Project Report

On

# Multiplier Effect of Infrastructure Investment

*Submitted towards the partial fulfilment of*
*The requirement for the award of the degree of*

**Bachelor of Technology**

*In*

**Information Technology**


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Under the supervision

*Of*

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# DECLARATION

We hereby certify that the work, which is presented in the Project-I entitled **Multiplier Effect of Infrastructure Investment** in fulfilment of the requirement for the award of the Degree of Bachelor of Technology, Delhi Technological University, Delhi is an authentic record of my/our own, carried out under the supervision of **Dr. Seema Pandey.**

The work presented in this report has not been submitted and not under consideration for the award for any other course/degree of this or any other Institute/University.

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**SUPERVISOR CERTIFICATE**

To the best of my knowledge, the report comprises original work and has not been submitted in part or full for any course/degree to this university or elsewhere as per candidate's declaration.

Place:Delhi **Supervisor name** **Signature and Date**

# INDEX

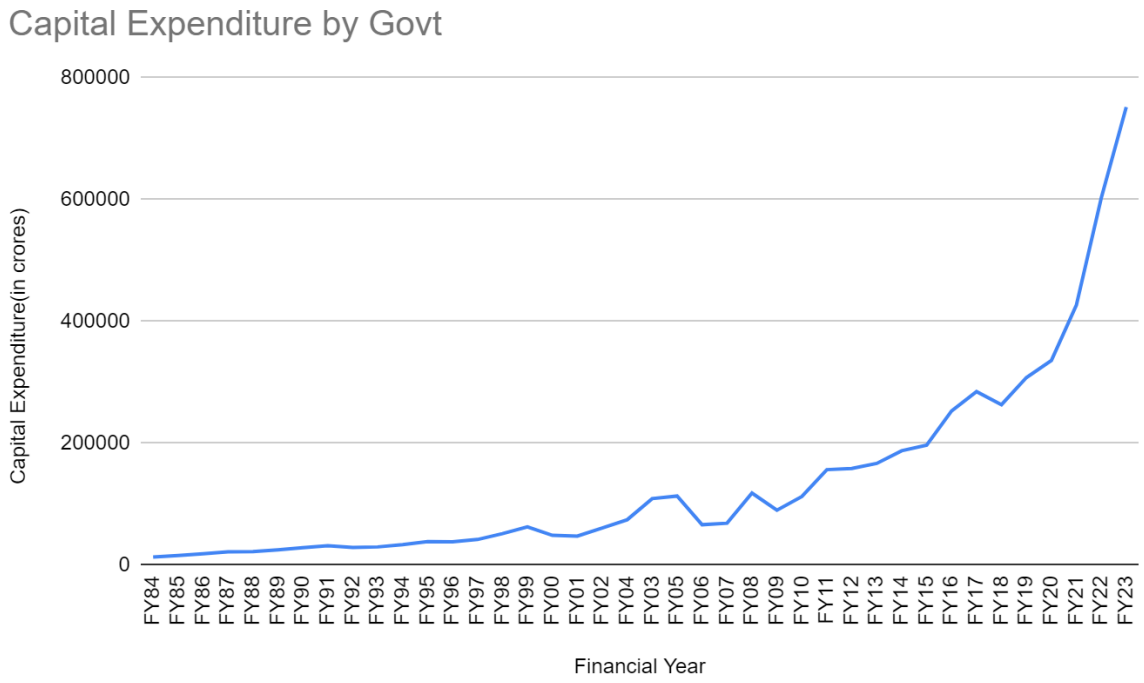
# EXECUTIVE SUMMARY

We have calculated the multiplier effect of infrastructure investment on the national economy. The capital expenditure done by the government to build various infrastructure like roads, railways, ports, etc. enhance accessibility and facilitate trade, improve mobility, generate greater employment opportunities, and boost overall economic productivity. The short to medium term multiplier effect that we have calculated here has come out to be 5.725 which clearly shows that infrastructure investment can provide substantial gains for an economy if done wisely.

# INTRODUCTION

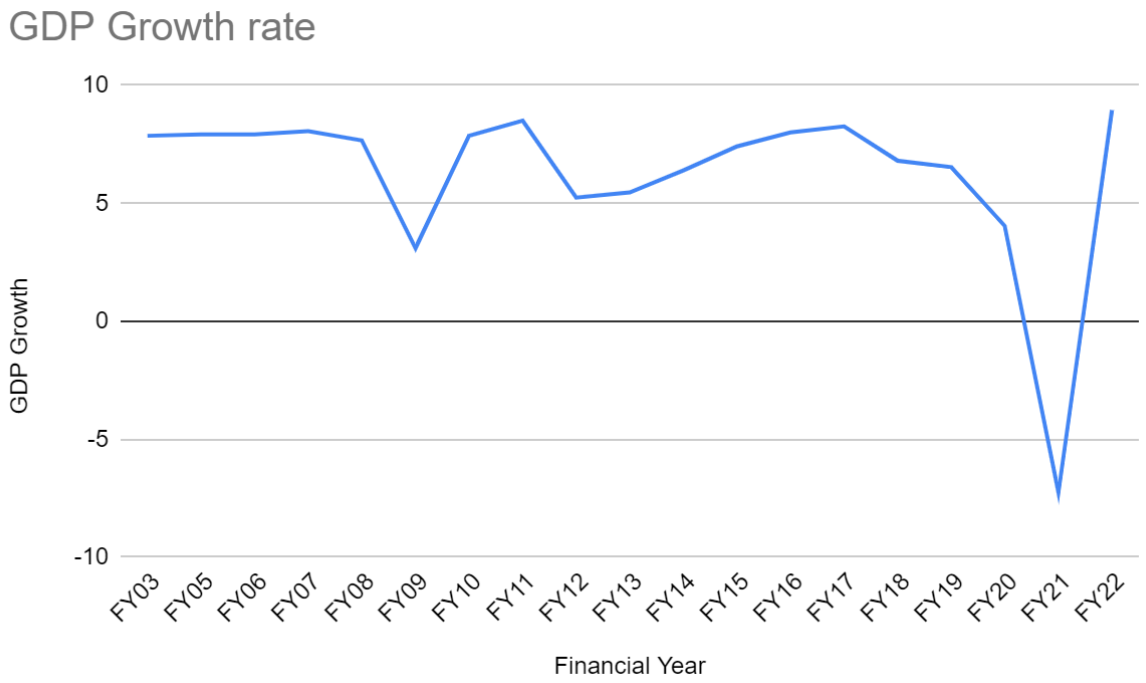
Since independence the efficiency and productivity of the Indian economy has been lower than western economies and with rapid industrialization of Asia, certain asian economies as well. The logistics cost for the Indian economy is around 14-16% as compared to around 8% for China and 10-11% for western economies. As a result of this manufacturing as a % of GDP peaked at around 17% of GDP in 2006. This has made the manufacturing uncompetitive in India which can be clearly seen as value added manufacturing as a % of GDP for China, a country of similar size in population stood at 27% in 2021 as compared to 14% for India.

The capital expenditure done by the government to build various infrastructure required for making the economy more competitive has picked up pace in recent years.




This infrastructure spending has also become more important for the economy as the growth has slowed down in the later half of 2010s, especially after FY17 due to lacklustre private sector investment as it creates much needed jobs in the economy which are very much needed has India has suffered from jobless growth in the past due the economic growth after 1991 being led by the service sector unlike most advanced

economies who first went from agriculture to manufacturing and then services. Other asian economies like ASEAN and South Korea have built themselves up with manufacturing as well.

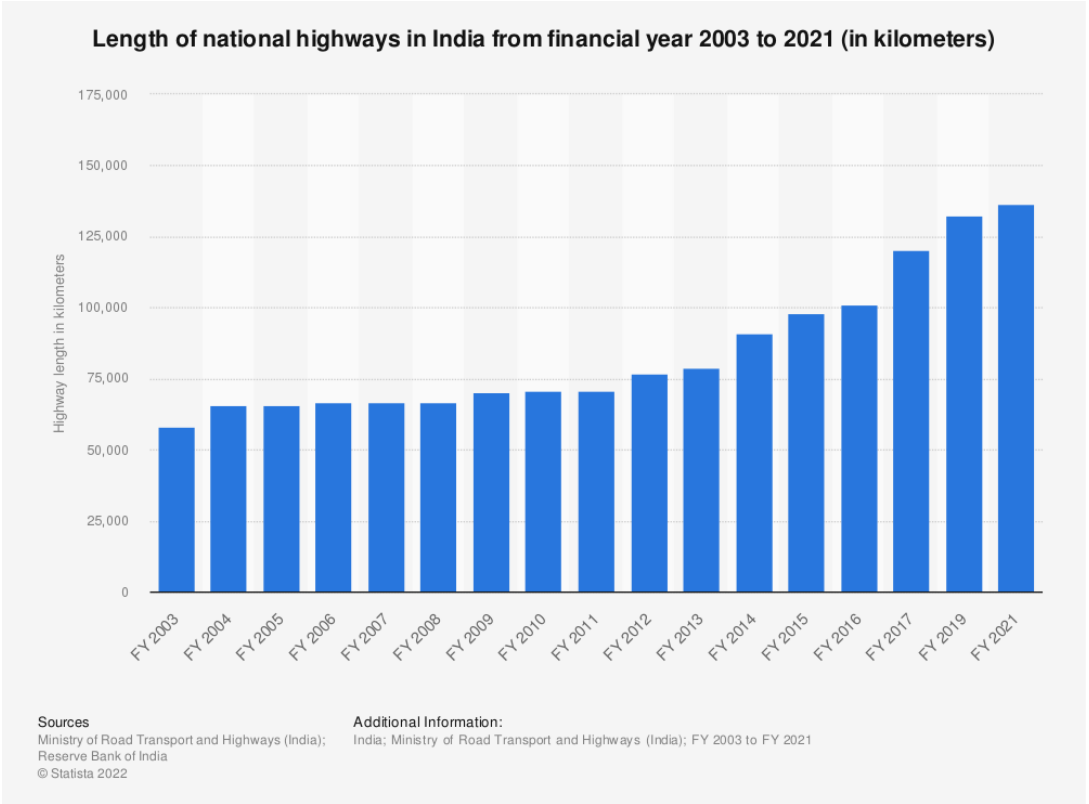



Rather than providing subsidies and handouts to people this way of injecting money is much more beneficial as even after the spending is done and the workers who were paid wages have spent the money they earned, in the long term we have an asset that helps in improving economic efficiency. Other than that, better quality infrastructure also improves the quality of life for citizens of a country.

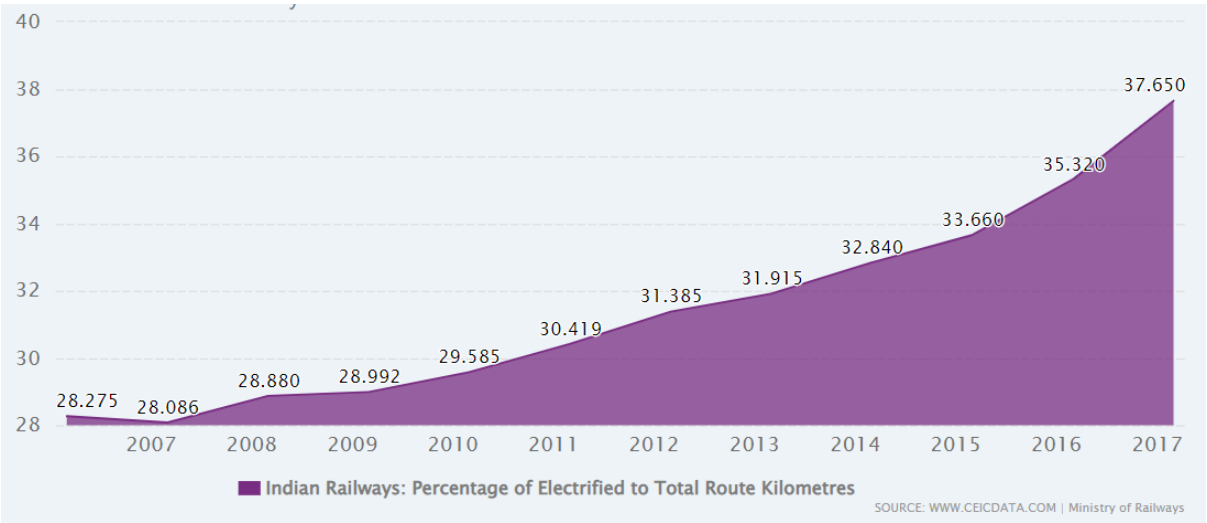
# INDUSTRY PROFILE

Capital spending to build infrastructure done by the government is done across several different sectors as each has its own important role to play in an economy, out of these the major ones that account for the bulk are roads & highways, railways, ports & shipping and electricity.

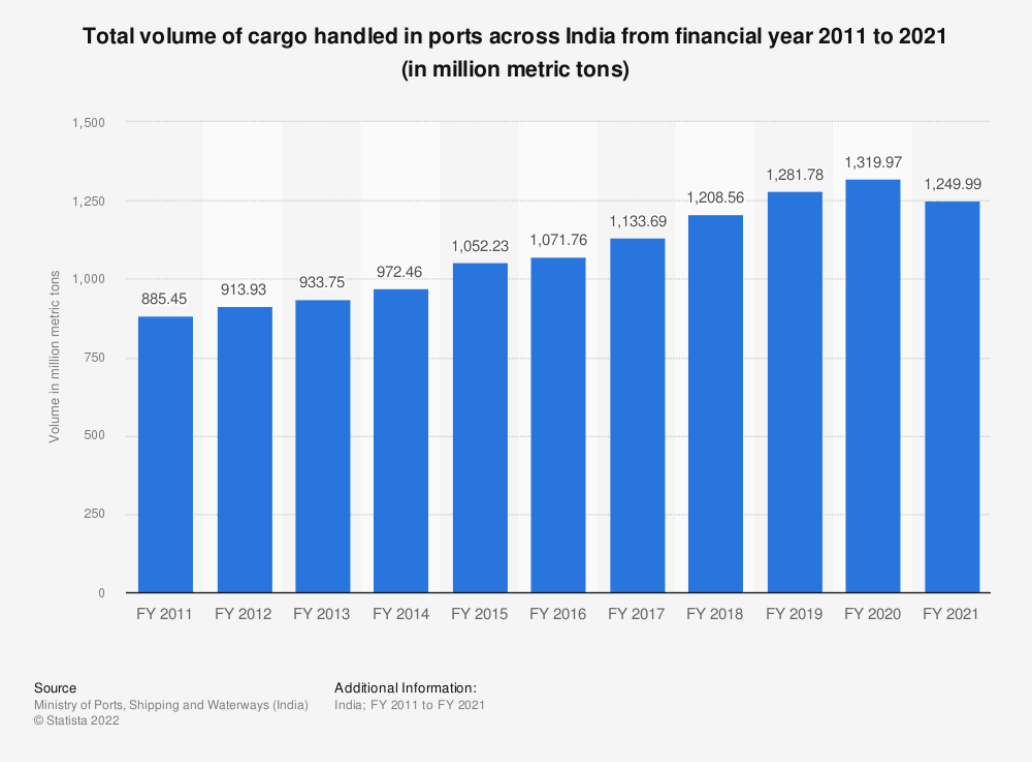
The government spending to build roads and highway networks has seen significant increase since FY2014 and the results of it are very clearly visible as close to 40% of all highways in India have been built after that. The government has further plans with the bharatmala project to further improve the logistics of the country. India's 6,215,797 km (3,862,317 mi) road network is second largest in the world, of which only 2% (~1,10,000 km) are national highways (NHs) carrying 40% road traffic. Bharatmala phase-I will raise the NH connection to a total of 80% or 550 districts out of total 718 districts from the current 42% or 300 districts connected to NH (dec 2017). Mapping of Shortest Route for 12,000 routes carrying 90% of India's freight, commodity-wise survey of freight movement across 600 districts, automated traffic surveys over 1,500+ points across the country, and satellite mapping of corridors was done to identify upgradation requirements for Bharatmala.



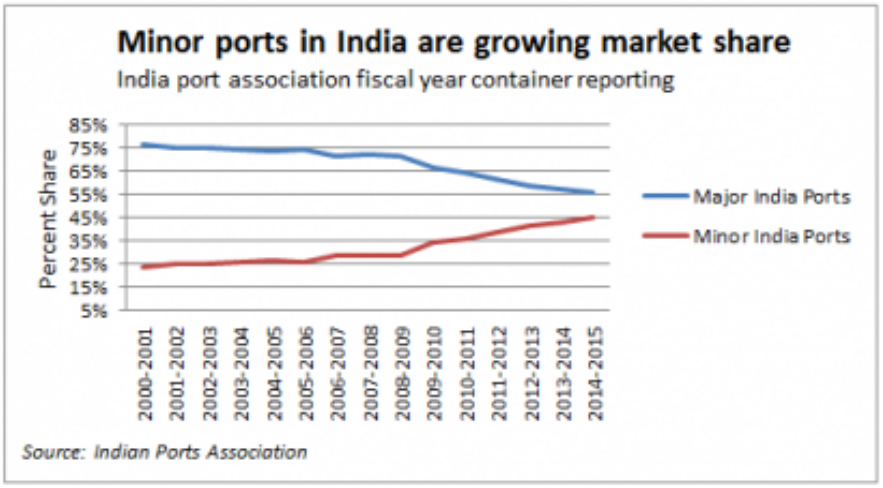
In case of railways, the rail track was mostly laid by the turn of the century and the primary task was broadening the rail gauge and electrifying the routes to stop the use of diesel locomotives which would help in cutting down the fuel imports and reduce pollution.




India has around 12 major and over 200 minor ports who together handled over 1320 million tonnes of cargo in FY20 out of which major ports handled about 704 million tonnes, this is up from around 885 million tonnes in FY11.

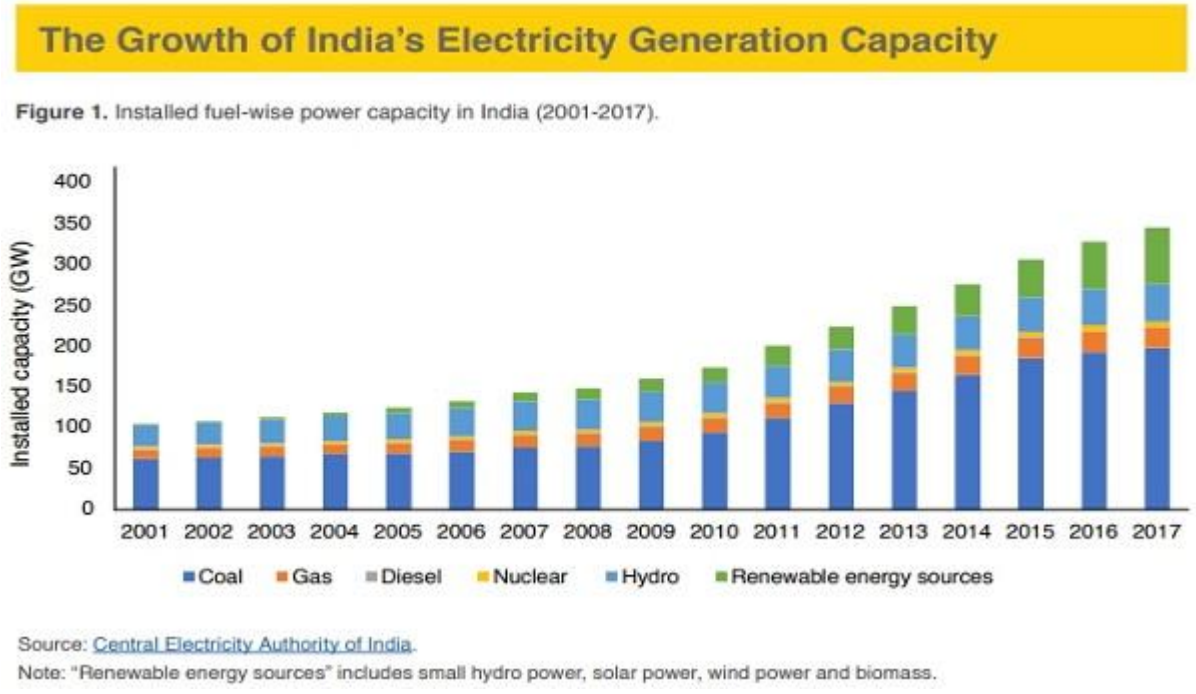


Among the major and non major/minor ports, the share of cargo handled by the minor ports have grown consistently.




The number of ports are poised to increase as well as the current ports will go through modernization and expansion in this decade as the share of Indian exports as a % of global exports is projected to grow to 4.5% by 2031 from the current 1.7%.

India's electricity production tripled from 2001 to 2017 as the economy has grown and electricity connection penetration has risen.

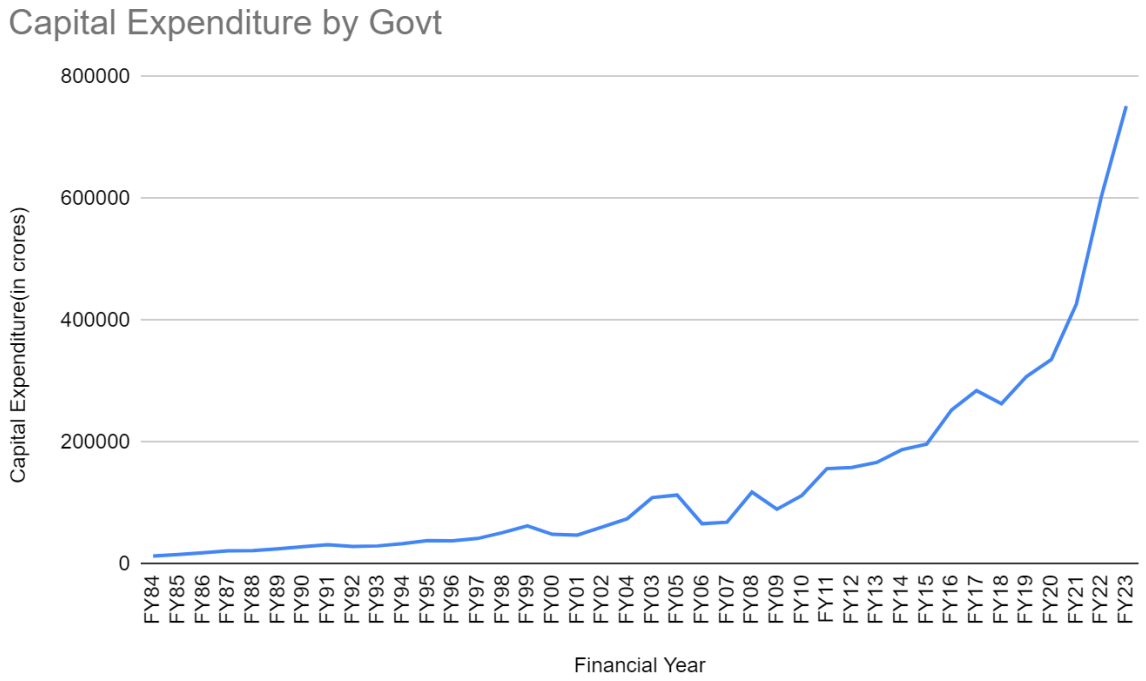



The demand for electricity is further projected to grow from 1152.4 BU in FY 2017 to 2976.3 BU in FY 2037 so going forward a lot of investment will have to be made in this sector to keep up with the demand.

Moreover, more than 50% of India’s installed capacity of coal based and more than 70% of production is coal based, going forward the we work towards mitigating climate change these power plants will have to be shut down and replaced with either nuclear or renewable sources.

# OBJECTIVE AND SCOPE OF STUDY

As the Indian economy has slowed after FY17 due to global headwinds and lack of private sector investment, the government has sought to spur economic growth and job creation as well as crowd in private sector investment by building infrastructure through capital spending which can be clearly seen in form of the meteoric rise in capital expenditure outlay by the government.




It is well known that infrastructure spending has a multiplier effect on the economy and has often been used by governments to pull economies out of economic downturns, the most prime example being China's $640 billion stimulus in the aftermath of 2008 financial crisis.

In this study we are going to calculate the short to medium term multiplier effect of infrastructure spending by the government. While different infrastructure assets have different multiplier effects over the long term, we have taken them all together to calculate the multiplier effect here.

# THEORETICAL BACKGROUND

GDP is the most commonly used metric to measure the economic output of an entity, it is the standard measure of the value added created through the production of goods and services in a country during a certain period and has been represented by the following equation.

$$Y = C + I + G + (X - M)$$

Y : GDP
C : Consumption
I : Investment
G : Government Spending
X : Exports
M : Imports

The government spending in this equation can be further classified into two categories :

- Revenue Expenditure : It is expenditure for the normal running of government departments and various services, interest charges on debt incurred by the government, subsidies and so on. Broadly speaking, expenditure which does not result in the creation of assets is treated as revenue expenditure.
- Capital Expenditure : It is the part of the government spending that goes into the creation of assets like schools, colleges, hospitals, roads, bridges, dams, railway lines, airports and seaports. It also covers the acquisition of equipment and machinery by the government, including those for defence purposes.

Now the change in national output in relation to government spending is represented by the following equation.

$$\Delta Y = (1/(1 - MPC)) * \Delta G$$

Where,
ΔY is change in national output
ΔG is change in government spending
MPC is marginal prosperity to consumer

$$Y_t - Y_{t-1} = {}_1(G_t - G_{t-1}) + e$$

Where ${}_1$ is the estimation of 1/(1-MPC)

Now to get the coefficient of capital spending we split the government spending into revenue spending and capital spending.

$$G = RE + CE$$
$$\Delta G = \Delta(RE + CE)$$
$$\Delta G = \Delta RE + \Delta CE$$
$$(1/(1 - MPC))\Delta G = (1/(1 - MPC))\Delta RE + (1/(1 - MPC))\Delta CE$$
$$\Delta Y = (1/(1 - MPC))\Delta RE + (1/(1 - MPC))\Delta CE$$

As we can see, the coefficients of ΔRE and ΔCE are theoretically the same.

# RESEARCH AND METHODOLOGY

We have taken the data for GDP, revenue expenditure, capital expenditure and total expenditure from FY84 to FY21.

| Year | GDP | Revenue expenditure | Capital expenditure | Total Expenditure |
|---|---|---|---|---|
| 1983-84 | 209356.00 | 22251 | 13283 | 35534 |
| 1984-85 | 235113.00 | 27691 | 15941 | 43632 |
| 1985-86 | 262717.00 | 33924 | 18742 | 52666 |
| 1986-87 | 292924.00 | 40860 | 22056 | 62916 |
| 1987-88 | 332068.00 | 46174 | 22087 | 68261 |
| 1988-89 | 396295.00 | 54106 | 25005 | 79111 |
| 1989-90 | 456540.00 | 64210 | 28698 | 92908 |
| 1990-91 | 531814.00 | 73516 | 31782 | 105298 |
| 1991-92 | 613528.00 | 82292 | 29122 | 111414 |
| 1992-93 | 703723.00 | 92702 | 29916 | 122618 |
| 1993-94 | 817961.00 | 108169 | 33684 | 141853 |
| 1994-95 | 955386.00 | 122112 | 38627 | 160739 |
| 1995-96 | 1118586.00 | 139861 | 38414 | 178275 |
| 1996-97 | 1301788.00 | 158933 | 42074 | 201007 |
| 1997-98 | 1447613.00 | 180335 | 51718 | 232053 |
| 1998-99 | 1668739.00 | 216461 | 62879 | 279340 |
| 1999-00 | 1858205.00 | 249078 | 48975 | 298053 |
| 2000-01 | 2000743.00 | 277839 | 47753 | 325592 |
| 2001-02 | 2175260.00 | 301468 | 60842 | 362310 |
| 2002-03 | 2343864.00 | 338713 | 74535 | 413248 |
| 2003-04 | 2625819.00 | 362074 | 109129 | 471203 |
| 2004-05 | 2971464.00 | 384329 | 113331 | 498252 |
| 2005-06 | 3390503.00 | 439376 | 66362 | 505738 |
| 2006-07 | 3953276.00 | 514609 | 68778 | 583387 |
| 2007-08 | 4582086.00 | 594433 | 118238 | 712671 |
| 2008-09 | 5303567.00 | 793798 | 90158 | 883956 |
| 2009-10 | 6108903.00 | 911809 | 112678 | 1024487 |
| 2010-11 | 7248860.00 | 1040723 | 156605 | 1197328 |
| 2011-12 | 8391691.00 | 1145785 | 158580 | 1304365 |
| 2012-13 | 9388876.00 | 1243514 | 166858 | 1410372 |

| | | | | |
|---|---|---|---|---|
| 2013-14 | 10472807.00 | 1371772 | 187675 | 1559447 |
| 2014-15 | 12467959.00 | 1466992 | 196681 | 1663673 |
| 2015-16 | 13771874.00 | 1537761 | 253022 | 1790783 |
| 2016-17 | 15391669.00 | 1690584 | 284610 | 1975194 |
| 2017-18 | 17090042.00 | 1878833 | 263140 | 2141973 |
| 2018-19 | 18886957.00 | 2007399 | 307714 | 2315113 |
| 2019-20 | 20351013.00 | 2350604 | 335726 | 2686330 |
| 2020-21 | 19745670.00 | 3083519 | 426317 | 3509836 |

We then calculate the year on year change in revenue expenditure, capital expenditure, total expenditure and GDP and afterwards we create a linear regression model to calculate the increase in GDP for every rupee of additional government spending.

We add a dummy variable which has value 0 before 1991 and 1 after 1991 for 1991 reforms as there is significant change in the Indian economy post the reforms going forward from there to enhance accuracy score and we further check if we can increase the accuracy for model by adding more dummy variables by using F test to see if increase in accuracy is statistically significant.

# ANALYSIS AND INTERPRETATION OF DATA

CREATIND MODEL TAKING REVENUE AND CAPITAL EXPENDITURE
Y = a + b*(revenue expenditure) + c*(capital expenditure)

```
#Creating Model
rev_cap_model = LinearRegression()

#Fitting the data into it
rev_cap_model.fit(xExpenditure, yGDP)

print("Accuracy score = ",rev_cap_model.score(xExpenditure, yGDP))
print("Coefficients = ",rev_cap_model.coef_)
```

```
Accuracy score =  0.6557919639958737
Coefficients =  [[6.04334406 6.50288673]]
```

The coefficients for revenue and capital expenditure in this model dont have a very big difference as we had seen theoretically and so we can just take the overall spending to create the model so we reduce the unnecessary complexity.

CREATING MODEL TAKING TOTAL EXPENDITURE
Y = a + b*(total expenditure)

```
#creating model
Total_exp_model = LinearRegression()

#Fitting data into it
Total_exp_model.fit(xTotal_expenditure, yGDP)

print("Accuracy score = ",Total_exp_model.score(xTotal_expenditure, yGDP))
print("Coefficients = ",Total_exp_model.coef_)
```

✓ 0.4s

```
Accuracy score =  0.6554798310408803
Coefficients =  [[6.094754]]
```

The accuracy of the model dips but by a very insignificant margin and thus is of no issue to us, but from here on we have to add a dummy variable for the periods before and after 1991.

| | Period | GDP | Revenue expenditure | Capital expenditure | Total expenditure | Dummy 1 |
|---|---|---|---|---|---|---|
| 0 | FY85 - FY84 | 25757.0 | 5440.0 | 2658.0 | 8098.0 | 0 |
| 1 | FY86 - FY85 | 27604.0 | 6233.0 | 2801.0 | 9034.0 | 0 |
| 2 | FY87 - FY86 | 30207.0 | 6936.0 | 3314.0 | 10250.0 | 0 |
| 3 | FY88 - FY87 | 39144.0 | 5314.0 | 31.0 | 5345.0 | 0 |
| 4 | FY89 - FY88 | 64227.0 | 7932.0 | 2918.0 | 10850.0 | 0 |
| 5 | FY90 - FY89 | 60245.0 | 10104.0 | 3693.0 | 13797.0 | 0 |
| 6 | FY91 - FY90 | 75274.0 | 9306.0 | 3084.0 | 12390.0 | 0 |
| 7 | FY92 - FY91 | 81714.0 | 8776.0 | -2660.0 | 6116.0 | 1 |
| 8 | FY93 - FY92 | 90195.0 | 10410.0 | 794.0 | 11204.0 | 1 |
| 9 | FY94 - FY93 | 114238.0 | 15467.0 | 3768.0 | 19235.0 | 1 |
| 10 | FY95 - FY94 | 137425.0 | 13943.0 | 4943.0 | 18886.0 | 1 |
| 11 | FY96 - FY95 | 163200.0 | 17749.0 | -213.0 | 17536.0 | 1 |
| 12 | FY97 - FY96 | 183202.0 | 19072.0 | 3660.0 | 22732.0 | 1 |
| 13 | FY98 - FY97 | 145825.0 | 21402.0 | 9644.0 | 31046.0 | 1 |
| 14 | FY99 - FY98 | 221126.0 | 36126.0 | 11161.0 | 47287.0 | 1 |
| 15 | FY00 - FY99 | 189466.0 | 32617.0 | -13904.0 | 18713.0 | 1 |
| 16 | FY01 - FY00 | 142538.0 | 28761.0 | -1222.0 | 27539.0 | 1 |
| 17 | FY02 - FY01 | 174517.0 | 23629.0 | 13089.0 | 36718.0 | 1 |
| 18 | FY03 - FY02 | 168604.0 | 37245.0 | 13693.0 | 50938.0 | 1 |
| 19 | FY04 - FY03 | 281955.0 | 23361.0 | 34594.0 | 57955.0 | 1 |
| 20 | FY05 - FY04 | 345645.0 | 22255.0 | 4202.0 | 27049.0 | 1 |
| 21 | FY06 - FY05 | 419039.0 | 55047.0 | -46969.0 | 7486.0 | 1 |
| 22 | FY07 - FY06 | 562773.0 | 75233.0 | 2416.0 | 77649.0 | 1 |
| 23 | FY08 - FY07 | 628810.0 | 79824.0 | 49460.0 | 129284.0 | 1 |

The reforms of 1991 and the ones after increasingly liberalised the economy making it open to foreign trade and thus increasing the competition for domestic industry causing manufacturing decline as a % of GDP and thus the dummy variable is important as we can see in the increase in accuracy score.

CREATING A NEWER MODEL USING THIS DUMMY VARIABLE ALONG WITH THE TOTAL EXPENDITURE
Y = a + b*(Total expenditure) + c*(Dummy variable)

```
#Taking both total expenditure and dummy variable for predicting variable
x2Total_expenditure = new_change_data.iloc[:, -2:]

#Creating model
newTotal_expenditure_model = LinearRegression()

#Fitting data into it
newTotal_expenditure_model.fit(np.array(x2Total_expenditure), yGDP)

print("Accuracy score : ", newTotal_expenditure_model.score(np.array(x2Total_expenditure), yGDP))
print("Coeffecients = ", newTotal_expenditure_model.coef_)
```

✓ 0.6s

```
Accuracy score :  0.6683250286858148
Coeffecients =  [[5.72514516e+00 1.84869422e+05]]
```

We get an accuracy score of 0.668 and the multiplier effect comes out at 5.725. From here on if we can try to add more dummy variables to further increase the accuracy the increase is not big enough so we have to check statistical significance.

CREATING ANOTHER MODEL USING BOTH DUMMIES AND TOTAL EXPENDITURE
Y = a + b*(Total Expenditure) + c*(Dummy 1) + d*(Dummy 2)

```
#Taking total expenditure and the two dummy variables
x3Total_expenditure = new_change_data.iloc[:, -3:]

#Creating model
nextTotal_expenditure_model = LinearRegression()

#Fitting data into it
nextTotal_expenditure_model.fit(np.array(x3Total_expenditure), yGDP)

print("Accuracy score : ", nextTotal_expenditure_model.score(np.array(x3Total_expenditure), yGDP))
print("Coeffecients = ", nextTotal_expenditure_model.coef_)
```

✓ 0.4s

```
Accuracy score :  0.6683285844881433
Coeffecients =  [[4.74897117e+00 1.75118774e+05 9.76419153e-01]]
```

NOW WE HAVE TO CHECK WHETHER ACCURACY INCREASE IN THE NEW MODEL IS STATISTICALLY SIGNIFICANT AND WORTH ADDING AN EXTRA VARIABLE

TO DO THIS WE WILL CONDUCT THE PARTIAL F TEST FOR COMPARING TWO LR MODELS

F = ((SS1 - SS2)/(df1 - df2))/(SS2/df2)
SS : Sum of sqaured errors
df : Degree of freedom

Step 1 : Calculating the sum of sqaured errors for both models

```
new_SSE = 0
for i in range(len(x2Total_expenditure)):
    new_SSE += (newTotal_expenditure_model.predict([[x2Total_expenditure.iloc[i,0], x2Total_expenditure.iloc[i,1]]]) - yGDP[i])**2

next_SSE = 0
for i in range(len(x3Total_expenditure)):
    next_SSE += (nextTotal_expenditure_model.predict([[x3Total_expenditure.iloc[i,0], x3Total_expenditure.iloc[i,1], x3Total_expenditure.iloc[i,2]]]) - yGDP[i])**2

print(new_SSE - next_SSE)
```

✓ 0.8s

```
[[44918512.46875]]
```

+ Code + Markdown

Step 2: Calculating the mean squared error for the full model(nextTotal_expenditure_model) and finding F value

```
next_MSE = next_SSE/len(x3Total_expenditure)
f = (new_SSE - next_SSE)/next_MSE
f
```

✓ 0.4s

The calculated F statistic is lower than the critical F and hence the null hypothesis for the F test cannot be rejected and hence the reduced model is better than the full model.

# FINDINGS

- The multiplier effect for infrastructure spending done by the government over the period of time under observation is 5.725 across all assets built.
- The dummy variable for 1991 is important and increases accuracy significantly.
- Any further dummy variables are not useful as they don't increase accuracy by a statistically significant margin.
- The marginal prosperity to consumers isn’t very different in the short term for both revenue and capital expenditure.

# CONCLUSION

Capital spending to build different infrastructure assets is a very important tool for the government to spur economic growth. Infrastructure investments have a powerful multiplier effect, 5.725 as we have calculated. They enhance accessibility and facilitate trade, improve mobility, generate greater employment opportunities, and boost overall economic productivity.

The government must use infrastructure spending with expansionary fiscal policy wisely to achieve all the different objectives.

# LIMITATIONS

- The multiplier effect is calculated only for short to medium term and hence doesn't give the full picture of economic advantages.
- The multiplier effect has been shown to vary from one infrastructure asset to another, for example, roads have a multiplier effect 2.5 while power sector investments like power grids have multiplier effect of 86, here we have just taken them all as one.
- There are some minor distortions even after 1991 that might pile up when taken together like the government reducing its debt by contractionary fiscal policy from FY04 to FY07 and then the 2008 financial crisis. Also the drastic increase in capital spending after 2014 due to different ideological views of the new government from the previous one.

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