other studies that link productivity changes to particular aspects of firms (importing, exporting or non-traded) or changes in demand and supply conditions (such as enlarged market and availability of new inputs). But it remains to be seen how these partial changes in the economy are reflected in the overall economic performance. The specific research question explored in this study is, to what extent the regional trade agreement, SAFTA, has affected the productivity performance of the South Asian countries. Analysing the impact of regional integration on productivity is important in that it will help policy makers to choose among alternative trade policy options. However, this topic has hardly been scratched in the context of South Asia.

The rest of the paper is organized as follows. Theoretical arguments and empirical evidence regarding the link between productivity and trade are explored in Section 4.2. A brief discussion of the existing literature on trade and productivity in general and in the context of preferential trade liberalization in particular is given in Section 4.3. Data along with their sources and the methodological framework for analysing them are presented in Section 4.4. Results of the estimated model and discussions of these results are contained in Section 4.5. The paper concludes Section 4.6.

4.2 Identifying the Channels of Trade-Productivity Linkage

Unless we can explain the logic behind trade-productivity linkage, simple statistical evidence of correlation between them will not solve the matter of causality. Productivity depends on a number of factors, of which openness and trade are considered important
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(Andersson and Loof, 2009). Creation of new or improved intermediate goods through research and development (R&D) expenditure in one country and their subsequent utilization in another country through imports enables the latter to boost productivity based on the R&D expenditure of the former. Innovators’ interests lie in having a larger market for the product that will cover the cost of innovation and bring profits. Thus, the benefit of the R&D expenditure is shared by all, though it may occur in one country.

While trade does not directly impact productivity, it does have some channels by which it can affect productivity. The following factors are believed to operate as the conduits of trade-productivity linkages:

(i) **Availability of better quality and wide range of inputs**: Access to foreign intermediate inputs can unleash domestic productivity in several ways, two of which are increased choices of inputs and better learning opportunities. Access to new sources of inputs enables firms to relax their technology constraints and grow on extensive margins. Ethier (1982) argues from a theoretical perspective that trade allows producers to choose from a variety of inputs, both domestic and foreign, thus making it possible to achieve cost efficiency in production. Methodologies for measuring such gains are discussed in Feenstra (1994) and Broda and Weinstein (2006). The gain is usually higher when domestic and foreign inputs are imperfect substitutes. Amiti and Konings (2007) find this type of productivity gain in the context of Indonesian firms when liberalization allows them access to cheaper and previously unavailable inputs.

Keller (1996) adds another element by pointing out that new products create an environment of learning, and importing firms may emulate that product or come up with a competing one. In this case, or in cases where interactions with foreign firms help reduce innovation costs of new products, permanent increases in productivity become realizable. If these two hypotheses of reduced cost and learning opportunities are valid, then the productivity levels of the importing countries should be boosted after liberalization. In accordance with this expectation, Coe and Helpman (1995) find a positive correlation between trade-weighted sum of the R&D expenditures of the trading partners and the total
factor productivity (TFP) levels of the importers. The relation is strengthened when the number of new varieties imported is positively related with the amount of imports (Grossman and Helpman, 1991) or imported inputs are complementary to domestic inputs (Zaclevicever and Pallendra, 2012).

The productivity gain from trade is also dependent on import sources and the absorptive capacities of the importers, the latter being influenced by the skill level of the labour force. Keller (1996), while examining the relation between trade pattern, technology flow and productivity growth, finds that there are significant variations in the estimated productivity growth that arise from different countries’ R&D expenditures. The importance of import origin in shaping productivity is also found in Schott (2004) and Kendelwal (2009) in the context of the US import data, and in Zaclevicever and Pallendra (2012) in the context of Uruguayan firms. These studies find imported inputs from developed countries to contribute more to the firm productivity compared to imports from less developed regions. Types of imported inputs also matter for productivity growth. Xu and Wang (2000), for example, find in their study that capital goods import contribute 10 per cent more productivity growth compared to the simple expenditure weighted imports.

(ii) Technology spillover via exporting activities: Trade opens up the opportunity for international exchange of technical information and makes research activities more efficient, as it eliminates the need for duplication of research in various countries. However, as technological innovations take place in a handful of developed countries, their proper diffusion is important for expanding the world technology frontier as well as for achieving an egalitarian world. Technological progress, which is at the heart of productivity growth, can be spilled over intra-industry, inter-industry, and within or across national boundaries. Technological spillovers at a global level can reduce income disparity among countries while local spillover can create geographic income divergence at national levels.

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1 According to Keller (2009), the seven largest industrialized countries accounted for 84 per cent of the world’s total research and development expenditure in 1995.
Technologies spread through imitations and learning, and traded commodities that embody new features become interfaces for technology spillovers. Keller (2009) shows that for many countries, around 90 per cent of total domestic productivity growth can be attributed to research and development activities of foreign countries, of which almost 20 per cent are trade related.

Exporting firms have chances to improve on their productivity as they come in contact with foreign consumers who impose higher quality requirements on the products. Improved ways of handling products and new sources of quality inputs are often suggested by foreign buyers. Frozen foods and medicine exports from Bangladesh, for example, face higher standards in the EU and the US market through the SPS (sanitary and phytosanitary) measures compared to the quality requirements of the domestic market. Exporting firms are provided with technical assistance which helps them to upgrade their technology and productivity.

Bernard and Jensen (1999) provide evidence from a cross-section of the U.S. manufacturing firms showing that exporting firms are on average more productive than non-exporting firms. Since output and employment grow at faster rates in firms that become exporters, liberalization raises total factor productivity through resource reallocation. These results are however based on the assumption that firms are randomly selected in the sample, which may not be true in practice. Firms that possess desirable performance attributes at the beginning become exporters more easily than average firms. This means that the causal direction from the exporting activity to the productivity growth is entangled.

Self selection of more productive firms into the export market raises the selection bias problem in the prior analyses of the productivity performance of exporting firms against non-exporting firms and thus makes the reported causal inferences unreliable. Clerides et al (1998) avoid the selection bias problem by using a dynamic discrete model in the context of firm-level data from Columbia, Mexico.
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and Morocco. Their results show that previous exporting experience does not have any significant impact on current performance. Biesebroec (2005) employs instrumental variable and semi-parametric methods to counter the endogeneity issue, and finds that African exporting firms are 25 per cent more productive than their domestic counterparts. The superior productivity performance of the exporting firms is ascribed to the opportunity of achieving scale economy after entering the foreign market. Hallaward et al (2002) argue in the context of Southeast Asian firms that the substantial amount of investment activities on behalf of the exporting firms compared to the domestic firms makes them more productive.

(iii) *Competitive Pressure and Market Discipline:* Imports raise the level of competition faced by the domestic producers, prompting them to become more productive by reducing inefficiency. Removal of tariff barriers invites low-cost foreign firms and increases competition. To survive in a competitive environment firms cannot afford sluggish behaviour among the labour force or keeping other resources idle. Firms that fail to increase efficiency are either forced to exit or lose market share.

Evidence suggests that firms become more disciplined in a competitive environment and management is under pressure to reduce x-inefficiency. Kalitzanakoses and Taylor (1990) investigate the productivity effect of the severity of competition by considering two sets of winter vegetables in Florida, one facing only limited competition from domestic firms and the other encountering both domestic and foreign competition. Since both sets of products enjoy similar technological innovations during the sample period and require comparable investment expenditure to adopt the technology, higher productivity performance of the vegetables facing import is attributed to the presence of additional competition from imports.

Competitive pressure also forces firms to reduce mark-ups over marginal costs and thus benefits the society at large. Lower price-cost margin can arise from
increasing returns, extended or thick market externalities, reluctance to labour hoarding behaviour (that is, the tendency of firms to keep labour force, especially skilled manpower, during recession or temporary fall in demand to make them readily available at boom time when demand survives), and reduced market power. The dynamics of mark-ups, however, differ across industry categories.

Siotis (2003) shows in the context of the Spanish economy that non-traded sectors like utilities and services can afford to determine higher mark-ups compared to the intentionally traded manufacturing sector. Spain’s gradual integration with the European Union during the second half of the eighties witnessed falling mark-ups in both these sectors. In a broader context, Allen et al (1998) examine the effects of the European single market program on the competitive behaviour of the participating countries. While the intensity of the effects depends on the country size, these authors obtain an overall 0.02 percentage point reduction in manufacturing mark-ups and dissipating price dispersion across the European Union countries.

There are, however, theoretical arguments explaining that preferential liberalization might not work the same way as unilateral or multilateral liberalization do on firms’ mark-up behaviour. Should integration produce trade diversion and offer regional producers protection from outsiders, the tendency for fixing prices at higher profit margins can remain. Moreover, the incentive to innovation and scale expansion might not work if domestic firms lose their market share after liberalization due to increased imports (Tybout, 2001 and Rodrik, 1992). Zeal for innovation may also fade away, as research and development activities become more of public goods in nature. Every country wants other countries to innovate and free ride on their innovations. All these factors work against the setting of reduced mark-ups by firms.

(iv) The FDI Channel: Trade and FDI are closely related. A large portion of export and import activities in the South Asian countries take place in the tariff shielded export processing zones or special economic zones where most of the
FDIs are attracted. To the extent that foreign firms bring with them management and organizational skills and are better equipped with technological know-how, increased FDI is expected to raise overall productivity. The decisions of foreign firms regarding export versus FDI activities, however, depend on the relative importance of shipping and technology transfer costs, the latter rising with complexity of technologies. As countries within a region are naturally proximate to each other, arm’s length trade is less expensive. Because of the low level of research and development expenditure, developing countries have low rate of product and process innovation. These countries compete with each other to attract FDI from developed countries.

FDI creates technological spillovers and productivity growth both horizontally and vertically. When domestic firms learn from a foreign firm in the same industry, the knowledge diffusion is horizontal. Haskel et al (2007) and Blalock and Gertler (2008) provide evidence of the positive horizontal spillover effects of FDI for firms in the UK economy. They show that expansion of foreign firms’ employment in 22 manufacturing industries has been instrumental in nurturing overall manufacturing productivity growth. Keller and Yeaple (2009) estimate horizontal spillovers with US data for the period 1987 to 1996 and find robust statistically significant effects of FDI on growth. The authors also suggest that high-tech sectors, like computer firms in Silicon Valley are likely to be more benefited from horizontal spillover compared to the low-tech toy or shoe producing sectors.

The vertical spillover effect of FDI activity takes place through backward and forward linkages. Multinational firms have much to gain from the better performance of their local input suppliers, and for this reason, Blalock and Gertler (2008) opine that it is in the interest of the former to transfer knowledge to the latter. Javorcik and Spatareanu (2008), in the context of Romania, show that compared to fully-owned foreign firms partially-owned foreign firms have a lower technology gap with domestic firms and, hence, have better chance to diffuse technology and improve productivity in the host country. Kugler (2000)
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argues that firms are often reluctant to horizontally transfer technology in the apprehension that this might lead to increased competition. However, imparting knowledge to their customers or their input sources, i.e. the vertical spread of technology is not conflicting with the interest of foreign firms.

Local workers hired for the multilateral affiliates learn through on-the-job or formal training program. They can quit jobs to start new businesses of their own or join a domestic firm. Poole (2009) finds for Brazil that workers with previous experience in multinational firms earn higher wages suggesting their higher productivity. Learning and gaining from the presence of foreign firms in this way is known as the productivity gain from labour mobility or employee turnover. Also, when foreign firms act as suppliers of quality inputs into the domestic market, the economy becomes more productive.

4.3 Review of Related Literature

Productivity growth in liberalized economies has been studied by various authors from different perspectives. Broadly considered, most of these studies are concerned with the productivity effects of some form of non-discriminatory (unilateral or multilateral) liberalization, while some others deal with the productivity effects of preferential liberalization. Both sets of these studies depend on either a sample of agricultural or manufacturing firms or the economy-wide aggregate variables to analyse the phenomenon of productivity growth in a liberalized economy. To a large extent, these studies attribute to the trade-openness induced productivity change, one or several of the factors of the trade-productivity links discussed in the previous section. This section highlights the major conclusions reached by some of these studies and at the end of the section indicates the contribution of the present paper to the current literature, especially in the context of regional trade liberalization and productivity growth in South Asia.

There is not much controversy in the literature when it comes to analysing the productivity effect of general trade liberalization. Most of these studies find some positive effects of openness on the overall factor productivity. Edward (1998), for
example, uses 9 different indicators of openness on a set of 93 countries, and finds that irrespective of how the openness is defined, more open countries experience higher productivity growth. Controlling for endogeneity by using instrumental variable approach does not change the results much. Similar positive effects of open economic environment on productivity are found in Topolova and Khandelwal (2010) for India, Khanal and Shrestha (2008) for Nepal, and in Karacaoglu (2011) for a set of US firms. When dynamics are incorporated, Andersson et al (2011), however, find productivity to fall at first and then to rise for the Swedish manufacturing firms in the short- and long-run respectively. The wavering productivity changes happen through a process of creative destruction, as increased competitive pressure forces the inefficient firms to exit and the efficient firms to expand productions.

The policy of regional integration affects productivity in a different way from that of the autonomous or multilateral trade liberalization. Since trade liberalization on a regional basis is discriminatory, it may protect some firms from competition of the extra-regional firms. Moreover, inputs of production can be sourced inefficiently from within the region, because of the uneven advantage granted to the regional firms. Several opportunities can arise within the bloc as member states offer market access to each other. In a larger regional market, there are prospects for division of labour and economies of scale. To take advantage of the local-content rule, firms may prefer intra-regional cross border investments. Badinger (2005) analyses both investment-led temporary and technology-led permanent effects on output and productivity of regional integration for the 15 European countries. The author argues that, regional integration creates favourable environment for entrepreneurial activity by reducing risk premium for investment and lowering the cost of collecting capital from a wider market.

The potential for productivity improvement through investment liberalization has got less priority in the current regional integration scheme in South Asia. In the SAFTA agreement, the signatories only express their willingness to remove barriers to intra-regional investment in a sub-section of an additional article (Article 8.b), which does not have any legal requirements or force, like the measures adopted for the traded goods in the Article-7 of the agreement. Intra-regional investment in South Asia is primarily
driven by bilateral agreements among the members or through some joint-venture projects among firms of the member states. For example, there is a joint-venture between the Indian motor vehicle company, Associated Motorways Private Limited, and the Sri Lankan tyre manufacturing company, CET, to exploit quality rubber from Sri Lanka and make tyres for vehicles in the Indian market. Similarly, India has substantial amount of foreign direct investment in Nepal and Bhutan through bilateral agreements. So the coefficient of the regional dummy in our analysis is not likely to reflect the effect on the output growth of SAFTA-induced investment changes. However, the coefficient of the capital stock in the production function will indicate the importance of taking concrete investment measures in future negotiations.

Formation of trade blocs among members that are asymmetric in terms of their sizes or level of development often raises concern about the consequences of the agreement for the weaker parties. Mexico is a relatively low income country in the NAFTA compared to the other members of the bloc. The productivity impact of NAFTA on the manufacturing sector of this developing country is analysed in López-Córdova (2003). The author follows the Olley and Pakes (1996) methodology to counter the selection bias and the endogeneity problems in the study. Instead of directly taking OLS residuals as measures of productivity, it is modelled as a function of the observed investment and capital stocks. Probability of a firm’s exiting from the industry is then estimated from a probit model. The information regarding survival possibilities based on investment expenditures and capital stocks are then used to estimate productivity form a Cobb-Douglas production function. Within this framework of analysis, inclusion of Mexico in NAFTA is found to be productivity enhancing for import competing firms and the US-owned foreign firms.

In general, firms that are in no way connected with the external market show poor performance after liberalization. Preferential tariff margins, import intensities, export activities and foreign investments, all positively explain the observed productivity performances of the sampled firms. Hoyos and Iakovone (2011) apply on the same dataset a difference-in-difference methodology, which controls for time-invariant firm-specific characteristics, to discover the channel of productivity growth in the Mexican
firms. Their results show that more integrated firms (both exporting and importing) experience higher productivity gain compared to both the less integrated firms (either exporting or importing) and the non-integrated firms (neither exporting nor importing). However, as a sharp devaluation occurred in Mexico in the same year NAFTA was implemented, the productivity effects reported in the study are intermingled with the effects resulting from the exchange rate changes.

The difference between NAFTA and SAFTA is that, while the former replaces the bilateral trade agreement between Canada and the USA, the latter retains active sub-regional groupings. Moreover, NAFTA is more integrated than SAFTA in terms of product coverage, investment measures, and the removal of non-tariff barriers. The policy measures covered under NAFTA are more elaborate and embrace policy changes in many areas including intellectual property rights (IPRs), services trade, and cross border capital movements. The shallowness of the South Asian agreement can be surmised by looking at its laconic 12 pages document and comparing it with the 573 pages detailed document of the NAFTA. In such circumstances, the market expansion and the productivity effects of the current free trade agreement could be expected to be quite different for the South Asian countries, compared to those experienced by the North American countries.

Free trade agreements can be signed among states that are part of different regions (for example, the FTA between Australia and China, or the agreement between India and Singapore) in which case factors other than transport cost (such as the complementarity of production structure, production network, and market expansion opportunity) get priority. In addition to being a free trade area, SAFTA is a regional bloc at the same time, and hence transport cost is an important consideration for this bloc. While most of the studies discussed so far, focus on productivity gain arising from tariff reforms, Blyde et al (2009) emphasize the role of reduced transport cost in improving productivity of the Brazilian and the Chilean firms. Trade costs appear as a more important factor than tariff barriers in affecting productivity in their analysis. These authors find trade liberalizations to improve productivity not only through the inter-sector resource allocation, but also through inter-firm resource mobility.
Trade costs and other barriers to trade hinder inter-firm resource allocation, which permits inefficient firms to stay in an industry and limit the expansion of the incumbent efficient firms. The results are in agreement with the prediction of Melitz (2003) regarding firm entry and exit that may result from regional integration. Reductions in trade costs in an integrated market lower the productivity threshold of the exporting firms. New firms that are drawn into the export markets are usually the productive ones. Liu (1993) in the context of Chile, and Ramaswamy (1999) for Indian firms also find supports for higher efficiency of the surviving and the newly entered firms and lower efficiency for the exiting firms.

When the impact of the intra-regional trade liberalization is analysed in a monopolistically competitive heterogeneous-firm setup, Melitz and Ottaviano (2008) find additional insights on welfare and long-run firm locations. Increased competition from import forces some domestic firms to cease operation in the short run. However, the short-run welfare rises, as new available varieties expand the choice set and increased import dominates the reduced domestic production. In the long run, industrial de-location takes place when firms find other countries as more attractive place for production. This pattern of shift in the geography of production is also highlighted in Venables (1985, 1987), Krugman and Venables (1996), and Baldwin et al (2003). Their basic argument is that, higher trade barriers enable different countries to maintain a mosaic industrial structure. Below a certain critical level of trade barriers, industry-specific basins of attraction are created across countries, from where the goods of the concentrated industries are supplied to the whole region.

Theoretical possibilities of such industrial locations or dislocations raise fear among the LDC members of the SAFTA that knowledge-intensive and increasing-return industries will be attracted to the urban centres of the relatively developed countries of the region. The state of initial comparative advantages among the countries will be further intensified, and it will be difficult for some of the countries to escape from their undesirable production structure. There is also the problem of short-run adjustment cost. The threat of maintaining unwanted industrial structure for some countries and the social tensions of unemployment are among several factors (notably, the political
misunderstanding between the two large members, India and Pakistan) that explain why the South Asian countries are so reluctant to deepen the level of their integration.

Though the productivity effect of SAFTA is not available in the literature, the impact on productivity of bilateral trade liberalization between India and Sri Lanka, and the geographic distribution of the gains among the exporting firms have been studied in Mukim (2011). A total of 313 major Indian exporting firms’ productivity performance is analysed over the period 1989 to 2008. Self-selection bias (for example, low-productive firms’ higher tendency to exit) is controlled for in the study by using the survival probabilities from a probit model. The simultaneity bias (for example, inputs and outputs may be chosen simultaneously, thus making input choices endogenous to the productivity) is taken care of by using intermediate inputs as proxy for time varying productivity shocks. A lagged export dummy (indicating whether the firm exported last year) is also included in the production function to assess whether exporting activities generate additional productivity.

The results in Mukim (2011) are consistent with the theoretical expectations. In addition to the learning by exporting evidence (significant positive coefficient on the lagged export dummy), export intensities are found higher among firms that are geographically proximate to Sri Lanka. Moreover, the location advantage in terms of providing better transport infrastructure, power supplies, and good regulatory environment also help firms to export more. A missing link from export to productivity not considered in the above study is the impact of geographic concentration on firm productivity. Since rival exporting firms are concentrated near the border, there is a possibility of high motivation among these firms to make strategic investment decisions that improve their productivity. This type of productivity improvement can arise independent of export activities and resembles the argument of Porter (1990) who, observing such positive effects of industry concentration on productivity, suggests that regional development policies should be designed in such a way that firms can locally control their investment and R&D expenditure decisions.
Most of the studies on productivity growth in the context of South Asia are country-specific and concerned with a selected set of manufacturing or agricultural firms. Overall productivity analysis, especially in the context of regional integration in South Asia, is missing from the literature. Prudent trade policy analyses require understanding of both the micro and the macro economic impact on productivity of policy changes. Data required to measure aggregate productivity are inadequate and sparse in almost all countries in South Asia. This has been a discouraging factor for measuring aggregate productivity-regionalism nexus in the context of developing countries. Utilizing the limited available data, multiple imputed datasets have been created for aggregated productivity analysis in this study. However, the results are also compared with those obtained from using the actual shorter dataset for checking their consistency. In addition, the South Asian dataset has been extended to include ten more neighbours from the Southeast Asia region, so that the productivity performance of these two sets of countries can be compared.

4.4 Data and Methodology

4.4.1 Description of the Data

The analysis of this study is also built on a panel dataset from the South Asian countries over the past three decades with variables that is relevant to the productivity measurement. Given the panel nature of the data, we can evaluate the average influence of variables experiencing inter-country variation along the time dimension. Simple cross-section data display only inter-unit variation in data and fail to control for the influence of unit-fixed effects. For example, Lee (2002) points out that in analysing the effect of schooling on wage, individual-specific unobserved abilities are ignored in the cross-section data. Similarly, inter-temporal variations of a single unit, obtained from a pure time-series data may not be applicable to other units. Conclusions reached by considering both the individual and the inter-temporal dimension of the data will be more general and widely applicable than would be possible if we considered only cross-section or time-series data.
The key variables used here for productivity analysis include labour, capital, education and output, each aggregated at the country-level. Depending on data availability, the sample of the relevant variables for the seven South Asian countries ranges from 1981 to 2010. Gross domestic products at constant prices (2000 US dollars) are treated as the aggregate output and these values are obtained from the online World Development Indicators data bank. Other variables collected from the same source include gross capital stock formations, total number of employed people aged over fifteen, and per cent of population that have completed secondary level of education.

Size of the labour force is not used as a measure of aggregate labour input on the ground that it includes both employed and unemployed persons which vary in accordance with the health of an economy. Moreover, the labour force participation rate is not stable due to the encouraged and discouraged worker effects. So, for that reason, the number of people aged over fifteen and employed is taken as the amount of labour input. Data for this variable are collected from the online databank of the World Bank (URL: www.databank.worldbank.org).

Total amount of capital stock is the other required variable in the aggregate production function. However, countries report gross fixed capital formation (GFCF) each year, not the total stocks that are needed for estimating the production frontier. The perpetual inventory method, as suggested in Fuente and Domenech (2000), is followed to construct the capital stock series from the GFCF of the concerned countries. The major tasks in obtaining such series are first to estimate the initial capital stock, and then with a differential equation, the remaining series are derived. More specifically, the following two equations are used to obtain the capital stock series:

\[
K_{1981} = \frac{GFCF_{1981}}{g_{(GFCF,1981-2010)} + \delta}
\]

\[
K_{t+1} = K_t - \delta K_t + GFCF_t , \text{ for } t = 1981, \ldots, 2010
\]

where g is the growth rate of capital stocks, averaged over the sample period, and \( \delta \) is the depreciation rate of capital stocks, which is assumed here at 0.05.
Presence of missing values makes the dataset an unbalanced panel and the total number of usable observations is adjusted accordingly in the estimation procedure, when the observed-only dataset is considered. Recent advances in imputations of missing values in panel data allows us to recover valuable information about the unobserved values and make the estimates more reliable. Little and Rubin (2002) suggested multiple imputation procedure has been applied with the help of the “Amelia II” software developed by Gary Kings (2012) to examine the pattern of missing data and recover model based stochastic imputed values. Stochastic nature of the imputed data makes them amenable to be used with the observed values for any statistical analysis. Results are, however, reported for both the imputed and the shorter observed-only dataset for comparison purpose.

4.4.2 Dealing with Missing Data

The data available for the study comes in such a way that, observations on various variables are missing not at the same point in time or for all countries at the same time point. List wise deletion of observations because of at least one missing value for only one variable, means that available information on other variables or from same variables on other countries that could have been used to predict the missing values are discarded. The information content and the estimation performance can be substantially improved by analysing the pattern of missing data and applying modern imputation procedures. Both cross-section and temporal relationship among the variables are used here to impute missing values. For example, if Bhutan is known to have a trade flow amount of 0.5 million dollars with Bangladesh in 1995, this information, along with other pieces of information retrievable from other relevant variables, is utilized in calculating the unknown trade flow between these two countries in 1993. It is shown in the literature (for example, in Honaker and King, 2010) that multiple imputations based inferences reduce bias and improve efficiency of estimates, compared to the estimates obtained from data with list-wise deletions of missing observations.

In multiple imputations, a conditional predictive distribution for the missing values $Z_M=(Y_M X_M)$ based on the observed data $Z_0=(Y_0 X_0)$ is defined, and then missing cells in the data matrix is filled in by drawing values from the posterior distribution,
$f(\theta | Z_0) = \int f(\theta | Z_0, Z_M) f(Z_M | Z_0) dZ_M$

where $\theta$ is the parameter vector of the distribution. $Z_O$ and $Z_M$ are the observed and missing values respectively. Some packages implement the draw with the Markov Chain Monte Carlo (MCMC) tool. However, Amelia-II follows the expectation-maximization bootstrapping (EMB) approach whereby multiple bootstrapped samples, which look like complete data, undergo expectation maximization procedure to generate parameters of the posterior distribution. Imputed values are then generated from the distribution with the bootstrapped parameters. Each missing cell is filled in with multiple imputed values, creating several datasets all of which have the same observed but different imputed values. These new datasets can be combined or used independently for statistical analysis, as is done for the observed-only data set (Honaker et al., 2011).

4.4.3 Methodology and Empirical Model Selection

Efficiency of the production process is inherent in the concept of productivity. Naively it can be measured as a ratio of the total output to the total amount of an input, as is done in the case of measuring labour productivity. In macroeconomic context, the Solow (1956) model is widely used to derive aggregate productivity measures. Though the measure of productivity change based on the Solow concept misses out the contribution of some other unknown factors, some economists still consider it as the best available measure of productivity change. Hulten (2000), for example, concludes that the residual based productivity measure provides a simple internally consistent framework for explaining economic growth and a guide to many other economic measurements.

Total factor productivity growth is not just technical progress. Organization of production and worker motivation can also influence productivity. Similarly, producing for a larger market can enable firms to reap the benefit of scale economy. Productivity growth is broadly defined here to include all these sources. However, technical inefficiency that arises from negligence or inefficient uses of resources can co-exist with total factor productivity growth. Availability and adoption of an advanced technology
but inability to fully capitalize on it, say because of skill shortage, can result in such a situation. Both possibilities are considered in the following analysis.

Literature suggests two alternative ways of estimating the production frontier, from which technical inefficiencies can be inferred. One is non-parametric linear programing based data envelopment analysis (DEA) and the other is parametric econometric estimation based stochastic frontier analysis (SFA) approach\(^2\). The former estimates a piece-wise linear deterministic frontier, based on linear programing and does not allow for noise factors or errors in measurement. The only source of deviation from the frontier is assumed to be arising from technical inefficiency and there is no room for statistical significance testing. To overcome this statistical decision making problem, Simar and Wilson (2000) have devised a bootstrap based technique that provides confidence interval for the DEA inefficiency estimates. Both these procedures are followed here to check the robustness of the results across these two methodologies.

The basic idea behind the stochastic frontier approach is that, a set of realized input-output combinations are observed for a number of countries over some time periods, and then among them the best performing aggregate activity levels are chosen to estimate a stochastic production frontier, which can be termed in our context as the South Asian technology frontier. Input combinations producing outputs that lie far below the frontier are technically inefficient, and are assumed to result from not utilizing the best available production methods that are being used by the countries near the frontier. The technical inefficiency may in fact also result from measurement errors or prevailing production environment like strikes or natural calamities. A similar exercise has been done in Growiec et al (2011) to construct a world technology frontier by using data from 19 highly developed OECD countries. However, whereas missing values of some the variables are extrapolated forward to obtain the required yearly observations in their

\(^2\) There is a third bootstrap based compromise approach pioneered by Kuosmanen and Kortelainen (2010), where properties of both the DEA and the SFA are combined. In this approach the piece-wise linear deterministic production frontier is replaced by an increasing and concave function that may be differentiable or not, and treating the composite error term as stochastic. This method results in a stochastic non-smooth data envelopment analysis.
sequential DEA estimation of the frontier, we rely here on the multiple imputations method to get the missing yearly observations.

Availability of panel data enables us to simultaneously investigate the technical change and technical efficiency across countries over time. In a panel data setup, the efficiency frontier along with the inefficiency model can be represented as:

\[(4.1a) \quad Y_{it} = \exp \left( X_{it} \beta + V_{it} - U_{it} \right), \quad \text{and} \]
\[(4.1b) \quad U_{it} = Z_{it} \delta + \varepsilon_{it} \quad i = \{BD, IN, MA, NE, PK, SL\}, \quad t = \{1, \ldots, 30\} \]

The dependent variable $Y_{it}$ is the aggregate output, measured by constant dollar GDP, of county $i$ ($i = 1, \ldots, 7$) in period $t$ ($t = 1981, \ldots, 2010$). Though observations along all the time points and cross sections are not available, Coelli et al (1995) argue that this type of model is still identified and estimable with the remaining unbalanced panel. The vector variable $X_{it}$ has within it gross capital stock ($K_{it}$) and the total number of person employed ($N_{it}$) of country $i$ in period $t$. It also includes the year variable as a measure of shift of the production frontier over period, and the regional integration dummy that is hypothesized to affect the overall productivity.

Of the two error terms, $V_{it}$ and $U_{it}$, in the technology frontier equation (4.1a), the first one possesses the standard independent and identically distributed variable assumption, i.e. $V_{it} \sim N(0, \sigma_v^2)$, while the second one is considered as the non-negative realizations of errors, intended to capture the (technical) inefficiency effects in the aggregate production process. The non-negative values of $U_{it}$ are obtained by truncating a normal distribution at zero that has a mean of $Z_{it} \delta$ and variance $\sigma_u^2$, i.e., $U_{it} \sim N(Z_{it} \delta, \sigma_u^2)$. However, the distribution collapses to the half-normal distribution if $\delta = 0$, that is, when inefficiencies are not explained by other factors. The representative error distributions are illustrated in Figure 4.2. It should be noted that $\sigma^2$ is the variance of a normal distribution and when it is truncated at zero the remaining distribution, as Coelli et al (1999) show, has the variance, $\sigma_u^2 = [(\pi - 2)/\pi] \sigma^2$. In case of a half-normal distribution,
the mode is at zero implying that most of the countries are efficient (since, $e^{-u} = e^0 = 1$) relative to their efficiency frontier, whereas for the truncated normal case most of the firms are inefficient to some extent.

**Figure 4.2 Normal, half-normal and truncated normal error distributions**

Any factor influencing inefficiencies are included in the $Z_{lt}$ vector. However, whether the model should accompany the inefficiency part is an empirical matter, and depends on the nature of the data. Introduction of this additional part uses up degrees of freedom and often creates parameter identification problem (Peyrache and Coelli, 2009). From a different perspective, Pascoe et al (2004) suggest to incorporate as many determinants as possible into the technology frontier, instead of adding an inefficiency equation. Their argument is that, for obtaining the unbiased estimates of capacity utilization, both the inefficiency and the utilization components should be measured directly from the production frontier.

In our implementation of the model (4.1) with the available South Asian data, the variance parameter, $\gamma$, is found to be above 0.98, implying that there are significant variations in the country effects relative to the total variation in the data. Any attempt to incorporate the year or the education variable in the inefficiency part of the model turns the variance matrix near singular. This makes the parameter estimates unstable. Moreover, the log likelihood value drastically falls from 192 for the main model (4.1a) to only 26 for the complete model (4.1a and 4.1b). From these considerations, we retain the main stochastic part of the model for our analysis. Unlike some other studies (as in
Regional Integration and Productivity

Cordova, et al, 2003), where the estimate of productivity is obtained in the first stage from a production function, and then in the second stage the productivity estimate is regressed on some other explanatory variables, we prefer here a single equation estimation strategy. The two-stage methodology is problematic in that the assumption of the independence of the error term in the first-stage is no longer tenable when a second-stage regression is performed.

4.5 Results and Discussion

In contrast to non-parametric approaches, analysis of a stochastic frontier is based on a chosen functional form. Three functional forms commonly applied in empirical works are the transcendental logarithmic or translog, the intrinsically non-linear constant elasticity of substitution (CES), and the Cobb-Douglas (CD) forms. Among these specifications, the translog form is the most flexible and can encompass many other forms including the above two. However, fitting this from requires estimation of additional parameters. An additional set of square and cross-product terms of the factors needs to be estimated along with the CD parameters. This requires a rich dataset so that a substantial amount of variation and independence remain along the extra-dimension created for the translog form.

When the current dataset is fitted to the flexible translog functional from, the estimated model behaves poorly in terms of its economic interpretation. Though the log likelihood value for the model is higher than the other two models, the coefficient of the capital term becomes negative and most of the predictors turn insignificant (results not reported). Creation of extra-dimensions thus appears to create multicollinearity problem in the new data. The CD and the CES functions can be derived from the translog form with appropriate parameter restrictions on the latter. While the CD form imposes zero restrictions on the additional parameters, the CES specification applies the $b_{kk} = b_{LL} = 0.5 \times b_{KL}$ constraint on the translog function.

Uses of a priori information through such restrictions eliminate the multicollinearity problem and give more sensible parameter estimates. The log likelihood value is reduced somewhat, as it should happen with any restricted model. However, the reduction is only
slight, from 200 for the translog model to 196 for the CES model and 193 for the CD model. When the data are plotted in three dimensional scatter diagrams in labour, capital, and output space (Figure 4.4), a smooth curvature through the points can be imagined. The gap in the scatter arises as the maximum amount of labour, capital, and output for some smaller member countries are substantially lower than the minimum amount of these variables for the larger countries. The gap is slightly reduces in the imputed dataset. Since our purpose is to provide some economic explanation of the frontier and not predict output based on the highest log-likelihood value, the CD and the CES form are chosen as the parametric representation of the frontier.

**Figure 4.4 Three dimensional scatter plot of labour, capital, and output.**

<table>
<thead>
<tr>
<th>Output</th>
<th>Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The maximum likelihood estimation of the technology frontier for South Asia is provided in Table 4.1. There are four estimated technology frontiers in the table. These are the CD and the CES technologies estimated from the observed and the imputed data. The standard errors, reported just below each parameter estimate, are the diagonal elements of the final directional derivative matrix of the log likelihood function.

Examining Table 4.1 for a quick comparison of the parameter estimates across datasets and technologies, several features can be detected. First, the log likelihood values of the two technologies are quite close when they are based on the same data, observed or
imputed. For the CD and the CES technology respectively, these values are 193 and 196 for the observed, and 302 and 308 for the imputed data. This suggests that the CES technology better fits the South Asian data. Second, the qualitative information or sign pattern of all the parameter estimates are unaffected, whether we consider the CD or the CES technology, or the observed or the imputed data. Differences emerge, however, when we are interested in the magnitude of the parameter estimates and the strength of the statistical significance of the parameters.

We need some caution when comparing the coefficients of the labour and the capital in the two technologies. In the case of the Cobb-Douglas technology, the coefficients of the two factors directly express the share parameters or output elasticities with respect to the respective factor use. Whereas the share parameter for the CES frontier is derived from the restrictions imposed on the translog frontier. The share parameters and the elasticity of substitution parameter for the CES frontier are derived in Appendix 4.1A at the end of this paper. The estimated share parameters for labour and capital for the CES production frontier are 0.49 and 0.51 respectively. These figures are more balanced than those obtained under the CD specification.
Table 4.1: Parameter Estimates of the South Asian Technology Frontier

(Independent Variable: Log of Output)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>CD Technology</th>
<th></th>
<th>CES Technology</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observed Data</td>
<td>Imputed Data</td>
<td>Observed Data</td>
<td>Imputed Data</td>
</tr>
<tr>
<td>Constant</td>
<td>2.273**</td>
<td>1.157**</td>
<td>4.303**</td>
<td>3.103**</td>
</tr>
<tr>
<td></td>
<td>(0.063)</td>
<td>(0.408)</td>
<td>(1.064)</td>
<td>(1.413)</td>
</tr>
<tr>
<td>Log(Capital)</td>
<td>0.731**</td>
<td>0.826**</td>
<td>0.511**</td>
<td>0.519**</td>
</tr>
<tr>
<td></td>
<td>(0.051)</td>
<td>(0.036)</td>
<td>(0.087)</td>
<td>(0.118)</td>
</tr>
<tr>
<td>Log(Labour)</td>
<td>0.231**</td>
<td>0.163**</td>
<td>0.169**</td>
<td>0.450**</td>
</tr>
<tr>
<td></td>
<td>(0.038)</td>
<td>(0.028)</td>
<td>(0.047)</td>
<td>(0.092)</td>
</tr>
<tr>
<td>$[\text{Log(Capital)}]^2$</td>
<td>---</td>
<td>---</td>
<td>0.005**</td>
<td>0.016**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(&lt;0.001)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>$[\text{Log(Labour)}]^2$</td>
<td>---</td>
<td>---</td>
<td>0.005**</td>
<td>0.016**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(&lt;0.001)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>$[\text{Log(Labour)}] \times [\text{Log(Capital)}]$</td>
<td>---</td>
<td>---</td>
<td>-0.0025**</td>
<td>-0.008**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(&lt;0.001)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Year</td>
<td>-0.005*</td>
<td>-0.009**</td>
<td>-0.006**</td>
<td>-0.005</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>RTA</td>
<td>-0.033**</td>
<td>-0.048**</td>
<td>-0.034**</td>
<td>-0.051**</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.013)</td>
<td>(0.015)</td>
<td>(0.013)</td>
</tr>
</tbody>
</table>

Variance Parameters

<table>
<thead>
<tr>
<th></th>
<th>CD Technology</th>
<th></th>
<th>CES Technology</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma^2$</td>
<td>0.174*</td>
<td>0.139**</td>
<td>0.183**</td>
<td>0.184</td>
</tr>
<tr>
<td></td>
<td>(0.095)</td>
<td>(0.075)</td>
<td>(0.099)</td>
<td>(0.134)</td>
</tr>
<tr>
<td>$\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}$</td>
<td>-0.987**</td>
<td>0.981**</td>
<td>0.989**</td>
<td>0.986**</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.011)</td>
<td>(0.006)</td>
<td>(0.010)</td>
</tr>
</tbody>
</table>

Log likelihood

<table>
<thead>
<tr>
<th></th>
<th>CD Technology</th>
<th></th>
<th>CES Technology</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(OLS log likelihood)</td>
<td>192.808</td>
<td>302.175</td>
<td>209.517</td>
<td>307.52</td>
</tr>
<tr>
<td></td>
<td>(18.47)</td>
<td>(19.56)</td>
<td>(35.154)</td>
<td>(25.52)</td>
</tr>
</tbody>
</table>

Notes:

- The numbers in the parentheses are standard errors of estimates.
- "**" and "*" indicate significance level at 0.01 and 0.05 respectively.
The calculated elasticity of substitution parameter for the CES is 0.95 which is slightly lower than the CD counterpart value of one. In both the functional forms, productivity of one factor rises with the increasing availability of the other factor. However, this productivity increase is constrained by the presence of a negative term associated the cross-product term \( \alpha_{LK} = -0.0025 \) for the observed data and -0.008 for the imputed data) in the CES case. The estimated substitution elasticity is slightly lower accordingly in this case.

Observing at the bottom of Table 4.1, we note that the log likelihood value for the stochastic model under CD technology and complete observation is calculated at 192.81, while the OLS fit produces a likelihood value of 18.47, much less than the former (Similar patterns are observed when the results are from the CES technology and the imputed dataset). Monte Carlo evidence suggests that (Coelli 1995) when the model parameters are estimated by the maximum likelihood method, likelihood ratio test has better size properties compared to the Wald test while performing one sided parameter tests. Therefore, we compare the two likelihood values obtained from the restricted (OLS) and the unrestricted (stochastic) models through a likelihood ratio test statistic. The value of the test statistic\(^3\) is 348.68, which is substantially higher than the critical value of 3.84 at 1 degree of freedom (the degrees of freedom equal the number of restrictions required to turn the stochastic model into the OLS model. The only restriction here is, \( \sigma_v^2 = 0 \) obtained from a mixed chi-square distribution and hence we reject the null hypothesis of no technical inefficiency in the model against the claim that inefficiency in the aggregate production data is present for the South Asian countries.

The coefficients of both the capital stock and the labour force variables are of expected signs and statistically significant at the conventional five per cent level. Relatively higher value of the capital parameter highlights its scarcity and the consequent importance of this factor for output growth in South Asia. The estimates suggest that an increase in capital marginally by one per cent leads to more than 70 per cent rise in

\[^3\] The test statistic is calculated according to the formula, LR = -2 [log likelihood (unrestricted model) – log likelihood (restricted model)] = -2(18.47 – 192.81) = 348.68.
output in case of the CD specification, both for the observed and the imputed data. This result is typical for labour abundant economies. These estimates also suggest that the estimated production function exhibits a return to scale value of 0.96 with a standard error of 0.004, the latter being calculated from the linear combination of the variance of the capital and the labour parameter estimates. So the assumption of constant returns to scale Cobb-Douglas aggregate production technology is statistically valid. Allowing for the CSE technology, reduces the importance of the capital share, but still remains slightly above 50 per cent.

Given demand structure, increased investment can come through supply-side measures. The quality of national institutions and government policies affect the economic environment within which firms make investment decision and interactions among various economic units take place. Hall and Jones (1999) show that the observed cross country differences in capital accumulation, educational attainment, and productivity experience to a large extent can be explained by the status of their social infra-structure and government policies. Importance of capital stock, however, does not downplay the role of labour force in output growth. In case of the Cobb-Douglas or the CES technology, there exists a symbiotic or complementary relationship between the two factors of production. That is, labour becomes more productive as additional capitals are available, and the vice versa. Mathematically speaking, the second cross partial derivatives of the production function with respect to both inputs are positive.

The coefficient of the year variable captures the Hicks-neutral technological change, whereby the production frontier shifts in such a way that the optimal choice of labour and capital remains same. This type of innovation is often assumed while working with an aggregate production function, where factor substitution activities occurring at micro levels are cancelled out in the aggregate. The very low coefficient of the year variable (-0.005 to -0.009, depending on model and data) implies that the production frontier for the South Asian countries as a whole slightly moved inward each year or at best remained stagnant in the study period. Mild decline in productivity also becomes apparent from the non-parametric Malmquist total factor productivity growth analysis performed later in this section.
The results of the stochastic frontier analysis remind us about the inappropriateness of using single-factor based productivity growth. Simple labour productivity growth does not automatically imply total factor productivity growth. Per capita outputs in the South Asian countries are obviously growing during the sample period. But once the contribution to output growth of the rapid capital stock growth is accounted for, there remains little or no room for total factor productivity growth. The spectacular output growth in the region (from 5 per cent for Bangladesh to more than 7 percent for Maldives, average yearly real output growth over the past three decades) can thus be attributed to the input growth and capacity utilization.

Of particular interest for this part of the paper is the coefficient of the RTA dummy, which is found here to be negative and statistically significant. The coefficient ranges from -0.033 to -0.051. This implies that the SAFTA regime has not been conducive to productivity growth in South Asia. Compared to the pre-SAFTA regime, the production frontier has moved further inward in the agreement period by about 3 per cent to 5 per cent, depending on models or data used. The poor performance of the SAFTA from the perspective of productivity growth can be attributed to the inability of the trade agreement to expedite investment flow within the region. Investment-output ratio of the South Asian countries during the past few decades has been in fact about half to two-thirds of that achieved by the neighbouring Southeast Asian countries (Collins, 2007).

There is another reason for the productivity to be negatively affected from regional integration. Knowledge diffusion through trade is found to be lower when both trading partners are from developing countries, compared to the situation where the partners are from a mixture of developed and developing countries (Schieff, 2003). Thus to the extent that preferential trade replaces the North-South trade with the South-South trade, productivity is expected to fall. Moreover, productivity depends not only on economic factors, but also on other factors like democracy, stability of government, level of corruption, congenial political environment and supporting domestic institutions. Bandarra and Karunaratne (2010) show in the context of Sri Lankan manufacturing that

---

4 These growth rates were obtained by regressing log output on a time trend for each country over the sample period.
political unrest and the absence of social order can overwhelm the force of economic policy reforms. They show that despite the liberalization polices of the subsequent governments since 1977, Sri Lanka experienced wavering productivity performance depending on investment climate and production uncertainty.

Education and training programme improve the quality of labour. They are part of human capital and are thought to increase output by improving the productivity of labour. Data on this variable for the South Asian countries are severely missing. Around 86 per cent of the potential observations for this variable are not reported in the available sources in the sample period. Adding education to the model increases the number of parameter to be estimated, but, because of missing data, row-wise deletion makes only 21 observations usable for estimation. Loss of information reduces the log likelihood value of the model to only 12 from 193 for the model without the education variable. The coefficient of education turns out as positive but insignificant. Other variables preserve their sign pattern, but most of them lose statistical significance. Consideration of the imputed data does not improve the situation either. The education variable still remains positive but insignificant. So, the education variable is not included in the models reported in Table 4.1 for analysing the productivity frontier.

**Implication for Technical Efficiency:**

Increases in total factor productivity can result from the intelligent uses of existing resources or by the tightening of their slack behaviours (technical efficiency), or by introducing cutting edge technology in the production process (technical change). Identifying the sources of productivity growth is important, as it helps government to make selective policy intervention in the problematic areas of output growth. Total factor productivity growth can accompany substantial amount of technical inefficiency if a major portion of the workforce is not trained enough to take advantage of the new technology. Skill shortage also creates the problem of capacity utilization, as the workers are unable to fully exploit the capabilities of the complex machines. Government supported training programs for displaced workers to cope with structural changes, building efficient institutions and developing required infrastructure throughout
the country can alleviate both the supply bottlenecks of skilled workers and the capacity underutilization problem.

One useful aspect of the estimated production frontier based on panel data is its ability to compare efficiency levels among various countries and over time. The estimated production function and the observed input-output vectors can be used to predict the technical efficiencies of the countries in the sample. It should be kept in mind, however, that the reported technical efficiency measures are relative to the South Asian Technology Frontier, not to the best practice technology of other countries outside the sample with similar inputs. The Debreu-Farrell measure of technical efficiency expressed as the ratio of observed output to potential output based on available inputs, i.e.,

$$\theta_{it} = \frac{y_{it}}{\hat{y}_{it}} = \frac{\exp(x_{it}^\beta - u_{it})}{\exp(x_{it}^\beta)} = \exp(-u_{it})$$

is reported in Table 4.2. These estimates are supplemented by and compared with the Simar and Wilson (1999) proposed bootstrapped DEA frontier based bias-corrected inefficiency scores. \(^5\) 95 per cent confidence intervals for these scores, reported in Table 4.2, are constructed from 2000 replications of these estimates. In all of the cases, except for Bhutan, the bootstrapped scores lie within the intervals. Both the SFA and the DEA based measures suggest that there are considerable variations in the efficiency estimates of the members. Varying country effects are consistent with the high gamma value obtained before in Table 4.1, where the stochastic frontier estimates are reported.

Several points emerge when the estimates are compared across the estimation methodologies and the chosen datasets. First, from technical efficiency consideration, both the SFA and the DEA approaches consistently rank Bhutan, India, and Maldives as

\(^5\) When the true frontier is unknown, the usual inefficiency estimates from the DEA frontier are upward biased. Simar and Wilson (2007), in particular, show that the estimated inefficiencies can be written as

$$\hat{\theta}_y = \theta_y + O_p(n^{-2/(p+q+1)})$$

where p and q are the dimension of input and output, and n is the sample size. Op is order of convergence in probability.
the seventh, the fifth and the sixth respectively. Other countries maintain their ranking across the observed and the imputed datasets, though estimation methodologies change their inefficiency ordering. For Sri Lanka, the change in position is minor, from the third under the SFA to the second under the DEA. The Maldives moderately shift position from the second to the fourth, while Bangladesh jumps to the first position from the fourth place. These changes are expected as these two approaches are based on different assumptions. The SFA imposes a parametric frontier on the dataset, and the DEA takes the outer boundary of the data points as the frontier, without considering the possibility of any stochastic variations in the data. Another point to note is that, the uses of additional information from the imputed data preserves inefficiency ordering among countries under both the SFA and the DEA methodologies. Moreover, if we note the bootstrapped 95 per cent confidence interval in the table, we see that the intervals shrink when imputed data are used. In case of the SFA, however, the imputed data give us more precise estimates, as reflected in Table 4.1 before.
Table 4.2 Technical Efficiency of the South Asian Countries  
(Averaged over the sample period)

<table>
<thead>
<tr>
<th>Countries</th>
<th>Observed Data</th>
<th></th>
<th>Imputed Data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SFA Efficiencies</td>
<td>DEA Efficiencies</td>
<td>SFA Efficiencies</td>
<td>DEA Efficiencies</td>
</tr>
<tr>
<td></td>
<td>Estimates (Rank)</td>
<td>Bias Corrected Estimates</td>
<td>95% Bootstrap Confidence Interval</td>
<td>Estimates (Rank)</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>0.7594 (Rank=4)</td>
<td>0.8424 (Rank=1)</td>
<td>(0.7275, 0.9481)</td>
<td>0.8340 (Rank=4)</td>
</tr>
<tr>
<td>Bhutan</td>
<td>0.4776 (Rank=7)</td>
<td>0.5961 (Rank=7)</td>
<td>(0.3452, 0.4466)</td>
<td>0.4878 (Rank=7)</td>
</tr>
<tr>
<td>India</td>
<td>0.6543 (Rank=5)</td>
<td>0.7021 (Rank=5)</td>
<td>(0.6376, 0.9921)</td>
<td>0.6928 (Rank=5)</td>
</tr>
<tr>
<td>Maldives</td>
<td>0.9720 (Rank=2)</td>
<td>0.7105 (Rank=4)</td>
<td>(0.6395, 0.9934)</td>
<td>0.9806 (Rank=2)</td>
</tr>
<tr>
<td>Nepal</td>
<td>0.5191 (Rank=6)</td>
<td>0.6838 (Rank=6)</td>
<td>(0.6193, 0.7378)</td>
<td>0.6118 (Rank=6)</td>
</tr>
<tr>
<td>Pakistan</td>
<td>0.9822 (Rank=1)</td>
<td>0.7781 (Rank=3)</td>
<td>(0.6810, 0.9935)</td>
<td>0.9823 (Rank=1)</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>0.8314 (Rank=3)</td>
<td>0.7658 (Rank=2)</td>
<td>(0.6752, 0.9930)</td>
<td>0.8514 (Rank=3)</td>
</tr>
<tr>
<td>Mean</td>
<td>0.7423</td>
<td>0.7255</td>
<td>--</td>
<td>0.7772</td>
</tr>
</tbody>
</table>

Note: SFA: Stochastic Frontier Analysis; DEA: Data Envelopment Analysis. DEA efficiency measures are output oriented and averaged over the sample period.

Investigating why some countries perform better than others will be useful in providing policy advice for the underperformers. In this respect we can examine Figure 4.3 where the data points are placed in the inputs-per-unit-output space. Instead of the usual production frontier, we are now interested in the unit isoquant, which can be thought of as the lower bound of the observed data. Countries with input combinations lying near the lower right-hand corner and the upper left-hand corner are representatives of capital-intensive and labour-intensive production units respectively. It is clear from the figure that Bhutan is using the former while Nepal is using the latter type of technologies.
Their inefficiency scores are around 50 per cent compared to the regional production frontier. In other words, they are producing half the output of their peers with similar amount of inputs. Both of these countries turned out at the bottom of the efficiency score ranking table. Moderate and top performers appear to be using more balanced technologies. So, the balanced use of inputs in the production process looks more promising for the South Asian countries.

**Figure 4.3 Capital-output, labour-output ratios and the perceived unit iso-quant**

Figure 4.3 also reveals some input combinations that are lying along the southwest to the northeast direction. These countries are using similar and balanced input ratios, but their performances are different. Productivity differences among these countries can be explained with the quantity versus quality argument. Larger amount of capital stocks to work with is not a guarantee for higher productivity. What matters for output growth is the innovative content or complexity of technology and the organization of production. Countries that are equipped with the latest technologies and have better human resources will lie near the frontier. Absence of these quality attributes will place countries further
away from the frontier. The Maldives and Sri Lanka have more or less balanced input ratios and their positions in the human development index are also relatively better than other countries in South Asia. The technical efficiency rankings of these two countries are accordingly good. Though in some years Nepal has achieved balanced input ratios in some years within the sample, lack of human development and advanced capital inputs did not allow her to reduce inefficiency relative to the regional frontier.

Poor technical performance is thus related to the influence of non-physical factors in utilizing available technologies. Muller (1974) points out that some non-tangible factors like the depth of knowledge among the workforce and the smooth flow of information throughout the economy can be determining factors in harnessing available technologies. If the mean year of schooling is taken as an indicator of these factors, then the estimated productivity performance for the South Asian countries can be rationalized. The Human Development Report (2011) identifies Bhutan and Nepal as the lowest and the second lowest countries in South Asia in terms of their mean level of schooling. These two countries have 2.3 years and 3.2 years of mean schooling respectively among their population. The figures for the other South Asian countries are comparatively better: 8.2 years for Sri Lanka, 5.8 years for Maldives, 4.9 for Pakistan, 4.8 for Bangladesh, and 4.4 for India (Human Development Report, 2011).

Though some countries like the Maldives, Pakistan and Sri Lanka are doing better by appearing near the frontier, their true performance can be evaluated if we take into consideration in the dataset some other countries outside the region that are more or less at the similar level of development. When the dataset were expanded to include the ten more Southeast Asian countries of Brunei, Cambodia, Lao, Indonesia, Malaysia, Myanmar, Philippines, Thailand, Singapore and Vietnam, the average estimated technical inefficiencies for the South Asian countries is found at 0.77 which is lower than the ASEAN average of 0.81 (results reported in Table A4.1 in the appendix). The data are then divided into two subsets, one corresponding to the SAFTA period and the other to the non-SAFTA period, to evaluate the comparative performance of these two sets of countries in these two periods. The result shows that the technical inefficiencies of the South Asian countries against the Southeast Asian countries seem to have
deteriorated in the SAFTA period. While the pre-SAFTA average technical efficiency in South Asia was 0.69 against 0.67 in Southeast Asia, the post-SAFTA technical efficiency in South Asia declined to 0.52 against 0.60 in Southeast Asia. The comparable efficiency estimates for these two regions are qualitatively similar for the DEA based analysis.

Changes in Total Factor Productivity:

Changes in total factor productivity give us an idea of how the total or aggregate output changes relative to the changes in all factors of production. The scopes for productivity improvement through technical and allocative efficiencies are limited. Unlimited and permanent increases in output are possible only through continued technical progress or innovation. While the previous section analysed the technical efficiency situation of the South Asian countries, a comparison of the total factor productivity changes for these countries over the sample period is provided in this section. Productivity changes involve consideration of both the changes in the amount of output produced and the corresponding adjustments in the input levels. Treatment of productivity in this way differs from the simple labour productivity measure. A general formula for productivity comparison, where multiple inputs and outputs are involved, is given by,

\[ \log(\text{TFP}_{st}) = \log(\text{Output Index}_{st}) - \log(\text{Input Index}_{st}) \]

Output and input quantity indexes in the above expression can be calculated indirectly by utilizing the link between the volume index and the price index or directly by using the index number formula. Since aggregate data series in the form of constant dollar values are available, the direct approach is employed here. The output and the input indexes are generally calculated from the Tornqvist formula, where the index number is expressed as a weighted geometric average of the price (or, quantity) relatives. More specifically,

\[ I^T_{st} = \sum_{i=1}^{n} \left( \frac{w_{is} + w_{it}}{2} \right) \left( \log q_{is} - \log q_{it} \right) \]
where $I_{st}^T$ is the Tornqvist quantity (input or output) index, and $w_{ts} = q_{ms} / \sum_{m=1}^{M} q_{ms}$ and $w_{st} = q_{mt} / \sum_{m=1}^{M} q_{mt}$ are the share of output (or, input as the case may be) of a country in period $s$ and $t$ respectively (M is the total number of input used or output produced). The sum varies over the number of outputs (here it is one, as we are using the aggregate GDP as the only measure of output) or inputs (here two, broadly defined labour and capital) considered in the analysis. Though the index itself does not pass the transitivity or circularity test, it can be modified to reflect the fulfilment of the transitivity property.

In the case of multi-country productivity comparison we require the transitivity property, whereby it is guaranteed that if a country A, for example, is 2 times more productive than another country B which in turn is 3 times more productive than a third country C then country A will show up as 6 times more productive than country C. Even the ideal Fisher index does not satisfy the transitivity property. Caves et al (1982) provide the following alternative index based on the Tornqvist index to obtain a transitive index (multilateral generalization):

$$I_{st}^C = \prod_{r=1}^{M} \left[ I_{sr}^T \times I_{rt}^T \right]^{\frac{1}{M}}$$

where the comparison between the two elements $s$ and $t$ (countries or time periods) is done indirectly via the $r$ (where, $r = 1, \ldots, M$) elements of available alternatives. In log form the above expression simplifies to (Coelli, et al, 2005),

$$\ln I_{st}^C = \frac{1}{2} \sum_{m=1}^{M} (w_{ms} + \bar{w}_m) (\ln q_{ms} - \ln \tilde{q}_m) - \frac{1}{2} \sum_{m=1}^{M} (r_{mt} - \bar{r}_m) (\ln q_{mt} - \ln \tilde{q}_m)$$

So intuitively the index shows, how two countries differ in terms of their output indexes when both are expressed relative to the overall mean of the sample countries in the dataset. The transitive index in the left hand side of the above equation is obtained by

---

6 The Tornqvist index which is derived solely on the basis of observed data can also be derived from the flexible translog parametric specification. Since the index can be calculated without parametric knowledge or functional form, it is has been termed as the superlative index in literature (Diewert, 1976).
considering all possible pairs of comparisons among the input or output indexes in the sample and taking the geometric mean over them. When expressed in log form, the index reflects the candidate country’s relative position compared to the average of all the permutations of country pairs’ productivity comparisons. A multilateral comparison of the productivity indexes and their trend for the South Asian countries is shown in Figure 4.3. These productivity indexes are based on the estimated distance measures of various component indexes. In particular, they depend on the following four distance measures:

\[ d_{11} = \text{A vector of length 7 containing distance function estimates under CRS in period 1 relative to the technology of period 1.} \]

\[ d_{12} = \text{A vector of length 7 containing distance function estimates under CRS in period 1 relative to the technology of period 2.} \]

\[ d_{21} = \text{A vector of length 7 containing distance function estimates under CRS in period 2 relative to the technology of period 1.} \]

\[ d_{22} = \text{A vector of length 7 containing distance function estimates under CRS in period 2 relative to the technology of period 2.} \]

The Malmquist index between any two periods, \( s \) and \( t \), is then estimated as:

\[
I_{st}^{'} = \left( \frac{d_{21}}{d_{11}} \times \frac{d_{22}}{d_{12}} \right)^{1/2}, \quad i = 1, \ldots, 7,
\]

Or, equivalently it can be decomposed into,

\[
I_{st}^{'} = \left( \frac{d_{22}}{d_{11}} \right) \times \left( \frac{d_{21}}{d_{22}} \times \frac{d_{11}}{d_{12}} \right)^{1/2}, \quad i = 1, \ldots, 7
\]

Where the term in the first bracket is the inefficiency component of the total factor productivity index and terms in the last bracket is the technical change component. Wilson (2010) considers further decomposition of this index into the pure technical change, the scale efficiency change and the change in the scale of technology. Since the
index is based on distance measures from the DEA frontier, price information is not required. It should be noted, however, that the returns to scale assumption is crucial in determining the magnitude of the index. In case of aggregate data, Coelli and Rao (2005) suggest that the assumption of the constant returns to scale (CRS) is more sensible, as the frontier is not specific to any particular firm. Griefell-Tatje and Lovell (1995) argue that the use of variable returns to scale (VRS) assumption confuses the gains or losses from the scale effect when it is used in the Malmquist index. From these considerations, the TFP measures are calculated here with a CRS technology assumption.

**Figure 4.3: Productivity Changes in the South Asian Countries**

Figure 4.3 shows that, the experiences of productivity growth for the South Asian countries were quite dissimilar during the past three decades. The Maldives enjoyed a
spectacular total factor productivity growth compared to the other member countries. The productivity gain for this island economy has been around 40 per cent since the beginning of the eighties. The global economic recession in the latter part of the 2000s severely affected the tourism revenue. According to a CIA world fact-book report, the real GDP of the Maldives was contracted by 7.5 per cent in 2009. This adverse effect is reflected in the dipping of the TFP for the Maldives in 2009 in the figure. Decomposition of the TFP growth, shown in Table 4.3 reveals that the overall TFP growth is driven by the technical changes or shift of the frontier. The inefficiency part remains constant.

At the other extreme lies Nepal with her dismal productivity performance over the sample period. Both technical change and technical efficiency contribute to this overall productivity decline. Other countries lie in the middle of these two extremes. Their productivities show slightly downward trend or stagnation. In the recent period, however, Bhutan, Sri Lanka, and India are showing signs of recovery from their long-term decline. For Bhutan, the recent productivity boost is coming from both the efficiency and the technical change components. When the productivity performances of these countries in the SAFTA period (2006-2010) against the pre-SAFTA period are compared, no unanimous result can be observed. Nepal, Pakistan, India, and Bangladesh have suffered from total productivity loss, the Maldives has gained, and the others have remained more or less unchanged in terms of their TFP performances in the regional trade agreement period.
Table 4.3: The Malmquist TFP Index and its Components

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<tr>
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<td>0.874</td>
</tr>
</tbody>
</table>

- **Key:** BD – Bangladesh, BH – Bhutan, IN – India, MA – Maldives, NE – Nepal, PK – Pakistan, SL – Sri Lanka.
- **MALM** – Malmquist TFP Index, **EFCH** – Efficiency Changes, **TECH** – Technical Changes.
Widespread differences in productivity performance among the South Asian countries point out the importance of regional cooperation beyond trade liberalization measures only. Since inputs across countries within the region show different levels of performance, free movement of labour and capital within the region can increase the overall factor productivity by ensuring regionally efficient allocation of resources. Where unrestricted trade indirectly increases productivity by intensifying competition, resource flows have direct impact on productivity. However, the weaker economies of the region have a nervous apprehension that their sovereignty might be under threat if large firms from the relatively developed countries of the region dominate their economic activities. In case where such drastic measures are politically infeasible, creating opportunities for training program for the low-performing countries and technical help can alleviate the productivity problem of the lagging countries. Extended cooperation will create an atmosphere of increased regional bonding at the same time. Similarly, as an alternative to full capital account liberalization, Steinherr (2006) suggests the introduction of a regional currency unit. Liberalizing the common currency unit will foster regional trade by alleviating import and export financing constraints.

**A Note on Aggregate Productivity:**

The aggregate factor productivity analyzed in this paper should not be taken as synonymous with microeconomic factor productivity. Total factor productivity is sometimes measured at the firm, industry or sector level, and as part of the system they affect the economy wide or aggregate productivity. Rises in the productivity of all the firms or an increase in market share of the higher productive firms can show up as an improvement in the aggregate productivity. However, productivity paradox might arise if the micro founded aggregated productivity index in not constructed properly. Fox (2011), for example, shows that popular methods of aggregation often give rise to situations where aggregate productivity falls in spite of increase in productivity of all the individual firms. When low-productive sectors have a lion share of output in the economy compared to the high-productive sectors, the economy can show falling productivity, though all sectors are improving. The paradox arises because of the changing shares that are used as weights in calculating the aggregate productivity index.
In a bottom up approach, Baily et al (1992) use a representative overlapping generation model to link macro-level productivity with micro-level measures, but do not find any correspondence between them. The problem arises as macro theories are based on the assumption that firms are perfectly competitive, whereas they are not in reality. Moreover, in macroeconomic productivity analysis it is assumed that only aggregate inputs affect the aggregate output. The possibility that input redistribution among sectors can lead to output growth is ignored. Hence, the results derived from national aggregates can be taken as an approximate or broad indicator of productivity change. Temple (2006) has more discussion on this issue.

4.6 Conclusion

This study shows how trade policy reforms in general, and intra-regional trade creation initiatives through SAFTA in particular, have affected various aspects of productivity growth in South Asia. Both the stochastic frontier and the deterministic frontier approaches have been applied on a panel data, comprising the seven member countries from the region and thirty years, to arrive at the results. The empirical analysis of the study shows that economic model based measure of productivity can be quite different from the simple per capita output growth.

Though independent policy reforms of the South Asian countries during the eighties and the nineties helped them to achieve moderate economic growths, these are basically input driven. The analysis of the study based on available data suggests that the productivity performance during the past three decades in South Asia has been far from satisfactory. The estimated stochastic frontier shows that the South Asian production frontier has in fact shifted slightly inward over the sample period. The coefficient of the year dummy in the production function, representing the Hicks neutral technical change, is found in the range of -0.005 to -0.009 depending on the chosen technology or the chosen data set. Introduction of the trade pact SAFTA in the latter part of the 2000s only deteriorated productivity by further shifting inward the production frontier.
The results remain unchanged when the analysis is performed using the data envelopment analysis (DEA) methodology, where a priori functional form for the production frontier is not imposed on the data. The total factor productivity and its components are investigated based on this non-parametric frontier. Except for the Maldives and to some extent for Bhutan in the recent period, the total factor productivity of the South Asian countries have shown downward trend. Sri Lanka and India, of late, are showing signs of recovery. The decomposition shows that, for most of these countries the principle source of productivity change is the efficiency change. For the two extreme countries, the Maldives and Bhutan, both the efficiency and the technical change components contributed to their overall productivity changes.

There is a consensus among economists that unilateral non-discriminatory trade liberalization usually results in productivity or efficiency gain. However this is not true in case of preferential trade liberalization. Extra preferential margins enjoyed by the regional partners create new export opportunities in the expanded regional market for them, which may turn into productivity gain through the trade-productivity linkage. However, regional integration at the same time destroy competitive environment to some extent in the regionally protected market. The negative result of the trade pact on the technology frontier of South Asia hints about its failure to intensify competition through increased trade flows or sourcing of quality inputs from the regional market. However, the different level of efficiency among the members, that is their different abilities to produce outputs from similar amount of inputs, implies the importance of allowing for cross border resource flows. This raises the case for deep integration beyond tariff concessions on a limited number of traded items.

Economic integration through the removal of trade barriers are intended to increase competition in the regional market and improve productive efficiency. Economic restructuring and adjustment costs take place along the way. The residual based measure of productivity change is considered as a supply-side constraint on achieving welfare. Consumer valuations of output are also required to arrive at a more comprehensive measure of economic welfare. Future studies can concentrate on the general equilibrium framework to evaluate the welfare implication of regional integration in South Asia.
Regional Integration and Productivity

Distributions of welfare changes among the trading partners and the pattern of output changes at the disaggregated sectors from various policy scenarios will emerge from that analysis.

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Regional Integration and Productivity


Appendix 4.1A

Share Parameter from the CES function:

The two-factor CES frontier is

\[ Y = \gamma \left[ \beta K^{-\rho} + (1-\beta)L^{-\rho} \right]^{\nu/\rho} \]

Or, in log form,

\[ \ln Y = \ln \gamma - \frac{\nu}{\rho} \log \left[ \beta K^{-\rho} + (1-\beta)L^{-\rho} \right] \]

Taylor expansion of (1b) around \( \rho \) gives

\[ \ln Y = \ln \gamma + \nu \beta \ln K + \nu(1-\beta) \ln L - \frac{\rho \nu}{2} \beta (1-\beta) (\ln K)^2 - \frac{\rho \nu}{2} \beta (1-\beta) (\ln L)^2 + \rho \nu (1-\beta) \ln K \ln L \]

The linear approximation to the CES shown in (2) resembles the translog function (3) below.

\[ \ln Y = \alpha + \alpha_K \ln K + \alpha_L \ln L + \alpha_{KK} (\ln K)^2 - \alpha_{LL} (\ln L)^2 + \alpha_{KL} \ln K \ln L \]

Comparing the parameters in (2) and (3), the share parameters for the CES can be derived. The parameter correspondence implies,

\[ \alpha_K = \nu \beta \]

\[ \alpha_L = \nu(1-\beta) \]

\[ \frac{1}{2} \alpha_K = \alpha_L = \frac{1}{2} \alpha_{KL} = \rho \nu \beta (1-\beta) \]

Equations (4), (5), and (6) can be solved for the CES share and scale parameter as,
Regional Integration and Productivity

\[(7) \quad \alpha_K + \alpha_L = \nu \]

\[(8) \quad \frac{\alpha_K}{\alpha_L} = \frac{\beta}{(1 - \beta)} \]

Using the estimated values of the estimates of \(\alpha_K = 0.519\) and \(\alpha_L = 0.450\) form the text we find from (7), \(\nu = 0.969\), a value close to the constant returns to scale. This is not surprising, since the CES approximation has been obtained here by taking Taylor expansion of the non-linear CES form around \(\rho = 0\). The share parameter, \(\beta\), which can be inferred from (8), is \(\beta = 0.49\). The substitution parameter, \(\rho = 0.05\), can be determined from equation (6). This implies an elasticity of substitution value of \(\sigma = 1/(1 + \rho) = 0.95\) which is again close to the Cobb-Douglas case of one.
Table A4.1: Technical Efficiencies Relative to the Combined South Asian and Southeast Asian Data

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<td>SFA</td>
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