

How International Aid and Rainy Season Impact the Dhaka Metro Program

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Abstract. This paper investigates the amplified effect of international aid on the Dhaka metro program and explores the correlation between rainfall and program costs. Drawing insights from the Kolkata metro, a linear regression equation is established to analyze the historical data of rainfall and operating costs from 2017 to 2021. The findings indicate a positive correlation between rainfall and total program costs, albeit with a relatively modest correlation coefficient. Furthermore, it is crucial to recognize that alongside maintenance costs attributed to rainfall, significant fixed expenses, such as workers' salaries, also contribute substantially to the program expenses. This study aims to elucidate these phenomena through the utilization of a mathematical model.

Keywords: International Aid; Rainfall; Program Costs; Linear Regression.

1. Introduction:

The construction of a metro line is often considered as evidence of a city's thriving economy and an effective solution to alleviate traffic congestion. Dhaka, the capital of Bangladesh, is plagued by one of the world's worst traffic jams, despite having a relatively stable economic foundation. In 2012, the municipal government officially confirmed the city's metro program to address this issue. Numerous countries extended financial and technical assistance to Dhaka following the program's approval. However, according to William Easterly's book "Can Foreign Aid Buy Growth?", a city's development does not necessarily correlate with the amount of international aid it receives. Hence, this paper aims to explore whether international aid has facilitated or hindered the progress of the Dhaka metro program. Moreover, the Dhaka metro program encounters various challenges, including the substantial maintenance and operational costs triggered by heavy rainfall. To illustrate the impact of precipitation on metro program, the Kolkata Metro, which shares similarities with Dhaka in terms of both economic and geographical aspects, will be used as a case study.

2. Background of Dhaka City and International Aid:

How to deal with traffic congestion is a challenge which many cities are facing. In particular, Dhaka, the capital of Bangladesh which has the highest population density in the world and the highest urban population growth rate in Asia[6]. The burden of such a large population creates a very serious traffic jam. According to Bangladesh's National Bureau of Statistics, some 6-10% of GDP is lost indirectly to urban traffic congestion. The direct economy lost Tk56,000 crore (\$6.5 billion) in 2020 from traffic, according to the Accident Research Institute (ARI) of Bangladesh University of Engineering and Technology (BUET). According to ARI, traffic congestion in Dhaka has long caused heavy losses in five areas, including lost working hours, extra fuel consumption, road damage, rush-hour accidents and environmental impact, resulting in a loss of Tk1.53 billion per day in 2020[1]. Although the Dhaka city government did make a series of moves to address traffic congestion, for example, the government promoted the Bus Rapid Transit system in last 10 years, the effect is not significant.

Traffic congestion plagued Dhaka until December 2012. The executive committee of National Economic Council of Dhaka city has passed the resolution to build Dhaka Metro which might cost Taka 22,000 crore approximately. And on June 26th, 2016, Prime Minister Sheikh Hasina unveiled the construction of the capital's much publicized first subway service. In 2012, Bangladesh's GDP



was only \$883.1 per capita. The projected cost of the program was well beyond the level of Bangladesh's economy at the time. But international financial aid has provided an opportunity for the program.

The Japanese government will lend Taka 166 billion of the total program cost of Taka 220 billion (\$2.5 billion) through Jica at an interest rate of 0.01% on February 2014. Additionally, the government signed a contract with Japanese Tokyu Construction Company to develop the Metro Rail depot on March 2015. And a joint venture between Italian-Thai Development Public Corporation and SinoHydro Corporation will carry out civil works worth Taka 15.95 billion at the metro station. In that case, the Dhaka municipal government currently plans to build six metro lines to mainly alleviate the traffic congestion in the city center[7]. Japan's financial assistance to the Dhaka city government has certainly helped the metro program. Without taking into account the cost changes brought by technical assistance, the 166million Taka assistance provided by the Japanese government in 2014 accounted for about 75% of the total estimated cost of 220 million Taka.

3. The Controversy of International Aid According to Easterly Theories:

But did the international aid buy the program's growth? In the paper "*Can Foreign Aid Buy Growth?*" published in 2003, author William Easterly stated that there is no positive relationship between the amount of foreign financial aid and urban development. Conversely, large amounts of foreign aid could also lead to a recession in the city's economy[10]. This statement is not rigorous for the metro program in Dhaka City. First, Easterly studied subjects from Israel, Liberia, Tunisia and Relatively backward developing countries or regions such as Reunion (a French colony). These countries and regions lack the necessary infrastructure for urban development such as medical and water facilities. So they can't make full and effective use of international aid. Bangladesh is different. Bangladesh's GDP is already \$2503 per capita in 2021 and has grown rapidly over the past decade[11]. As the capital of Bangladesh, Dhaka City contributes more than 40% of the country's GDP, ranking first in Bangladesh. It is crucial to recognize the distinct context of Dhaka City when considering the impact of international aid on its metro program. The city's economic strength and capacity for development set it apart from the subjects of Easterly's study. While the influence of aid on urban growth is complex and multifaceted, Dhaka's circumstances suggest that international assistance has played a constructive role in promoting the metro program's growth and success.

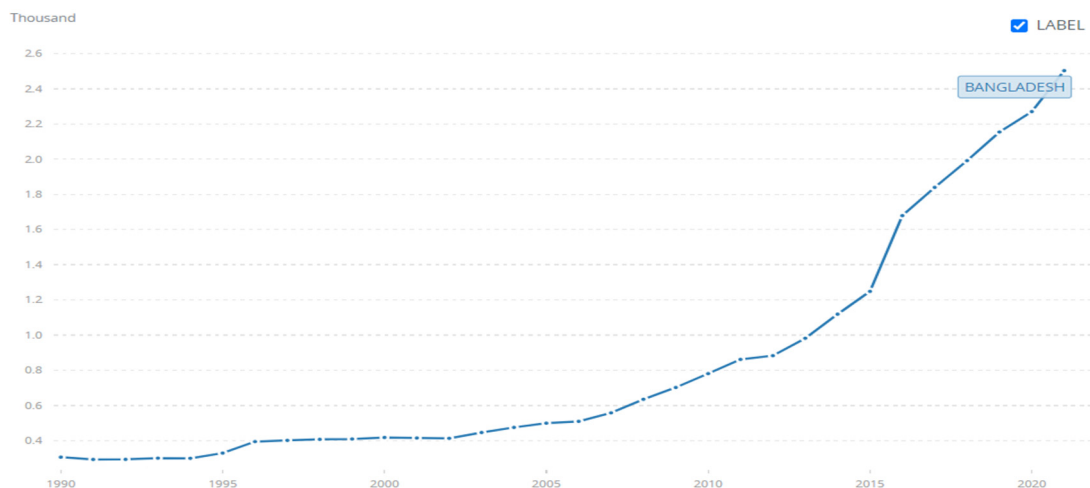


Fig 1. Dhaka's metro project has been developed rapidly with international assistance [11]

Furthermore, the metro program is progressing smoothly and quickly with the help of international aid. As of February 2022, the first phase of the metro program, with nine stations totaling 7.29 miles in length, has been 90.8% complete and is scheduled to officially open for use in December 2022[7]. The second phase (5.2 miles) is currently more than 70% complete and is scheduled for commercial use in December 2023[2]. Under the influence of the Great Pandemic, such progress has been rapid.

4. The Basic Geographical and Financial Data of Kolkata Metro:

On the contrary, the program has to solve some challenges. The biggest challenge is not the technical problem of building it, but the cost of maintenance after it is officially put into use, specifically, the large precipitation will bring metro lots of trouble. I would compare the Dhaka metro program with Kolkata Metro based on the geographical position and economic development. On one hand, the latitude and longitude of Dhaka(23.8103°N, 90.4125°E) city are very close to Kolkata City(22.5726°N, 88.3639°E). Consequently, the climate of Dhaka is similar to Kolkata's. On the other hand, there is only a little difference between Dhaka and Kolkata's density which is 23,234 and 24,000 people per square kilometer respectively. What's more, both Dhaka and Kolkata are the economic center of Bangladesh and India. Furthermore, both of them are coastal cities, built along the Bay of Bengal. As a result, Kolkata's metro line can be a great sample for Dhaka's.

The following charts are the Kolkata's metro earning and expense profile of the last five years, respectively. (Unit Crore)

Table 1. The Kolkata's metro earning and expense profile of the last five years, respectively [4]

Description	2016-17	2017-18	2018-19	2019-20	2020-2021
Salary Relate Cost	241.16	256.18	279.60	301.10	319.14
Elect Traction	47.39	48.83	49.58	50.83	20.31
Elect Non Traction	30.50	29.84	32.45	40.57	17.91
Contractual Payment	46.85	48.14	42.67	47.05	41.82
Stock Non-stock	13.28	16.56	17.08	21.46	20.10
MSC Other EXP.	-8.57	11.56	11.98	9.49	18.41
Total Network Expense	370.61	411.11	433.36	470.50	437.69
Appropriation To DRF	75.00	21.25	4.02	5.00	3.00
Appropriation to Pension Fund	108.00	152.00	144.00	69.90	2.00
Gross Working Expenses	553.61	584.36	581.38	545.40	442.69
Capital Expenditure	550.06	424.60	764.54	904.03	1001.46

And here is the earning profile of the metro including the passengers, sundry and other business income (advertisement etc.). (Unit Crore)

Table 2. The earning profile of the metro including the passengers, sundry and other business income (advertisement etc.) [3]

Year	Passenger	Sundry and Others	Total
2016-17	187.14	27.60	214.74
2017-18	193.95	16.18	210.13
2018-19	201.68	33.19	234.87
2019-20	219.53	33.78	253.31
2020-21	42.46	23.55	66.17

According to the cost chart, Salary Relate Cost occupies the most. Because of the inflation and the expansion of the workers, the Salary Relate Cost increased continuously but slowly. However, the total cost increased significantly from 2020 to 2021. One of the most important reasons is the large flood in 2021. Because of the heavy rainfall, part of the subway has been flooded. Since Sept. 20 2021, the operation of the Kolkata Circular Railway, a railway loop that encircles the entire city, was

suspended[5]. Not only did government lose the revenue of metro for the long suspending duration, but also spent plenty of money fixing the whole metro line after the damage caused by flood.

Additionally, it is obvious to see the total profit fell down to the cliff in 2021. Specifically, the passenger part decreased dramatically. Basically, the profit depends on passengers' tickets. But the Great Flood and the Great Pandemic made government stop to maintain the metro line. Never mind that the massive floods of 2021 shut down the Kolkata Metro for a long time, which was suspended for about two more months due to the pandemic[8].

5. Linear Regression Model:

Establishing a single factor linear regression equation to discuss will be helpful to study the relationship between rainfall and annual maintenance costs. Before doing that, here is the reason of choosing linear regression. Rainfall has a certain impact on the maintenance cost of most subways. The linear regression is able to show the strength of the relationship between variables, and the strength of the relationship between rainfall and maintenance costs. coefficient was calculated to determine the positive or negative correlation and significance between rainfall and maintenance cost.

$$Y_i = \alpha + \beta X_i + \mu_i$$

This regression represents the total maintenance costs(unit Crore) in year i with the X_i rainfall(unit mm) in the raining season(usually from May to the September) in Kolkata. α is the intercept which means the additional fixing costs. β is the coefficient of rainfall in the raining season. μ_i is the standard error of the regression. The reason why this regression equation uses the monsoon rainfall instead of the annual total rainfall as the independent variable is that the climate of Kolkata and Dhaka is tropical monsoon climate. A notable feature of this climate is that the year is divided into very distinct rainy and dry seasons. Rainfall during the rainy season accounts for more than 90 percent of the annual rainfall. When calculating the regression equation, if the annual total rainfall is used as x, then the average value of x will be affected by the very low rainfall in the dry season. The greater the difference between the maximum and minimum, the less representative the average is of the whole data. The selection of annual rainfall in rainy season not only reduces the range and enhances the reliability of the average, but also does not affect the accuracy of the regression equation.

The method of estimating is the least square regression. Consequently,

$$\beta = \frac{\sum_{i=1}^n (X_i - \bar{x})(Y_i - \bar{y})}{\sum_{i=1}^n (X_i - \bar{x})^2} \quad \alpha = \bar{y} - \beta \bar{x} \quad (1)$$

$$\bar{y} = \frac{\sum_{i=1}^n Y_i}{n} \quad \bar{x} = \frac{\sum_{i=1}^n X_i}{n} \quad (2)$$

Table 3. X_i and Y_i Data [9]

	2021	2020	2019	2018	2017	Average
X_i	2090.4	1267	923.7	1110.1	1420.4	1362.32(x)
Y_i	1001.46	904.03	764.54	424.6	550.06	728.938(y)

Taking the data of Table. 3 to formula (1) and (2) for calculation, the least square regression is

$$Y = 0.291127X + 332.329517 + \mu_i$$

After calculating, it is obvious to find the relationship between the rainfall in the raining season and the total fixed cost is positive. With the increasing of the rainfall, the total fixed cost will also rise. But there is also one very important point in this regression equation. That is the intercept α . According to the regression equation, the value of α is as high as 332.329517 Crore. This represents a hidden danger, that is, even if the rainfall in the rainy season is not large, it does not mean that the flood level has not been reached. Kolkata and Dhaka still need to pay a lot of fixed maintenance costs to ensure the operation of the metro. This also explains why Kolkata still has a very high maintenance cost when there is no large-scale flood from 2016 to 2019.

6. Conclusion

In conclusion, although Bangladesh is also a developing country, Dhaka, as the capital of Bangladesh, has a relatively good foundation for economic development. Therefore, international assistance has played a role in promoting the metro program of Dhaka. Whether it is direct financing or becoming a franchisee in the economic aspect, technical consultant or construction equipment in the technical aspect, these assistance is of great significance to the Dhaka Metro program. And the operating cost is a very serious challenge for the metro program in Dhaka. Frequent rainfall will bring a large amount of maintenance costs, and flood caused by a large amount of rainfall will seriously reduce the operating income of the subway. Even if Dhaka city does not experience a lot of rainfall in a year, according to the calculation, it can be found that in addition to the maintenance costs caused by precipitation, other aspects of maintenance costs are very high. In summary, the Dhaka metro program represents a daring and ambitious endeavor. To ensure its sustained success, the program must confront and surmount the challenges associated with high operating costs and the impact of rainfall. By doing so, the program can establish itself as a transformative and essential transportation solution for Dhaka city.

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