PUBLIC INVESTMENT AS A SOLUTION TO LOW GROWTH

- Infrastructural efficiency in developing countries

By

Eun Young PARK

THESIS

Submitted to

KDI School of Public Policy and Management

in partial fulfillment of the requirements

for the degree of

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- Infrastructural efficiency in developing countries

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<Table of Contents>

1. Background and Objective of the Study

1.1. Background of the thesis

1.2. Objective: How to enhance efficiency of public investment?

2. Research Questions

2.1. Definition of efficiency and productivity of public investment

2.2. Estimating public investment efficiency

3. Hypothesis or main arguments

3.1. Public Investment Management: Efficiency Enhancement Method

3.2. PIMI: Index to Assess Public Investment Management

3.3. CPI: Assessing Degree of Corruption

3.4. Substitution of PIE-X: Assessing Efficiency of Public Investment

4. Literature Review (short summary)

4.1. Making public investment more efficient

4.2. Investing in Public Investment: An Index of Public Investment Efficiency

4.3. Corruption, Public Investment, and Growth

4.4. Infrastructure productivity: How to save $1 trillion a year

5. Research Methodology and Data

5.1. Research Methodology

5.2. Input Data: PIMI, CPI, CPIA

5.3. Output Data: PIE-X

6. Analysis and Results

6.1. Quantitative analysis and result

7. Conclusion and Policy Implications

7.1. Conclusion

7.2. Political Implications

<Abstract>

There are well-known obstacles of linkage between public investment and growth: infrastructure gap and efficiency gap. And the difference of efficiency between groups of countries by economic development level. Further, the most efficient group is twice as efficient as the least efficient group.

IMF, the most authoritative institution in analyzing public investment, insisted that PIM (public investment management) is the key issue to enhance efficiency in public investment.

The hypothesis of this thesis, "strengthening of PIM effects on efficiency of public investment" is proven by regression analysis but under income quartile control. The income group under the lowest 50% quartile showed that it has a lower inefficiency (i.e., higher efficiency) if its PIMI (public investment management index) is higher.

Therefore, the goal of this thesis is to verify the relationship between PIM and efficiency. Moreover, it tries to find other variables that affect the efficiency of public investment.

For the analysis, the dependent variable is efficiency (inefficiency score), which is assessed by the PIE-X index and the independent variable is public investment management, which is assessed by the PIMI index. To prevent some biases, this analysis corrects the methodology to assess input data constructed by the IMF. To differentiate the adjusted index from the original PIE-X, it is named as "Neo PIE-X"

For analyzing other variables, the result of CPIA (an index similar to PIMI) was not different that of PIMI, but CPI was statistically insignificant. This suggests that the effect of corruption on public investment is not certain.

The effect of strengthening PIM is stronger in low income countries than in middle income countries. This is recommendable for MDBs(Multilateral Developing Banks) to put a higher priority on strengthening PIM, when they consider public investment especially in low income countries.

Neo PIE-X, is very accessible to efficiency related data. I hope that this study would be a catalyst for other studies to focus on enhancing the efficiency of public investment, following IMF's study.

1. Background and Objective of the Study

1.1. Background of the thesis

Global economy, which has been gradually recovering from the 2008 crisis, is entering a new phase. Some economists urge that this is the so - called 'secular stagnation'. The old theory spurred by Hansen A.H. in 1938 has been applied again for US and Japan recently[1]. Irrespective of whether secular stagnation is prevalent, it is clear that most countries are worried about their low growth problem. One of the main reasons for this problem is the structural change- in the society due to aging population, low productivity, etc., which cannot changed within in the short term. Therefore, we should prepare for possibly long - lasting global low growth. Further, many analyses insist that the most effective solution for the problem is investment in infrastructure. The IMF advocates public investment to contribute to growth and demands more investment in infrastructure to help global recovery in 2014 World Economic Outlook. McKinsey Global Institute claimed that just to keep pace with anticipated growth, the world needs to invest $57 trillion in infrastructure.[2]

On the other hand, some empirical analyses suggested an adverse effect of government spending on growth. From five cases, Warner found the reason for limited impact on long-run growth to be weak or circumvented project appraisal, selection and management procedures (2014)[3]. However, Gupta et al (2006) found public investment management to be a significant factor in the relationship between public investment and growth in a study of 52 low-income developing countries.[4]

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[1] Secular stagnation occurs under highly developed capitalism due to change of population structure, low interest rate, perfect employment, and low growth.

[2] McKinsey, 2013, "How can save US$1 trillion" p1

[3] Warner, A., 2014a, "Public Investment as an Engine of Growth", p44

[4] Gupta, S.,et al, 2006 "Public-Private Partnership, Government Guarantees, and Fiscal Risk," (Washington; International Monetary Fund)

Straub (2008) suggested that improvements in infrastructure led to focused not only directly increase in productivity, but also indirect decrease in transportation costs, thus increasing economies of scale, productivity and even growth[5]. Although there are some arguments, overall, the empirical and theoretical result suggest that public investment, greater the growth effect.

-Why every country doesn't follow the panacea-like prescription?

In the literature review, there are numerous empirical evidences and theories that indicate that higher input in public investment can enhance growth. Further, recent studies suggest that the growth impact of increasing infrastructure investment in low-income countries is potentially substantial.[6] If economic recovery is possible simply by increasing public investment, it is important to question why most countries do not implement another immediately.
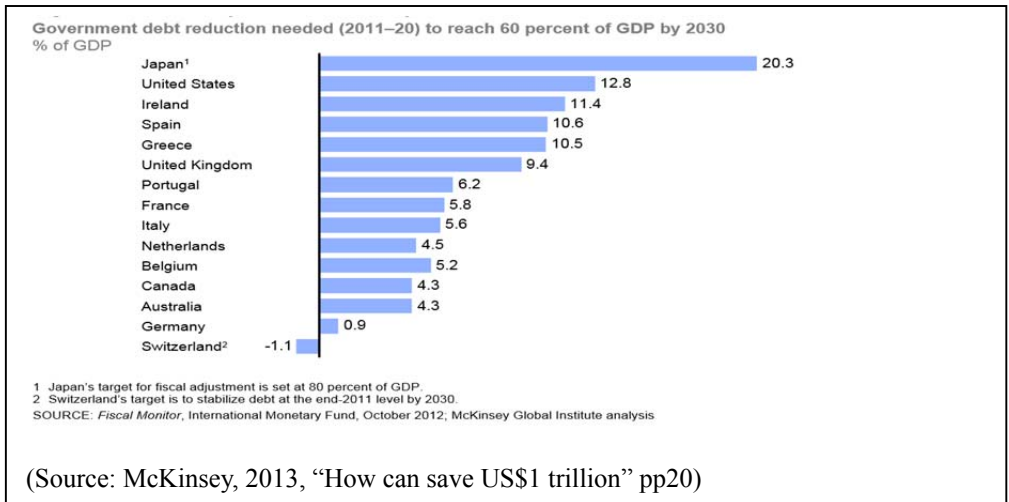
We aim to find the answer from the empirical data. The first reason is fiscal pressure. According to McKinsey, many governments planned to consolidate and deleverage to decrease public debt to 60% of GDP or lesser.[7] (Figure 1) Moreover, under the expectation of global low growth, it is hard to increase public investment.

[5] Straub, S., 2008, "Infrastructure and Growth in Developing Countries: Recent Advances and Research Challenges," p14

[6] Calderon and Serven find that "If low-income countries halved their infrastructure gap, reaching the level in middle income countries, annual growth rates would increase by 2 percent." Calderon, C. and L. Serven, 2008, "Infrastructure and Economic Development in Sub-Saharan Africa", p29

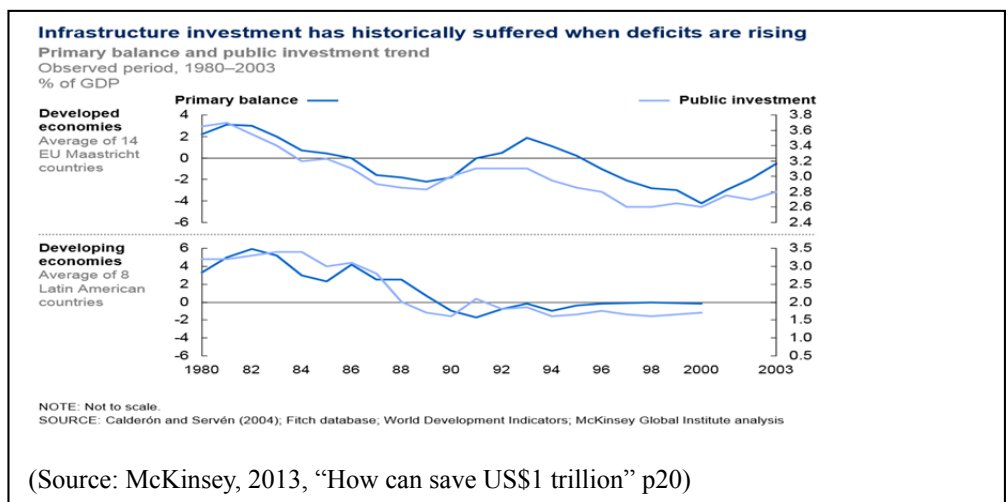[7] McKinsey, 2013, "How can save US$1 trillion a year" p20

<Figure 1> Expected Government Reduction by 2030

Government debt reduction needed (2011–20) to reach 60 percent of GDP by 2030
% of GDP

Japan[1]	20.3
United States	12.8
Ireland	11.4
Spain	10.6
Greece	10.5
United Kingdom	9.4
Portugal	6.2
France	5.8
Italy	5.6
Netherlands	4.5
Belgium	5.2
Canada	4.3
Australia	4.3
Germany	0.9
Switzerland[2]	-1.1

1 Japan's target for fiscal adjustment is set at 80 percent of GDP.
2 Switzerland's target is to stabilize debt at the end-2011 level by 2030.
SOURCE: *Fiscal Monitor*, International Monetary Fund, October 2012; McKinsey Global Institute analysis

(Source: McKinsey, 2013, "How can save US$1 trillion" pp20)

-Infrastructure Gap

McKinsey referred to the difference between demand and supply of infrastructure as infrastructure gap, which is bigger in developing countries than in developed countries. Moreover, developing countries tend to demand more public investment for infrastructure than developed countries do for lack of existing infrastructures. However, when a country suffers from rising deficit, developing countries tend to shrink public investment more than developed countries do.[8](Figure 2)

<Figure 2> Comparing Developed and Developing Economies

Infrastructure investment has historically suffered when deficits are rising
Primary balance and public investment trend
Observed period, 1980–2003
% of GDP

NOTE: Not to scale.
SOURCE: Calderón and Servén (2004); Fitch database; World Development Indicators; McKinsey Global Institute analysis

(Source: McKinsey, 2013, "How can save US$1 trillion" p20)

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8 During 1980~2003, annual investment in infrastructure fell by 0.2% of GDP across EU nations, but the reduction was 0.8% in Latin American. McKinsey, 2013, "How can save US$1 trillion", pp19

-Efficiency gap

The second reason why investment in infrastructure isn't an all-round remedy for low growth problem is efficiency gap, which refers to different performances for the same amount of investment between countries by level of economic development. IMF insisted that the value of public capital (input) and measures of infrastructure coverage and quality (output) across countries shows about 30 percent average inefficiency. Further, the efficiency gap between the lowest and the highest group is almost double.[9]

Infrastructure gap and efficiency gap- are larger in developing countries than in developed countries. According to IMF, low efficiency of public investment could weaken the connection between public capital spending, capital stock accumulation and growth. Because a high degree of inefficiency, waste, or corruption restrain the effect of public spending, and hence the belief that public investment spending is equal to capital accumulation might be wrong.[10]

This paper focuses on the methods to decrease the efficiency gap. To decrease infrastructure gap - one has to simply increase the public infrastructure - but it takes time and demands complicated processes, such as the ratification of the parliament. Further, there is a substantial limit to increase considering their current growth, taxation policy, etc. Contrarily, it is possible to enhance efficiency under similar budget constraints as the existing ones. Therefore, this thesis argues that it is critical to enhance efficiency and it attempts to find other factors that affect efficiency of the public investment.

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[9] "1% increase of GDP in public investment results 0.3% increase of output in lowest efficient countries but 0.6% increase in highest efficient countries", (IMF, 2015, "Making public investment more efficient", p18)

[10] Dablar-Norris et al, 2011, "Investing in Public Investment: An Index of Public Investment Efficiency" p5

1.2. Objective: How to Enhance Efficiency of Public Investment?

Public investment of infrastructure has been core remedy whenever growth had to be increased. The New Deal after the Great Recession in US and the large public investment in Japan are representative ones. Both theoretical and empirical studies have emphasized the positive relationship between public infrastructure of high quality and economy-wide productivity.[11] Lant(1996) referred that a dollar of public investment often does not transfer to a dollar's worth of public capital, especially in developing countries, even in the case of typical developing countries, this value is less than 50cents.[12] Therefore, it needs to be determined what differentiate the result between US and Japan and how to decrease the efficiency gap between developed and developing countries.

To enhance public investment efficiency, many studies insisted that managing the investment is important. Collier (2008) insisted that country-level efforts to strengthen the investment process can play a key role in increasing the returns on public and private investment[13].

Therefore, this thesis aims to verify the relationship between public investment management (PIM) and efficiency. Moreover, it attempts to investigate other factors that can enhance the efficiency of public investment.

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[11] Buffie, E., and others, 2012, "Public Investment, Growth, and Debt Sustainability: Putting Together the Pieces," p26

[12] Lant Pritchett, 1996, "Mind Your P's and Q's- The Cost of Public Investment is Not the Value of Public Capital" p2

[13] Collier, P. and Venables, A., 2008 "Managing Resource Revenues: Lessons for Low Income countries," African Economic Research Consortium 2008 Annual Conference, p25

2. Research Questions

2.1. Definition of efficiency and productivity of public investment

Before assessing the efficiency of public investment, it is inevitable to define the process and the relevant terminology. During the literature survey, it is clear that the IMF – the unique institution to analyze public investment. Therefore, IMF's terminologies related to public investment are as follows

<Box 1> Definition of Public Investment Efficiency, Productivity, and Performance

Public Investment. Public investment is measured as general government gross fixed capital formation (GFCF) and comprises the total net value of general government acquisitions of fixed assets during the accounting period, plus variations in the valuation of non-produced assets (e.g., subsoil assets). The general government comprises central and subnational governments, but excludes other public entities, such as state-owned enterprises (SOEs) and public-private partnership (PPP) arrangements.

Public Capital Stock. The public capital stock is the accumulated value of public investment over time, adjusted for depreciation (which varies by income group and over time), and is the principal input into the production of public infrastructure.

Public Infrastructure. Public infrastructure is the network of physical assets created by public investment. These fixed assets include both economic infrastructure (e.g., highways, airports, roads, railways, water and sewer systems, public electric and gas utilities, pipelines, and telecommunications) and social infrastructure (e.g., public schools, hospitals, and prisons). The volume of infrastructure is measured using indicators of both access to and quality of the key infrastructure assets, including roads, electricity, water, education, and health care institutions.

Public Investment Efficiency. The efficiency of public investment is the relationship between the value of the public capital stock and the measured coverage and quality of infrastructure assets. As described in Section II and Annex II, the level of efficiency in a given country is calculated as the distance from an efficiency frontier, which is defined by the countries with the highest coverage and quality of infrastructure (output) for a given level of public capital stock (input).

Public Investment Productivity. Public investment productivity is the relationship between investment and economic growth measured by the ratio of average real rate of capital stock growth to the average real rate of economic growth.
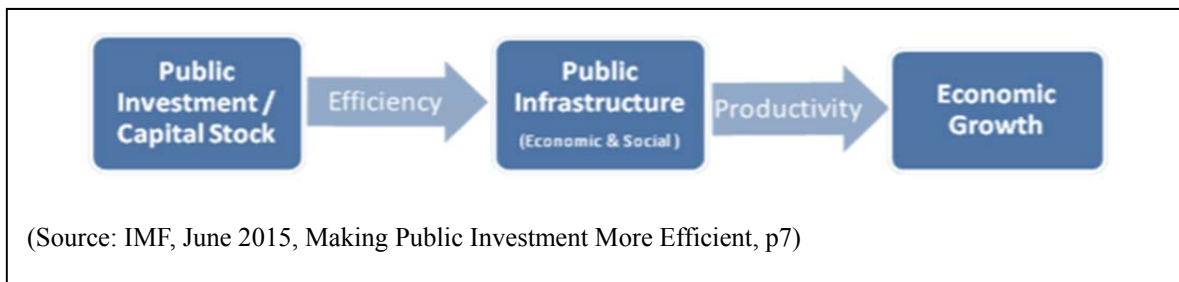
(Source: IMF, 2015, "Making Public Investment More Efficient", p7)

2.2. Estimating efficiency of public investment

According to the IMF, productivity of public investment is the degree of public infrastructure transferred to economic growth. According to McKinsey, a 60 percent increase in infrastructure productivity is possible. 2030, the amount transferred is estimated 1 trillion dollars a year. [14]

<Figure 3>   Public Investment Performance

(Source: IMF, June 2015, Making Public Investment More Efficient, p7)
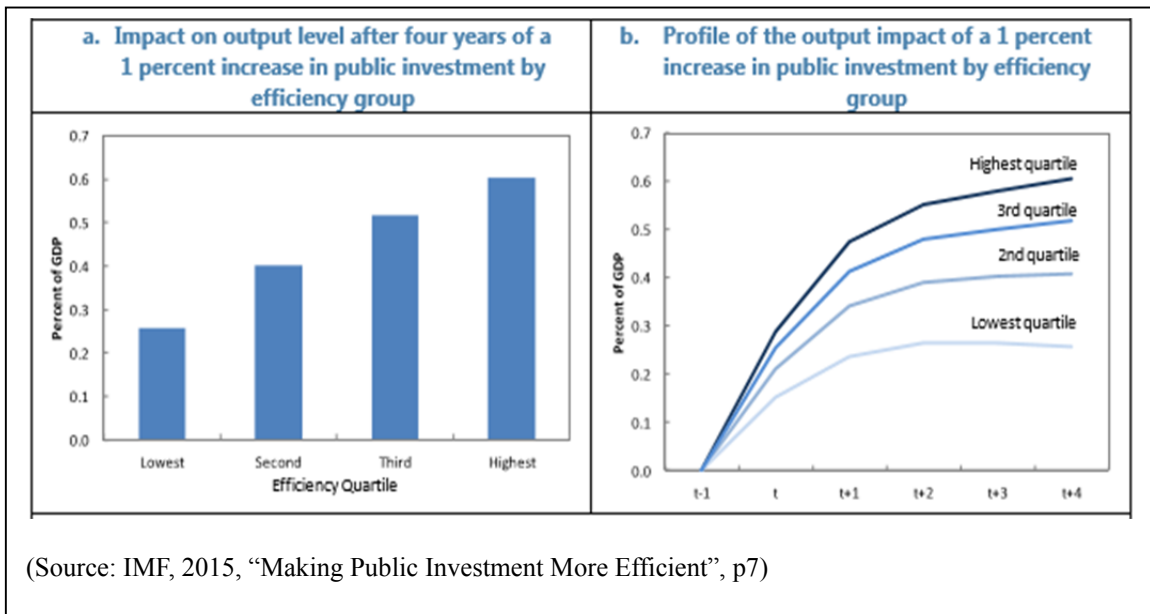
On the other hand, efficiency of public investment is the degree how much public investment/capital stock transferred to public infrastructure (Figure 3). The impact of efficiency of public investment on growth has got less attention than that of productivity.[15]

IMF (2015) found that higher investment impact on growth is resulted in AE (advanced economies) for more efficient public investment. In AE, public investment stocks increase growth by around 0.4 percent in the first year, and 1.5 percent after four years. In developing countries, the impact on growth was smaller, at around 0.25 percent in the first year, and 0.5 percent after four years (Figure 4a). An unusual aspect is that the difference between quartile 1 and 4 is double (Figure 4b). Further, many organizations argue that the reason of the difference is mainly PIM.

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[14] McKinsey, 2013, "How can save US$1 trillion"

[15] One of the reasons might be the difficulty of assess. So, IMF construct efficiency index by itself, PIE-X which will be used in this thesis. It will be explained in chapter 3 in detail.

<Figure 4> Public Investment, Efficiency, and Output (percent of GDP)

(Source: IMF, 2015, "Making Public Investment More Efficient", p7)

The economic dividend from closing the public investment efficiency gap could be critical—moving from the lowest quartile to the highest quartile in public investment efficiency could double the impact of that investment on growth. Figure 4a shows that a one-time 1 percent of GDP increase in public investment increases output by just 0.3 percent in the lowest efficiency quartile countries, but 0.6 percent in the highest efficiency quartile countries.

The empirical results of IMF would support the argument "investment efficiency matters for growth."[16] The result of cross-country regression suggests that the growth dividend of investment is larger in high-efficiency countries than in low-efficiency countries. Regardless of the relationship between public investment efficiency and growth across countries, improving efficiency has standing out impact on growth.[17]

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[16] IMF, 2015, "Making Public Investment More Efficient", p17

[17] IMF, 2015, "Making Public Investment More Efficient", p17

3. Hypothesis

According to the IMF, even though the literature suggests that a scaling-up of investment in low-income countries is important, quality and efficiency of public investment are critical to obtain development dividends. In addition, studies suggest that countries with more efficient PIM arrangements would also expect a bigger growth due to result from their investment.[18]

Under the hypothesis that better PIM enhances public infrastructure quality and economic growth, this thesis focuses on determining the factors that affect the enhancement of public investment, and it tries to find other variables by regression analysis.

The analyses presented in chapter 5 and 6 suggest that improvements in public investment management practices could reduce the efficiency gap.

The empirical research on relationship between PIM and efficiency is positive. Regression analysis using hybrid PIE-X of the IMF suggests that additional 1 point of PIM overall score is statistically significantly associated with a 5% increase in PI efficiency.[19]

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[18] This is supported by theoretical (Chakraborty and Dabla-Norris, 2009) and empirical (Gupta and others, 2014) analyses.

[19] Hybridization is one of the methodologies to induce PIE-X, IMF, 2015, "Making Public Investment More Efficient" p28

4. Literature Review (short summary)

4.1.Making Public Investment More Efficient (IMF, June 2015)

This report interpreted the relationship between public investment and efficiency and how to assess the quality of infrastructure by using PIMI. Public investments not only are the source of the public services that connect individuals and firms but also serve as an important factor for growth.

The economic impact of public investment substantially depends on its efficiency. Comparing the difference across countries suggests that average inefficiency is about 30 % in public investment processes.

Improvement in PIM can enhance to enhance either efficiency or productivity. From a sample of 25 countries, Public Investment Management Assessment by the IMF finds significant scope to strengthen key institutions of 15 countries. Strengthening the institutions could reduce the efficiency gap of EM (Emerging Markets) and LIDC (Less Income Developing Countries) by up to 2/3rd.

In this paper, the IMF emphasizes importance of efficiency in public investment, and there is enough room for this to be applied towards enhancing the efficiency in EM and LIDC countries. Further, it suggested how to assess and enhance the efficiency.

4.2. Investing in Public Investment: An Index of Public Investment Efficiency (Dablar- Norris et al., 2009)

It's well known that increasing public investment in developing countries is necessary for their development particularly in infrastructure. However, it's not applicable in many global cases. Further, empirically, weaknesses in public investment management resulted in inappropriate returns, especially in many developing countries. Limited information, waste and leakage of resources result poor selection and implementation and diffident technical expertise, eventually leading to low returns to public investment. Moreover, a substantial increase of public investment under a weak institutional environment is accompanied by the risk of undermining its growth and prospects for sustainable fiscal and debt.

This underscores several aspects—country capacities to carry out project appraisal and selection, mechanisms for implementation, oversight, and monitoring, and ex post evaluation. Further, the transparency and accountability of these functions are supportive. Indicators to assess these aspects can play an important role in increasing productive public investment and its growth dividends.

The most valuable contribution of this thesis is that it might be the first one to attempt the development of a new index that acquires the difference between the before-and- after phases of each investment process. The index has been developed as a composite index of the efficiency which relates to the public investment management processes of 71 countries (of which 40 are low-income countries).

4.3. Corruption, Public Investment, and Growth (Vito Tanzi and Hamid Davoodi, 1997)

This suggests some case studies and reason why corruption happened especially in public investment and why public investment is particularly sensitive to the existence of political corruption. Higher corruption tends to be associated with higher expenditures such as infrastructure projects. Because economist believe that scaling-up of capital spending contributes to growth, they tend to favor high capital spending. Generally, many influential economists (Harrod, Domark, Rostow etc) favored increase in either government expenditure or spending economy results. Politicians prefer large, new projects than capital spending such as operation and maintenance, although the latter is inevitable. In many cases, in developing countries, there are numerous cases that demanded to be repaired within a short period after completion of construction.

It also cited that widespread corruption in the budget will not only decrease the return of new investment, but will also affect the return of existing infrastructure. This is proven by empirical analysis and this thesis uses this methodology.

Therefore, considering the negative effect of corruption in public investment, this thesis takes the corruption - related index as a variable in regression analysis.

4.4. Infrastructure productivity: How to save $1 trillion a year (McKinsey Global Institute, 2013)

McKinsey Global Institute (MGI) estimated $57 trillion of infrastructure investment will be demanded from 2013 to 2030 to simply sustain expected global GDP growth. However, $57 billion of infrastructure stock is higher than the estimated value of the current worldwide infrastructure. Further, many countries are facing challenges such as budget constraints in the public sector, commercial debt issue after financial crisis, and higher and more volatile resource costs.

17

This paper emphasized the infrastructure gap. MGI emphasized the role and cooperation of the private sector which are different from IMF's solution. According to the IMF, the portion of private sector is trivial at around at 5%, hence, it did not highly regard the investment from private sector. However, MGI's approach to solve this problem (expected insufficient supply for public investment) is to enhance the productivity.

In this paper, productivity should be enhanced by making better choices about which project to execute, streaming the delivery of project and taking the most of existing execute. These there levers could result in annual savings of $1 trillion.
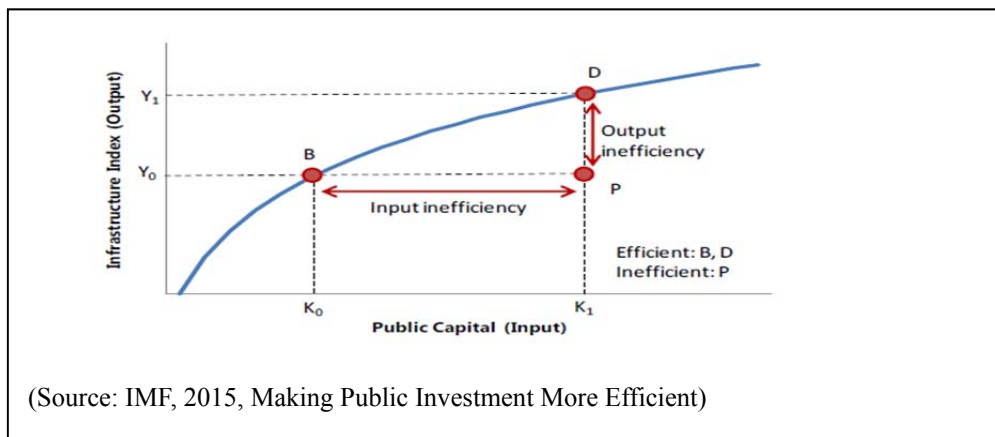
By reviewing this analysis, I aim to understand the current global public investment sector and its expected demand and supply. However, to induce the solution, although MGI underscored enhancement of productivity, this thesis focuses on the enhancement of efficiency. Therefore, this paper refers to the status quo of global infrastructure and the relationship between infrastructure and growth.

5. Research Methodology and Data

5.1. Research Methodology

In the analysis, this thesis use parametric frontier techniques in the frontier stochastic model (See Appendix 3)[20] to analyze the relationship between public investment and efficiency. (Figure 5)

<Figure 5> Constructing the Public Investment Efficiency Frontier

(Source: IMF, 2015, Making Public Investment More Efficient)

5.2. Input Data: PIMI, CPI, CPIA

This paper referred to the studies regarding relationship between public investment and efficiency (e.g., IMF 2015) and analysis of the PIM practices (e.g., IMF 2010). In the light of growth regression analysis, the variables of first - order interest are the interaction between PIMI and other factors than the level degree of PIMI itself. Therefore, this thesis considers regression analysis in addition to CPI and CPIA. In other words, the input data is composed of PIMI, CPI, and CPIA and output data is PIE-X.

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[20] Murillo- Zamorano, Luis R. "Economic efficiency and frontier techniques." Journal of Economic surveys 18.1 (2004), p 47

- PIMI: Index to Assess Public Investment Management

According to the MF, there are no weren't available indices to assess efficiency of public investment management. Therefore, the institution constructed an index for analyzing the real strength of PIM institutions in low and middle- income countries.[21]

The data used in this paper cover the 2007-2010 period and include 71 countries (see Appendix 1 for more detailed data sources, and Appendix 2 for released PIMI). The index is composed by 4 major phases: strategic guidance and project appraisal; project selection; project management and implementation; and project evaluation and audit. Further, each major phase comprises of 17 individual components (Box 2).

<Box 2> **Key Aspects of the Public Investment Management**

<table>
<tr><td>

1. Strategic Guidance and Project Appraisal
    -Nature of strategic guidance and availability of sector strategies
    -Transparency of appraisal standards
    -Observed conduct of ex ante appraisal
    -Independent review of appraisals conducted

2. Project Selection and Budgeting
    -Existence of medium term planning framework and its integration to the budget
    -Inclusion in budget (or similar) for donor funded projects
    -Integration of recurrent and investment expenditures in budget
    -Nature of scrutiny and funding supplied by legislature, including its committees
    -Public access to key fiscal information

3. Project Implementation
    -Degree of open competition for award of contracts
    -Nature of any complaints mechanism relating to procurement
    -Funding flows during budget execution
    -Existence and effectiveness of internal controls, such as commitment controls
    -Effectiveness of system of internal audit

4. Project Evaluation and Audit
    -Degree to which ex-post evaluations are conducted
    -Degree to which external audits are produced on a timely basis and scrutinized by the legislature

    The maintenance of asset registers, and/or asset values

    (Source: IMF, 2011, "Investing in Public Investment", p8)

</td></tr>
</table>

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[21] Concept of PIMI was derived from existing analysis of Rajaram et al. (IMF, 2015, "Investing in Public investment: An Index of Public Investment Efficiency" pp7)

The empirical research on the relationship between PIM and efficiency is positive. Regression analysis using hybrid PIE-X suggested that additional 1 point of PIM overall score is associated with a 5% increase in PI efficiency.[22]

For each question, 0-4 range of scale is used, where a higher score reflects a better performance.

- CPI: Assessing Degree of Corruption

One of the expected results of strengthening PIM is anti-corruption, because occasionally, public investment projects provide lucrative opportunities for corruption. The literature on PIM practices emphasized the importance of transparency and well-governed institutions at important stages of the investment cycle.

The IMF analyzed the relationship between PIM score, where the corruption index of ICRG is highly positive(R^2=0.5349). However, in this paper, CPI (Corruption Perceived Index) by Transparency International is used for regression analysis.[23] According to Transparency Institution website, CPI measures the perceived levels of corruption degree in public sector globally, based on expert opinion. The scale of the issue is vast. Worldwide, 68 % countries have a serious corruption problem, with half of the G20 among them.

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[22] Hybrid is one of the methodologies to induce PIE-X, IMF, 2015, "Making Public Investment More Efficient" p28

[23] As a corruption indicator, even ICRG data is well-known and composed of many representative data which reflects each country comprehensively, this is not open data so difficult to approach and test. So this paper used CPI which is open to public for free by Transparency Institution.

- CPIA: Assessing Degree of Country Policy

The Country Policy and Institutional Assessment (CPIA) is an index similar to PIMI. According to World Bank website, "CPIA means Rating of countries against a set of 16 criteria grouped in four clusters: economic management, structural policies, policies for social inclusion and equity, and public sector management and institutions."[24]

5.3. Output Data: PIE-X

- PIE-X: Assessing Efficiency of Public Investment

Efficiency of public investment is assessed by the quality of infrastructure. With regards to assessing the efficiency of public investment, the most representative indicator is PIE-X which is constructed and released by the IMF.[25] This is composed of 3 methodologies: just use of index from WEF (World Economic Forum), physical index, and hybrid index. However these are not feasible to assess efficiency gap and regression analysis, and hence, this paper uses Neo PIE-X with some adjustment.

a) Original PIE-X

The IMF developed this indicator to assess the efficiency of public investment. This is between 0-1 for countries based on their performances. Relatively, vertical distance to the frontier shows their performance. Three measures of infrastructure quality and access are considered in constructing the frontier.

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[24] World Bank website (http://data.worldbank.org/data-catalog/CPIA)

[25] IMF, 2015, "Making public investment more efficient", p18~19

- A physical indicator: Combination of data- volume of economic infrastructure (e.g., length of a road, production of electricity, and access to water) and social infrastructure (e.g., number of hospital beds and secondary teachers). According to IMF, it doesn't measure the quality of the infrastructure fully even it provides a sense of the coverage of infrastructure network.

- A survey based indicator: This is based on the survey of WEF (World Economic Forum) that question business leaders' impressions on the quality of infrastructure assets. However, it is affected by individual perception biases and fails to capture the coverage dimension adequately.

- A hybrid indicator: Combination of physical and survey-based indicators to construct a synthetic index. Because of the limitations of the above two indicators, this hybrid indicator is more recommended.

The usefulness of PIE-X is that it can clearly show the substantial scope for improving of efficiency on public investment. According to IMF, the average efficiency gap is 27 percent, while some countries having much higher gaps. This efficiency gap is measured as the distance between the average country and the frontier under a given public capital stock and income. Therefore, the size of the gap decreases as income rises: on an average, LIDCs cause a gap of 40 %, EMs cause a gap of 27 %, and AEs cause a gap of 13 %. This means that there is enough room to enhance the efficiency, especially for LIDCs.

b) Neo PIE-X (Adjusted PIE-X)

Besides the above two gaps which are obstacles between public investment and growth linkage, another gap exists which has been underestimated regarding public investment. Because all public investment spending doesn't transfer to effective capital, so a comprehensive gap is located between the traditional assessments and effective capital stock (See figure 3 in Chapter 2). Therefore, the bias that a public capital stock of a low efficient country is emphasized than its effective level is possible. This means that the real infrastructure gap could be bigger than they have known.

As of date, all empirical studies of public capital to growth have assumed that public investment spending as productive capital assets. According to Gupta, some critical issues could happen in preparing productivity of public capital data from cross-country regression. And it's difficult to find a good proxy of efficiency-adjusted public capital stock.[26]

To solve this problem, this paper uses the method of Pritchett (2000) which considered efficiency of public investment. He argued that cross-country research using investment rates or CUDIE (Cumulated Depreciated Investment Effort) cannot be used to induce the impact of public capital (investment on growth). This is because such studies ignore the efficiency with which public investment is transferred to productive physical capital.[27]

Therefore, this thesis considers the net flow of capital stock from the World Bank, instead of the accumulated stock.

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[26] Sanjeev Gupta et al, 2011, "Efficiency-Adjusted Public Capital and Growth", (Washington; International Monetary Fund), p7

[27] Pritchett, L., 2000, "The Tyranny of Concepts: CUDIE (Cumulated, Depreciated, Investment Effort) Is Not Capital," Journal of Economic Growth 5, p. 361–84.

Few studies - that amount of public capital and compared it with the actual stock of public capital.[28] According to Rebelo (1993) and Pritchett (2000), the reason for this is that the analysis of public investment flows tends to find ambiguous and negligible growth effects, especially in the low-income countries. Moreover, calculating the stock of public capital or spending is difficult. Therefore, several attempts to use the sum of past investment flows are being adjusted by depreciation (perpetual inventory method). However, as there are various kinds of infrastructures, different types of infrastructures have different lifespan and depreciation.[29]

Most studies about infrastructure used "capital stock" than "net capital flow." But spending in public sector is not translated into physical capital frequently because of low efficiency. We already referred to capital stock as "efficiency affected" output data in the chapter 2. This paper eliminates the effect of "efficiency" from input data so that our methodology considers adjusted "Neo PIE-X" instead of the original "PIE-X"

Another reason why this paper chooses an adjusted index rather the original one is that the IMF doesn't release PIE-X regularly, leading to a problem of data collection. Moreover, it's not adoptable to use the already released PIE-X because the IMF selected the mode among three methodologies (problem of data consistency). This thesis estimates public investment efficiency adjusting PIE-X as below

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[28] According to paper of Jakob de Haan et al, empirical research on the relationship between public capital and growth should prepare answers for the question "what is the net effect of more infrastructures given that infrastructure construction diverts resources from other uses?" instead "what is the effect of extra infrastructure, holding everything else constant?" (De Haan, J., W. Romp, and J.-E. Sturm, 2007, "Public Capital and Economic Growth: Key Issues for Europe: Canning and Pedroni 1999) p7

[29] De Haan referred that the lifespan of a railroad bridge cannot be compared with that of an electricity line.

- Use only index released by WEF and excluding physical data to get consistency and regression analysis

- Use "flow", not capital "stock"

- Investment: instead of average during 2007-2010, use incremental investment annually

6. Analysis and Results

6.1. Quantitative analysis and result

To verify the clear effectiveness, more variables are analyzed. However, the education and governance indices were not statistically significant. Thus, this chapter does not refer to the results of these those input data.

- Control of Population

By using the efficiency score estimated using the frontier model (See Appendix 4) from 6.1., we analyze the inefficiency effects of PIMI and CPI. Further, Model 1 is not controlled for population, while Model 2 is (See Appendix 4). The models are divided by income quartile. (the lower group has the least 30% and the median group has 30-50% income). The following are the results.

1) Effect of PIMI

Number of observations is 48. Models are divided by income quartile.

	GDP<median_GDP				GDP>median_GDP			
	model1		model2		model1		model2	
	coef	se	coef	se	coef	se	coef	se
PIMI	-0.112**	0.044	-0.103**	0.052	0.020	0.073	0.051	0.086
_cons	0.474***	0.084	0.426***	0.100	0.221	0.140	0.128	0.166

note: *** p<0.01, ** p<0.05, * p<0.1

According to the PIMI effect analysis based on model 1-2, this assumed inefficiency score as the dependent variable. When we did not control the income quartile, it wasn't statistically significant. However, after we control income, lower income group of under the lowest 50% quartile showed that it has a lower inefficiency (i.e., higher efficiency) when its PIMI is higher.

2) Effect of CPIA

Number of observations is 31.

	GDP<median_GDP				GDP>median_GDP			
	model1		model2		model1		model2	
	coef	se	coef	se	coef	se	coef	se
CPIA	-0.047**	0.021	-0.042**	0.021	-0.040	0.033	-0.037	0.033
_cons	0.220***	0.018	0.196***	0.019	0.231***	0.030	0.192***	0.031

note: *** p<0.01, ** p<0.05, * p<0.1

As mentioned in chapter 3 and 5, we add another dependent variable (CPIA) in the analysis and confirm that the efficiency of government administration lowered inefficiency of public investment in the lower income group.

3) Effect of CPI & CPIA

Number of observations is 60.

	model1			
	GDP<median_GDP		GDP>median_GDP	
	coef	se	coef	se
CPI2010	-0.012	0.010	-0.015	0.062
_cons	0.272***	0.040	0.405***	0.325

note: *** p<0.01, ** p<0.05, * p<0.1

	GDP<median_GDP			
	model1		model2	
	coef	se	coef	se
CPI2010	0.092***	0.028	0.054*	0.032
CPIA	-0.242***	0.062	-0.157**	0.070
_cons	-0.144	0.111	-0.018	0.126

note: *** p<0.01, ** p<0.05, * p<0.1

When another dependent variable, CPI, was included for analyzing the corruption effect on efficiency of public investment, its results were statistically not significant. If we control for efficiency of government administration, coefficient of CPIA is still statistically significant (negative) but CPI is positive. It suggests that the effect of corruption on public investment is not certain.

In assuming inefficiency score based on above efficiency frontier model, if we choose input data to capital flow instead of spending, the effectiveness of CPI on efficiency is not linear and statistically not significant. Thus, substantial considerations may be required.

7. Conclusion and Policy Implications

7.1. Conclusion

Common sense about public investment follows the logic of "the more, the better." Further, many empirical results proved the relationship between input (infra stock) and output (GDP). However, the difference between country groups by income quartile was double that of the lower group at the most, and the expected result of efficiency enhancement is higher in developing countries than in developed countries.

The object of this paper is to find and prove the factors that affect the efficiency of public investment. Many analyses emphasized the public investment management (PIM) as the key issue to enhance the efficiency. However, even after IMF's release of efficiency index (PIE-X), its study wasn't not developed outside of the IMF. This is because without internal data of IMF, it's hard to test or develop any hypothesis regarding efficiency of public investment. I believe that it was one of the reasons why the study of efficiency in public investment was not developed actively, except IMF.

So, this paper used adjusted PIE-X (named Neo PIE-X) instead original PIE-X, which is approachable and measurable outside of IMF. To prevent some biases, this analysis corrects the data of capital stock which are based on net increase. (See more in chapter 3). Further, instead of other indices which correlation studies are done (Budget Institutions Index, Government Effectiveness, Control of Corruption, and Average of Governance Indicators, CPIA - subindex), and a new index (CPI) was chosen for interactional result.

This is not the first attempt at adjusting the existing index according to users' intention but it might be first to include the PIE-X, which represents the efficiency of public investment. I hope that this study could be a catalyst for researchers outside the IMF to further investigate the methods to enhance the efficiency of public investment.

Findings from this paper are that we can assume that PIM is more important for the lower income group than the higher income group. To assess this effect, the paper suggests a new efficiency assessment methodology by adjusting PIE-X. This attempt of using a new indicator would enhance the possibility of new approaches to efficiency related data collection and mining.[30]

In addition to the overall index of PIMI (with 17 sub –indices), researchers or policy makers are able to breakdown and examine different aspects of the investment management process by various weighing and aggregation. The index is useful to evaluate the ongoing efforts to improve investment environment in low-income countries.[31]

7.2. Political Implications

Preventing the Bi-polarization for Sustainable Global Growth

This this shows correlation and interaction between efficiency, management and corruption. However, statistically (though not necessarily quantitatively) the empirical results of this paper also indicate a lack of convergence effects across developed and developing countries. With a high efficiency and management system, bi-polarization is inevitable.

Without intervention, it's foreseeable that bi-polarization of infrastructure gap and efficiency gap can happened and even be accelerated further between developed and developing countries. According to recent analyses, high or increasing level of bi-polarization may affect growth negatively.[32] So, we'd like to examine the relationship and interaction with other variables. We hope that further studies are able to prove that the closing efficiency gap

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[30] By using a PIMI-adjusted capital stock, Gupta and others (2014) prove the fact that the quality of PIM as an important determinant of the productivity of public capital.

[31] Dablar - Norris et al, 2011, "Investing in Public Investment: An Index of Public Investment Efficiency" (IMF)

[32] Michal Brzezinski, 2013, "Income polarization and economic growth"

is helpful to the developed and the developing countries.

- Role of MDB

Several decades ago, the infrastructure and the efficiency gaps were partly narrowed by aid from developed countries. Recently, it is substituted by the private sector but only at 5%. So the MDB (Multilateral Developing Bank) has tried to decrease the infrastructure gap of less developed countries. In particular, the new-comer AIIB initiated to invest in global infrastructure and many expect that it can effectively close the infrastructure gap. However, when we cannot anticipate some external effects such as MDB, each country should enhance its efficiency of public investment under budget constraints.

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<Appendix 1>- Data used in construction PIMI

The data used in construction PIMI (Dablar-Norris et al, 2010, "Investing in Public Investment: An Index of Public Investment Efficiency" IMF, p43~44)

World Bank Public Investment Management Case Studies. These case studies developed out of the World Bank's *Diagnostic Framework for Assessing Public Investment Management.* Countries were assessed among eight "must have" features of an efficient public investment system: Investment Guidance & Preliminary Screening; Formal Project Appraisal; Independent Review of Appraisal; Project Selection and Budgeting; Project Implementation; Project Adjustment; Facility Operation; and Project Evaluation. Twenty seven have had this diagnostic.

Public Expenditure and Financial Accountability (PEFA) assessments. The PEFA framework was developed between 2003 and 2005 as a joint undertaking of the World Bank, the European Commission, the U.K.'s Department for International Development (DFID), the Swiss State Secretariat for Economic Affairs, the Royal Norwegian Ministry of Foreign Affairs, the French Ministry of Foreign Affairs, and the IMF. Since 2005, the PEFA program conducts assessments, some of which are publicly available in the form of country reports, on the technical and institutional basis for sound budget governance covering a broad range of PFM performance indicators. It uses 28 indicators grouped in three areas: credibility of the budget; comprehensiveness and transparency and budget cycle. PEFA assessments are done every three years and cover 96 countries.

Budget Institutions Database. The database was developed by the IMF in 2010 to assess the various stages of budget institutions in low-income countries, and uses several indices and sub-indices to benchmark countries across income levels, regions, and different institutional arrangements. The index was constructed using 35 questions,

covering two dimensions of the budgeting cycle: (1) planning and negotiation, approval, and implementation, and (2) the degree of centralization of budgetary decision-making; the existence and effectiveness of rules and controls; the sustainability and credibility of the budget as a key policy instrument; and its comprehensiveness and transparency. Seventy low-and-middle income countries are scored among these parameters.

OECD International Budget Practices and Procedures Database. The database, which was originally developed by the OECD, contains the results of the 2007 OECD survey of budget practices and procedures in OECD countries, the 2008 World Bank/OECD survey of budget practices and procedures in Asia and other regions, and the 2008 CABRI/OECD survey of budget practices and procedures in Africa. The database contains the results of surveys for the 30 OECD member countries and 67 developing countries from Africa, the Middle East, Eastern Europe, Asia, Latin America and the Caribbean. Questions cover most of the stages and several aspects of the budget cycle, including preparation, approval, execution, accounting and audit, and performance information. The questions are of the multiple-choice or check-the-box type.

Country Procurement Assessment Reports (CPAR). The diagnostic framework was developed in 1998 by the World Bank to analyze procurement policies, organization, and procedures in its member countries. These reports assess a country's legal framework, procurement system organizational framework, procurement capacity building, system/institutions, procurement procedures/tools, decision-making and control system, anti-corruption initiatives and programs, private sector participation in the system, contract administration and management, and system for addressing complaints. To date, 112 reports have been completed for 93 countries.

Public Expenditure Reviews (PERs). PERs are core diagnostic studies prepared to help countries establish effective and transparent mechanisms to allocate and use available public resources in a way that promotes economic growth and helps in reducing poverty. As part of the World Bank's country economic and sector work, PERs are undertaken to assist the Bank's borrowers to understand their development problems and potential solutions as well as help illuminate the World Bank's own country assistance strategy.

Source:

http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/LACEXT/EXTL

ACREGTOPECOPOL/0,,contentMDK:20857505~pagePK:34004173~piPK:3400

3707~theSitePK:832499,00.html

County Financial Accountability Assessments (CFAAs). CFAAs are a key diagnostic tool to describe the financial accountability arrangements in countries' public and private sectors with the objective of strengthening these environments. CFAAs support both the exercise of the Bank's fiduciary responsibilities and the achievement of its development objectives through assessing the strengths and weakness of countries' accountability arrangements and identifying the risks that these may pose to the use of Bank and other public funds.

Source:

http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/EXTFINANCIAL

MGMT/0,,contentMDK:21388739~menuPK:3914288~pagePK:210058~piPK:21

0062~theSitePK:313218,00.html

<Appendix 2>- Country Scores of PIMI – Overall

Country Scores of PIMI-Overall (Dablar-Norris et al, 2010, "Investing in Public Investment: An Index of Public Investment Efficiency" IMF, pp36)

Country Name	Overall Index Score	Country Name	Overall Index Score
South Africa	3.53	Albania	1.64
Brazil	3.12	Montenegro	1.64
Colombia	3.07	Mozambique	1.62
Tunisia	2.97	Pakistan	1.57
Thailand	2.87	Cambodia	1.57
Peru	2.61	Benin	1.56
Bolivia	2.44	Azerbaijan	1.53
Armenia	2.39	Kenya	1.49
Kazakhstan	2.38	Indonesia	1.47
Botswana	2.35	Uganda	1.44
Moldova	2.33	Egypt	1.43
Rwanda	2.26	Kyrgyz Republic	1.41
Jordan	2.21	Tanzania	1.38
Mali	2.16	Djibouti	1.37
Afghanistan	2.10	Barbados	1.19
Burkina Faso	2.09	Nigeria	1.14
Belarus	2.06	Guinea	1.13
Bangladesh	2.04	Trinidad and Tobago	1.10
Serbia	1.99	Swaziland	1.08
Madagascar*	1.96	Haiti	1.07
Ukraine	1.93	Sudan	1.07
FYR Macedonia	1.93	Sierra Leone	1.03
Lesotho	1.91	Chad	1.00
Turkey	1.88	Gabon	0.96
Cote d'Ivoire	1.87	Senegal	0.94
Zambia	1.87	Togo	0.92
Ghana	1.87	Burundi	0.92
Philippines	1.85	Gambia	0.91
Malawi	1.85	Lao PDR	0.90
Namibia	1.81	Sao Tome and Principe	0.90
El Salvador	1.77	West Bank and Gaza	0.80
Kosovo	1.76	Yemen	0.80
Jamaica	1.72	Solomon Islands	0.77
Mongolia	1.72	Congo, Republic of	0.50
Mauritania	1.72	Belize	0.27
Ethiopia	1.65		
Median			1.65
S.D.			0.65

\<Appendix 3\>- Stochastic frontier models[33]

Suppose that a producer has a production function $f(z_i, \beta)$. In a world without error of inefficiency, the ith firm would produce

$$q_i = f(z_i, \beta)$$

Stochastic frontier analysis assumes that each firm potentially produces less than it might due to a degree of inefficiency. Specifically,

$$q_i = f(z_i, \beta)\xi_i$$

where ξ_i the level of efficiency for firm i; ξ_i must be in the interval $(0,1]$. If $\xi_i = 1$, the firm is achieving the optimal output with the technology embodied in the production function $f(z_i, \beta)$. Where $\xi_i < 1$, the firm is not making the most of the input z_i given the technology embodied in the production function. Because the output is assumed to be strictly positive (that is, $q_i > 0$), the degree of technical efficiency is assumed to be strictly positive(that is, $\xi_i > 0$).

Output is also assumed to be subject to random shocks, implying that

$$q_i = f(z_i, \beta)\xi_i \exp(v_i)$$
$$v_i \sim N(0, \sigma_v^2)$$

Taking the natural log of both sides yields

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[33] Above model is for assessing efficiency and introduced in the thesis, Murillo- Zamorano, Luis R. "Economic efficiency and frontier techniques." Journal of Economic surveys 18.1 (2004), pp 33-77

$$\ln(q_i) = \ln f(z_i, \beta) + \ln(\xi_i) + v_i$$

Assuming that there are k inputs and that the production function is linear in logs, defining $u_i = -\ln(\xi_i)$ yields

$$\ln(q_i) = \beta_o + \sum_{j=1}^{k} \beta_j \ln(z_{ij}) + v_i - u_i$$

Because u_i is subtracted from $\ln(q_i)$, restricting $u_i \geq 0$ implies that $0 < \xi_i \leq 1$, as specified above.

<Appendix 4>- Analysis Model

	model1		model2	
	coef	se	coef	se
ln(spending)	0.117	0.087	0.132	0.086
initial WEF	-0.195***	0.073	-0.184**	0.072
ln(population)			0.058*	0.031
_cons	19.017***	1.269	17.871***	1.395

note: *** p<0.01, ** p<0.05, * p<0.1

The table is the result of frontier stochastic model; input is infra investment spending during 2005-10 and output is increment of infra quality (WEF).

Model 1 didn't control population, model 2 controlled population. We also have tried that education and GDP might effect on efficiency, but the result doesn't.