HUL 213 : Assignment 4

Pratyush Pandey - 2017EE10938
Abhishek Rao - 2017PH10804
Sumanth - 2017MT60855
Manavi Garg - 2017CH10120
Hridayesh Lal - 2017CH10210

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All the files, data, plots and figures are included here : `https://csciitd-my.sharepoint.com/:f:/g/personal/ee1170938_csciitd_onmicrosoft_com/ErW13p8RfDlHrhkxV9rHOH8BqPrn2MF4BHH3Bg06iA?e=NgXfsf`

1 Intro - What is Cobb Douglas Function?

In economics and econometrics, the Cobb–Douglas production function is a particular functional form of the production function, widely used to represent the technological relationship between the amounts of two or more inputs (particularly physical capital and labor) and the amount of output that can be produced by those inputs.
Output elasticity measures the responsiveness of output to a change in levels of either labor or capital used in production, ceteris paribus. For example, if $\alpha = 0.45$, a 1% increase in capital usage would lead to approximately a 0.45% increase in output.

Sometimes the term has a more restricted meaning, requiring that the function display constant returns to scale, meaning that doubling the usage of capital K and labor L will also double output Y. This holds if

$$\alpha + \beta = 1,$$

If

$$\alpha + \beta < 1,$$

returns to scale are decreasing, and if

$$\alpha + \beta > 1,$$

returns to scale are increasing. Assuming perfect competition and $\alpha + \beta = 1$, α and β can be shown to be capital's and labor's shares of output.

2 Data, calculations and Plots

L	K	Y	log Y	log K	log L
3.28E+08	9.19E+10	3.17E+11	11.50064	10.96322	8.51536
3.35E+08	6.47E+10	2.67E+11	11.4257	10.81123	8.525445
3.43E+08	7.3E+10	2.84E+11	11.45387	10.86338	8.535737
3.52E+08	6.81E+10	2.76E+11	11.44023	10.83344	8.546347
3.61E+08	8.9E+10	3.23E+11	11.50908	10.94935	8.557438
3.68E+08	1.00E+11	3.55E+11	11.55081	11	8.566109
3.75E+08	1.02E+11	3.88E+11	11.58845	11.0086	8.574338
3.83E+08	1.17E+11	4.10E+11	11.61312	11.06819	8.582685
3.9E+08	1.12E+11	4.16E+11	11.61881	11.04922	8.591111
3.98E+08	1.34E+11	4.53E+11	11.65581	11.1271	8.59957
4.06E+08	1.25E+11	4.62E+11	11.66478	11.09691	8.608013
4.17E+08	1.29E+11	4.79E+11	11.6803	11.11059	8.62014
4.29E+08	1.40E+11	5.08E+11	11.70592	11.14613	8.632318
4.41E+08	1.79E+11	6.00E+11	11.77786	11.25285	8.644487
4.53E+08	2.56E+11	7.00E+11	11.84491	11.40824	8.656567
4.66E+08	3.12E+11	8.09E+11	11.9079	11.49415	8.66853
4.67E+08	3.66E+11	9.20E+11	11.96394	11.56348	8.669471
4.68E+08	5.10E+11	1.20E+12	12.07958	11.70757	8.670362
4.69E+08	4.54E+11	1.19E+12	12.07443	11.65706	8.671175
4.7E+08	5.38E+11	1.32E+12	12.12187	11.73078	8.67194
4.71E+08	6.74E+11	1.66E+12	12.21922	11.82866	8.672662
4.74E+08	7.22E+11	1.82E+12	12.2608	11.85854	8.675488
4.77E+08	7.01E+11	1.83E+12	12.26189	11.84572	8.678337
4.86E+08	6.32E+11	1.86E+12	12.26875	11.80072	8.686553
4.95E+08	6.99E+11	2.04E+12	12.30944	11.84448	8.694573
5.04E+08	6.68E+11	2.10E+12	12.32271	11.82478	8.702288
5.13E+08	6.90E+11	2.27E+12	12.35683	11.83885	8.709919
5.2E+08	7.99E+11	2.60E+12	12.41455	11.90255	8.716165

Figure 1: Data and calculations

From regression analysis on above data, The value of power of capital in production function is 0.78 while that of labour is 0.41. That is α=0=78 , β=0.41

$$Y = AK^{\alpha}L^{\beta}$$

So we observe that

$$\alpha + \beta = 1.19 > 1,$$

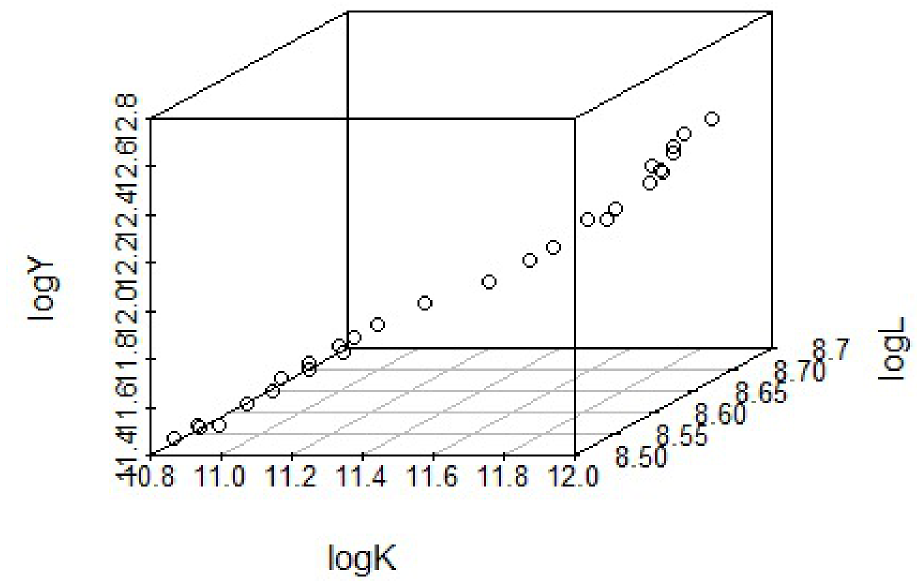

Figure 2: 3D scatter plot of Log Y, Log K, Log L - Highlighting Dependencies

Year	A	Change in A
1990	0.548865522	
1991	0.571123071	0.022257548
1992	0.561568196	-0.009554875
1993	0.564596192	0.003027996
1994	0.549888981	-0.014707211
1995	0.549077637	-0.000811344
1996	0.564388215	0.015310577
1997	0.550242901	-0.014145314
1998	0.559696812	0.009453912
1999	0.54455839	-0.015138422
2000	0.560631465	0.016073074
2001	0.560521189	-0.000110275
2002	0.556489424	-0.004031766
2003	0.547341658	-0.009147766
2004	0.515734093	-0.031607565
2005	0.511032853	-0.004701239
2006	0.511765336	0.000732482
2007	0.513089638	0.001324302
2008	0.530845301	0.017755664
2009	0.52527836	-0.005566942
2010	0.536160738	0.010882379
2011	0.545374211	0.009213473
2012	0.550821384	0.005447173
2013	0.572526665	0.021705281
2014	0.574334371	0.001807706
2015	0.589157425	0.014823053
2016	0.601032204	0.01187478
2017	0.604235009	0.003202805

Figure 3: A vs time and Change in A vs time

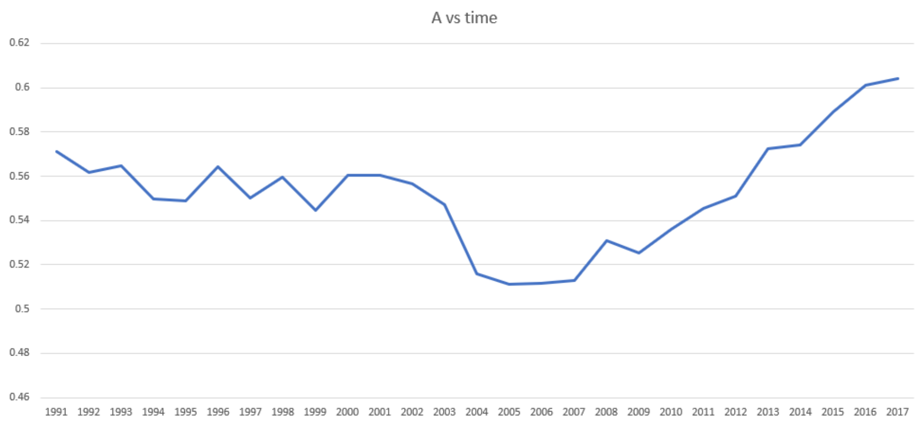

Figure 4: A vs time

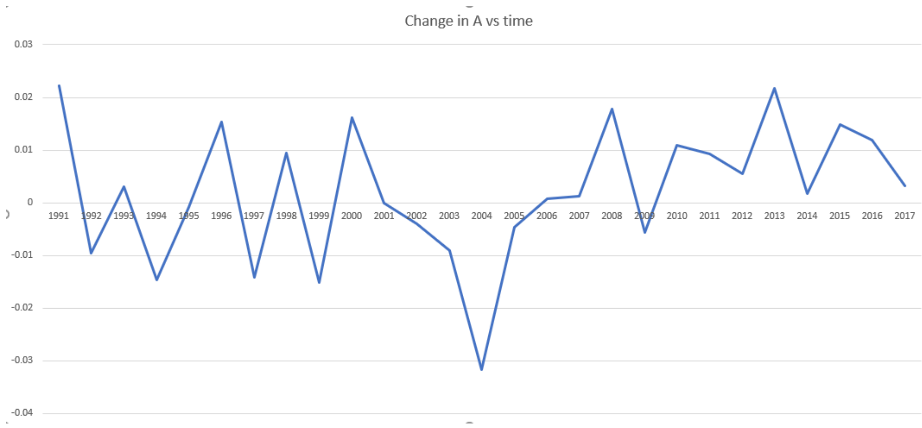

Figure 5: Change in A vs time

The following is the R code used on the above data to obtain the Scatter Plot

```
Data <- read.csv("Data.csv")
logK <- as.matrix(Data[5])
logL <- as.matrix(Data[6])
logY <- as.matrix(Data[4])
library('scatterplot3d')
scatterplot3d(logK, logL, logY)
linearReg <- lm(logY~logK+logL, data=Data)
summary(linearReg)

#to calcuate the A values
logA <- logY - 0.7821*logK - 0.4141* logL
A <- exp(logA)
#write to a csv file
write.csv(A, file="A values.csv", row.names=FALSE)
```

```
Call:
lm(formula = logY ~ logK + logL, data = Data)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.077108 -0.017443 -0.002654  0.022314  0.090406 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  -0.5949     3.0823  -0.193    0.849    
logK          0.7821     0.0687  11.384  2.2e-11 ***
logL          0.4141     0.4414   0.938    0.357    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.04592 on 25 degrees of freedom
Multiple R-squared:  0.9822,	Adjusted R-squared:  0.9808 
F-statistic: 691.3 on 2 and 25 DF,  p-value: < 2.2e-16
```

Figure 6: the output of the R code on the above data.

We see that R^2 is 0.98, so it's a really good fit to the data.

3 Explanation of data

3.1 1995

In 1995 we can see an increase in total factor productivity. The main reason for this is because of India being exposed to advanced technology from the modern world. This resulted in an increase in both the productivity of labour and productivity of capital as both of these resources could now be used much for effectively.

3.2 1995-2000

The period from 1995-2000 saw a rapid increase in total factor productivity. In 1993, the release of the Mosaic web browser made access to the World Wide Web easier. Internet usage increased as a result of the reduction of the digital divide and advances in connectivity, uses of the Internet, and computer education. All this resulted in the emergence of several online services and which helped increase productivity drastically. During this time, the productivity growth also resulted from the services created in the IT sector. One of the major reasons was the Y2K bug which is a class of computer bugs related to the formatting and storage of calendar data for dates beginning in the year 2000. Problems were anticipated, and arose, because many programs represented four-digit years with only the final two digits — making the year 2000 indistinguishable from 1900. The assumption of a twentieth-century date in such programs could cause various errors, such as the incorrect display of dates and the inaccurate ordering of automated dated records or real-time events. Therefore, to prevent this problem and find a solution, Silicon Valley companies outsourced the task of fixing the bug and a large part of this was done to India. This resulted in a mass creation of jobs in India. Thus, this resulted in an increase in the productivity during this period.

3.3 2000-2005

Soon after the year 2000, the drop in productivity can be attributed to the collapse of the dot com bubble.The dot com bubble that formed over the next five years was fed by cheap money, easy capital, market overconfidence and pure speculation. Valuations were based on earnings and profits that would not occur for several years if the business model actually worked, and investors were all too willing to overlook traditional fundamentals. By the end of 2001, a majority of publicly traded dot-com companies folded, and trillions of dollars of investment capital evaporated. The reallocation of resources from agriculture sector to services and manufacturing sector led to an increase in productivity since the free access to foreign technology made the manufacturing processes more efficient. Increasing growth in Research and Development Activities in the country attributed to the increasing number of patents and licenses being filed proved to be a major reason for the surge in total factor productivity of the country's labour.

3.4 2005-2010

Since 2003 , the inventory investment started increasing unprecedentedly. In fact in 2007, it was Rs. 40,000 crore. Most of this inventory investment actually brought in newer technologies and hence the efficiency of the production process increased dramatically which explains the peak in 2009 (since there is always a time lag between investment and realizing the productivity growth). Also the number of patents filed by Indians increased to a great extent in this period (around 36,000 in 2008) which explains the technological advancements. The higher total productivity in this period is mainly attributed to the growth in the services sector. The productivity in this sector depends hugely on the compensation of the employees and therefore with increased salaries and benefits there was a shift towards services sector and clubbed with increasing efficiency and technical progress, the overall total factor productivity increased.