Transport Infrastructure and Economic Efficiency : A cross country comparison using Data Envelopment Analysis

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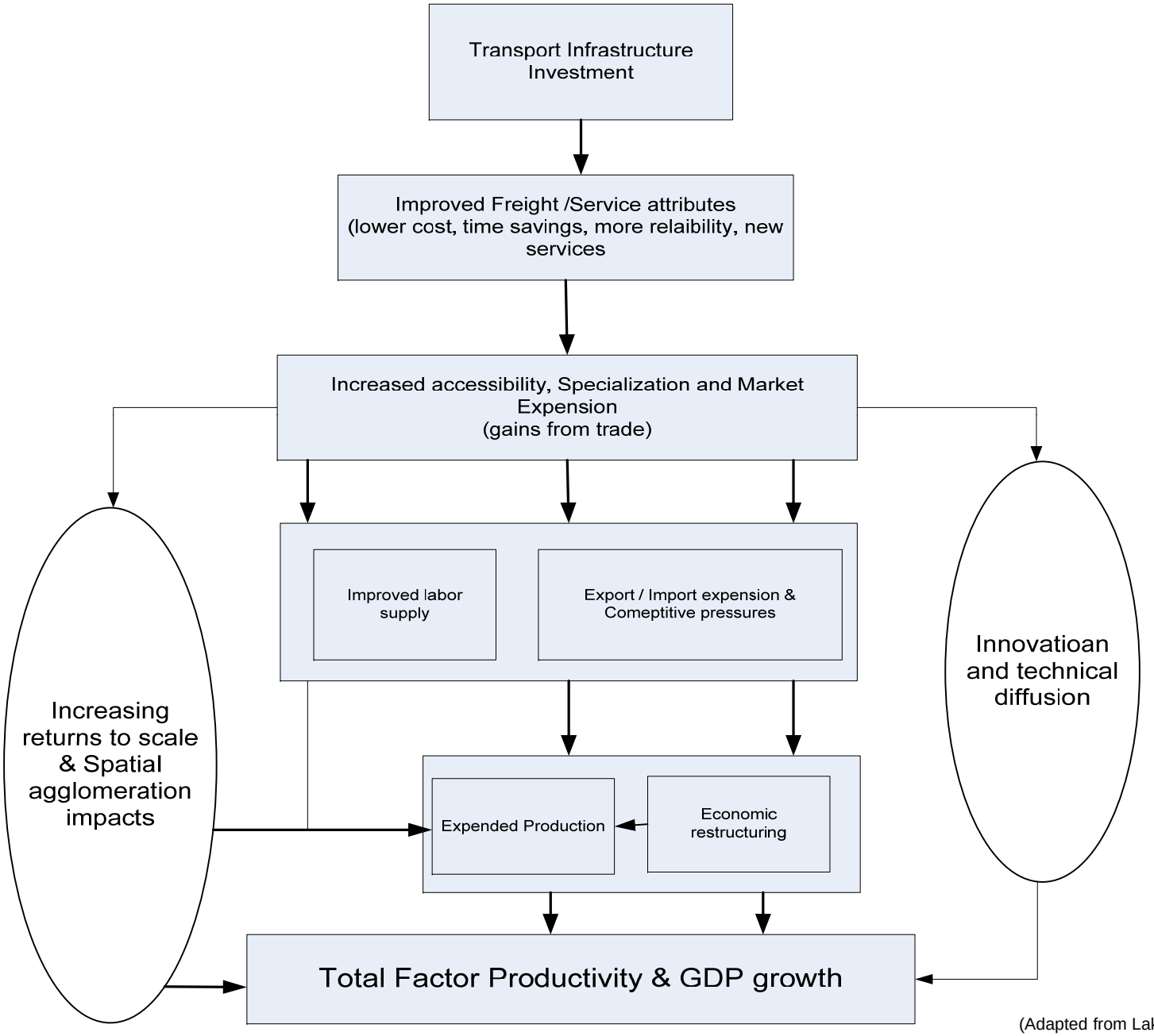
Research Question

- To investigate the link between the transport infrastructure investment and economic growth.
  - To compare the response of developing and developed countries towards the investment in transport infrastructure investment.
    - are nations that spend more on infrastructure investments more efficient than those who spend less?
  - What other factors contribute towards the (in) efficiency of countries.

Transport Infrastructure and Economic Growth

- There are numerous examples of interaction between transport infrastructure investment and economic growth in literature.
  - Kessides (1993)implies that transport infrastructure investment has two way impact:
    - On national output (through supply and demand)
    - On quality of life (accessibility, time saving etc)
  - Olsson (2009) describes the relation as a circular mechanism where direct impacts trigger the indirect impacts.
  - Banister and Berechman (2001) argue that the transport infrastructure works as a complimentary factor to the other investments or development programs.



(Adapted from Lakshmanan 2010)

Empirical Studies

- Many researchers have investigated this link … BUT
  - Most of the studies are limited to one sector or one economy.
  - Hardly any cross country study.
  - Some Important studies:
    - Aschauer (1989)
    - Munnell (1990)
    - Eberts (1986,1988)
    - Bryan *et al* (1997) and Dodgson (1974) studied the impacts of motorway projects on the regional development in different parts of UK.
    - Demurger (2001) studied the growth of 24 Chinese provinces for the year 1985-1998.
    - Ghosh and De (2005) analyzed the impact of infrastructure investment on regional development in India.

Authors	Year	Infrastructures	Focus area	Technique	Results
Fan, S & Zhang X	2004	Road Density Electricity use Rural Telephone Education	Rural China cross section of counties 1996	Simultaneous Equation	•Investing more in rural infrastructure is key to increase in overall income.
Loncan, A.H	2005	Rail roads Urban transport Roads Ports Telecom Energy Hydro works	Spain 1845-1935, 10 year average	Production function	•Positive impact of infrastructure on economy
Fedderke, J.W *et al*	2006	Rail Roads Air Travel Electricity Telephones	South Africa 1875-2001	Time series	•Controversial results •Causality running in both directions
Bronzini, R and Piselli , P	2009	R & D Human Capital Public Infrastructure	Italy Regional 1980-2001	Panel Co-integration	•Human capital has the strongest impact •Casualty from infrastructure to economic development
Fay, M. *et al*	2005	GDP Malnutrition Mortality Rate School enrollment Literacy Rate	Across different groups of countries based on income level	Regression	•Increased GDP and higher literacy rate decreases child mortality and malnutrition
Teruel, R.G and Kuroda, Y	2005	Irrigation Roads Electrification (rural)	Philippine Agricultural sector 1974-2000	Trans-log cost function	•Public infrastructure is found to be a substitute for labor and intermediate inputs •Infrastructure reduces production cost
Gunasekera, K *et al*	2008	Highways	Sri Lanka (firms)	Production function	•Firms located with in 10 Km of road shows 70% more production than those situated more than 10 Kms
Mamatzakis, E.C	2003	Public Infrastructure	Greece (rural)	Cost function	•Public infrastructure brings positive change in the rural agriculture
Valdivia, M	2004	Poverty & Health Infrastructure	Peru	Pannel data 1992-1996-2000	•Reduction in waiting time and increased accessibility are necessary to improve child health and nutrition

Methodology

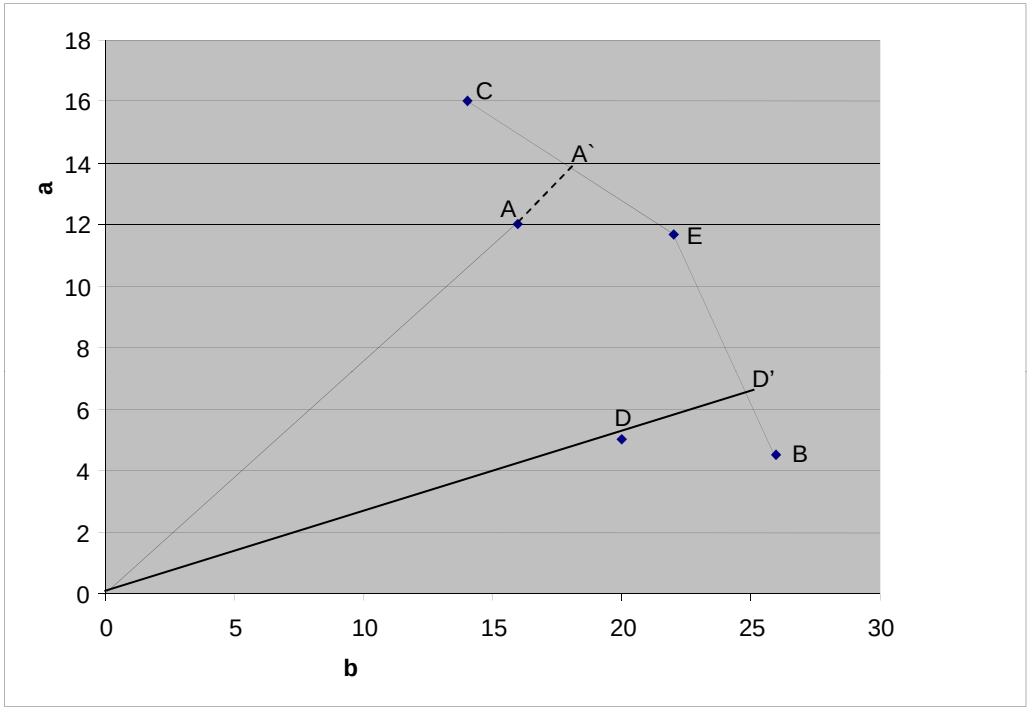
- Many different techniques have been used in previous studies:
  - Cobb-Douglas production function
    - Aschauer (1989), Munnell (1990a,1991), Tatom (1991) and Mera (1972).
  - Trans-log production function
  - Cost function approach
    - Conrad and Seitz (1992), Lynde and Richmond (1992, 1993), Nadiri and Mamuneas (1991)
  - Simultaneous equation models
  - Time series

Methodology (contd)

- Data Envelopment Analysis have been used in this study.
- This study is divided into two stages;

Stage 1:	The relative efficiency scores of 35 countries are calculated with the help of data envelopment analysis.
Stage 2:	An effort is made to explain the reason for the differences in efficiency scores by using *truncated regression* model.

Data Envelopment Analysis



•Best practice units are on the curve i.e. C, E & B where E = 1

• DMU, to the left of the frontier CEB is inefficient e.g. point A and D i.e E < 1

•The relative inefficiency of points below the curve depends on their difference from the best practice frontier.

•The efficiency rating for project A is the ratio of the distance of the line segment from the origin to point A and from the origin to point A`

$$e_A = \frac{OA}{OA`} \quad \& \quad e_D = \frac{OD}{OD`}$$

Data Envelopment Analysis

Merits	*Demerits*
• Does not require any pre-formulation of functional form.	•Very sensitive to the quality of data.
•Can handle the multiple inputs and multiple outputs at same time.	•Bias in case of very high number of inputs and outputs.
•Works independently of the nature of distribution.	•The information regarding the marginal products and elasticities is not included.
•Provides a way to break down economic efficiency into its components.	•Does not produce any standard errors.

Model

- Stage 1:
  - Output :
    - Gross Domestic Product
  - Input:
    - Gross Capital formation
    - Total Labor Force

GDP = f (CF, LF)

- Justification for model ?

Data

- No concrete and concentrated data base of required data for all countries.
- Mostly World Bank, IMF and UN data bases are used.
    - Problems in data collection
    - No evidence from literature on use of such huge data
- Time period 1991-2006
- Proxies and Normalization of data
    - Huge range among the countries
    - Use of growth rate?
    - *Use of Indices*

2nd stage Analysis

- Common in DEA studies
  - Different Methods
- Data is comprised of 36 countries which vary in economic, social, political and geographical conditions
  - Use of Country specific variables
    - Investment in Transport Infrastructure
    - Development stage
    - Access to Port (land lock)
    - Access to hub airport
    - Rural population (percentage)
    - Paved roads (percentage of total road network)
  - Truncated Regression Analysis

Low & Lower Middle Income	Upper Middle Income	High Income
Bangladesh	Argentina	Australia
Kenya	Belarus	Canada
Bolivia	Costa Rica	Czech Republic
Guatemala	Iran	Denmark
India	Kazakhstan	Estonia
Jordan	Mauritius	France
Moldova	Russia	Iceland
Pakistan	Romania	Latvia
Philippines	Venezuela	Norway
Sri Lanka		Poland
Thailand		Slovenia
Tunisia		Sweden
Ukraine		United Kingdom
Only Bangladesh and Kenya belongs to low income category		

World Bank's classification

Summary of DEA

Year	No. of countries	Mean Efficiency score	Std. Dev.	Min Efficiency	Max efficiency	No. of efficient country(s) E = 1
1991	35	.9454620	.0426225	.82066	1	3
1992	35	.9317720	.0635821	.65332	1	4
1993	35	.9303334	.0392236	.83242	1	3
1994	35	.9428971	.0406961	.81519	1	4
1995	35	.9343677	.0337107	.85934	1	2
1996	35	.9461689	.0310828	.86609	1	3
1997	35	.9361394	.0429048	.82177	1	3
1998	35	.9272300	.0337038	.86685	1	3
1999	35	.9265317	.0362778	.84394	1	3
2000	35	.9405500	.0314618	.85980	1	2
2001	35	.9344357	.0398885	.82707	1	3
2002	35	.9413740	.0399520	.84894	1	3
2003	35	.9549703	.0289255	.89844	1	5
2004	35	.9178063	.0408329	.85532	1	2
2005	35	.9478829	.0332353	.89138	1	2
2006	35	.9424054	.0277099	.89042	1	3

Truncated Regression

All countries

e	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
ti	8.16e-07	6.13e-07	1.33	0.183	-3.86e-07	2.02e-06
landlocked	.0221468	.0101327	2.19	0.029	.002287	.0420065
hubairport	.0234439	.0076239	3.08	0.002	.0085013	.0383865
ruralpop	.0001852	.000158	1.17	0.241	-.0001245	.0004948
proads	-.0001666	.0000944	-1.77	0.077	-.0003516	.0000183
dev1	.015813	.0086709	1.82	0.068	-.0011816	.0328076
dev2	.0051915	.0082786	0.63	0.531	-.0110343	.0214174
_cons	.0216673	.0151294	1.43	0.152	-.0079858	.0513203
/sigma	.0334213	.0023229	14.39	0.000	.0288686	.0379741

Truncated Regression for different income groups

	Low and Low Middle income countries		Upper Middle income countries		High income countries	
Variable	*Coef.*	*Z-value*	*Coef.*	*Z-value*	*Coef.*	*Z-value*
ti	2.23e-06	1.06	-7.73e-06	-2.11	1.15e-06	1.81
landlocked	0.0284216	1.80	0.248361	0.98	0.0027905	0.18
hubairport	0.0015756	0.14	0.484745	2.37	0.0068923	0.47
ruralpop	0.000221	0.90	0.0009595	1.73	-0.000726	-1.45
proads	-0.000246	-1.75	-0.000584	-1.69	0.00002	0.13
Sigma	0.0328656	9.26	0.0347636	6.66	0.0274512	9.64

Conclusion and Future Research

- This paper is part of my doctoral thesis.
- The analysis can be extended on productivity analysis with the use of *Malmquist Productivity Index.*
- Different approaches of efficiency measurement can be compared.
    - My another paper comparing DEA and SFA.
- 2nd stage analysis can be extended in form of *F-test* and *Mann-Whitney* tests etc.