

## Testing Rybczynski theorem: case for India

Meet Mehta\*<sup>1</sup>, Priyanshu Raj<sup>2</sup>, Sagar Dasani<sup>3</sup>, Nivedhitha Balachandran<sup>4</sup>, Vaibhav Jain<sup>5</sup>,  
Vanshika Madaan<sup>6</sup>, Akshay Ghaisas<sup>7</sup>

*Second Year, B. Sc. Economics, Sarla Anil Modi School of Economics, Narsee Monji Institute of Management Studies  
(Deemed-to-be University), Mumbai, Maharashtra-40056, India*

<sup>1</sup>meet\_mehta703@yahoo.co.in, <sup>2</sup>praj2799@gmail.com, <sup>3</sup>sagardasani77778@gmail.com, <sup>4</sup>nivedhitha\_b99@yahoo.com,  
<sup>5</sup>vaibhav2399@gmail.com, <sup>6</sup>van.madaan@gmail.com, <sup>7</sup>akshay.ghaisas6@gmail.com

### Abstract

**Objectives:** To check whether the Rybczynski theorem holds for the case of India. The theorem explores the impacts of dynamics in factor endowments on final output produced by a nation.

**Statistical Analysis:** We use the KLEMS [Capital (K), Labor (L), Energy (E), and Materials (M)] database which was prepared as a project under RBI to determine the factor endowments of the country and factor intensities of commodities in India. The theorem is tested by running multiple regressions under Ordinary Least Squares (OLS) Method to test the theorem. Furthermore, we use the K/L ratio and exports/import data from WITS (World Integrated Trade Systems Database, WTO) to check the underlying support of the theorem.

**Findings:** We observe a pattern of movement in output very similar to the predictions of the Rybczynski theorem but we don't find enough evidence for the theoretical underpinnings of the same. Mainly, the data on K/L ratio and Terms of trade do not seem to be in agreement with the assumptions of the theorem. We also observe some possible explanation for regional divergence in India.

**Improvements:** Questions like why the pattern similar to Rybczynski Theorem is observed despite proven support of the other assumptions of the same can be addressed in further research using more rigorous and sound econometric techniques.

**Keywords:** Rybczynski theorem, Factor endowments, Factor intensity, Labor Force, Terms of Trade.

### 1. Introduction

This research examines the change in factor endowment of India and checks whether the Rybczynski theorem holds for the trade pattern of India for the time period 1980 to 2015. Assumptions of the theorem are conducted to scrutiny. Two factors of production, labor force and capital stock are used and three labor intensive sector and three capital intensive products are used in the model.

#### 1.1. Why India?

Before the drastic measures adopted in 1990, India was a relatively closed economy and much of its production was carried out by public sector. India was mainly a labor abundant economy producing labor intensive commodities. Post 1990, Liberalization, Privatization and Globalization Reforms adopted which changed the outlook of the Indian Economy.

##### 1.1.1. Liberalization, Privatization, Globalization

In the 1990s, the then Prime Minister Narasimha Rao along with then Finance Minister Dr. Manmohan Singh implemented ground-breaking economic reforms which determined the economic growth of India. LPG was introduced whose main objective was to make India the fastest growing economy among the developing nations to match the developed economies of the world.

1. Liberalization: Loosening government regulations.
2. Privatization: Participation of private institutions and transfer of ownership from public sector (government) to private sector.
3. Globalization: India opened its economic boundaries and started operating on an international level.

These economic reforms targeted the growth and efficiency of India and promoted foreign investment, international trade, abolished license raj and implemented various tax reforms which has led to increase in capital endowment over the years.

### 1.1.2. Transition from labor abundant to capital abundant

Following the LPG reforms, India made a gradual shift from a labor abundant to capital abundant economy with increasing foreign investments in the economy. Therefore, India makes an interesting case to test how much accelerated capital endowment has affected the outcome of labor intensive sectors.

### 1.2. Rybczynski theorem

Let  $L$  be amount of labor,  $K$  be amount to capital,  $X$  be the labor-intensive commodity and  $Y$  be the capital-intensive commodity.

The Rybczynski Theorem states that “At constant commodity prices, an increase in the endowment of one factor will increase by a greater proportion the output of the commodity intensive in that factor and will reduce the output of the other commodity” [1].

Thus, if labor doubles, as per the theorem, the output of labor intensive commodity should be more than doubled while the output of capital intensive commodity should decrease, given the prices of commodities remain constant. This more than proportionate increase in labor intensive commodity is called The Magnification Effect.

The underlying intuition behind the theorem is that for commodity prices to remain constant, the input prices should remain constant for which the  $K/L$  ratios should remain constant. This can only happen when production of  $Y$  decreases, which releases enough  $K$  in order to absorb the increased  $L$  in labor intensive commodity.

Therefore, for the theorem to hold, 2 things should be observed:

Magnification Effect Constant  $K/L$  ratio over the given time period

## 2. Data and Methodology

### 2.1. Data source

A major source of data for our research is the KLEMS database (Capital (K), Labor (L), Energy (E), Materials (M) and Services (S)) which was prepared as project under RBI [2]. We use the data on output, labor force and labor quality from KLEMS Database. FRED Database [3] is used for taking Capital Stock data, while the data on trade is taken from WITS (World Integrated Trade Solution) website [4].

### 2.2. Identifying sectors

The selection of sectors was done based on the  $K/L$  ratio of 1980 calculated from the KLEMS database, from which 3 for top 5 labor intensive sectors and 3 from top 5 capital intensive sectors were selected. Table 1 gives the calculated  $K/L$  ratios.

Table 1.  $K/L$  Ratios of all selected sectors

Labor Intensive Sectors	$K/L$ Ratio (1980)	Capital Intensive Sectors	$K/L$ Ratio (1980)
Agriculture, Hunting, Forestry and Fishing	2.552206	Machinery, nec.	24.91566
Textiles, Textile Products, Leather and Footwear	3.172938	Electrical and Optical Equipment	47.86899
Wood and Products of wood	1.372304	Coke, Refined Petroleum Products and Nuclear fuel	62.47964

### 2.3. Identifying output and input growth

The data for gross output at constant prices for the selected sectors was collected and indexed for the simplicity of calculation. Indexing is carried out for all the data collected to maintain uniformity throughout the findings. After getting the output data, we collected data for the above-mentioned inputs: labor force and capital stock. Data for labor basically means the labor force of India and for capital it is the capital stock, both from 1980 to 2015. The method used to approximate the growth of these two inputs is given:

Table 2. Changes in labor force and capital stock over the selected time period

	1980	2015	Percentage change
Labor force	335309031	494963721	+47.61%
Capital Stock (constant) (in million US \$)	4902708.500	21898016.000	+346.65%

Table 2 clearly shows that though both the inputs here have increased but capital has increased relatively much more than labor, almost 8.5 times compared to labor. However, the Rybczynski Theorem postulated the effects while keeping the other factor to be constant. Therefore, to estimate the outcome of the theorem, the relative increase should be taken into consideration. Also, when both the factors increase, it is possible that production of none of the commodities decrease.

The best way to separate the effects of labor and capital stock on the output of a commodity 'i' is to run regression on the output of all the commodities. On this basis, we form the following regression equation:

$$Output\_Index_i = \alpha_i + \beta_1 Labor\_Force\_Index_i + \beta_2 Capital\_Stock\_Index_i + u_i$$

Where  $\alpha_i$  is constant and  $u_i$  is the error term.

Since the data used are indexed values, a more than proportionate increase in output of a commodity can be indicated when the value of regression coefficients ( $\beta_1$  and  $\beta_2$ ) is  $>1$ . When there is less than proportionate increase in the output, the value of coefficients will be  $<1$ .

As both labor and capital are increasing, the decrease in output of the other commodity might not be observed, however, the increase in the output of that other commodity will always be less than proportionate. Based on this hypothesis, Table 3 shows the expected results if the Rybczynski theorem holds:

Table 3. Hypothesized values of regression coefficient based on the theorem

Output	$\beta_1$	$\beta_2$
Labor Intensive Commodity	$>1$	$<1$
Capital Intensive Commodity	$<1$	$>1$

### 3. Results and Findings

#### 3.1. Magnification effect

Table 4. Values of regression coefficients of Labor intensive commodities

Labor Intensive Commodities		
	$\beta_1$	$\beta_2$
Agriculture, Hunting, Forestry and Fishing	1.00894**	0.159659**
Textiles, Textile Products, Leather and Footwear	0.497869	1.65778
Wood and Products of wood	-0.931428	0.168379

From the Tables 4 and 5, we observe that the magnification effect of the theorem is observed in all the selected capital-intensive industries, while it holds only for the agriculture sector among the labor-intensive commodities.

Table 5. Values of regression coefficients of capital intensive commodities

Capital Intensive Commodities		
	$\beta_1$	$\beta_2$
Machinery, nec.	-0.102798**	2.27928**
Electrical and Optical Equipment	-0.800132**	5.58838**
Coke, Refined Petroleum Products and Nuclear fuel	0.557954**	1.69514**

One of the reasons why Textile and Wood sector show the behavior of capital intensive commodities is that these sectors significantly improved their K/L ratios during the time period 1980-2012 (Figure 1). If we treat these sectors as capital intensive sectors, then the magnification effect holds. Therefore, magnification effects hold for India.

### 3.2. Constant K/L Ratios

To explain the intuition behind the theorem, it is necessary that K/L ratios of all the commodities remain the same, so that  $w/r$  remains constant leading to constant relative prices. The K/L ratios of the selected commodities over the given time period is as follows:

Figure 1. K/L ratios over the selected time period

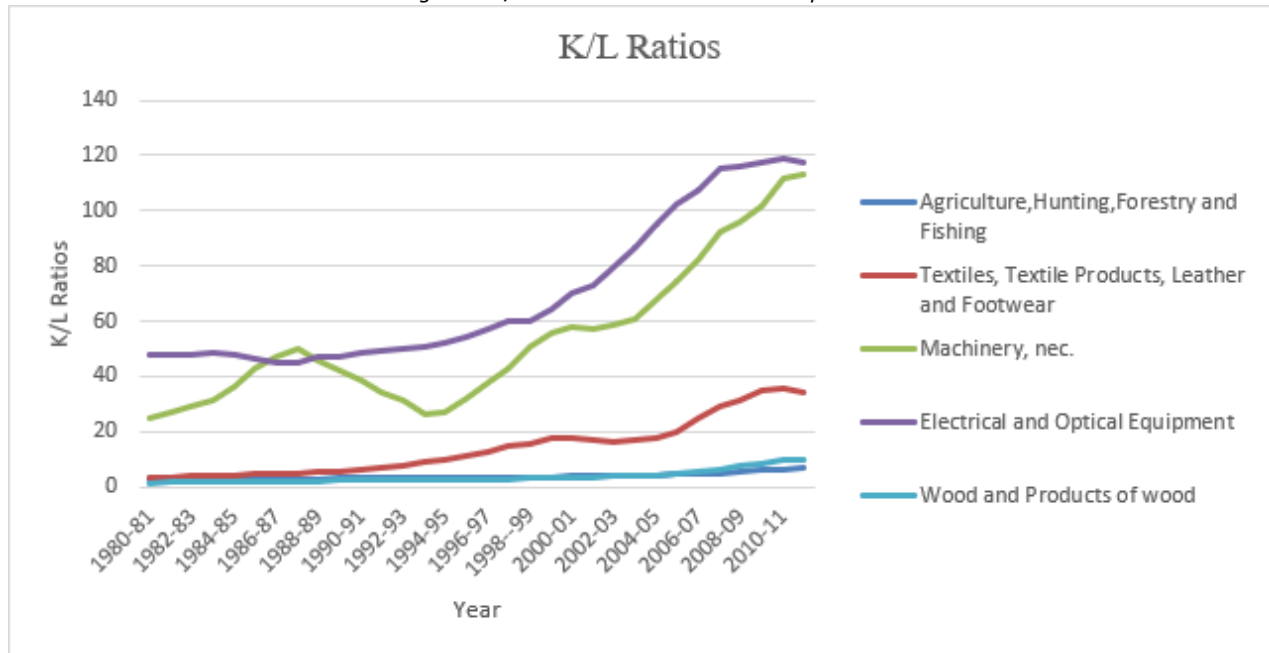
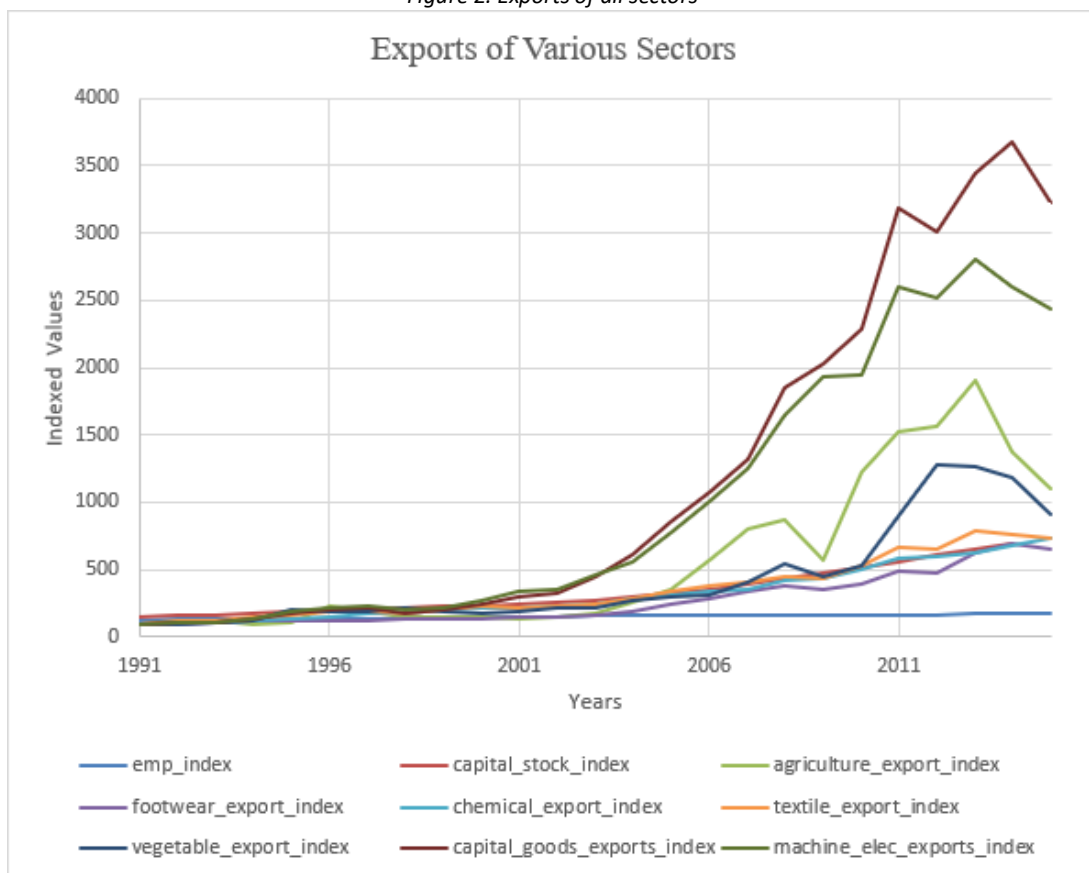


Figure 2. Exports of all sectors



As shown in the Figure 1, the K/L ratios all sectors except agriculture drastically rise during the given period. This implies that the relative commodity prices must have changed during the given period. This change in relative commodity prices can also be used as an explanation for drastic rise in exports shown in Figure 2. Note that the amount of sectors shown in this figure is more since the data is extracted from the different database, the WITS Database. To conclude, even though we see Rybczynski pattern in the outputs, but we don't find the K/L ratios to be constant. Therefore, the Rybczynski theorem doesn't hold for the case of India.

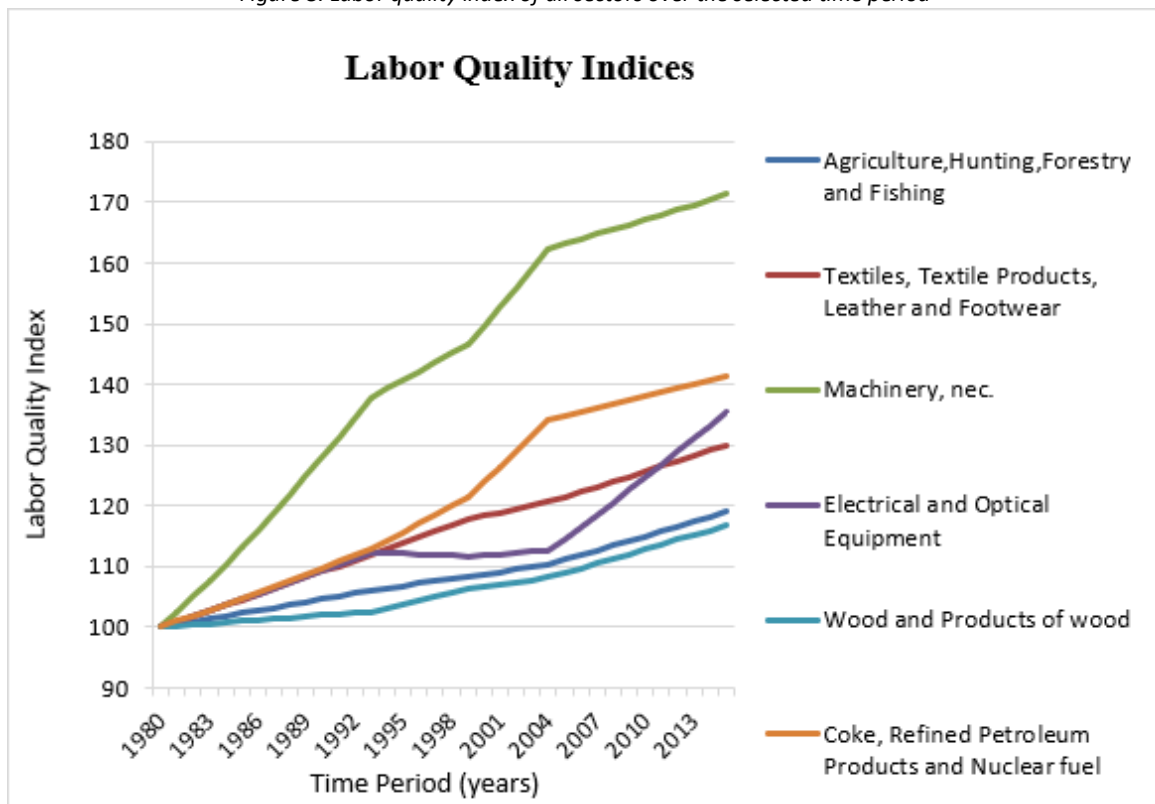
#### 4. Reasons

In this section, we try to evaluate the reasons behind why we witness a magnification effect despite the theorem not holding and also share some of our findings.

##### 4.1. Improving labor quality

Labor quality improves when the workers start getting education and becomes equipped with new skills. The KLEMS database provides Labor Quality Index which is measured using the data on labor's education, training and the amount spent on its development. This index can be used as a proxy for human capital. Figure 3 shows that the labor quality of all sectors has improved significantly in the observed time period, especially in capital intensive sectors.

Figure 3. Labor quality index of all sectors over the selected time period



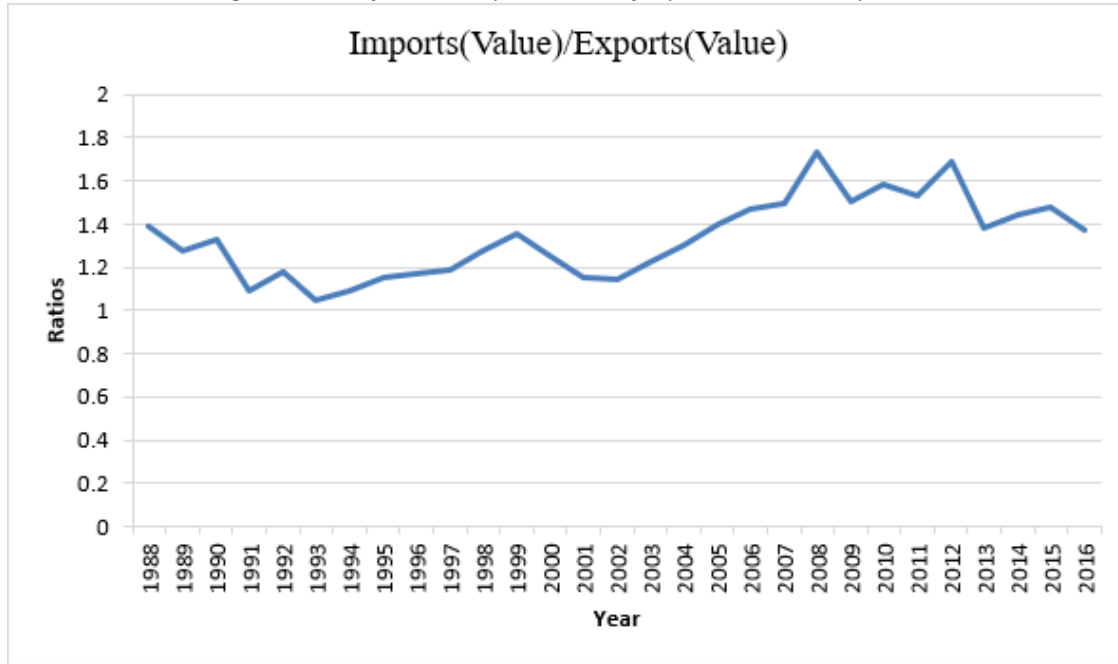
##### 4.2. Improved capacity utilization

In [5] finds that in the pre-1991 period, most of the industries which ran under public sector were very inefficient. As per the study, the capacity utilization in some industries during that period even reached 40-50%. Encouragement to private sector after the reforms improved the capacity utilization of the industrial sector. This gives us an idea that the production in 1980s period used to occur well below the country's PPF and after the reforms; it approached the full utilization point. The high inflation during the 2013 period indicates that the economy overheated during that period, which meant that the output gap was almost closed. Thus, the magnification effect in output was also a factor of increased efficiency of the industries.

**4.3. Fluctuating terms of trade**

The share of India’s exports in the world increased from 0.63% in 1988 to 1.83% 2016. This increased share might have changed the terms of trade of India. Moreover,  $P_x/P_y = \text{Imports (Quantity)} / \text{Exports (Quantity)}$ . We try to estimate India’s terms of trade by taking the ratios of value of imports to value of exports. As per Figure 4, we find it fluctuating during our timeline.

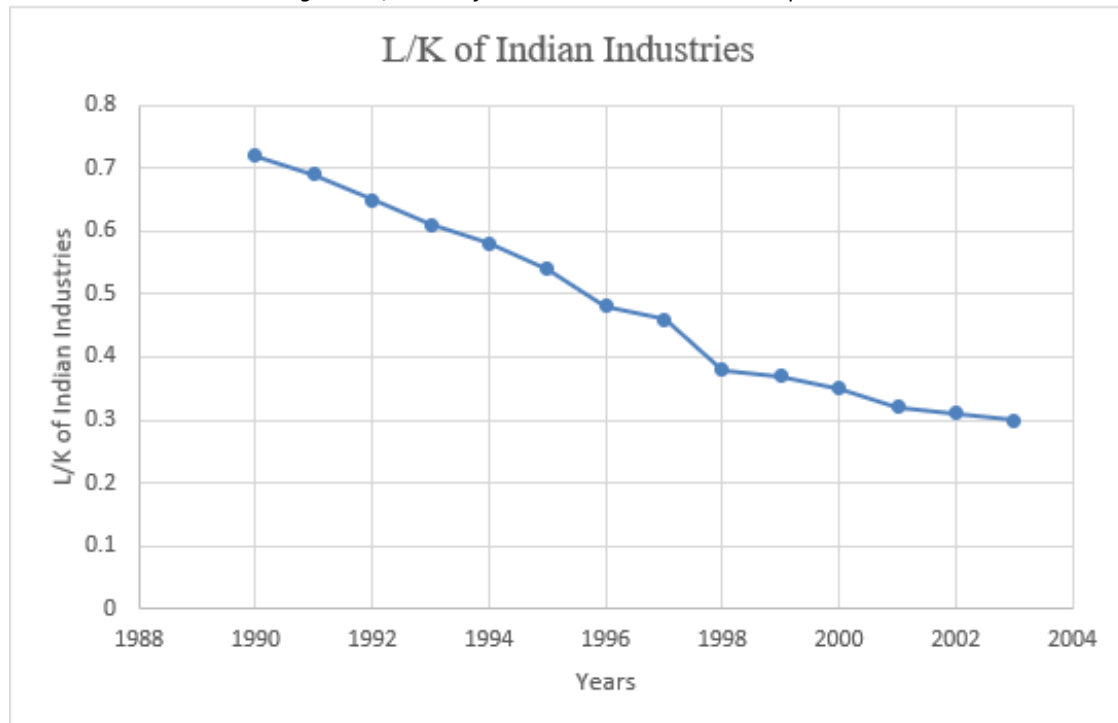
Figure 4. Ratio of value to imports to that of exports over the time period



**4.4. Transition from labor intensity to capital intensity**

In [6] observes that all the sectors in India have gradually become capital intensive as compared to its past and shows that L/K ratio has fallen continuously (Figure 5).

Figure 5. L/K ratio of Indian Industries over the time period



Moreover, as the Figure 1 shows, the K/L ratios of capital intensive sectors have increased significantly as compared to that of agriculture. This indicates increased bargaining power of labor in capital intensive sectors. This might have resulted in higher increase in salaries of industrial workers as compared to agricultural labor. This finding explains the increased regional divergence in India observed by [7] since agriculture is more prevalent in rural areas and industries in urban areas.

## 5. Limitations

The ideal analysis of Rybczynski Theorem must test the variables in kilograms or number of units produced. The unavailability of data in volumes is one particular limitation of our research. However, to avoid this obstacle as much as possible, we have used the constant prices to remove the fluctuations on prices and indexed most of the data to make comparison easy. However, we remain cautioned that the actual results may differ because of taking value instead of volume. Moreover, the tool used for our analysis is a very basic Ordinary Least Squares regression. It is possible that our data might not be following any of the Gauss-Markov assumption, which might risk our estimator not being a Best Linear Unbiased Estimator (BLUE).

## 6. Conclusion

We find the pattern of Rybczynski Theorem in the data of Indian economy from 1980-2015. However, we do not find the supporting evidence which makes holding Rybczynski Theorem sufficient. In the due process, we found that India's production was much below its PPF in the pre-1991 period and now has started moving closer to the full utilization point. Moreover, improving labor quality and rising capital intensity in capital intensive sectors suggests improved bargaining power of labor in these sectors which may be an explanation for regional divergence in the country. Also, India is now a relatively capital abundant country as compared to its past.

## 7. Scope for further research

It is very fascinating to notice that India's output is reacting to the increase its factor endowments in a very similar way as predicted by the Rybczynski Theorem, however, there are no theoretical underpinnings of such a behavior observed. Therefore, we will bring in notice of expert researchers in the field of international trade and development to ask questions like why do we see a pattern like Rybczynski Theorem? We mainly guess that the answer to such question maybe the growth in Total Factor Productivity. However, we still call for formal research to be made in this aspect. Moreover, a more rigorous econometric approach is required to Rybczynski Theorem in India and studies some possible effect it had on the economic development of the country. Even though the conduct of our study was very basic, the results of it encourage us to call the attention for further research in this field.

## 8. Acknowledgements

This study was initiated as an assignment under the course International Economics II. We thank our course instructor Prof. Nahid Fatema (Assistant Professor, Sarla Anil Modi School of Economics) for conducting such a wonderful course and guiding us throughout this project.

## 9. References

1. T.M. Rybczynski. Factor endowments and relative commodity prices. *Economica*. 1955; 22(88), 336-41.
2. KLEMS Database. [https://rbi.org.in/Scripts/BS\\_PressReleaseDisplay.aspx?prid=43504](https://rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=43504). Date accessed: 27/03/2018.
3. FRED Economic Database. [https://en.wikipedia.org/wiki/Federal\\_Reserve\\_Economic\\_Data](https://en.wikipedia.org/wiki/Federal_Reserve_Economic_Data). Date accessed: 18/10/2018.
4. WITS database. [https://en.wikipedia.org/wiki/World\\_Integrated\\_Trade\\_Solution](https://en.wikipedia.org/wiki/World_Integrated_Trade_Solution). Date accessed: 16/08/2018.
5. A. Azeez. Economic reforms and industrial performance: an analysis of capacity utilisation in Indian manufacturing. Centre of Development Studies Working Paper Series. 2002; 1-46.
6. A. Bhatia, B. Kaur, B. Trend of capacity utilization in Indian manufacturing sector. *Gian Jyoti E-Journal*. 2016; 6(2), 1-12.
7. V.D. Praveen Chakravarty. Will GST exacerbate regional divergence? *Economic and Political Weekly*. 2017; 52(25), 97-102.

*The Publication fee is defrayed by Indian Society for Education and Environment (www.iseeadyar.org)*

***Cite this article as:***

Meet Mehta, Priyanshu Raj, Sagar Dasani, Nivedhitha Balachandran, Vaibhav Jain, Vanshika Madaan, Akshay Ghaisas. Testing Rybczynski theorem: case for India. *Indian Journal of Economics and Development*. Vol 6 (11), November 2018.