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ESTIMATION OF URBAN INFRASTRUCTURE DEMAND WITH CONSIDERATION OF URBAN CHARACTERISTICS

Hosung Jung[1] and Jae-Dong Son[2,*]

[1]Global Studies Department
Samsung Economic Research Institute
No. 4, Seocho-daero 74-gil, Seocho-gu, Seoul 137-072, Korea
panco88@gmail.com

[2]Department of Industrial and Information Systems Engineering
Soongsil University
Sangdo-Ro 369, Dongjak-Gu, Seoul 156-743, Korea
*Corresponding author: son88@ssu.ac.kr

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Abstract. *The urban infrastructure has emerged as a promising business, with urbanization taking place around the world. Especially in developing countries the infrastructure investment is accelerated because of the increasing income and the growth of the middle classes because of industrialization. In order to target this infrastructure market in developing countries, accurate forecasting should be put first. This study estimates the national level of infrastructure demand based on a theoretically verified national demand forecasting model, rather than on the city data itself. The estimated results are applied to the urban level of infrastructure demand, according to various urban characteristics. This paper provides the estimated demand for the following eight infrastructure sectors: electricity, railroads, roads, airports, mobile, Internet, water and sanitation, and houses.*
Keywords: Urbanization, Infrastructure demand

1. **Introduction.** Urbanization, which is a population shift from rural to urban areas, has been accelerating further. The proportion of people living in urban areas was only about 20% one hundred years ago, whereas it was below 5% in low-income countries. However, as the urbanization rate went beyond 50% in 2009, thus, the "urban millennium" has arrived [1]. According to the UN (2012) estimates, about 200,000 people will transfer to the city every day until 2015. It predicts that if this trend continues, the urbanization rate will be 60% in 2030, and reach 67.2% in 2050. This means that the current 7 billion total world populations will increase to 9.3 billion in 2050. In other words, 6.3 billion people (67.2% of the total global population) will live in urban areas. Urbanization is taking place at a faster speed in developing countries. As shown in Figure 1, urbanization rate in developing countries increased to 38.3% in 2011, which has been 20%p up since the 1970s because of the rapid economic growth, and it will expand to 55% by 2050; hence, 5.1 billion people will live in urban areas.

This urbanization in developing countries contributes to the global economy growth by producing infrastructure expansion and promotion of consumption [2]. However, the rapid growth of population in urban areas gave rise to serious environmental and health problems because of the lack of basic infrastructure, such as water or sanitation, for those people flocking to the cities. Thus, political and economic movements have emerged to settle the complaints of the citizens because of poor infrastructure. Especially in Asia, as remarkable high growth continues, there has been the start of infrastructure investments related to an industrial cluster in order to foster the industrial foundation needed for economic growth, which needs further infrastructure, such as electricity and transportation,

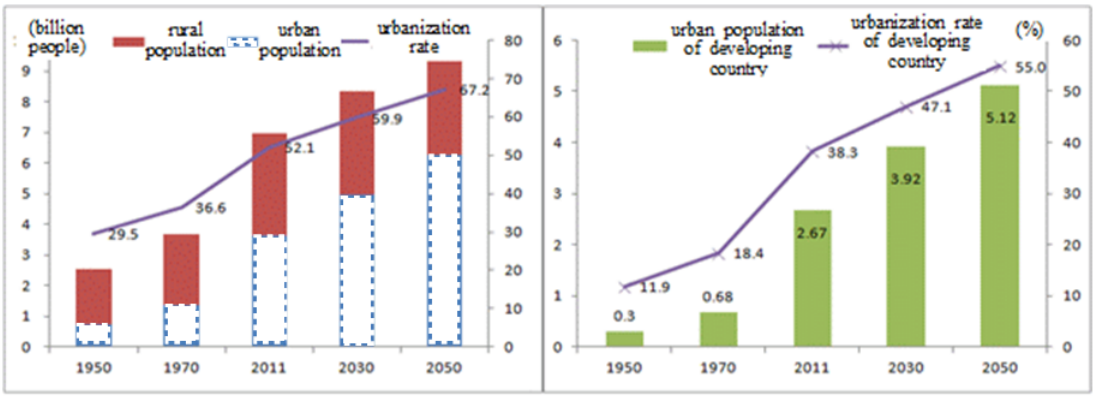

FIGURE 1. Urbanization rate and urban population in developing countries (source: UN (2012))

to connect each industrial cluster together. Many existing developing countries have emphasized the development of basic infrastructure, such as roads, water and sewage, and housing. However, urban development has recently tended toward self-sufficiency by providing for commercial and business facilities in a basic infrastructure; and it further goes toward the construction of city operating systems that integrate IT with various fields.

In developing countries, because of the increasing demand for urban infrastructure and the promising development potential, competition for orders among companies around the world is becoming intensified. For example, state-owned Chinese infrastructure companies are accelerating the unprecedented expansion of the African continent through their enormous funding and offer of credit since the mid-2000s. Japan has been moving aggressively not only to advance to the package type of overseas city development but also to build an industrial complex by constructing an academia-industry-government collaboration. Singapore has succeeded in promoting overseas city development by using its know-how for limited land development, in part, because of a government investment company, Temasek, and the state-owned Jurong International (consulting), and so on, which play leading international roles in obtaining orders for overseas urban development. Global enterprises have seized the initiative with an advanced technology in the area of control system and infrastructure management. For example, a few global corporations such as Bombardier (Canada) and Alstom (France) hold an important place in rail and plane transport and control system that requires a high degree of technology. In addition, French water and waste utility companies Veolia, Suez, etc. are the leaders in the integrated water treatment solutions market by taking advantage of their operational and management expertise.

In order to be successful in developing countries where the competition for urban infrastructure projects is intensifying as aforementioned, it is more important than ever to figure out the demand forecasting for those germane cities [3]. This paper attempts to estimate the urban infrastructure demand based on a theoretically verified national demand forecasting model, rather than on the city data itself.

To date, because of the characteristics of city data that provide limited information such as population and income, there has been little research on urbanization except population forecast by UN [4,5] and GRDP (gross regional domestic product) for each city by McKinsey [6,7]. Lee [8] conducted a research on infrastructure needs by limiting the scope of analysis to the city instead of a whole country. What this research has in common is that it considers the scale and income of the city besides the dynamic changes of the city. On the contrary, much research has been done using national data, instead of city data [9-13], which are already theoretically proved, and thus, it swamps the city data in terms of its data availability.

Using the same macro model that links growth and demand for infrastructure services that was developed in Fay and Yepes [14], we estimate infrastructure needs across a cross section of countries. This study then redistributes the national level of results obtained from the model to the city level of infrastructure demand according to the various city characteristics. In addition to the population and the income of the city, the urban characteristics covered in this paper are not only basic information that whether it is the capital or metropolitan of the nation but also the intensity of natural hazard and geographic location. This paper provides the estimated demand for the following eight infrastructure sectors: electricity, railroad, roads, airports, mobile users, Internet users, water and sanitation, and houses.

The remainder of this paper is organized as follows. Section 2 explains the process of estimation of the urban infrastructure demand. Section 3 represents the estimated demand for the eight infrastructure sectors. Finally, Section 4 is a summary of the paper.

2. **Methodology.** The demand for urban infrastructure is estimated according to the following 3 steps.

Step I: The BPP (Best Practice Price) will be calculated in order to derive the market size of each infrastructure sector. Although the BPP usually implies a procedure or guideline that is widely recognized as an effective way to achieve the desired goals, it is important to note that in this paper it means the average cost to complete the infrastructure construction, regardless of the country. Table 1 represents the BPP of each infrastructure sector. The total cases provided by BMI are 5,989, of which 4,126 cases that include the amount of orders are used to calculate the values per unit for each infrastructure sector, and the average of each value/capacity is shown in Table 1.

Table 1. BPP of each infrastructure sector

Infrastructure sector	**No. of cases**	**unit**	**Value/capacity (million, US$)**
Electricity (plant)	950	MW	1.77
Railroad	447	Km	40.55
Roads	477	Km	9.79
Airports	121	million people	304.4
Mobile	332	thousand people	0.355
Internet	332	thousand people	1.981
Water and sanitation	140	million m^2/year	11.29
Houses	18	a house	0.07

Step II: We build a forecasting model of each infrastructure sector based on DB of 123 countries and predict the expected needs for each infrastructure sector by 2025. The forecasting model used in this paper is a prediction model of Fay and Yepes below [14], which has been frequently utilized by the world's leading international organizations in order to estimate the infrastructure needs of a specific region.

$$I_{i,t} = \alpha_0 + \alpha_1 I_{i,t-1} + \alpha_2 y_{i,t} + \alpha_3 M_{i,t} + \alpha_4 D_t + \varepsilon_{i,t}$$

where variables $I_{i,t}$, $y_{i,t}$, $M_{i,t}$, D_t, and $\varepsilon_{i,t}$ denote, respectively, demand for infrastructure sector type of i at time t, income per capita, the share of manufacturing value added in GDP, a time dummy such as population density and urbanization rate, and the error term.

Step III: We finally estimate the urban infrastructure demand for each infrastructure sector by adding an amount of increment by the urban characteristics (capital, metropolitan, geographical location, natural disaster, etc.) to the nation level of demands for each infrastructure obtained in Step II. Note, here the weights over each variable were driven

based on the infrastructure stock data of 288 Chinese cities where the time series data are available. In particular, it is very useful in case of intercity networks to use the model of Fay and Yepes [14] because it enables us to assign the estimated national level of results to the city level of results, whereas it is almost impossible to use a city type of model in the case of intercity networks.

3. **Results.** In short, it can be said that US$25.8 trillion (83.3%) of US$31 trillion (the total amount of investment in the entire world) will be invested in the cities that are studied in the paper. That is to say, US$2 trillion of the infrastructure market will be formed every year until the next 12 years. Table 2 shows the total amount of demand for each infrastructure sector as well as the percentage of investing amount in urban infrastructure with respect to the total amount of the relevant infrastructure where the percentage ranges from 34% (mobile users) to 100% (houses). We can see that the investment for electricity and communication sectors can be made outside the city and that almost all of the investment for roads and railroad sectors are made in the city with over 75 million people to connect intercity networks.

TABLE 2. Total demand for each infrastructure sector (unit: US$, trillion)

Classification	**Electricity**	**Railroad**	**Roads**	**Airports**	**Mobile**	**Internet**	**Water**	**Sewage**	**Houses**
Amount	6.1	4.6	12.5	0.18	2.0	1.0	0.30	0.20	1.00
Percentage (%)	66.6	100	100	69.5	34.0	40.0	85.0	100	100

Table 3 represents the estimated urban infrastructure demand by regional groups. In the table, we see that the amount of money invested in the developing countries, versus the advanced countries, reaches about $16.2 trillion, of which $10.8 trillion (73.7%) is concentrated on the Asian (including China and India) and African regions. These results can be interpreted as follows. First, overseas direct investment is expanding and industry clusters have begun in earnest around the labor-abundant metropolitans of Asia and Africa, which contributes to economic growth as an export-driven growth model. Second, the population and the birth rate of Asia and Africa are expected to grow rapidly through 2025, and this leads to the necessary expansion of infrastructure as well. Third, the current quantitative and qualitative levels of infrastructure in the metropolitan areas of Africa are relatively weak, which means a higher possibility of infrastructure expansion, when economic growth takes place. Thus, the total investment in Africa is expected to surpass that in the Middle Asia and CIS region.

TABLE 3. The estimated urban infrastructure demand by regional groups

Group	**China**	**India**	**Asia**	**Middle East**	**Africa**	**Latin America**	**CIS**	**Advanced countries**
No. of cities	143	58	52	58	46	64	35	176
Amount (US$, trillion)	5.81	2.32	1.22	1.16	1.40	3.07	1.18	11.03

Table 4 shows the estimated urban infrastructure demand of the OECD and developing countries for the following eight infrastructure sectors. The total demand of electricity in 2015 will increase by 50%, compared with 2012, because of economic growth. The total length of railroads and roads will be expanded by 30% and 26%, respectively. The total number of travelers using the airports will increase by 3.8 billion people. The total number of mobile users in developing countries will be 2.63 billion, 3 times more than that of the OECD, while the Internet users in developing countries will be almost similar to those

TABLE 4. The estimated urban infrastructure demand for each infrastructure sector

	classification	**total production (TWh)**		**average production (GWh)**		**production per person (KWh)**	
		2012	2025	2012	2025	2012	2025
electricity	global	6,820	10,250	10.8	16.2	4,234	4,822
	OECD	4,410	5,910	25.0	33.6	9,259	10,674
	developing country	2,410	4,340	5.3	9.5	2,135	2,784
	classification	**total length (10,000 km)**		**average length (km)**		**length per 1,000 people (km)**	
		2012	2025	2012	2025	2012	2025
railroads	global	34.1	43.9	540	694	0.21	0.21
	OECD (28)	23.9	28.7	1,359	1,629	0.50	0.52
	developing country	10.2	15.2	223	333	0.09	0.10
	classification	**total length (10,000 km)**		**average length (km)**		**length per 1,000 people (km)**	
		2012	2025	2012	2025	2012	2025
roads	global	1,040	1,390	1.64	2.20	6.48	6.58
	OECD	667	807	3.79	4.58	14.0	14.5
	developing country	10.2	586	0.80	1.28	3.2	3.8
	classification	**total number of traveler (100 million people)**		**average number of traveler (10 thousand people)**		**proportion to population (%)**	
		2012	2025	2012	2025	2012	2025
airports	global	9.08	12.89	143.7	204.0	56.5	61.0
	OECD	6.57	8.04	373.3	456.9	138.2	145.1
	developing country	2.51	4.85	55.0	106.4	22.2	31.1
	classification	**total number of user (100 million)**		**average number of user (10 thousand)**		**per capita (%)**	
		2012	2025	2012	2025	2012	2025
mobile	global	13.8	34.9	219.2	552.6	0.86	1.65
	OECD	5.0	8.7	286.0	492.8	1.05	1.56
	developing country	8.8	26.3	193.5	575.6	0.78	1.68
	classification	**total number of user (100 million)**		**average number of user (10 thousand)**		**per capita (%)**	
		2012	2025	2012	2025	2012	2025
Internet	global	2.1	4.0	33.7	63.8	0.13	0.19
	OECD	1.3	1.9	73.6	113.5	0.27	0.36
	developing country	0.8	2.1	18.3	44.6	0.07	0.13
	classification	**total number of water user (100 million)**		**total number of sewage user (100 million)**		**supply ratio of sewage (%)**	
		2012	2025	2012	2025	2012	2025
water and sewage	global	8.4	13.0	7.3	10.8	45.9	51.2
	OECD	3.6	5.1	3.5	4.7	73.0	86.1
	developing country	4.9	7.9	3.9	6.1	34.5	38.7
	classification	**total number of houses (100 million)**		**average number of house (10 thousand)**		**per capita**	
		2012	2025	2012	2025	2012	2025
houses	global	3.7	5.1	58.6	81.4	0.23	0.24
	OECD	1.9	2.3	106.9	130.8	0.39	0.41
	developing country	1.8	2.8	40.0	62.3	0.16	0.18

in the OECD. Although the increment of the water users does not show a significant difference between the developing countries and the OECD, the supply ratio of sewage in developing countries will be 39% per capita, which is a relatively low level compared with the OECD, 86%. Finally, the total number of houses at the global level will increase by 1,400 million, with most of them being built in the developing countries.

4. **Concluding Remarks.** In this paper, we have estimated the national level of infrastructure demand based on a theoretically verified national demand forecasting model. The national level of results was applied to the urban level of infrastructure demand according to the various urban characteristics. We have forecasted the urban infrastructure demand in the OECD and developing countries, not to mention that the global, for the following eight infrastructure sectors: electricity, railroad, roads, airports, mobile users, Internet users, water and sanitation, and houses. The results obtained in this research could be helpful for a company targeting an infrastructure market of the developing countries in order to establish its investment strategy. In addition to the demand forecasting, an assessment of the business environment would be needed in order to more successfully enter an urban infrastructure market.

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