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A Methodological Framework for Prioritizing Infrastructure Investment

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Abstract

Policy makers are often confronted with a myriad of factors in the investment decision-making process. This issue is particularly acute in infrastructure investment decisions, as these often involve significant financial resources and lock-in technologies. In regions and countries where the infrastructure access gap is large and pubic budgets severely constrained, the importance of considering the different facets of the decision-making process becomes even more relevant. This paper discusses the trade-offs policy makers confront when attempting to prioritize infrastructure investments, in particular with regard to economic growth and welfare, and proposes a methodological framework for prioritizing infrastructure projects and portfolios that holistically equates such trade-offs, among others. The analysis suggests that it is not desirable to have a single methodology, providing a single ranking of infrastructure investments, because of the complexities of infrastructure investments. Rather, a multidisciplinary approach should be taken. Decision makers will also need to account for factors that are often not easily measured. While having techniques that enable logical frameworks in the decision-making process of establishing priorities is highly desirable, they are no substitute for consensus building and political negotiations.

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A Methodological Framework for Prioritizing Infrastructure Investment

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1. Introduction

Despite recent rapid growth and poverty reduction, developing countries continue to experience a combination of uneven economic growth, population boom, increasing urbanization and sizeable infrastructure service gaps that together could jeopardize future progress. For example, the South Asia region (SAR) has the largest population below the poverty line of any region. Between 1990 and 2010, the number of people living on less than $1.25 a day decreased by only 18 percent,[2] while the population grew by 42 percent. At the same time, structural change has been slow, with urbanization (around 31 percent) lower than in any other developing region, despite economic growth rates that have exceeded most other regions over the past two decades. In effect, departing from similar points, South Asian countries are remarkably "under-urbanized" when compared to East Asian countries over the past half century (income and urban population as percentage of total population). The result of these trends has been a dramatic rise in demands for infrastructure, but access to infrastructure services is generally poor – even below other developing regions, the only exception being Sub-Saharan Africa.

Yet, as urbanization continues, there is a growing demand for infrastructure services that are already severely stretched. Latin America, which is the most urbanized developing region in the world, needs to increase its investments in infrastructure to meet the demand from firms and consumers. A recent study shows that Latin America would need to spend, on average, around 5.2 percent of GDP annually in order to maintain the infrastructure investment flows required to meet the needs of companies and consumers between 2006 and 2020 and it would need to spend 7.9 percent of GDP annually to reach the levels of the East Asian countries.[3] South Asia requires significant infrastructure investment (roads, rails, power, water supply, sanitation, and telecommunications) not only to ensure basic service delivery and enhance the quality of life of its growing population but also to avoid a possible binding constraint on economic growth owing to the substantial infrastructure gap. A mix of investment in infrastructure stock and the implementation of supportive reforms will allow SAR to close its infrastructure gap. Andres et al. (2014) estimates of the cost of doing so by 2020 give a lower bound of US$ 1.7 trillion and an upper bound of US$ 2.5 trillion at current prices. If investments are spread evenly over the years until 2020, SAR needs to invest between 6.6 and 9.9 percent of the regional gross domestic product (GDP) per year. These estimates represent an increase of up to 3 percentage points from the 6.9 percent of GDP invested in infrastructure by SAR countries in 2009.

But faced with this enormous demand for infrastructure investment and only limited available financial resources, it is critical for countries to prioritize infrastructure investment needs. How much financial resources should be allocated to infrastructure development, within infrastructure sectors and other sectors (such as health, education, public safety and national defense)? Given substantial lock-ins associated with infrastructure investments, should a country continue attempting to fill current gaps or direct investments to infrastructures that are likely large bottlenecks in the medium term? How does one account for the social and environmental issues of these trade-offs related to the directly impacted population? These are questions asked across the world, particularly in developing countries; but unfortunately, there is no rule to determine the investment allocations. It depends on a country's priority, economic growth and welfare objectives. Considering that infrastructure is both a means to facilitate economic growth and development, and a measure of the former, one could expect that a higher share

[2] The proportion of people living on less than $1.25 a day decreased from 54 to 31 percent (a 42 percent decrease), between 1990 and 2010, mainly due to the increase in population.
[3] ECLAC (2011).

of GDP would need to be allocated for infrastructure investment.[4] This is the case, at least for developing countries where there is greater scarcity of man-made and human capital related to infrastructure.

Economics would direct policy makers towards cost-benefit analysis, but given incomplete information and uncertainty, a multidisciplinary approach is needed. The complexities of infrastructure investments indicate that a single methodology which provides a single ranking of infrastructure investments is far from desirable. All methods have advantages and disadvantages. The paper proposes a methodological framework for prioritization of infrastructure projects and portfolios to holistically equate trade-offs among different policy objectives per key infrastructure sectors. The analysis suggests that it is not desirable to have a single methodology, providing a single ranking of infrastructure investments, because of the complexities of infrastructure investments. Rather, a multidisciplinary approach should be taken. Decision makers will also need to account for factors that are often not easily measured. While having techniques that enable logical frameworks in the decision making process of establishing priorities is highly desirable, they are no substitute for consensus building and political negotiations.

The paper is organized as follows. Section 2 begins with a discussion on the tension between economic growth and welfare when infrastructure interventions are being prioritized. This is followed by a methodological framework for prioritization of infrastructure projects and portfolios. Section 4 presents a stylized prioritization of these investments. Finally, section 5 presents concluding remarks.

2. Economic Growth versus Welfare Debate

There is a false dichotomy between prioritizing large-scale infrastructure versus addressing the needs of the poor. At a very basic level, this dichotomy is false because many large-scale infrastructure investments may concurrently facilitate economic growth and increase the welfare of poorer populations. For example, a large transport project may primarily target facilitating trade of raw materials, but at the same time it may also connect isolated poorer populations to better services. A more interesting debate is at which stage of development a particular infrastructure investment has a higher impact on economic growth versus on welfare. For instance, a power distribution project may have large welfare impacts given that it enables education and health outcomes, which may in turn translate into future economic growth as a more educated, healthier labor force join the labor market in the medium to long run. Yet, it may also facilitate growth in manufacture today, which in turn may promote short-term economic growth. The remaining of this section thus briefly discusses the linkages between infrastructure, economic growth, and welfare improvements.

2.1 Infrastructure and Economic Growth

Investment in infrastructure is accumulated in man-made capital formation and thus contributes to GDP growth.[5] A significant number of micro and macro studies find a positive link between infrastructure investments and growth (see Straub, 2008), which holds for both long-run economic growth and specific

[4] Based on information from a previous study (Fay and Yepes, 2003), Estache and Fay (2007) estimate that developing countries might need 6.5 percent of GDP, on average, during 2005-2015 period. Of which 2.3 percent would be needed to maintain the existing infrastructure, whereas remaining 3.2 percent would be required for new infrastructure projects.

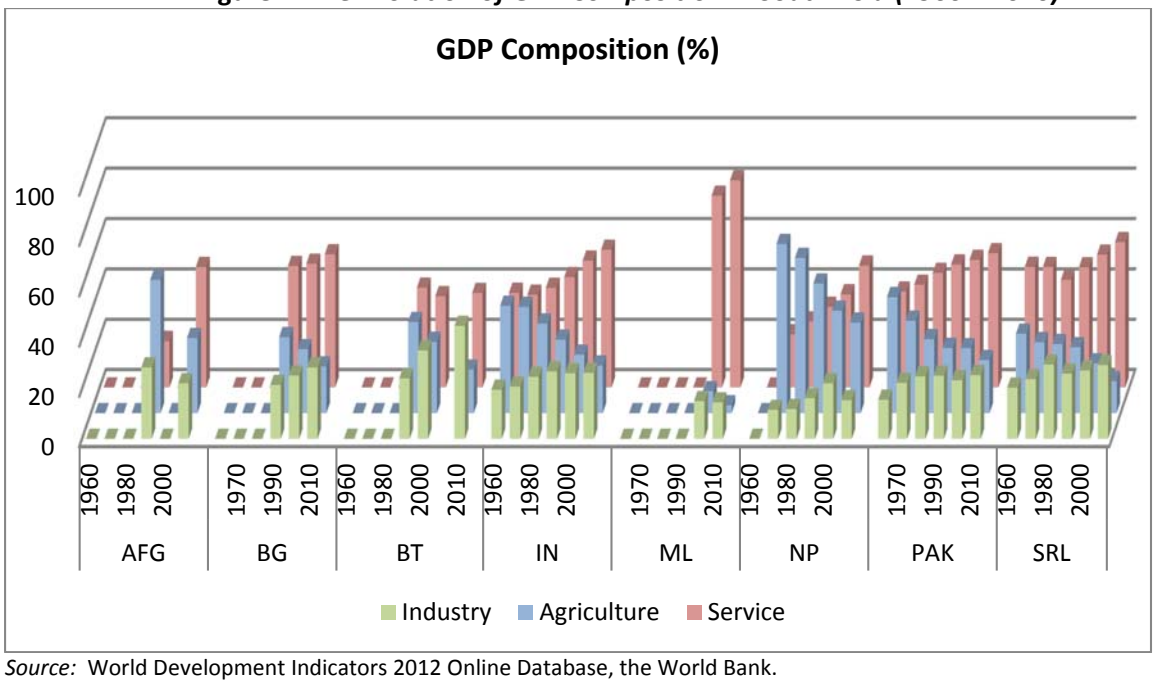
[5] See for example Yoshino (2008), Calderón and Servén (2004), Estache and Fay (2010).

factor outputs. For example, looking mostly at U.S. public capital stocks, the macro-level literature finds very large estimates for the elasticity of infrastructure—between 0.20 and 0.40.

Connective infrastructure, such as roads, is likely to have the greatest impact on economic growth. Improved connectivity within a country and within a region increases firms' access to markets for their goods and for cheaper inputs; assists businesses in developing competitive advantages; and provides workers, particularly those in lagging areas, with greater job and income opportunities. Transport typically facilitates agglomerations, which in turn promotes economic growth. For example, Njoh (2009) finds a strong positive relationship between transportation infrastructure and growth based on evidence from 24 West African countries. As countries develop, economic growth becomes more closely linked to a "principle of connectivity" (Biller and Nabi 2013).

Other capital intensive infrastructures such as power are also closely related to economic growth via connectivity. While not directly linked to connectivity (in terms of moving people, goods, and services), power facilitates information flows, thereby enabling agglomerations. More importantly, power is a key input in the production process, and power constraints have been identified as a major bottleneck for growth and job creation in several developing countries. A good example can be found in Nepal. Over the past few years, Nepal has faced up to 16 hours of electricity load shedding in dry months – stalling the manufacturing sector and severely curtailing basic services (like health care), other services, and commerce. The economic loss of such a huge power outage must be tremendous. In transport, Nepal has similar constraints, being a mountainous landlocked country. Yet while geography may be more benign in other South Asian countries like Pakistan and India, connective infrastructure is also severely lacking and the existing ones are poorly used.[6]

Figure 1: ***The Evolution of GDP Composition in South Asia (1960 – 2010)***



Source: World Development Indicators 2012 Online Database, the World Bank.

[6] See Sanchez-Triana et al. (2013) for a detailed analysis on the potential of transport investment on economic growth in Pakistan.

Substantial lock-ins exist in infrastructure investments, which in turn may constrain or incentivize future economic growth. For example, much of the existing connective infrastructure in South Asia has been built or initiated by former colonial powers, whose main goal may have been different from the current or future reality of the region's output. Even after independence the region's economy has changed significantly as indicated by Figure 1. For example, at independence, Sri Lanka had a reasonably well-developed road and rail network. At the time, priority was given to connecting the tea, rubber, and coconut plantations with the Colombo Port – the gateway to Great Britain. Electricity was available only in few areas. Over time, the economy's reliance on agricultural commodities diminished significantly not only in Sri Lanka but also in South Asia as a whole. Agriculture's loss has been primarily service's gain. Yet, the region remains with large numbers of infrastructure assets like irrigation canals targeting agriculture production. How much of these assets should be maintained if a country's output is less reliant on agriculture? To what extent does their sole existence pressure governments to allocate funds to their maintenance because of the rent-seeking behavior of a few? The same situation could be found in transport (e.g. connecting isolated communities, which is costly, or providing quality services for a few) and in other infrastructure sectors as well. They are aggravated by the substantial lock-ins that are common to many infrastructure investments because of their long-term nature. This in turn also partly pre-determines future economic growth and is an integral part of the tension existing in a country's path to structural change such as rural–urban transformation and a corresponding change in shares of a country's output.

2.2 Infrastructure and Welfare

Infrastructure investments help improve welfare through three mechanisms. They are based on either a direct or indirect relationship between infrastructure investments and welfare, and they center on alleviating poverty, enhancing prosperity, and boosting economic growth.

First, physical infrastructure – such as roads, electricity, and water supply and sanitation systems – provide services that directly contribute to improving the quality of life; and hence, increase household welfare. On the education front, a better transportation system and a safer road network help raise school attendance (Brenneman and Kerf, 2002). Access to electricity improves school performance by allowing kids to spend more time studying and use computers (Leipziger et al., 2003). On the health front, several studies show that access to clean water has significantly helped reduce child mortality (Behrman and Wolfe, 1987; Lee et al. 1997; Jalan and Ravallion, 2003). In Argentina, expanded access to water and sanitation has reduced child mortality by 8 percent, with most of the reduction taking place in low-income areas where the expansion in the water network was the largest (Galiani et al., 2002). Transport also makes a difference. Lokshin and Yemtsov (2005) show that road and bridge rehabilitation projects generate clear economic benefits at the community level – not only by increasing the number of small and medium-size enterprises but also by improving access to emergency medical assistance. Infrastructure raises an economy's ability to produce health services, which, in turn, enhances labor productivity (Aegnor, 2010). Similarly, Ganelli and Tervala (2010) shows that a higher domestic stock of public capital financed by lower public consumption increases domestic welfare if the productivity of public capital is not too low and the importance of public consumption (relative to private consumption) in private utility is not too high.[7]

[7] On the empirical side, there is a vast literature on valuating the welfare impacts of some infrastructure services, particularly those with strong externalities associated with them (see Andres, Iimi, Orfei, and Samad (2013) for a survey of this literature).

Second, infrastructure services help increase household income and therefore welfare (e.g., market access to household products, job created by the construction and operation of the infrastructure projects). Infrastructure projects, such as construction of road, irrigation canal, and power plants, provide jobs to low-income households, which are the main source of unskilled labor in the short-run. In South Asia, a key source of cash income to unskilled labor is construction work in infrastructure projects. Using a sample survey of cities from 20 developing countries over the period 1980-2005, Seetanah et al. (2009) find that transport and communication infrastructure helps reduce urban poverty in developing countries. Using a large panel data set encompassing over 100 countries and spanning the years 1960-2000, Calderon and Serven (2004) find that increased infrastructure quantity and quality reduces income inequality. Another strain of the literature argues that connective infrastructure services, such as roads, do not necessarily help reduce poverty in rural and remote areas as poor households cannot afford them. Using survey data from Ethiopia, Zambia, and Vietnam, Bryceson et al. (2008) find that, in extremely remote areas, enhancing the mobility of the rural poor does not necessarily reduce poverty given the poor's lack of access to motor vehicles and ability to pay for public transport. This finding shows that infrastructure investments are not a silver bullet for reducing poverty.

Third, infrastructure investment boosts economic growth, which spills over to household welfare. Economic growth and welfare are positively correlated. This reflects the fact that when a country achieves higher economic growth and development, the welfare of its population would also increase. Gupta and Barman (2010) support this hypothesis developing an endogenous growth model with special focus on the role of health capital, public infrastructure, and environmental pollution. They find no conflict between the social welfare maximizing solution and the growth rate maximizing solution in the balanced growth equilibrium in an economy.

3. Methodological Framework for Prioritization of Infrastructure Projects/Portfolios

The demand for infrastructure investment is enormous but the available financial resources are limited; therefore, prioritizing infrastructure investment needs is crucial. Criteria used to prioritize infrastructure investment needs play a major role in mitigating the infrastructure gap. A few existing studies attempted to address this question (see e.g., Berechman and Paaswell, 2005; Karydas and Gifun, 2006), but the methodological framework they developed is narrow and can be applied only to rank infrastructure investment projects. This section aims to develop a methodology that would be helpful in prioritizing infrastructure needs in developing countries, particularly in South Asia.

How to prioritize investment projects or portfolios is a common question a government at any jurisdictional level asks. This question is especially critical in developing countries, particularly in South Asia and Sub-Saharan Africa where demand for investment is huge and financial resources are limited. Without an appropriate methodological framework to assess investment projects, it is difficult to allocate funding across various investment projects. The methodological framework consists of three main steps: (i) identifying factors that affect infrastructure investment decisions, (ii) quantifying identified factors, and (iii) ranking the infrastructure projects.

3.1 Identifying and Quantifying Factors Affecting Infrastructure Investment Decisions

A large number of factors could influence investment decisions. The list of specific factors might change depending upon the nature of infrastructure projects and country's development plans and priorities. In general, these factors, which are captured by different methodologies, can be classified into four categories: (i) project level factors, (ii) economy-wide impacts, (iii) project related market failures, and (iv) country's institutional system.

Direct costs and benefits play an important role in determining infrastructure investment priorities. In fact, cost/benefit analysis (CBA) is the first step in any investment decision process. CBA aims at providing two key pieces of information: (i) whether a given project is feasible or not; and (ii) whether a given project provides the highest return to society from a list of projects analyzed. While problems of underestimation are not uncommon, assessing the costs of a given project is generally the simplest part of the CBA. Estimation of benefits in many infrastructure projects is significantly more complex as actual benefits are either uncertain or not tangible, which in turn provides short comings in that it limits the use of CBA as the only ranking method. For instance, even in projects where CBAs are routinely done (e.g. transport, power, water and sanitation), accounting for external benefits (like improved health, pollution abatement) is rarely undertaken. Another important project level factor affecting investment decisions is financing. The public sector in developing countries is not always capable of undertaking infrastructure projects alone. Participation of the private sector via firms or communities in financing, building, and operating infrastructure investments is often sought. However, the first step should be to determine whether a specific project or portfolio is economically sensible, and then determine the optimal financial structure that makes it feasible.

Indirect project costs and benefits (also known as economy-wide impacts) –those that spill over to an economy from a project – must also be identified. They can be further divided into two sub-categories: (i) impacts on economic growth and employment generation, and (ii) distributional impacts (e.g., welfare impacts, poverty alleviation) across different income level and geographical jurisdiction. In some cases, the size of indirect costs and benefits of an infrastructure portfolio might be as high as the corresponding direct costs and benefits. Typically a variety of approaches are used to assess economy-wide impacts of investment portfolios (including input-output approach, macroeconomic approach, and CGE approach), with the focus often on GDP and employment. If it is feasible to measure economic impacts,[8] this is a powerful factor in prioritizing infrastructure projects or portfolios—most recently, for renewable and clean energy technologies and green growth agendas.

External costs and benefits – those that are not captured in direct or indirect costs and benefits – also matter but they are not easily quantifiable. One example is a better quality of life due to access to electricity, telephone lines, clean water and adequate sanitation, or a road network. Another is the loss of forest or biodiversity while constructing a highway or electricity transmission lines. Although a social appraisal of an investment project attempts to assess external costs and benefits of an infrastructure project, such an assessment is qualitative in nature. Alternatively, valuation techniques can be used to appraise where markets fail—notably revealed and stated preference approaches. While different approaches are available to attempt to monetize at least part of the values associated with nonmarket goods and services, these are seldom used in project economic analyses, input-output, macroeconomic, or CGE approaches. It is also difficult to link what is mostly locality based methods with economy-wide approaches. Basing decisions solely on any of these approaches can thus skew infrastructure investments

[8] In many circumstances, measuring economy-wide impacts of a project would not be feasible as necessary data (such as input-output table and social accounting matrix of an economy) are not available.

toward projects easily valued, while one could argue that public funds should go to those projects that yield the most public goods (e.g. power distribution versus flood protection).

A final factor that needs to be accounted for is the strength or weakness of a country's institutional system. In the best case scenario, politicians and policy makers account for the aforementioned factors and the information coming out from the respective methods when negotiating the prioritization of particular interventions. Independent or quasi-independent regulatory institutions (including the judicial system and civil society) may also weigh in with checks and balances, blocking questionable infrastructure projects. However, the result of such a decision process is unlikely to be optimal when there is rent-seeking behavior – which refers to situations where individuals organized in special interest groups (or acting alone) are motivated by their particular interests rather than by the general interest of the society. Examples are industrialists wanting infrastructure investments that only (or mainly) benefit them and farmers seeking cheap or free power for irrigation. Rent-seeking behavior leads some groups to attempt to capture key state institutions (such as public contracts agencies) where they can extract rents. Infrastructure projects are by nature highly politicized and a significant source of rents. Political economy analysis focuses on distributing power and wealth between different groups and individuals, and the processes that create, sustain, and transform these relationships. This type of analysis helps to identify potential winners and losers of particular infrastructure interventions. For example, Sanchez et al. (2013) investigate the winners and losers in the rural and urban spaces of an increase in total factor productivity (TFP) in Pakistan's transport sector. Understanding the political, economic, and social processes that promote or block pro-poor investments – and understanding the role of institutions, power, and the underlying context in countries – allow more effective and politically feasible investments.

3.2 Valuing or Weighting the Factors[9]

The biggest challenge in prioritizing infrastructure projects is how to value or weigh different factors that influence investment decisions. Decisions require understanding a goal or a set of goals and alternative paths to achieving these goals. In the case of infrastructure investments, these goals usually fall under welfare improvements ("a principle of inclusion"), including those that come from public goods like a cleaner environment, or fostering economic growth ("a principle of connectivity") or both (Biller and Nabi, 2013). If one considers that costs also imply forgone goals due to trade-offs that need to be equated, minimizing costs may be viewed as a goal or as a constraint to achieve other goals. A simple decision making matrix would thus bring together different goals with different paths to achieving these goals, and each cell would be filled by indicators (e.g. increase economic growth by 0.5 percent in year 1). One of the goals may act as a numeraire and weights may be assigned to the other goals with respect to this numeraire. From such a matrix, a weighted score of benefits can be derived. Once divided by the costs of each alternative path, a cost-effective indicator would be derived, indicating a preferred option. Both indicators and weights may have a high degree of subjectivity given the measurement issues. Weights may differ spatially (e.g. local versus global, across countries, rural versus urban), across economic sectors, across stakeholders, and across time (outcomes now versus future outcomes).[10]

A number of non-economic theories/techniques exist in the decision science literature to weight these factors. While desirable, not all factors affecting priority setting can be measured in monetized or quasi-

[9] It should be noted that the discussion here is not exclusive to infrastructure investments but encompasses decision making processes. Much of this discussion comes from OECD (2002).

[10] This last factor becomes particularly important under uncertainty and over a long term as argued in Hallegatte et al. (2012).

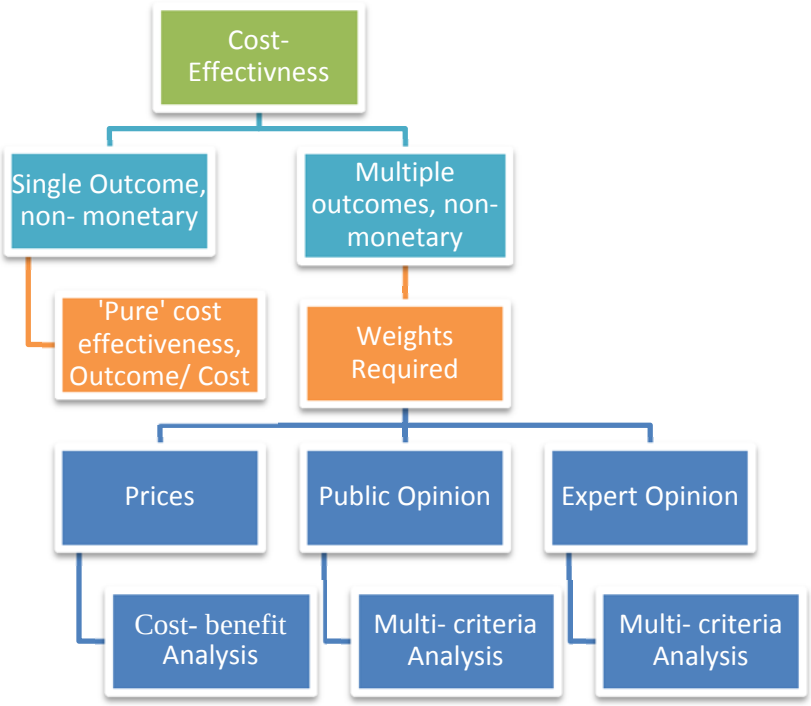
monetized forms. In these cases, non-economic methods need to be used – including multi-attribute and multi-criteria decision theory, Delphi approach, and analytical hierarchy process (AHP).

Multi Attribute Utility Theory (MAUT) and Multi Criteria Decision Making Approach (MCDM) have been used for decades to support decision making processes. The objective of MAUT is to attain a conjoint measure of the attractiveness (utility) of each outcome of a set of alternatives. The method is employed when prospective alternatives are evaluated to prioritize them. In its most basic form MCDM assumes that a decision maker is to choose among a set of alternatives whose objective function values or attributes are known with certainty. MAUT is sometimes subsumed under MCDM, but is usually treated separately when risks or uncertainties have a significant role in the definition and assessment of alternatives. Many problems in MCDM are formulated as multiple objective linear, integer, or nonlinear mathematical programming problems. On the other hand, MAUT embraces both a large body of mathematical theory for utility models and a wide range of practical assessment techniques that pay attention to limited abilities of assessors. The role of the value function is a demarcating feature between MAUT and MCDM. Generally, if the value function is explicit, the method is considered in the MAUT category; if the value function is implicit (assumed to exist but is otherwise unknown) or no such function is assumed to exist, the method is usually classified under MCDM (Dyar et al., 1992).

It is also interesting to understand the relationship between MCDMs and CBAs. If options are well-defined and constitute the whole set of feasible options, a cost-effectiveness approach can be sufficient for the purpose of decision making. This works well if there is only one outcome and the choices to be made relate directly to the outcome. Yet, as multiple outcomes are possible, weighting becomes important and cost-effectiveness become more complex. If weights are provided by prices (willingness to pay - WTP), cost-effectiveness can be translated into CBA (figure 2). If weights are not provided by a price form, cost-effectiveness becomes MCDM. While MCDM provides a framework for a “best choice”, it cannot really answer the question of whether any alternative should be chosen (e.g. doing nothing is also an alternative which is seldom discussed in practical decision-making).

A commonly used MCDM is the Delphi Method. This technique was developed in the 1950s by two research scientists working at The Rand Corporation, Olaf Helmer and Norman Dalkey, and synthesizes perspectives from individual experts through rounds of surveys. The process begins with an open-ended questionnaire that is given to a panel of selected experts to solicit specific value judgment (assigning numerical weight) about a subject or content area. The responses from the first round of surveys are analyzed and the summary statistics are presented to the respondents. The respondents then review their original individual responses relative to the summary statistics and could make adjustments to the weights assigned. Theoretically, the cycle of iterations continues until there is no change in the scores. However, due to cost and other reasons, consensus is normally built within two iterations. The final scores are then averaged to yield the relative weights (Sinha and Labi, 2007). This technique is frequently modified depending upon the research issue at hand. Custer et al. (1999), for example, modified the technique by providing to respondents some knowledge drawn from various sources including related competency profiles, synthesized reviews of the literature, and interviews with selected content experts. This modification improves the initial round response rate and provides a solid grounding in previously developed work.

Figure 2: *Cost-Effectiveness Approaches*



Source: OECD (2002).

An application of Delphi technique for infrastructure projects decision making can be found in number of existing studies, such as Migliaccio et al. (2008) and Thomas et al. (2006). One example is Berechman and Paaswell (2005), which developed a methodology to prioritize infrastructure investments proposals submitted by various public agencies in New York City, including the Metropolitan Transportation Authority, Port Authority of New York and New Jersey, New Jersey Transit, New York State Department of Transportation and the city and state economic development corporations. The methodology includes four criteria: (i) benefits from the projects including direct transportation and indirect economic development benefits; (ii) costs associated with projects such financial costs, costs caused by disruptions from the construction; (iii) distributional impacts of costs and benefits across population groups and geographical location; and (iv) environmental effects. Numerical indices constructed in each criterion are integrated following Goal Achievement Matrix (GAM) approach.[11] Variations on Delphi technique and MCDM were also used to analyze hydropower planning in Norway (OECD, 2002).

Analytical hierarchy process (AHP) is a process of ranking objects based on psychology and mathematical techniques. Developed by Thomas L. Saaty in the 1970s, this method derives priority scales using measurement technique through pairwise comparisons based on expert judgments. The scales measure

[11] The GAM approach, developed by Hill (1968), produces a common yardstick for a systematic and unambiguous ranking of all projects/activities combining multiple attributes/criteria of those projects or activities. This method presents each criterion used for the evaluation against each project in a matrix form whose entries are normalized scores assigned to each project for each criterion. Since not all criteria are considered equally important, a vector of weights is produced showing what decision makers regard as the relative importance of each criterion. By multiplying the matrix by this vector an weighted core matrix is then generated. Summing across each project yields a vector of ranked projects (Berechman and Paaswell, 2005). The weights are the critical component of the GAM method and they can be generated in different ways. Berechman and Paaswell (2005) uses Delphi approach in which the weights are generated based on opinion of panel of experts.

intangibles in relative terms. The comparisons are made using a scale of absolute judgments that represents, how much more, one element dominates another with respect to a given attribute. The derived priority scales are synthesized by multiplying them by the priority of their parent nodes and adding for all such nodes (Saaty, 2008).The method has been widely used in infrastructure investments prioritization (e.g., Ridgley, 1991; Ziara et al., 2002; Smith and Tighe, 2006).

The study by Ziara et al. (2002) develops a methodological framework to prioritize urban infrastructure projects in Palestine. The key criteria used to evaluate the projects include: (i) project importance, (ii) sector importance, (iii) finance suitability, (iv) execution suitability, (v) operational suitability, (vi) reliability, and (vii) consequences of failure. Project importance is measured in terms their added values to the economy as a whole. Sector importance is determined by following government's national development plan. Financial suitability is measured based on project's capital intensity and risks associated with the financial market. Execution suitability was measured based on whether the project requires high technology and expertise. Operation suitability was reflected through the need of a continuous supply of raw materials, sophisticated technical experience and/or a large operational budget, lack of maintenance due to technical or financial reasons, environmental impact. Reliability criterion was the one that influences project prioritization based on its failure rates and associated maintenance and repair requirements. The consequence of failure was represented by the penalty of deviating from planned targets. Experts invited to weigh these factors included project proponents, project evaluators, resource experts, observers and peer reviewers. The case study concluded that it was possible to obtain cardinal priority ranking of projects from mixed infrastructure sectors in a transparent way, despite the complexity of the decision situation. The main institutions involved accepted the prioritized projects, despite the disparity of the sectors.

All methods and techniques for priority setting in decision making come with caveats. Monetizing across the board has the advantage of converting factors in a common unit of measurement, but often generates important moral dilemmas. Alternatively, solely using expert opinion to direct decision making may result in skewed investments, as experts usually have their own bias toward their expertise. Given the long-term nature of most infrastructure investments and their lock-in characteristic, the time dimension and how to discount the future play a particularly important role. Yet, this further complicates decision making since decisions made today generate political pressures and future rent-seeking. For example, implicit and explicit subsidies to urban sprawl in the United States generated a pattern of private vehicle dependency and expectations of a "rural" living combined with an urban experience and income generation. This in turn has tremendous external consequences that are difficult to address often because of political reasons. The process advanced mostly in the 1950s but continues today given vested interests. This results in a very low pattern of urban density development when compared with other regions of the world. It is also well known that the way in which the future is discounted in decision making economic methods like CBA penalize the future with respect to the present. The economic logic of the currently used discount factor remains and enables comparisons of "apples and apples." Yet, if long-term discrete or continuous phenomena that may potentially cause severe harm to societies – like pandemics, and climate change – are to be effectively addressed by decision makers, better methodologies need to be designed to enable comparisons for prioritizing investments across long time horizons under scarce resources.

4. Stylized Priority Ranking of Infrastructure Investments

The previous sections briefly discuss the links between infrastructure and economic growth and infrastructure and welfare/poverty. They also review different methodologies to measure these impacts

and hence serve as mechanisms to establish priorities. They recognize that while desirable not all factors impacting priority setting can be measured in monetized or quasi-monetized forms and non-economic methods are also introduced (e.g. MAUT and MCDM). All methods and techniques for priority setting in decision making come with caveats and are not necessarily compatible.

When attempting to rank infrastructure investments, it is important to assess the infrastructure gap so as to understand overall needs and potential financing requirements. Yet, it should be noted that infrastructure gap assessment (IGA) does not necessarily determine which investments are priorities. IGA is usually based on a baseline of where a country, state, or municipality is in terms of infrastructure provision and where it would like to be in x years. The fact that IGA may be substantially larger in one infrastructure sector versus another does not infer that the large gap sector should be given all resources in a priority setting exercise. The size of the gap after all is also dependent on investment costs, existing technologies etc. The departure for priority setting exercises is the goals decision makers are attempting to reach. For example, if a goal is to generate employment, decision makers may place a large weight in labor-intensive infrastructure investments, while the IGA may indicate that the largest gap is in capital-intensive infrastructures.

The methodologies presented here are mainly ex-ante. They support decision making before the decision is taken. Yet, equally important for learning and adjustment in future decision making is to understand the impact of the interventions. For this purpose, one would need to design robust impact evaluations such as randomized control trials, which are particularly challenging in infrastructure or infrastructure related investments. This is also an area that remains a major gap in the literature of decision making and priority setting.

Taking into account all the aforementioned caveats, some stylized rankings can be designed to facilitate prioritization of infrastructure investments. Table 1 relates infrastructure services with some of the factors discussed above. Specifically, it ranks infrastructure services according to input intensity of use, degree of spatial manifestation, typical development outputs, and commonly debated market failures. The infrastructure services listed often fall under the public sector, but in some cases may be a combination of public and private provision. For example, sanitation via off-site systems is typically provided by public utilities, but on-site sanitation such as septic tanks are generally private investments. The list is not meant to be exhaustive and provides ranks from 1 to 3, with 1 being the lowest relative weight, based on the existing literature on infrastructure services and its impacts discussed in the previous sections.

Different infrastructure services rank better depending on the specific factor of interest. Take the case of solid waste. This service (both collection and processing) is primarily labor intensive, dominates urban agendas, has an important impact on welfare improvement but less of a generalized impact on economic growth, and while it generates important market failures it is not a major contributor to agglomeration effects. In contrast, connective infrastructure (such as transport infrastructure) yields higher agglomeration effects and a higher impact on economic growth than solid waste infrastructure, but a lower impact on welfare. Similarly, connective infrastructure has a higher impact on economic growth than water and sanitation infrastructure, while the ranking is reversed when talking about welfare. When it comes to negative externalities such as local/global pollution, these are higher in the case of fossil fuels based power generation than water and solid waste infrastructure.

Table 1: *Ranking of Prioritization of Infrastructure Investments* (Scale: 1 to 3)

	Infrastructure Services[1]		Inputs Intensity[2]				Spatial Manifestation		Development Challenges					
									Outputs		Externalities			
			Capital	*Labor*	*Land*	*Natural Resources*	*Urban*	*Rural*	*Economic Growth*	*Welfare*	*Agglomeration*	*Local Pollution*	*Global Pollution (Climate Change)*	*Green Growth*
Power	Grid-connected Generation	Fossil Fuels (Gas, Coal, etc)	2	1	1	3	2	2	2	2	3	3	3	1
		Hydro	3	1	2	3	1	3	2	2	3	1	1	3
		Wind	3	1	2	3	1	3	2	2	3	1	1	3
		Geothermal	2	1	1	3	1	3	2	2	3	1	1	3
		Biofuels	2	1	1	2	1	3	2	2	3	1	1	3
	Off-grid Generation	Diesel	2	2	1	3	2	3	2	2	1	3	3	1
		Small Hydro	2	2	1	3	1	3	2	2	1	1	1	3
		Wind	3	2	1	3	1	3	2	2	1	1	1	3
		Solar	3	2	1	3	2	2	2	2	1	1	1	3
		Biofuels	2	2	1	2	1	3	2	2	1	1	1	3
	Transmission Grid		2	1	2	1	3	1	2	2	3	1	2	2
	Distribution Grid		2	1	1	1	3	1	2	2	3	1	2	2
Water	Piped water into dwelling		2	2	1	3	3	1	1	3	3	1	1	3
	Water well		1	3	1	3	1	2	1	3	1	1	1	2
	Protected spring		1	3	1	3	1	3	1	3	2	1	1	2
Sanitation	Piped sewer system		2	2	1	1	3	1	1	3	3	2	1	2
	Septic tank		1	3	2	1	2	2	1	3	1	3	1	2
Solid Waste	Collection and processing		1	3	2	1	3	1	2	3	1	2	2	2
Transport	Roads	Rural	2	2	2	1	1	3	3	2	3	2	2	2
		Urban	2	2	2	1	3	1	3	2	3	3	3	1
		Highway	2	2	2	1	2	2	3	2	3	2	2	2
	Railways		3	2	2	1	2	2	3	2	3	1	1	2
	Ports		3	1	1	1	3	1	3	1	3	1	1	2
	Airports		3	2	1	1	3	1	3	1	3	3	3	1

Notes: 1. The provision modalities considered for each infrastructure service are the best available technologies (BAT) to provide the specific infrastructure service. The BAT for a specific infrastructure service is the best ranked technology according to a cost-benefit analysis. In the case of power generation, the BAT varies by location; hence the different options; 2. Inputs intensity is based on BAT to provide the specific infrastructure service and the BAT for building the infrastructure needed to provide the infrastructure service.

Ultimately, investments that clearly target economic growth in the short run and those that attempt to reduce poverty in the short run are needed. The right combination as well as the level at which design and implementation take place is highly dependent on country-level institutions, the policy makers' objectives, and the economic characteristics of the infrastructures under consideration. Policy makers should be cognizant that attempting to apply the same standards across the board may yield unwanted consequences such as no provision to some segments of the population and negative externalities on the rest. For example, strict standards of offsite sewage collection may translate into no collection in slums, generating negative externalities to the rest of the city that the strict standards were trying to avoid.

5. Conclusions

Growth and poverty alleviation in developing countries may slow down or even halt if addressing the infrastructure gap is not given priority. Demand for infrastructure in the developing world varies by region but the commonality in all regions is the sizable magnitude of the demand. Latin America needs to spend, on average, around 5.2 percent of GDP annually in order to maintain the infrastructure investment flows required to meet the needs of companies and consumers between 2006 and 2020, and it would need to spend 7.9 percent of GDP annually to reach the levels of the East Asian countries.[12] South Asia, which lags behind Latin America on most infrastructure indicators, requires significant infrastructure investment to ensure basic service delivery and enhance the quality of life of its growing population, but also to avoid a possible binding constraint on economic growth owing to the substantial infrastructure gap. If investments are spread evenly over the years until 2020, South Asia needs to invest between 6.6 and 9.9 percent of the regional GDP per year (Andres et al., 2014). These estimates represent an increase of up to 3 percentage points from the 6.9 percent of GDP invested in infrastructure by SAR countries in 2009.

Governments have often struggled to allocate adequate resources to infrastructure projects and demonstrate commitment to what essentially are long term investments. Faced with the enormous demand for infrastructure investment and only limited available financial resources, it is critical for countries to prioritize infrastructure investment needs. But the demands are enormous not only from infrastructure sectors, but also other sectors. How much financial resources should be allocated to infrastructure development, within infrastructure sectors and other sectors (such as health, education, public safety and national defense)? Given substantial lock-ins associated with infrastructure investments, should a country continue attempting to fill current gaps or direct investments to infrastructures that are likely large bottlenecks in the medium term? How does one account for the social and environmental issues of these trade-offs related to the directly impacted population? These are questions asked across the world, particularly in developing countries where there is greater scarcity of man-made and human capital related to infrastructure.

In this paper, we proposed a methodological framework for prioritizing infrastructure projects and portfolios that builds on the existing literature. It is not desirable to have a single methodology, providing a single ranking of infrastructure investments, because of the complexities of infrastructure investments. All methods have strengths and weaknesses, which a decision maker should be aware of when using them. In addition, decision makers need to take into account factors that are often not easily measured, which further complicates decision-making. And while having techniques that enable logical frameworks in the decision making process of establishing priorities is highly desirable, they are no substitute for consensus

[12] ECLAC (2011).

building and political negotiations. Hence, any infrastructure prioritization exercise should be based on a multidisciplinary approach to provide a robust outcome.

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