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Trade, Infrastructure and Income Inequality in Selected Asian Countries: An Empirical Analysis

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Abstract

Theoretical and empirical works related to international trade are confined to models which have labour and capital as explicit factors of production. Although income inequality and trade openness have been given importance in the literature, role of quantity and quality of infrastructure has hardly been investigated in this context. Similarly growth regressions did highlight the role of infrastructure and trade openness in economic growth, inclusive growth has not got that much attention. The present study tries to unravel the interlinkages and interconnections among infrastructure, trade openness and income inequality, using panel data of 14 Asia-Pacific countries at different levels of development. The empirical exercise clearly reveals influence of trade openness and infrastructure on income inequality but the reverse is not necessarily true. Moreover, country specific factors turn out to be important determinants of trade openness and income inequality. Further, dynamic panel estimates reveal importance of initial values of both income inequality and trade openness as important determinants in the evolution of these variables, apart from the positive influence of infrastructure as a determining variable.

Keywords: Trade, Infrastructure, Inequality, Poverty, Asia-Pacific

JEL codes: F13, F16, F18

1. Introduction

The relation between trade, inequality and poverty within countries is not beyond controversy. Most international trade economists have a perspective of a world in which countries exchange goods, factors and ideas. Free trade in goods leads to equalization of factor prices across countries according to the factor-price-equalization theorem. In the traditional literature on neo-classical growth model, capital and labour play the central role as two main factors of production. From the perspective of conventional one sector neo-classical growth theory (*a la* Solow) international linkages do not matter, but from the trade perspective they are the crucial determinants.

Under free trade and competitive conditions, trade promotes growth and growth reduces poverty (Bhagwati and Srinivasan, 2003). In the literature on international trade, the issues of income distribution, growth as well as distortions are more or less discussed in terms of endowments of capital and labour, their growth as well as their relative prices. Countries that initially had a more regulated trade sector experienced an increase in inequality, where trade reform, however, does not appear to have significantly affected changes in income distribution.[1] In the income distribution literature, it is again the functional distribution of the two major factors of production which explain the movement of inequality in income distribution over time. Although infrastructure plays the role of a very important catalyst, it hardly gets any mention explicitly in the relevant literature on trade and inclusive growth.[2][3]

Over the past decades of globalization, economies in Asia and the Pacific had grown rapidly till the ongoing global economic and financial crisis appeared in mid 2007. This acceleration of growth, in which international trade has played an important role,

[1] There is a strong literature on trade and income distribution supporting the fact that trade liberalization not necessarily leads to equality of income in presence of trade distortion. See, for example, Edwards (1997).

[2] However, development in endogenous growth theory has introduced the possibility of a productive role of public expenditure on infrastructure with an associated possibility of increasing returns to scale (Barro, 1990, 1991).

[3] In economics, we need to concentrate on economic infrastructure which includes services from:
(a) public utilities, like power, telecommunications, piped water supply, sanitation and sewerage, solid waste collection and disposal, and piped gas; (b) public Works, like roads and major dam and canal works for irrigation and drainage; and (c) other transport sectors, like urban and inter-urban railways, urban transport, ports and waterways, and airports (World Development Report, 1994, p.2)

has helped Asia-Pacific countries make impressive strides in economic development (ESCAP, 2009). At the same time, empirical evidence suggest that in some supply-constrained larger economics in Asia and the Pacific such as China, India, Indonesia prosperity through trade has also been accompanied by rise in inequality.[4] As a matter of fact, globalization in Asia-Pacific has resulted in growing social and income inequalities.[5] Thus, free trade is not necessarily a pro-poor growth strategy, where by pro-poor growth, we take either the change in first order inequality as captured by Gini coefficient, or change in the number of people below a pre-specified poverty line.

There are compelling reasons why rising levels of inequality can slow down growth prospects when distortions are affecting different income groups unequally in Asia and the Pacific (e.g. Lao PDR vs. Thailand). Among other things, high levels of inequality can have adverse consequences for social cohesion, quality of institutions and policies, and infrastructure. In turn, social divisions, low-quality institutions and policies, and lack of infrastructure can have adverse implications for growth prospects of Asia-Pacific countries. Since the increases in income inequality can have important implications for the evolution of economic well-being in the long run, it is aptly important to understand the present symptom of linkage, if any, between inequality, trade and infrastructure in developing Asia-Pacific countries. This paper attempts to provide a succinct answer to the debate on trade, inequality and infrastructure linkages. Besides, it deals explicitly with the recent literature which aims at bringing infrastructure to the forefront in the context of trade and inclusive growth.

The paper is organized as follows. Section 2 presents review of literature on interconnections between infrastructure, trade and inequality. Section 3 provides data and methodology. Section 4 presents stylized facts on infrastructure, trade and inequality in Asia-Pacific countries. The analytical results and possible implications are presented in Section 5. The final section concludes.

[4] Refer, for example, ADB (2007, p.7)
[5] See, for example, ESCAP (2002)

2. Infrastructure, Trade and Inequality: Literature Review

Infrastructure – Growth Relationship

The role of infrastructure in promoting growth is perhaps the most discussed topic as far as infrastructure's role in the economy is concerned. The linkage between infrastructure and economic growth is multiple and complex, because not only does it affect production and consumption directly, but it also creates many direct and indirect externalities, and involves large flows of expenditure thereby creating additional employment (Ghosh and De 2005). Estache (2006) pointed out that since the late 1980s, over 150 published papers in English, French, or Spanish have analyzed the macroeconomic effects of infrastructure. This literature in respect to infrastructure has mainly resulted from conceptual and technical developments associated with new growth theory and new economic geography. According to Estache, the most common way of estimating the impact of infrastructure on growth is to calculate the social rates of return of investment in various types of infrastructure. The methodology used is quite common- it is *growth* regressions. The findings of the regressions are quite significant. They suggested that in recent years *economic* returns on investment projects average 30–40 per cent for telecommunications, more than 40 per cent for electricity generation, and more than 200 per cent for construction of new roads (although, when the outliers are excluded, the average is about 80 per cent for roads). It is also found that returns tend to be higher in low-income than in middle income countries (Estache, 2006). The upshot of the above story is that infrastructure has a very strong impact on the growth process of a nation, especially if it is a low income country.

Change in public capital structure is one of the important factors affecting the long-term behaviour of a country. Decline in US productivity was preceded by lower infrastructure investment (Munnell, 1990). Aschauer (1989) while discussing US productivity slowdown, argued that (i) public physical capital along with private and human capital are crucial inputs in the steady state production function; (ii) means of financing public capital affect the level of productivity; and (iii) efficiency of use of public capital along with the quantity of public capital are crucial determinants of the effective public capital stock. He also found that one percentage point increase in the

efficiency of public capital increases transitional growth by 0.29 percentage point, while a rise in the debt financed public capital reduces growth rate by 0.25 per cent. Thus, quality of public capital, which incidentally in the US context points to infrastructure, plays a very important role in increasing growth rate of the economy so long it is not counter balanced by external debt.

A similar work, done by Hulten (1996), stresses more on the quality of public capital or infrastructure capital. He defined effective public capital by $K_g^e = \theta K_g$, where θ measures the degree of efficiency in the use of public capital. He used four different indicators to quantify performance of public capital, namely, faults in 100 telephone mainlines, satisfactory paved roads as percentage of total roads, electricity generation losses to total, and percentage of diesel locomotives to total rolling stock for transportation and then aggregated them into one performance index. He then used data for 46 low and middle income countries in the period spanning over 1970 to 1990. The regression used is real GDP growth per capita on infrastructure performance index, private investment and human capital. The output elasticity to infrastructure which includes the efficiency term shows variability from 0.009 to 0.244, that indicates countries which used infrastructure more efficiently, attained much faster growth of per capita real GDP. More explicitly, his comparison of four East Asian fast growing countries with 17 African countries shows that had the African countries used infrastructure at the same level of efficiency as the East Asian countries, their growth rates per annum would have been 0.75 per cent rather than -0.20 which is the actual recorded growth.

Thus the above points to the importance of not only amount of public capital embodied mainly in infrastructure but also its effective use. Existence of large public spending per se, does not promote rapid growth. It is the performance of this capital which is the main variable that promotes faster growth. As Hulten (1996) found, public capital does not influence the growth of low and middle income countries much, the effectiveness index influences it decisively. Aschauer's later study (1998) supported the same conclusion. It does point to the basic premise that total factor productivity has a close positive relation with the performance of the infrastructure capital.

Briceño-Garmendia, Estache and Shafik (2004) highlighted the importance of infrastructure in developing countries unlike the impact of the same for the developed countries. The authors mentioned that of about 102 studies conducted over the past 15 years, few found that infrastructure investment has a negative effect on productivity or growth. The sample included 30 studies of multiple countries (including developing countries), 41 studies on the United States, 19 on Spain, and 12 on individual developing countries (Argentina, Brazil, Colombia, India, and the Philippines). As already mentioned the authors found unambiguous result for the developing country studies. According to them the role infrastructure is more prominent for the developing countries. Thus, infrastructure does not have any perverse signal for economic growth of any developing country.

Roland-Holst (2006) sounded a note of caution in this context. According to him infrastructure and growth have both ways causation. Thus, failure to take this into account would result in the overestimation of the contribution of infrastructure to growth. In fact, Calderón and Servén (2005) presented an empirical analysis focusing on Latin America. They reported positive and significant output contributions of three types of infrastructure assets, namely, telecommunications, transport, and power. Fedderke, Perkins and Luiz (2006) attempted to explain the relationship between investment in economic infrastructure and long-run economic growth by examining the experience of South Africa in a time-series context. Their results indicated that infrastructure does have both a direct and an indirect impact on output, and it may have an important role in pushing the country onto a higher long-run growth trajectory.

Infrastructure and Inclusive Growth

The previous discussion gives an overview of the interconnection of infrastructure with growth. But as we have emphasized before, a strong positive influence of infrastructure on economic growth does not necessarily ensure an inclusive growth. The discussion of inclusive growth can move in several directions, but the literature discusses this either in terms of access and affordability of and access to infrastructure by the poor or effect of infrastructure on income distribution. As already mentioned, the concept of inclusive growth is used interchangeably with the concept of pro-poor

growth already defined earlier. We will confine the present section to this aspect alone.

Brenneman and Kerf (2002) argued that infrastructure expands education (especially for transport and energy services), and positively affect health outcomes (especially for water/sanitation, energy and transportation sectors), although it is not that visible for telecommunications. Ravallion and Datta (1999) found that between 1960 and 1990 rural poverty levels changed considerably in Indian states. According to them, their results show that non-farm economic growth was less effective in reducing poverty in states with "poor" initial conditions in terms of rural development and human resources. They explained that factors such as low farm productivity, low rural living standards relative to urban areas and poor basic education caused that the poor do not participate fully in growth of the non-farm sector. Deninger and Okidi (2003) had similar findings regarding growth and poverty reduction in Uganda during the 1990s. Their work indicates the importance of improving access to basic education and health care. At the same time the authors point out the dependence of social infrastructure on complementary investments in electricity and other infrastructure.

Ghosh and De (2005) carried a detailed study on the role of infrastructure in exacerbating the inter-state inequality in India. They have taken data for 18 major Indian states for the period 1970-71 to 1999-2000. They regressed real per capita state GDP on several social, financial and physical infrastructure variables. This study indicated (i) inter-state disparity in per capita net state domestic product among Indian states has been rising significantly over the last quarter century; (ii) inter-state disparities in physical, social and financial infrastructure facilities have remained at an alarmingly high level over the same period. That is, the relative positions of the states have remained unchanged in terms of any definition of development. In other words, there have been enormous differences in individual performance among the states in terms of all the basic indicators of development; and (iii) physical and social infrastructure facilities have been proved to be highly significant factors in determining the inter-state level of development.

Ghosh and De's conclusions support the findings of Ravallion-Datt (1999). Hence, inclusive growth requires a balanced development of infrastructure across regions so

that growth is evenly spread across rich and poor states over time. However, to overcome initial imbalance, the poorer regions need more accelerated investment in infrastructure as revealed in case of Indian states.

Khandker and Koolwal (2006) analyzed the impact of infrastructure development on pro-poor growth in context of Bangladesh. Using quantile regression techniques, the authors concluded that growth in overall income indeed leads to a significant reduction in poverty, and has had a significantly higher impact on extreme as compared to moderate poverty reduction. This study argued that while these pure growth effects on household poverty incidence are not very large, it finds that income growth through certain policies — namely, proximity to roads, electrification, and commercial bank penetration — can lead to substantial reductions in overall poverty in the sample. This is an important observation that investment on specific infrastructure produces welfare enhancing distributional effect compared to pure growth.

In a similar paper, Khandker, Bakht and Koolwal (2006) found the importance of rural roads in Bangladesh. Again using panel quantile regression, the authors find that in RDP (Road Development Project) areas, both moderate and extreme poverty declined in project villages. In RDP project villages, about 57 per cent of households were moderately poor before the road was paved, while some 48 per cent of households were poor after the road was paved. About a 6 per cent reduction of extreme poverty (from 35 per cent to 29 per cent) was registered in RDP project villages after road was paved. Interestingly, the authors found that for control villages there was no significant change in poverty over time.

This is very similar to Binswanger, Khandker and Rosenzweig (1989) who highlighted the importance of rural roads in India's rural economy. They said it works through marketing and distribution scopes, and also through reduced transportation costs of agricultural goods. Somewhat complementary to this is what Barnes and Binswanger (1986) found in case of the effect of rural electrification on agricultural productivity in India.

Fan et al. (2002) documented the critical role of infrastructure development in China. Using provincial data of China from 1970-1997, the simultaneous equations model indicated that government investment in irrigation, education and infrastructure (particularly roads, electricity and telecommunications), not only helped in raising the growth levels but also contributed significantly in reducing rural poverty and regional inequality in China. The authors have shown that this happened mainly because of the increased opportunity of rural non-farm employment that followed expansion of infrastructure. The study pointed out that in 1997, although 69 per cent of people lived in the rural areas, rural investment was only 21 per cent of total investment, leading to larger rural-urban gap. Similar to the findings in India and Bangladesh, rural roads had the highest impact on rural poverty reduction in China as well.

Jacoby (2000) found somewhat a discordant note in his research for the landlocked South Asian country of Nepal. This study found that extending road access to the entire rural population of Nepal would raise average income by about 10 per cent. The benefits of rural roads are due to the lower costs of transporting crops to market and obtaining modern inputs such as fertilizer. Although many of these benefits would go to the poor, who tend to live in more remote areas, the benefits are not large enough to make big progress on poverty alleviation. Part of the reason for this is that the primary beneficiaries of infrastructure projects are landowners, who are typically not that poor. This is a disturbing finding in the sense that rural roads increase income and accelerates rural growth but it did not promote inclusive growth in a poor state like Nepal. Jacoby further stated that new road construction directly benefits landowners by raising the value of their land, but landless households that supply farm labour are unlikely to benefit at all. The study found that wages are lower in more remote rural areas of Nepal: half a percentage point lower for a 10 per cent increase in travel time. However, the lower wages in more remote areas are probably offset by the lower cost of living. Road construction would therefore have little net benefit from the perspective of the landless household, since any increase in wages would be accompanied by a rise in the cost of living. So, one must critically looks at the infrastructural investment in the context of inclusive growth.

Calderón and Servén (2005) delved into both growth and inequality aspects of infrastructure investment. The paper provides an empirical evaluation of the impact of

infrastructure development on economic growth and income distribution using a large panel data set encompassing over 100 countries and spanning forty years (1960-2000). The authors concluded on infrastructure and income inequality that availability and quality of infrastructure services for the poor in developing countries have a significant positive impact on their health and/or education and, hence, on their income and welfare as well.

Calderón and Servén (2005) also dealt with the issue of private participation in infrastructure investment examining how large if at all is its pro-poor effect? The important aspect of the distributive impact of private participation in infrastructure that has attracted considerable attention was dealt by the authors, which involved both macro and microeconomic linkages. One important macro effect is that on employment and the major controversy of this is whether private participation will lead to downsizing leading to fall in employment. According to Calderón and Servén, "the distributive impact of downsizing depends on the access of lower income segments of the population to public sector employment in infrastructure, and on the monetary compensation to workers laid-off for efficiency reasons. If the investment by the newly reformed providers of infrastructure promotes growth and new jobs, the process of job destruction in the public sector may be offset by the creation of employment in other sectors". The micro impact may be sector wise withdrawal of subsidies after private participation that might make access to infrastructure quite difficult for the poor.

A recent World Bank's Independent Evaluation Group (IEG) (2008) of World Bank sponsored electrification schemes found a pro-rich bias in the rural electrification schemes. The report first identified the number of schemes promoted by the World Bank in last 28 years or so. The report then went on to highlight that poor has not benefited much from these schemes in no uncertain terms. This study pointed out that a high figure of RE does not guarantee that the poorest and those living in fringe areas of rural sector benefit from this kind of electrification.

Raychaudhuri (2004) discussed the role of rural roads in the context of agricultural productivity growth as well as poverty reduction in the state of West Bengal in India. The state of West Bengal, in the eastern part of India, had one of the highest rural

poverty levels in India in the early part of the 1970s. West Bengal saw two major turnarounds in the rural sector from the eighties, namely (a) a spectacular jump in the growth rate of production of the major food-crop rice from 1.8 per cent during 1960-80 to 4.68 per cent during 1977 to 1994 and (b) a remarkable fall in the rural poverty level from 73 per cent in 1973 to 31 per cent in 1999. In fact, on both count, this state surpassed the achievements of other states substantially. At the same time, the budget surveys show much heavier dependence of the population on food items (dominated by rice consumption) in West Bengal (65.9 per cent) compared to Indian average (59.4 per cent) in 1999-2000. At the same time, the rural population earns the maximum from rice production since it occupied 84.87 per cent of total foodgrains area in 1980-81 going up to 90.62 per cent in 1999-2000. Thus, a rise in agricultural productivity for the monsoon rice crop, which is practiced by the poor farmers most, helps in raising income levels as well as expands the consumption possibility set of the poor farmers.

Raychaudhuri (2004) tried several explanatory variables to explain the change in agricultural productivity of the monsoon rice crops. Apart from some land reform related variables, rural roads maintained by the local level administration happened to be the variable which influences the agricultural productivity of this crop the most. The reason is that better connectivity helped the farmers to sell their surplus crops in time as well as procure the inputs with relative ease. Thus, it not only helped growth of agriculture but it also directly helped in the reduction of poverty of small farmers.

Rodriguez (2006) in an interesting work tried to understand the role of infrastructure in growth and divergence of the rich and poor states in the world. The paper notes that the growth scenario is accompanied in many cases by a falling infrastructure stock. Thus, although infrastructure stock is found to be a significant variable which influences growth, the same may have caused divergence among states in the developing countries. Rodriguez (2006) reviewed the empirical evidence supporting the assertion that the collapses in infrastructure investment that occurred during the eighties and nineties in many developing countries are a major force behind growing disparities in world incomes. While we have argued that the empirical evidence supports the existence of a positive effect of infrastructure provision on productivity and growth, Rodriguez (2006) find little evidence that the retrenchments in

infrastructure provision have played a major role in growing disparities. According to the author, the basic reason is that most developed countries also experienced a deceleration in their accumulation of infrastructure stocks during this period, allowing some developing countries to catch up and others not to fall behind in terms of infrastructure provision. So, the upshot of the story is not to neglect the infrastructure in any economy so that countries can both maintain the tempo of work and maintain parity with the fast growing states.

A different line of thought can also be found in Songco (2002) who discussed the importance of community perception based infrastructural development in the context of rural Vietnam. In many cases, the community failed to grasp the direct benefit of infrastructural investment. The author suggested in these cases that the complementarity of investments in the infrastructure capital should be recognized. Songco noted that the rural poor interviewed in Vietnam appreciate road improvements in their communities; yet they can also suggest initiatives in other areas to improve household welfare, such as expanded credit opportunities for the poor, or improvement of existing services, such as increased staffing of already established local health centers. The new Community- Based Rural Infrastructure Project in Vietnam is one example of a project that seeks to enable community-driven infrastructure selection to reduce rural poverty. Attention is needed to ensure that the rural poor (as opposed to simply the rural non-poor) are duly consulted and involved in planning and decision-making in a meaningful way.

Infrastructure, Trade and Inequality

As pointed out in the beginning, the neo-classical as well as new trade theories rely heavily on two country- two factor- two goods model (the 2x2x2 model). Hence, infrastructure appears mainly as a complementary factor which facilitates trade. This will be visible in one of the two following ways: one, it has a strong positive influence on trade volume (Deardorff, 2001), and second, it might influence the trade cost (Anderson and van Wincoop, 2004).

Infrastructure might influence trade cost more than tariff and non-tariff barriers but measurement is probably even more difficult. The supposed impact of tariff and non-

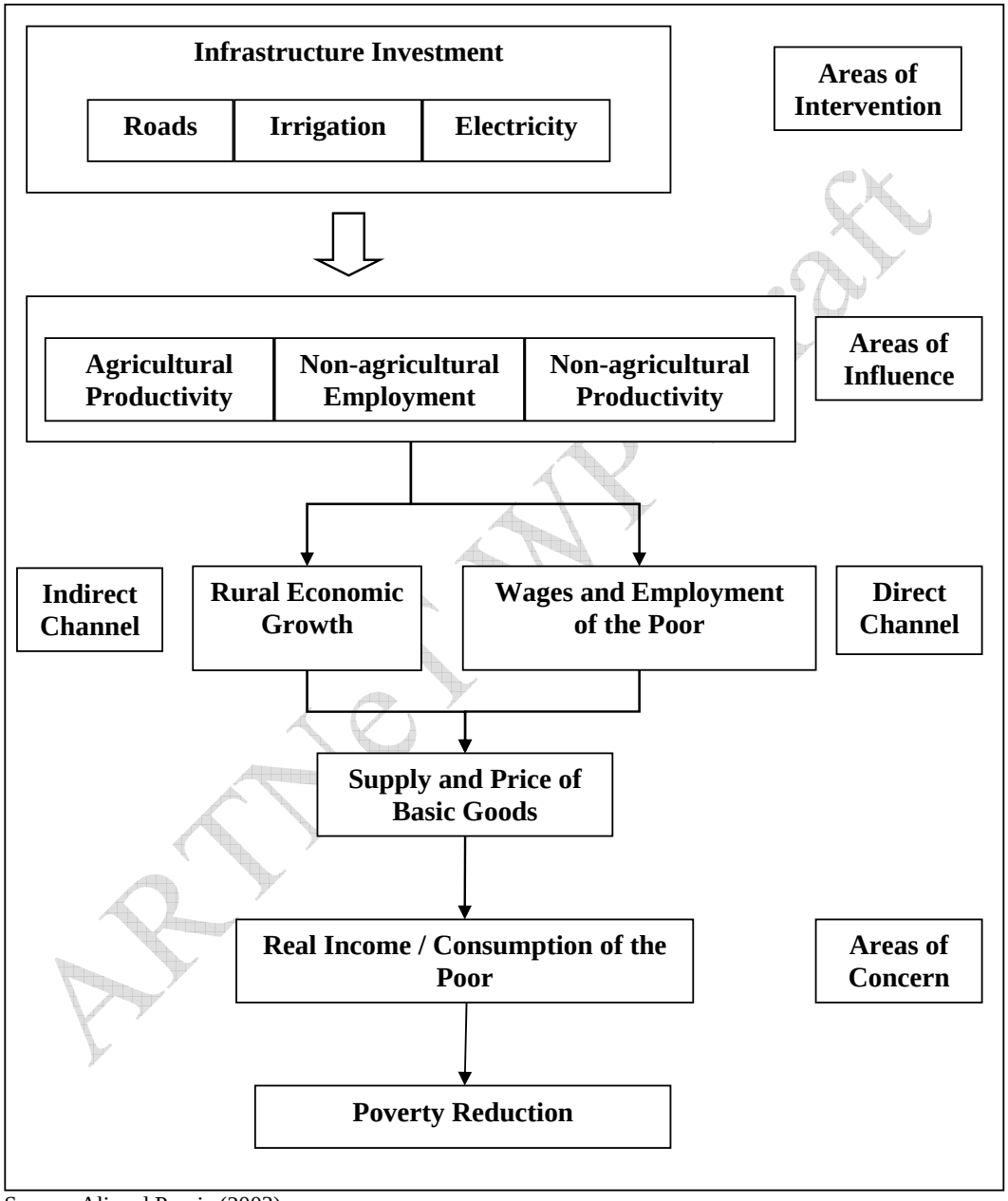
tariff barriers may be less in magnitude compared to inefficiency and enforcement related costs of infrastructure. Although it is difficult to measure it very accurately and also directly, following Limao and Venables (2001) trade costs do depend heavily on infrastructure. They gather price quotes for shipment of a standardized container from Baltimore to various points in the world. Infrastructure is a composite term measured as an average of the density of the road network, the paved road network, the rail network and the number of telephone main lines per person. The authors found that a deterioration of infrastructure from the median to the 75th percentile of destinations raises transport costs by 12 per cent. A similar conclusion was reached by the studies undertaken by the Asian Development Bank Institute, which has shown that port infrastructure is the most important one for reduction in trade costs for Asian countries, given the pre-ponderance of sea-freight in trade costs for Asian countries (De, 2009a, 2009b; Brooks and Hummels, 2009)

Pinstrup-Andersen and Shimokawa (2006) argued that insufficient domestic rural infrastructure is a major bottleneck to achieving the potential benefits from international trade liberalization and other aspects of globalization, where China's recent experience illustrates the point. The authors emphasized that poor infrastructure is one of the major reasons for slow growth of exports from African countries. In fact, the authors rued that India's road density in 1950 was 4 to 5 times higher compared to road density of many African countries in 1990. Authors found that low transport cost due to good infrastructure would have increased price and non-price competitiveness of products from African countries in addition to attracting FDI, which is vital for betterment of infrastructure.

An OECD study on trade facilitation (OECD, 2003) dealt mainly with the WTO definition of border related trade transaction costs, but has the following interesting observations. After analyzing border process quality across the 102 countries it found that countries with a higher per capita income generally score better with respect to border process quality than countries whose inhabitants are less well off. However, some countries which are not that well off, exhibited better border processing. It concluded that low-income countries do not necessarily have to wait until they become rich before being able to adopt good border practices. This is a very optimistic conclusion: poorer countries can also show efficiency and need not be

written off as countries with little hope of competing with the richer nations in terms of price and non-price competition.

Figure 1: Infrastructural Development Helps in the Reduction in Poverty



Source: Ali and Pernia (2003)

While dealing with the Indian case, Acharyya (2008) argued growth impact of trade had remained weak over the period 1985 – 1999. Acharyya (2008) argued that urban poverty in India has declined and income inequality increased significantly during the

1990s when some policy changes with regard to trade and exchange rates had been implemented.

Winters, McCulloch and McKay (2004) nicely summarized a number of studies which discussed the role of trade liberalization on poverty reduction. According to them, although trade liberalization may work through many channels, the outcome depends on a number of factors. They include the starting point of reform, the precise trade reform undertaken, the characterization of the poor and the way they sustain it. One main result they emphasized from their survey is that poor may well be able to enjoy the benefits of trade reform less than their richer counterparts. Hence, trade policy needs to be complemented by other policies, one of which may well be better access (or may result in better access) to infrastructure by the poor. The Figure 1 highlights some of the points raised above. Infrastructure development helps in the reduction of rural poverty through various channels as described in Figure 1.

Figure 1 shows schematically the linkage between infrastructure and poverty reduction. One must remember that reduction in income inequality may reflect a strong poverty reduction programme in a country but this is not a necessary condition. The trade costs throw an additional dimension to this. The link between trade, infrastructure and income inequality as well as poverty reduction may be posed as follows: how far lack of infrastructure might affect small and unorganized producers in developing countries? This is crucial since trade might promote inequality as a number of small producers may not be able to take part in liberalized trade regime for lack of infrastructure. As is shown in Figure 1, roads, electricity and irrigation are key factors which increase agricultural and non-agricultural productivity and employment. If one adds the international trade dimension to it, one may add freight carried by sea and air as well as tele-density to this list of infrastructural facilities. However, this also creates possibility of unequal access to these facilities since large farmers and non-farm producers could take advantage of these compared to small farmers and non-farm producers.

Datt and Ravallion (1998) discussed about the role of social infrastructure in enabling some states in India to reduce rural poverty faster than the others. The state of Kerala reduced rural poverty fastest and this state had the highest literacy levels among men

and women for whole of India. According to the authors, this helped Kerala to export skilled workers even from poorer rural households abroad – it is factor out-migration to mainly the Gulf region. This generated a huge inflow of factor remittances from abroad which is a key factor in raising income level of the rural poor. Trade thus is not confined to goods alone, but it also encompasses international factor movements which plays a key role in the reduction of poverty as is clear from the case of the Indian state of Kerala.

Raychaudhuri and De (2010) analyzed the impact of increased trade in services in India on Inequality. It was found that one major component in India's service sector growth is the Information and Communication Technology (ICT) services. The study showed that ICT sector leads the service trade in India. However, the sector is skill and infrastructure intensive. The major IT and IT enabled services are located in big metropolitan cities. As a result it neither supported the unskilled workers nor the sector made its presence felt in the rural areas. Thus, this kind of increase in services trade has increased the inequality within the urban region in India along with more income divergence between rural and urban income.

3. Data and Methodology

To understand the interconnection and interdependence among trade, inequality and infrastructure, cross-country panel data regressions is a common technique used by a number of researchers as mentioned in the literature survey section. Hulten (1996) used panel regression to show the importance of quality of infrastructure on growth, which incidentally has a large number of countries taken from all parts of the world for growth rate in 1990 over 1970. Datta and Ravallion (2002) used an unbalanced panel fixed effect regression to understand the reduction of poverty in different states in India caused by several infrastructural variables. Pinstrup-Andersen and Shimokawa (2006) described a number of studies which used both panel data regressions as well as simultaneous regression models to study the impact of infrastructure on agricultural productivity. An excellent analysis which compares different cross-country dynamic panel data estimates with more standard pooled OLS and fixed effect estimates for measuring impact of infrastructure on growth was done by Calderón and Servén (2005). A good discussion on technicality of a number of

such studies can be found in Levine and Renelt (1991), which we have mentioned later in this section also. Following above, we therefore have done an Asian cross-country study on the same. For this purpose we have taken data from 14 Asian countries, namely, Bangladesh, China, Hong Kong, China; India, Indonesia, Republic of Korea, Malaysia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, and Viet Nam.[6]

Table 1: Basic Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Inequality (INQ), represented by Gini coefficient	120	39.82	6.69	23.20	53.10
Trade openness (TO), represented by trade-GDP ratio	120	100.53	104.95	9.69	476.78
Infrastructure stock (IS)	120	3.97	1.21	2.50	7.14
Infrastructure quality (IQ), represented by transmission and distribution losses in electricity	120	12.93	7.62	2.41	35.62
Income per capita (PCI)	120	4010.54	6893.20	142.39	32250.00
Geography (Land), represented by per capita availability of land	120	5.62	4.80	0.15	26.19
Inflation (Inf)	120	6.23	5.49	-17.63	24.56
Population (Pop)	120	62.66	6.18	52.45	73.17

Table 2: Correlation Matrix

	INQ	TO	IS	IQ	PCI	Land	Inf	Pop
INQ	1							
TO	0.3981*	1						
IS	0.1499	0.0821	1					
IQ	-0.1067	-0.5372*	-0.0935	1				
PCI	0.2670*	0.8778*	0.1316	-0.4877*	1			
Land	0.0473	-0.3533*	0.2216*	-0.0343	-0.4442*	1		
Inf	-0.0900	-0.2794*	-0.2274*	0.2140*	-0.3619*	0.1327	1	
Pop	0.0813	0.6363*	0.1222	-0.6840*	0.6595*	-0.3418*	-0.3368*	1

Note: *Significant at 5 per cent level

While Appendix 1 provides the definitions of variables and sources, here we present some basics about these variables. From the Table 1, we can see that inequality (represented by average Gini coefficient) is quite large at 39.82 and it has a range of 23.20 to 53.10. Trade openness (represented by total trade (export + import as a percentage of GDP) has an average value of 100.53 per cent but has a large variation as given by a standard deviation of 104.95. The infrastructure stock has an average of 3.97 with a range of 7.14 to 2.50. Infrastructure quality (represented by electric power

[6] The chosen set contains both LDCs and developing Asian countries since their per capita GDPs (in US constant $2000 prices) range from US$142.39 to US$21322.16, over the period 1971 to 2006.

distribution losses as percentage of output) stands at an average value of 12.93 percent and its range is from 2.41 to 35.62 percent. Among the control variables, except per capita income (PCI), rest variables do not have much variation as shown by their respective standard deviations. There is thus quite a remarkable disparity between the prosperous and poor Asian countries in terms of per capita income and trade openness.

However, there is strong correlation among some of these variables (Table 2). Trade openness and per capita income are two variables which are highly correlated between themselves as well as with the population. However, population variable is not correlated with infrastructure stock, so that they could be used together. Similarly, infrastructure stock is not highly correlated with infrastructure quality, so that they could be also paired in a panel regression. Although Levine and Renelt (1991) suggested that collinearity among the independent variables really shows a weak dataset and that 'extreme bound' analysis following Leamer will show how truly independent a variable is, this problem of multicollinearity precludes use of the full set of regressors.

To explore the relationship of inequality with trade openness and infrastructure, we use the following equation.

$$INQ_{it} = \alpha + \beta_1 TO_{it} + \beta_2 IS_{it} + \beta_3 IQ_{it} + \sum_l \delta_l Z_{it} + e_{it} \quad (1)$$

where *INQ* stands for inequality measures (represented by Gini coefficient), *TO* stands for trade openness (represented by trade-GDP ratio), *IS* represents physical infrastructure stock, *IQ* presents infrastructure quality (represented by transmission and distribution loss in electricity), *Z* is set of control variables, and *e* is the error term. Here, *i* represents country and *t* is time period. To control for country-level heterogeneity, we introduce country dummies in equation (1). The use of country fixed-effects reduces considerably the variance in inequality to be explained and the measurement errors therein.[7] The final estimable equation takes following shapes.

[7] In case the fixed effect model, Least Square Dummy Variable (LSDV) technique is used. The result establishes the fact that country specific effects that are not explicitly mentioned, are significant and explain the movement of the explained variable in addition to the common explanatory variables that are taken for each country.

$$INQ_{it} = \alpha_0 + \alpha_i + \beta_1 TO_{it} + \beta_2 IS_{it} + \beta_3 IQ_{it} + \sum_l \delta_l Z_{it} + e_{it} \quad (2)$$

While the equation (2) provides us the stochastic relationship of inequality with trade openness and infrastructure, it does not indicate functional relationship of trade openness with inequality and infrastructure. Therefore, to explore the reverse relationship, specifically the relationship of trade with trade openness and infrastructure, we use following equation (3).

$$TO_{it} = \alpha_0 + \alpha_i + \beta_1 INQ_{it} + \beta_2 IS_{it} + \beta_3 IQ_{it} + \sum_l \delta_l Z_{it} + e_{it} \quad (3)$$

We have created an unbalanced panel data from the above. The problem is that the data is driven to a large extent by the availability of inequality and infrastructure variables data. The problem with the inequality data is that although World Income Inequality Database (WIID) quotes from a variety of sources, there is a great problem of compatibility.[8] We have sorted the data in a way that it reflects the overall inequality of gross income of a country. The additional problem is availability of multiple values for one year. Although WIID database puts a rank to each study in terms of its reliability, we are largely guided by that rank but if one figure looks like an outlier, we have not taken it. The infrastructure variables data also poses time series continuity problem. This precluded the use of some variables like paved roads, default in telephone mainlines, railway freight and route kms, education and health related statistics, etc. As a result, the study could not do proper justice to qualitative variables, as emphasized by Hulten (1996) above. Our number of years is much more but the countries under consideration are much less. Thus, the final panel could not accommodate all the variables we would have liked to be included. Despite that we tried to take the best possible dataset, but as we will mention, multicollinearity problem precluded simultaneous use of some of the variables even within this reduced set.

Robustness checks

The relationships described above cannot be interpreted as causal until we rule out the possibility of endogeneity in equations (2) and (3). To address this problem, we use a

[8] WIID stands World Income Inequality Database (UNU-WIDER World Income Inequality Database, Version 2.0c, May 2008).

dynamic GMM estimator (system-GMM) to analyze changes across countries and over time.[9] The estimator also effectively deals with reverse causality by including lagged dependent variable to account for the persistence of the inequality and/or trade openness indicators.

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

One may raise the issue that what prompts us to go for a cross-country regression since in case fixed effect models are found to be justified, country specific factors may prove to be most important. The reason cross-country regressions technique is chosen here is the fact that this is the methodology used by most of the papers discussed in our literature survey above to gain generalizations in the results. Thus, although it is true that few of the country specific policies and variables, some of them even not varying much over time, may lead to movements in trade and inequality. The cross-country regression generalizes the result focusing on some important accepted variables which are significant determinants. This in itself is important. Also, one can also establish the fact that country specific variables, along with the commonly accepted variables mentioned above, are indeed important catalysts in our analysis.

4. Inequality, Trade and Infrastructure: Stylized Facts

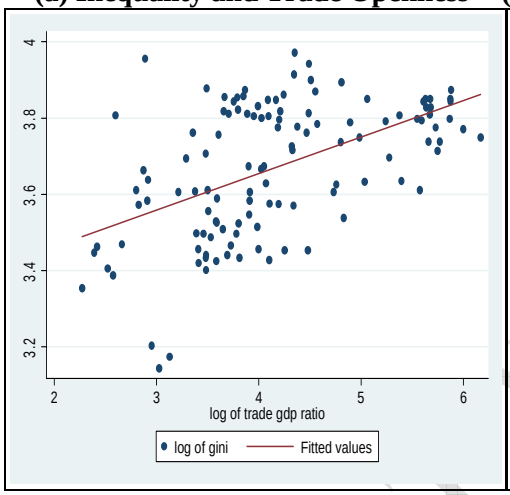
The scatter diagram of inequality with trade openness, per capita income and infrastructure stocks for 14 Asia-Pacific countries in a panel of years (1975 to 2006) show that inequality is positively associated with all of them (Figure 2). Both trade in

[9] It was first introduced by Arellano and Bond (1991)

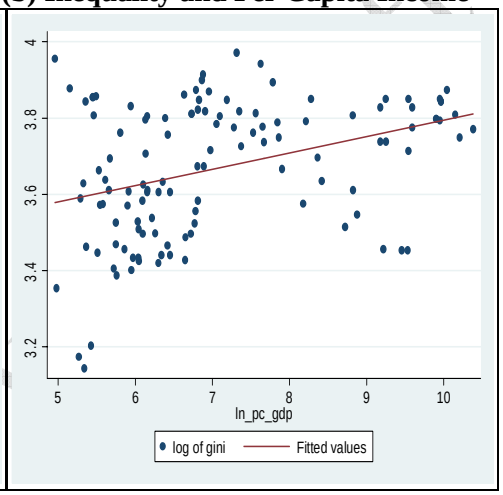
Asia-Pacific countries and rising per capita income have been associated with higher inequality. Figure 2(c) suggests that infrastructure stock in Asia-Pacific countries did generated inequality, albeit at a lower magnitude, compared to trade openness. Trade openness and infrastructure stock, however, show a positive correlation, suggesting that infrastructure underpins trade openness (Figure 3), whereas trade openness in the region is driven by trade liberalization with high tariff at the initial years (Figure 4).

Figure 2:

(a) Inequality and Trade Openness



(b) Inequality and Per Capita Income



(c) Inequality and Infrastructure

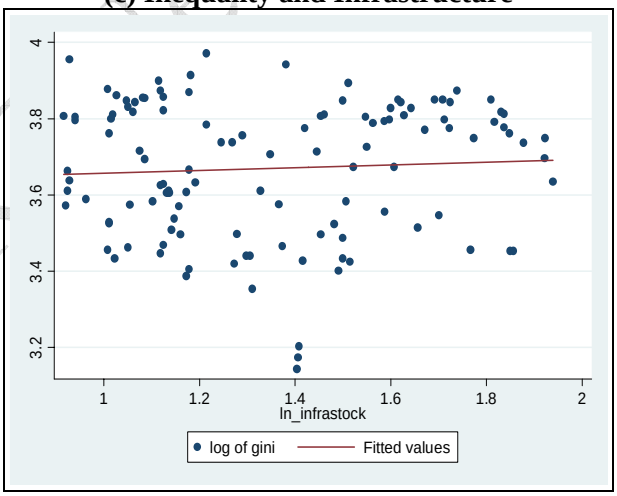


Figure 3:
Infrastructure and Trade Openness

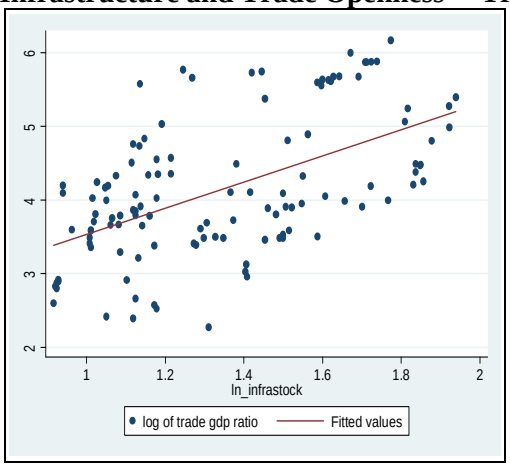
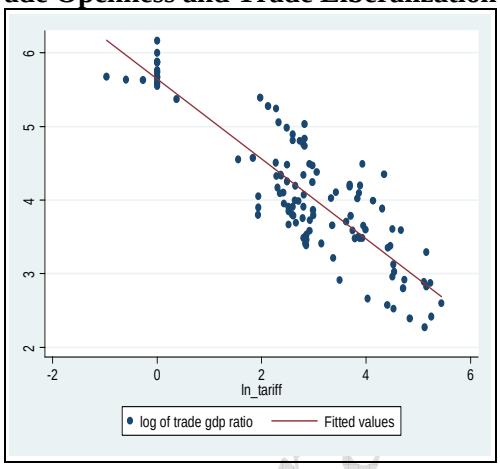


Figure 4:
Trade Openness and Trade Liberalization



Therefore, it can be concluded that given other things constant, Asia-Pacific countries have experienced an increase in inequality. There are following three important observations in this discussion.

Figure 5: Inequality Trends

Figure 6: Trends in Trade Openness and Trade Liberalization

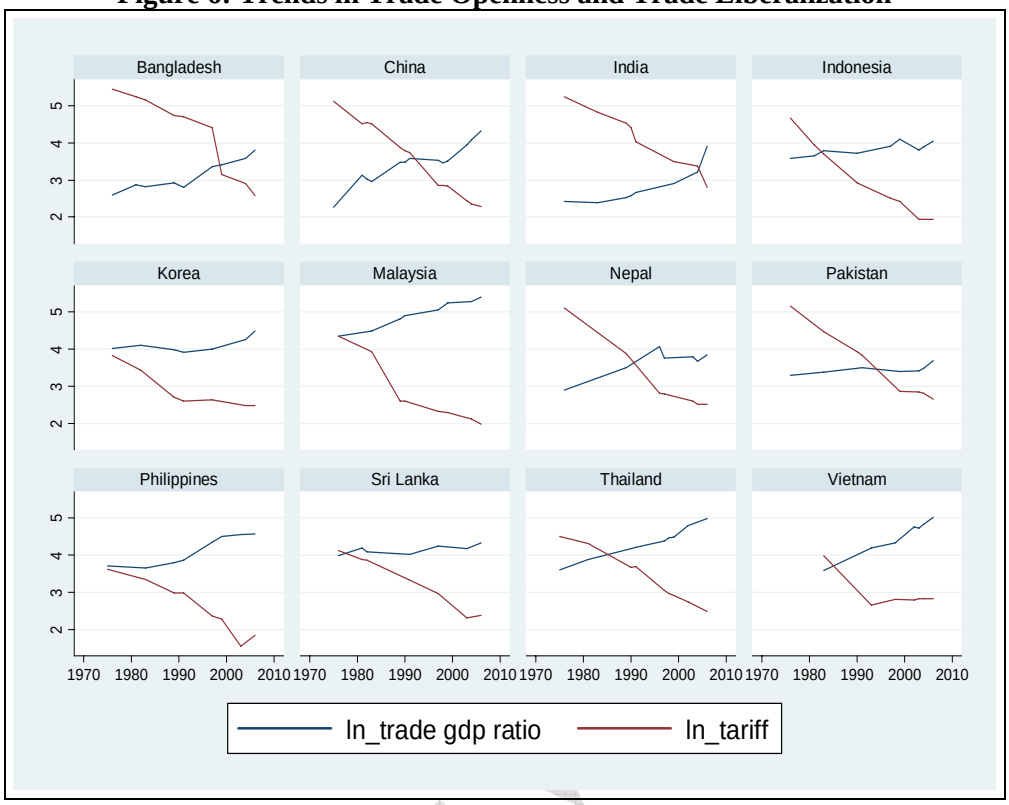
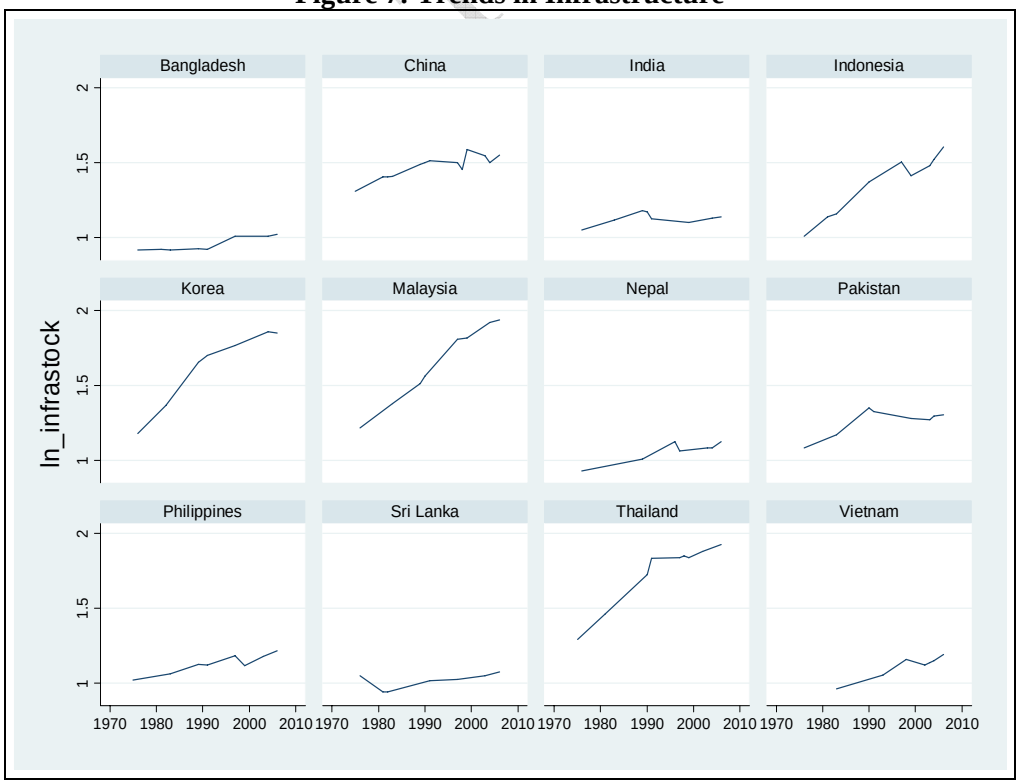


Figure 7: Trends in Infrastructure



First, bigger Asia-Pacific countries have witnessed absolute rise in inequality over time (Figure 5). China, for example, has witnessed a steep rise in inequality, increased from 28.60 in 1975 to 41.50 in 2006 with a lowest of 23.20 in 1982. Bangladesh, on the other, has witnessed a fall in inequality from 45.00 in 1976 to 31.00 in 2006, with rise of inequality at 43 percent in 1997. Thus, cross-country variability in the inequality is very important when we attempt to understand its consequences on trade and infrastructure.

Second, Asia – Pacific countries have witnessed a rise in trade liberalization (fall in import tariffs) and trade openness (rise in trade-GDP ratio), but the trends vary across countries. For example, countries like Republic of Korea, Malaysia and Philippines have witnessed parallel movement of trade liberalization and trade openness from the initial years, whereas others have witnessed a mixed result showing relatively higher distortions in initial years. Those countries which adopted export-led growth strategy have also associated with drastic trade liberalization in terms of tariff cuts. Nonetheless, trade liberalization and trade openness are uncontested and documented development in Asia-Pacific countries.

Third, infrastructure disparity is very rampant across Asia-Pacific countries, and the stock of infrastructure in Asia-Pacific countries is not too large. For example, China, Republic of Korea, Indonesia and Malaysia have higher infrastructure stocks than others Starting with low base, Indonesia appears to have progressed much faster than rest others in raising its infrastructure stocks. Therefore, change in infrastructure stock is one of the important factors affecting the long-term behavior of the Asia-Pacific countries.

5. Trade, Infrastructure and Inequality: The Empirical Relationship

We start exploring whether or not trade openness reduces inequality with reference to equation (2). Estimated results are presented in Table 3. Following observations are worth noting.

Table 3: Inequality, Trade and Infrastructure: Baseline Regression Results
Dependent variable = Inequality (ln_gini)

Variables	**ln_gini**	**ln_gini**	**ln_gini**	**ln_gini**	**ln_gini**	**ln_gini**
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Trade openness (ln_trade_gdp)	0.124***		0.137***	0.122***		0.121**
	(0.0243)		(0.0344)	(0.0367)		(0.0474)
Trade liberalization (ln_tariff)		-0.0430**	0.0122		-0.0156	-0.002
		(0.0194)	(0.0232)		(0.0355)	(0.0401)
Infrastructure stock (ln_infrastock)	-0.304***	-0.393***	-0.297***	-0.251**	-0.304**	-0.251**
	(0.0965)	(0.101)	(0.097)	(0.108)	(0.116)	(0.109)
Infrastructure quality (ln_tdloss)	0.0871**	0.0724*	0.0907**	0.0903**	0.0835**	0.0905**
	(0.0399)	(0.0419)	(0.0398)	(0.034)	(0.0349)	(0.0347)
Per Capita Income (ln_pc_gdp)	0.0919***	0.140***	0.0921***	0.263***	0.317***	0.264***
	(0.0289)	(0.0275)	(0.0294)	(0.0678)	(0.0664)	(0.072)
Land (ln_land)	0.0605***	0.0830***	0.0561***	0.475**	0.323*	0.475**
	(0.0157)	(0.0166)	(0.0179)	(0.18)	(0.161)	(0.181)
Inflation (ln_inf)	-0.0248	-0.0319*	-0.0244	0.00948	0.0119	0.00922
	(0.0206)	(0.0191)	(0.0207)	(0.0108)	(0.0104)	(0.00978)
Population (ln_pop)	-0.269	-0.240	-0.244	-0.689**	-0.598	-0.693**
	(0.204)	(0.211	(0.214)	(0.323)	(0.371)	(0.295)
Constant	3.789***	4.109***	3.588***	4.448**	4.186**	4.549***
	(0.845)	(0.952)	(0.942)	(1.55)	(1.541)	(1.386)
Observations	107	107	107	107	107	107
R-squared	0.442	0.357	0.444	0.855	0.843	0.855
Country fixed effects	No	No	No	Yes	Yes	Yes
Model	OLS	OLS	OLS	OLS	OLS	OLS
Breusch and Pagan LM test, chi2 (p-value)				63.60 (0.000)	89.89 (0.000)	62.46 (0.000)
Hausman test, chi2 (p-value)				17.76 (0.0131)	15.23 (0.0331)	16.37 (0.0374)
Mean VIF	4.07	3.88	4.72			
Cameron & Trivedi's IM-test, chi2 (p-value)	49.61 (0.0519)	57.97 (0.0086)	65.52 (0.0193)			
Ramsey RESET-test, F (p-value)	4.09 (0.0089)	3.27 (0.0246)	4.00 (0.0100)			
Wald test, F (p-value) (Trade openness = Trade liberalization)			24.79 (0.000)			14.52 (0.001)

Notes: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

First, estimates in column 2 in Table 3, with no fixed effects, suggest that trade openness raises inequality (estimated coefficient is significant at 1 percent level), given other things constant; 10 per cent rise in trade openness would lead to increase 1.24 percent inequality in 14 Asia and the Pacific countries. However, if trade openness is replaced by trade liberalization (column 3 in Table 3), we get an opposite result (reduction of inequality by 0.43 per cent). The estimated coefficient (significant at 5 per cent level) shows that trade liberalization indeed reduces inequality, other

things being equal, in Asia and Pacific countries. Since only 36 per cent to 44 per cent variations of observations are explained by the estimated models in columns 2 and 3, the regression fits are not strong, thus telling some country specific observations must be included in order to better determine the inequality.

Second, when we introduce country fixed effects in columns 5 and 6, we get better fits (adjusted R^2 becomes 85 per cent). Therefore, adding country fixed effects for the source of inequality in columns 4 and 5 improves considerably the fit while keeping unchanged the sign of coefficients. At the same time, with fixed effects trade liberalization becomes insignificant (column 6), thereby indicating country specific policies beyond the trade liberalization are much important in case of Asia-Pacific countries.

Third, trade openness and trade liberalization may work together in determining the inequality. Column 4 (without fixed effect) and Column 5 (with fixed effect) present the estimates when both trade openness and liberalization were counted. Trade liberalization has appeared as statistically insignificant in both cases with switching over the signs. Insignificant Wald test F statistics in both cases rejects the null hypothesis that coefficient of trade openness is the same as coefficient of trade liberalization. However, size of effect of trade openness on inequality increases marginally from 0.124 to 0.137 in this particular case. Therefore, one can presume that trade liberalization and trade openness may work together while determining the income inequality, but no certainty of trade liberalization alone is significantly determining income inequality, with or without controlling for country specific policies.

Fourth, infrastructure stock (proxy of factor endowments) is significant in all the models. The estimated coefficients of infrastructure stock clearly indicate that infrastructure improvement reduces the income inequality, other things being equal. Controlling for country fixed effects, 10 per cent improvement in infrastructure would lead to fall of 2.5 – 3 per cent in Asia and the Pacific countries. Rise in infrastructure stock helps countries to increase income in medium to long run, thus generates scopes of redistribution of income both within and across countries. At the same time, quality of infrastructure is very important. All the estimated coefficients of infrastructure

quality are significant at 5 – 10 per cent level. The estimated coefficients of infrastructure quality (here, represented by transmission and distribution loss of electricity) indicate that quality deterioration of infrastructure facilities (e.g. rise in transmission and distribution loss of electricity) would lead to rise in income inequality. It is intuitive that higher losses in transmission and distribution of electricity lead to less availability of electricity to the users, causing disadvantage to the poorer income groups. This may well lead to inequality in income distribution as the latter is disadvantaged with respect to one crucial input in production of goods and services.

Fifth, the estimates also suggest that inequality is high in land-endowed countries (per capita land density) and in countries with higher per capita income in Asia and Pacific region. On the other, inequality is less in low inflation countries and in countries with a higher share of population between 15 and 64 years old. However, inflation becomes insignificant and positive sign when we consider country specific fixed effects. Perhaps, country specific effects nullify the effect of inflation on inequality.

Finally, regression diagnostics suggest that our models are statistically robust. For example, the models do not suffer from (i) multicollinearity (low value of mean VIF, lower than tolerance level of 10)[10]; (ii) heteroscedasticity (insignificant p-value of Cameron - Trivedi's decomposition of IM-test statistic); and (iii) omitted variable bias (insignificant p-value of Ramsey RESET-test statistic). Further, the models also do not suffer from selection-bias. For example, insignificant p-values of Breusch and Pagan LM test support the selection of random effects over classical regression, and then insignificant p-value of Hausman test indicate that fixed effects regression is more appropriate than random effects.

Therefore, it may be concluded from the estimates of equation (2) in Table 3 that controlling for country level heterogeneity trade openness increases the income inequality in selected Asia and the Pacific countries, whereas access to higher infrastructure stocks along with its quality maintenance help reduce the income inequality.

[10] Refer Appendix 2 for VIF scores of independent variables for first three equations (columns 2 to 4). The estimated scores show models do not suffer from multicollinearity.

Let us know explore whether or not there is a reverse relationship from income inequality to trade openness with reference to equation (3). Here, trade openness is taken as dependent variable, and we have income inequality, infrastructure stocks and infrastructure quality and other control variables as independent variables. Estimated results are presented in columns (2) – (5) in Table 4. Following observations are worth noting.

Table 4: Trade, Inequality and Infrastructure: Baseline Regression Results

Dependent variable = Trade openness (ln_trade_gdp)

Variables	**ln_trade_gdp**	**ln_trade_gdp**	**ln_trade_gdp**	**ln_trade_gdp**
(1)	**(2)**	**(3)**	**(4)**	**(5)**
Income inequality	1.456***	0.993***	0.670***	0.352
(ln_gini)	(0.304)	(0.217)	(0.165)	(0.307)
Infrastructure stock	-0.21	-0.315	-0.251	-0.489*
(ln_infrastock)	(0.310)	(0.249)	(0.194)	(0.295)
Infrastructure quality	-0.145	-0.206*	-0.122**	-0.115
(ln_tdloss)	(0.122)	(0.106)	(0.0496)	(0.0778)
Per Capita Income	0.363***	0.209***	0.215*	0.143
(ln_pc_gdp)	(0.084)	(0.066)	(0.117)	(0.140)
Land	-0.0178	0.115***	-1.525***	-0.751***
(ln_land)	(0.051)	(0.038)	(0.433)	(0.242)
Inflation	-0.0213	-0.0235	0.0286	0.00241
(ln_inf)	(0.059)	(0.048)	(0.029)	(0.029)
Population	1.569**	0.271	1.415	1.060
(ln_pop)	(0.743)	(0.68)	(1.164)	(1.023)
Trade liberalization		-0.362***		-0.104**
(ln_tariff)		(0.0404)		(0.0517)
Constant	-9.539***	-0.262	-6.972	-1.870
	(3.043)	(2.847)	(5.621)	(3.994)
Observations	107	107	107	107
R-squared	0.754	0.848	0.967	0.965
Country fixed effects	No	No	Yes	Yes
Model	OLS	OLS	OLS	GLS
Breusch and Pagan LM test, chi2 (p-value)			108.54 (0.000)	82.50 (0.000)
Hausman test, chi2 (p-value)			16.38 (0.0219)	3.29 (0.9150)
Mean VIF	3.90	4.04		
Cameron & Trivedi's IM-test, chi2 (p-value)	64.92 (0.0016)	71.75 (0.0002)		
Ramsey RESET-test, F value (p-value)	1.27 (0.2905)	2.76 (0.0461)		
Wald chi2 (p-value)				4925.42 (0.000)

Notes: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

First, trade liberalization strongly influences trade openness in both with or without country fixed effects.

Second, income inequality does not influence trade openness directly. Although the relation is significant in columns (2) to (4) in Table 4, it is not the direct one since the relation becomes insignificant when we introduce country effects in column (5) in Table 4. It also looses its coefficient size when we introduce trade liberalization in columns (3) and (5). In fact, this implies one has to bring more primitive factors which cause income inequality in order to understand causality between trade and inequality. It is also evident that there is non-linearity in the data structure so that logarithmic form regression improves significance levels of explanatory variables. In addition, it seems infrastructure related variables significantly affect trade as is expected. We should remember that infrastructure related variables also determine income inequality, whereas trade (trade liberalization) related variables do not affect inequality significantly. It is important to note that all regressions show country specific factors play important role in determining trade variables. This is consistent with other studies which show that trade variable like export is influenced by factors like real exchange rate and world demand (Marjit and Raychaudhuri, 1997). Since, we tried to focus on the role of infrastructure, to avoid problems like multicollinearity, we did not take the real exchange rates and world income. To note, the latter variables will be country specific and do show up in the significant fixed effect coefficients.

Third, infrastructure stock variable does not carry correct sign, even when country level effects are considered in the models. We may have to ignore them because none of the estimated coefficients are statistically significant. However, its significance level increases when we control country level heterogeneity. In other words, country specific factors (not explicitly investigated here) may enhance the interdependence of infrastructure with trade. This is something to be explored in future research case by case. However, the negative sign may imply several things – especially it implies infrastructure may be inversely related with some factors not taken here explicitly which on its part is promoting trade. One example may be that highly developed infrastructure is ensured through Public Private Partnership (PPP), including FDI, which requires less regulation but promotes higher trade. Thus infrastructure is inversely related to regulatory structure of the economy, which shows up in a similar

inverse relation of infrastructure with trade, since regulatory variables are absent in the regression. Fall in infrastructure quality (rise in transmission and distribution losses in electricity) would obviously lead to corresponding fall in trade values.

Fourth, regression diagnostics suggest that although our models do not suffer from multicollinearity (low value of mean VIF, lower than tolerance level of 10) and heteroscedasticity (insignificant p-value of Cameron - Trivedi's decomposition of IM-test statistic); they do suffer from omitted variable bias (significant p-value of Ramsey RESET-test statistic). Further, the models also do not suffer from selection-bias. For example, insignificant p-values of Breusch and Pagan LM test support the selection of random effects over classical regression, and then insignificant p-value of Hausman test indicate that fixed effects regression is more appropriate than random effects, except the regression presented in column 5 for which we consider random effects.

Finally, it may be concluded from the estimates of equation (3) in Table 4 that controlling for country level heterogeneity income inequality does not influence trade openness directly. Therefore, inequality and trade openness are not direct causal factors for each other.

Table 5: System Dynamic Panel-data Estimation (System GMM)
Dependent variable = Inequality (ln_gini)

Variables	Coefficient	S.E.	t-Statistic
Inequality (ln_gini)			
L1.	0.001	0.134	0.011
L2.	0.167**	0.102	1.646
Per Capita Income (ln_pc_gdp)	0.249**	0.090	2.780
Trade openness (ln_trade_gdp)	-0.130***	0.041	-3.208
Infrastructure stock (ln_infrastock)	-0.442*	0.212	-2.089
Infrastructure quality (ln_tdloss)	-0.061*	0.052	-1.182
Hansen J-statistic, chi2 (p-value)	8.329 (0.402)		
Observations	78		

Note: Dynamic panel counts White period instrument weighting matrix, and White period standard errors & covariance (d.f. corrected) Notes: *** p<0.01, ** p<0.05, * p<0.1. L1 and L2 stand for lags 1 and 2 respectively.

Table 6: System Dynamic Panel-data Estimation (System GMM)
Dependent variable = Trade openness (ln_trade_gdp)

Variable	Coefficient	S. E.	t-Statistic
Trade openness (ln_trade_gdp)			
L1.	0.292*	0.134	2.175
L2.	0.172*	0.090	1.913
Inequality (ln_gini)	0.097	0.143	0.678
Trade liberalization (ln_tariff)	-0.200**	0.081	-2.468
Infrastructure stock (ln_infrastock)	0.428*	0.311	1.376
Infrastructure quality (ln_tdloss)	0.164*	0.141	1.162
Hansen J-statistic, chi2 (p-value)	11.588 (0.171)		
Observations	78		

Note: Dynamic panel counts White period instrument weighting matrix, and White period standard errors & covariance (d.f. corrected) Notes: *** p<0.01, ** p<0.05, * p<0.1. L1 and L2 stand for lags 1 and 2 respectively.

Robustness checks

The relationships described above cannot be interpreted as causal until we rule out the possibility of endogeneity in equations (2) and (3). To address this problem, we use a dynamic GMM estimator (system-GMM), also known as Arellano-Bover/Blundell-Bond linear dynamic panel-data estimation, to analyze changes across countries and over time.[11] The estimator also effectively deals with reverse causality by including lagged dependent variable to account for the persistence of the inequality and/or trade openness indicators.[12] Table 5 provides system-GMM estimates when dependent variable is income inequality, whereas Table 6 presents the same when trade openness as dependent variable. To test the appropriateness of the instruments used, we use the Hansen J statistics of over-identifying restrictions in Tables 5 and 6. The J- statistics show that the applied instruments are valid.

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

It is quite apparent that past inequality itself significantly determines the present level of inequality (two periods lagged inequality is statistically significant) and so also the trade openness. In contrast to our previous findings (Table 3), system-GMM estimates suggest initial level of inequality along with rising trade openness, improvement in infrastructure stock and quality of infrastructure lead to fall in income inequality. Therefore, it can be concluded that initial level of endowment is important for future equality in the Asia-Pacific region.

Similarly, when it comes to trade openness, both one period and two period lagged values of trade openness significantly influence current trade to GDP ratio. Although tariff liberalization has an expected inverse relation with trade openness along with infrastructure quantity and quality variable, income inequality does not play any significant role in trade openness. Thus, although a more open economy reduces inequality, the reverse is not true. However, infrastructure improvement is important for both more trade and less inequality in the economy.

6. Concluding Remarks

The foregoing analysis gives a synoptic view of the role of infrastructure in economic growth and income inequality as well as international trade of countries in the Asia and the Pacific. The point we have stressed throughout is that infrastructure mainly appears as a complementary factor in the standard literature. As a result, authors have discussed the role of infrastructure in somewhat a compartmentalized manner. In the existing literature on the subject, although not specific and comprehensive to the theme under consideration here, the positive impact of infrastructure on growth is proved through growth regressions, but the important point to note is that infrastructure (or public capital) is a factor whose efficiency is equally important to its quantity. Possibly this applies to all factors of production, but for infrastructure, this is emphasized time and again. The developing countries unambiguously show this positive impact unlike some of the developed countries.

Unfortunately, most of this work does not address either trade or income distribution issues. The literature which deals with inclusive growth and poverty highlights that accessibility to infrastructure like rural roads or electricity do not benefit the poor

much. Hence, the result may be an unintended widening of income disparity. The authors suggest direct targeted policy intervention in this case.

The literature on infrastructure's role on growth or inclusive growth hardly discusses the trade issues at the same time. Given the 2x2x2 structure of trade models, the role of infrastructure is discussed mainly as a trade enabling or facilitating device as well as something whose more efficient use could reduce trade costs. The existing literature on infrastructure and trade more or less concentrates on these two themes, without caring much for growth or inclusive growth in an integrated framework.

Going through the above literature, it is clear that one needs a study which looks at the individual causalities in an integrated framework which would discuss the role of infrastructure on growth and income distribution issues in an open economy framework. This would look at infrastructure, both its quantity and quality, as an important causal factor promoting trade and inclusive growth in the economy. The Panel regressions carried out here fulfill this gap to some extent. But we must hasten to add, country specific studies are essential to understand this better, as is clearly revealed by the regression results.

In the panel regressions carried out here, we have found the same set of infrastructure that affects inequality also affects trade. However, although for trade the causality is in the expected directions, for inequality, it points to some problem of unequal access between large and small producers. In addition, country specific policies are shown to be significant determinants of both trade and inequality apart from infrastructure development. Thus for trade, it may be exchange rate or foreign exchange management policies as well policies of protection to specific goods. For inequality it may be some directly targeted poverty alleviation policies. Therefore, infrastructure development may raise trade volumes for a country, but the same set of infrastructure may also exacerbate income inequality of a nation. This is a message that comes out from our unbalanced panel regressions run for 14 Asia-Pacific countries at different levels of development for a period spanning over 1975 to 2006.

Controlling for country level heterogeneity, estimated results in the study show trade openness increases the income inequality in selected Asia and the Pacific countries.

But, the reverse relationship does not hold empirically valid. Income inequality does not influence trade openness directly. Therefore, inequality and trade openness are not direct causal factors for each other. Nevertheless, access to higher infrastructure stocks along with its quality maintenance help reduce the income inequality.

Past inequality itself significantly determines the present level of inequality, as the estimated findings of this study show. The dynamic panel analysis suggests initial level of inequality along with rising trade openness, improvement in infrastructure stock and infrastructure quality lead to fall in income inequality. This is the bottom line of this study. Further, this study also argues that initial level of endowment is important for future equality in the Asia-Pacific region.

To conclude, infrastructure development unambiguously increases trade but its effect on inequality is not that unambiguous. The message is that infrastructure needs to be developed for an open economy that wants to grow, but one must carefully analyze the possible effects of such development on inequality. At the same time, there is no substitute of country specific studies to understand such linkages since such country specific policies come out to be significant determinants along with infrastructure development for achieving higher trade accompanied by lower inequality of income.

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Appendix 1
List of Variables and Sources

Label	Content	Sources
Inequality (INQ)	Gini coefficient	UNU-WIDER World Income Inequality Database, Version 2.0c, May 2008 (UNU-WIDER, 2008), and ADB (2007)
Trade openness (TO)	Trade (export and import) as percentage of GDP (%)	World Development Indicators CD-ROM 2009, World Bank (2009)
Trade liberalization (TL)	Simple average tariff (%)	World Trade Integrated Solution (WITS)
Infrastructure stock (IS)	Infrastructure quantity, which is summed over normalized indicators such as (i) air freight transport (million tons-km); (ii) electric power consumption (kWh per capita); (iii) fixed line and mobile phone subscribers (per 1,000 people); (iv) households with television (% of total households); (v) rail lines (km per 1,000 sq km of geographical area); (vi) roads, (km per 1,000 sq km of geographical area); and (vii) personal computers (per 1,000 people).	World Development Indicators CD-ROM 2009, World Bank (2009), and Asia Infrastructure Database Version 1.0 (AID), (De, 2009)
Infrastructure quality (IQ)	Electric power transmission and distribution losses (% of output)	
Income per capita (PCI)	GDP per capita (constant 2000 US$)	World Development Indicators 2009 Online database, World Bank (2009)
Geography (Land)	Per capita land availability (sq. km)	
Inflation (Inf)	GDP deflator (annual %)	
Population (Pop)	Working population (population ages 15-64, % of total population)	

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Appendix 2

(a) VIF scores (Table 3)

Variable	VIF*	1/VIF
Corresponding to column (2)		
ln_pc_gdp	9.080	0.110
ln_infrastock	5.230	0.191
ln_trade_gdp	3.320	0.301
ln_tdloss	3.290	0.304
ln_land	3.220	0.311
ln_human	3.150	0.317
ln_inflation	1.240	0.804
Mean VIF	4.07	
Corresponding to column (3)		
ln_pc_gdp	7.440	0.134
ln_infrastock	5.010	0.200
ln_tariff	3.490	0.287
ln_land	3.380	0.296
ln_tdloss	3.330	0.300
ln_human	3.250	0.307
ln_inflation	1.230	0.813
Mean VIF	3.88	
Corresponding to column (4)		
ln_pc_gdp	9.080	0.110
ln_tariff	5.960	0.168
ln_trade_gdp	5.680	0.176
ln_infrastock	5.310	0.188
ln_land	3.860	0.259
ln_tdloss	3.380	0.296
ln_human	3.250	0.307
ln_inflation	1.250	0.802
Mean VIF	4.72	

*Tolerance value 10

(b) VIF scores (Table 4)

Variable	VIF*	1/VIF
Corresponding to column (2)		
ln_pc_gdp	8.760	0.114
ln_infrastock	5.680	0.176
ln_land	3.590	0.278
ln_tdloss	3.420	0.293
ln_human	3.070	0.325
ln_gini	1.470	0.680
ln_inflation	1.270	0.786
Mean VIF	3.900	
Corresponding to column (3)		
ln_pc_gdp	9.360	0.107
ln_infrastock	5.690	0.176
ln_land	4.000	0.250
ln_tariff	3.690	0.271
ln_tdloss	3.440	0.291
ln_human	3.280	0.305
ln_gini	1.560	0.643
ln_inflation	1.270	0.786
Mean VIF	4.040	
Corresponding to column (4)		
ln_pc_gdp	9.63	0.10
ln_infrastock	5.70	0.18
ln_trade_gdp	4.06	0.25
ln_land	3.60	0.28
ln_tdloss	3.46	0.29
ln_human	3.19	0.31
ln_gini	1.79	0.56
ln_inflation	1.27	0.79
Mean VIF	4.14	

*Tolerance value 10