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2019

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[***Abstract***: *The basic motivation of this work is to find how the sector-wise factor proportions are placed in an open and market driven economy. Literature emphasises a greater relevance of factor proportions in resource allocations for economic activity as compared to intersectoral linkages. However, the measurement of factor requirements is, prima facie, based on direct factor proportions, and can be misleading due to the its partial nature of assessment. Working with the Semi-Input-Output Model provides an advantage to distinguish between tradable and non-tradable sectors while also including the indirect factor use. The analysis confirms an underestimation of factor proportions, if only the direct factor usage is taken into consideration. It also provides a benchmark for comparison of the sector-wise factor proportions. It is insightful to note that most tradable sectors have higher capital coefficients than the corresponding labour coefficients, underscoring stronger than expected capital requirements.*]

JEL Classifications: *C67, D24, D57*

Keywords: Factor proportions; tradables; capital-to-labour ratio; semi-input-output; linkages; India.

1. Introduction

The opening up of Indian economy offered an opportunity for domestic industries to access modern and more sophisticated technologies at one level and Foreign Direct Investment (FDI) flows at another. This process impacts the factor proportions in the

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Acknowledgments: This work draws funding support under the ICSSR project: IMPRESS/P574/01/2018-19/ICSSR. The author is indebted to Professor Atul Sarma for suggesting an approach which focuses on the tradable sectors while also taking into account their interactions with non-tradable sectors. His continued and deep involvement at various stages of work through guidance, inputs and suggestions has been instrumental in shaping the research. However, any shortcomings in the paper are those of the author. An edited version of the paper is published as ISID Working Paper No, 212, October 2019.

economy. At the same time, the existing domestic capital intensive industries also picked up on their technology upgradation drive to stay competitive against the imports, further strengthening their proportion of capital relative to labour. Therefore, it is highly likely to expect a general increase in the number of capital intensive sectors when compared with a national benchmark figure. The traditional labour intensive sectors such as textiles also witnessed a gradual technology upgradation through the use of modern spinning machinery, which has a labour displacing effect. All this suggests a general increase in capital proportion even in the not so capital intensive sectors (ILO, 2018, Rathee, 2016). Capital incentives through one time capital subsidises and reduced credit rates contributed to higher capital proportions in specific industries (Gulhane and Turukmane, 2017).[1]

A recent declining trend in the share of labour in national income has been observed for many countries. At the outset, this would be a conventional finding for the industrialised and developed economies such as the OECD, implying higher returns to capital as compared with the returns to labour. However, some developing countries, including India, have been no exception to the observed phenomena. In India, the share of labour compensation in GDP declined from 0.68 to 0.51 between the period 1991 to 2017.[2] The decline was secular till 2005 and stabilised at 0.51 thereafter. This is contrary to the common perception of constant and invariant labour shares and is likely to have affected the factor proportions at aggregate and sector level. In fact, in India labour intensity is observed to have fallen across industries – both capital-intensive and labour-intensive – due to rising real wages and declining rental price of capital (Sen and Das, 2015). Lower labour share in income has varying implications for different classes of people (Jayadev and Narayan, 2018) sparking the debate on unequal gains from technology or productivity, and globalisation for an economy which has implications of poverty reduction, the first of the 17 Sustainable Development Goals set by the United Nations General Assembly in 2015.

It is in this context that makes it useful to assess India's factor proportion for a recent time period. However, measurement of factor requirements is prima facie based on the direct factor proportion which makes the assessment partial in nature due to exclusion of the interactive effects. It is required to take into account the interactions of different linkages into the production process. The paper maintains focus on tradable sectors of the economy which are more probable to capital expansion in both new and existing firms, through either of the two channels of investment viz. domestic and foreign. Our basic motivation is to find how sector-wise factor proportions are placed in an open and

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[1] Incentives refer to the schemes such as Technology Upgradation Fund Scheme (TUFS) and Amended Technology Upgradation Fund Scheme for Textiles Industry (ATUFS).

[2] As noted from data in Penn World Table, Version 9.1.

market driven Indian economy. We compute and analyse factor proportions in tradable sectors of the economy for a recent year of 2013-2014. By making use of the Semi-Input-Output (SIO) modelling of Tinbergen (1967), we are able to account for the direct and indirect factor proportions in the economy which in provides general equilibrium sense to the analysis.

2. The Measurement Issues

The background dates back to H-O Theory (HOT) of international trade which attributes trade to difference in relative factor abundance between partner countries.[3] A scrutiny of the HOT sparked the famous Leontief paradox (1953) where his findings on the US economy confronted HOT as a capital abundant economy was found exporting labour surplus products. Later, attempting to solve the paradox, Vanek (1968) visualised international trade as disguised trade of factors embodied in the basket of goods traded. His contribution through Heckscher-Ohlin-Vanek (HOV) theorem drifted focus from trade in goods to trade in factors of production embodied in the goods traded, emphasising that a country exports its abundant factor.

Greater relevance of factor proportions in resource allocations for economic activity as compared to sectoral linkages has been emphasised by Riedel (1974). Although, direct factor requirements are relevant for allocations across production and trade flows, total factor intensities are relevant for net trade balance of factors in the traded products (Baldwin, 1971). Likewise, Hamilton and Sevensson (1983) also mandate to consider total factor intensities of traded goods so as to include the direct factor inputs in producing the non-traded goods which are in turn used in production of the traded goods of an economy. Indirect requirement for factors of production are also emphasised by others (Aladdin and Tisdell, 1988). Most earlier studies (Stewart and Streeten, 1971) adopted measures for direct labour requirements in relation to the value added ignoring the factor content of the intermediates used within the specific industry. This, it has been argued, tends to underestimate the factor requirements particularly of industries with high proportionate consumption of intermediate products.

Thus, expansion of output for a given sector entails factor requirements that are estimated based on the factor proportion of the corresponding sector. However, measurement of factor requirements based on the direct factor proportion which makes the assessment partial in nature due to exclusion of the interactive effects with other sectors of the economy. An approach to expand the scope of measurement is to include

[3] The primary work for H-O theorem was done in 1919 by Hecksher, before it was strengthened along with Ohlin in 1933.

the indirect effects so that the factor requirements, both explicit and implicit, of the additional activity are known. While the direct factor requirements are measured proportionate to the capacity expansion of the sector, the indirect effects account for factor usage in the sectors which supply output for intermediate use in the given sector. The IO model proposed by Leontief is equipped to capture the interactive effects of intermediates and using sectors.

However, Tinbergen (1967) has argued for a distinction criterion among sectors of the economy to facilitate development planning in phases. He emphasises that national sectors (which cannot be traded) must be expanded in accordance with domestic demand; while stating that factor returns are more determining in the case of expansion in international (i.e. tradable) sectors (Tinbergen 1967, 99). Tinbergen proposes a formulation of the **IO**, referred as the Semi-Input-Output (SIO) method. By virtue of the distinction between tradable and non-tradable sectors, the SIO is considered to be more focussed on tradables while also maintaining the spirit of a general equilibrium analysis through inclusion of indirect quantities of multiple orders.

With regard to tradables and non-tradable sectors, a strand of literature also shows their differential productivity levels and heterogeneity within the two categories (Mano and Castillo, 2015) thus highlighting the need for a distinguished policy focus.

3. Methodological Approach – Semi-Input-Output Model

The details of SIO method are introduced as follows. The conventional I-O model represents interactions among the m sectors through a system of linear equations corresponding to each sector of the economy. The domestic output of a given sector can be disposed as intermediate use, final demand or traded. Generally, the trade components are subsumed in aggregate final demand. However, given our specific focus on tradables, we show the trade component distinct from other components of final demand viz., private final consumption, government final consumption, gross fixed capital formation and change in inventories, for a given year. Intermediate use is represented through a matrix of intersectoral transactions while the sector-wise output (X_i), final demand (D_i) and trade (B_i) are represented through column vectors as shown in Equation (1).[4]

$$\begin{bmatrix} x_1 \\ \vdots \\ x_m \end{bmatrix} = \begin{bmatrix} x_{1,1} & \cdots & x_{1,m} \\ \vdots & \ddots & \vdots \\ x_{1,m} & \cdots & x_{m,m} \end{bmatrix} \begin{bmatrix} x_1 \\ \vdots \\ x_m \end{bmatrix} + \begin{bmatrix} d_1 \\ \vdots \\ d_m \end{bmatrix} + \begin{bmatrix} b_1 \\ \vdots \\ b_m \end{bmatrix} \dots \dots (1)$$

[4] The variable X traditionally denotes output. Here in addition, we use variable D denoting demand and variable B to denote balance of trade.

where x_i, d_i and b_i denote the output, domestic final demand and net trade and for the i^{th} sector of the economy, i=1,....,m. The Equation (1) can be compactly written as follows:

$$X = AX + D + B \dots \dots (2)$$

$$\text{Or, } X = AX + D + (X - M) \dots \dots (3)$$

Where the column vectors X, D, and B represent output, final demand and net trade. The intersectoral flows are given by the square matrix A of dimension m.

Given our focus on factor proportion of the tradable sectors, which are likely to receive more foreign investments than the non-tradables, we re-arrange the m sectors so that the t tradables are placed above the n non-tradables of the economy (t+n=m). Thus, the elements of the matrices in Equation (1) are ordered as shown in Equation (4).

$$\begin{bmatrix} x_1 \\ \vdots \\ x_t \\ \hline x_{t+1} \\ \vdots \\ x_{t+n} \end{bmatrix} = \left[\begin{array}{ccc:ccc} x_{1,1} & \cdots & x_{1,t} & x_{1,t+1} & \cdots & x_{1,n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{t,1} & & x_{t,t} & x_{t,t+1} & & x_{t,n} \\ \hdashline x_{t+1,1} & & x_{t+1,t} & x_{t+1,t+1} & & x_{t+1,n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{t+n,1} & \dots & x_{t+n,t} & x_{t+n,t+1} & \dots & x_{t+n,t+n} \end{array}\right] \begin{bmatrix} x_1 \\ \vdots \\ x_n \\ x_{n+1} \\ \vdots \\ x_{n+t} \end{bmatrix} + \begin{bmatrix} d_1 \\ \vdots \\ d_n \\ d_{n+1} \\ \vdots \\ d_{n+t} \end{bmatrix} + \begin{bmatrix} b_1 \\ \vdots \\ b_n \\ b_{n+1} \\ \vdots \\ b_{n+t} \end{bmatrix} \dots \dots (4)$$

In effect, we have partitioned the system of m equation into two segments, one each for tradables and non-tradable sectors as shown in Equation (5).

$$\begin{bmatrix} X_t \\ X_n \end{bmatrix} = \begin{bmatrix} A_{t,t} & A_{t,n} \\ A_{n,t} & A_{n,n} \end{bmatrix} \begin{bmatrix} X_t \\ X_n \end{bmatrix} + \begin{bmatrix} D_t \\ D_n \end{bmatrix} + \begin{bmatrix} B_t \\ B_n \end{bmatrix} \dots \dots (5)$$

The intersectoral interactions and the components of final demand and trade can now be expressed as:

$$X_t = A_{t,t}X_t + A_{t,n}X_n + D_t + B_t \dots \dots (6)$$

and

$$X_n = A_{n,t}X_t + A_{n,n}X_n + D_n + B_n \dots \dots (7)$$

According to Equation (6), the output of a tradable sector is dependent upon its intermediate use within tradables, intermediate use by non-tradables, its final demand and traded components which can be re-arranged as shown in Equation (8).

$$X_t = \underbrace{A_{t,t}X_t}_{interactive\ effect\ of\ intermediate\ tradabales\ on\ tradables} + \underbrace{D_t + B_t}_{Final\ demand\ effects\ of\ expansion\ in\ tradables} + \underbrace{A_{t,n}X_n}_{interactive\ effect\ of\ intermediate\ non-tradabales\ on\ tradables} \quad \ldots\ldots (8)$$

In estimating the interactive effects of non-tradables ($A_{t,n}$) on the tradables, through the intermediate input use of the former in the production of latter, the final demand and trade components of the tradable sector will not have a contribution and are therefore dropped from the specification. Thus, any loss of generality Equation (8) can be rewritten as:

$$X_t = A_{t,t}X_t + A_{t,n}X_n \ldots\ldots (9)$$

Equation (9) is reformulated to express the complementary effect of expansion in the non-tradables on the tradables ($A_{t,n}$) through the interaction with the total requirement coefficient matrix of the tradables given by $(I\text{-}A_{t,t})^{-1}$.Thus, we express the indirect effects as:

$$X_t = (I - A_{t,t})^{-1}A_{t,n}X_n \ldots\ldots (10)$$

Further, the interactive effect of output expansion of X_n due to interaction with non-tradables and tradables is expressed in Equation (7) above. Since we are attempting to account for the effect of non-tradable on tradable, essentially through the interlinkages, the term D_n becomes irrelevant for consideration. Also, $B_n=\phi$ given the non-tradable nature of the input under consideration as the sector cannot be traded. Thus, Equation (7) can be simplified as follows:

$$X_n = A_{n,t}X_t + A_{n,n}X_n \ldots\ldots (11)$$

Equation (11) can be transformed to provide an expression for the interactive effect of non-tradable as follows:

$$X_n = (I - A_{n,n})^{-1}A_{n,t}X_t \ldots\ldots (12)$$

Substituting the expression in Equation (12) into the Equation (10), we get:

$$X_t = (I - A_{t,t})^{-1}A_{t,n}(I - A_{n,n})^{-1}A_{n,t}X_t \ldots\ldots (13)$$

The output vector X_t, on the extreme right of the expression takes the value of an identity vector since we are interested in assessing the effects for a unit of expansion. Thus, the right hand side of Equation (13) represents the complementarily effect of non-tradable in

increasing the output of a tradable sector, through inclusion of the interactive effects among the non-tradables and the tradables. It follows that the interaction of indirect expansion in output with the direct factor proportions of tradables, F_t, provides the factors required indirectly by a tradable sector on account of use of a non-tradable. Thus, expanded factor proportions for tradabales are expressed as sum of the direct and indirect proportions as shown in Equation (14).[5]

$$F_t = F_t + F_t(I - A_{t,t})^{-1}A_{t,n}(I - A_{n,n})^{-1}A_{n,t}X_t \dots\dots (14)$$

The vector F_t represents the direct factor coefficients. These are obtained using the RBI KLEMS data.[6] The data provides the shares of labour and capital income in value added for each of the sectors of the economy. Using the proportions, the total value added, as in the economy-wise Input-Output Transaction Table (IOTT), the sub-component of value added on account of labour and capital is computed. The values are used in the overall cost structure of the column to compute the direct factor coefficients for a given sector.

4. Data Sources and Time frame

We make use of the IOTT for the latest available year of 2013-2014 which is based on SUTs for the aforementioned years (Singh and Saluja, 2016). For sector-wise factor proportions, the Reserve Bank of India (RBI) provides KLEMS database for measuring productivity at the industry level (Das et al., 2018). The database provides productivity indicators for 27 economy-wide sectors which are in turn mapped to 130 sectors of the CSO I-O scheme of sectors. We retain each of the 27 sectors for our analysis. The IOTT is aggregated from 130 sectors to 27 sectors of the database. The factor proportions are computed as the share of capital and labour payments in sector-wise output. The 27 sectors are classified into a sub-set of eighteen (18) tradable sectors and nine non-tradable sectors (Table 1). The categorisation of tradables is designed keeping in mind that output of tradables sectors is exportable (as commodity or service) and are more likely recipients of capital and foreign investment. This facilitates our objective to study factor proportions of the tradable sector in Indian economy.

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[5] Note the use of term 'expanded factor proportions. This signifies the increase upon accounting for the interlinkages with the non-tradable used as intermediate input. For clarification, it may be mentioned here that the total requirement coefficients, as refereed in the conventional Leontief I-O modelling, are inclusive of the linkage effects of both tradables and non-tradables, making it difficult to distinguish the effect.

[6] KLEMS stands for capital (K), labour (L), energy (E), materials (M) and service (S) inputs.

Table 1: Sector Scheme of Analysis

*Sector Description**	*Tradable (T)/ Non-Tradable (N)*
Agriculture, Hunting, Forestry and Fishing	T
Mining and Quarrying	T
Food Products, Beverages and Tobacco	T
Textiles, Textile Products, Leather and Footwear	T
Wood and Products of wood	T
Pulp, Paper, Paper products, printing and Publishing	T
Coke, Refined Petroleum Products and Nuclear fuel	T
Chemicals and Chemical Products	T
Rubber and Plastic Products	T
Other Non-Metallic Mineral Products	T
Basic Metals and Fabricated Metal Products	T
Machinery, nec.	T
Electrical and Optical Equipment	T
Transport Equipment	T
Manufacturing, nec; recycling	T
Electricity, Gas and Water Supply	N
Construction	N
Trade	N
Hotels and Restaurants	N
Transport and Storage	N
Post and Telecommunication	N
Financial Services	T
Business Service	T
Public Administration and Defense; Compulsory Social Security	N
Education	T
Health and Social Work	N
Other services	N

Note: The table provides classification of the sectors into tradable and non-tradable sectors.

* Description as used in RBI, KLEMS database.

Source: Authors' classification of tradable and non-tradable based on the tradability of the sector output.

5. Results and Discussion

Sectors of the economy comprise tradable and non-tradable sectors. The tradable sectors include the goods and services which are exposed to international competition. Remaining sectors of the economy are classified as non-tradable which include utilities (such as power generation), public administration and construction activities among others. The importance of tradables for the economy is recognised through their greater contribution, compared with the contribution of non-tradables, in each of the key indicators of structure of the economy. The tradables account for 60% of total output, 73% of intermediate use, 87% of the exports and 76% of total FDI.[7]

However, while maintaining focus on tradable sectors of the economy, it is also necessary to take into account their interactive effects with the non-tradables given the roundaboutness of the production process where the tradables depend on inputs from the non-tradables. The inclusion of this interaction, in estimating the factor proportions, is the mainstay of analysis in the present paper.

The present paper uses the share of factor income in total output as an indication of factor proportion of a given sector. For instance, the shares of labour and capital income in total output of a tradable sector represent the labour and capital proportion (or intensity) of the sector, respectively. These are also referred as direct labour and capital coefficients, respectively, in the I-O terminology as they represent the requirement of the corresponding factor in one unit of the sector output. The SIO model expands the scope of measurement in the direct coefficients to provide expanded factor coefficients whicha re inclusive of the interactive effects of non-tradables.

The sector-wise expanded factor proportions of labour and capital, as computed using the RBI KLEMS data, are provided in Table 2. In order to assess the relative use of factors among sectors, the necessary benchmark is chosen as the average of all tradable sectors, referred as the group average. The average expanded capital coefficient of the tradable group is observed as 0.252 while the average expanded labour coefficient of the group is 0.174, indicating a relative higher capital use in the tradable sectors at an aggregate level. The accounting of labour and capital use of non-tradable inputs into the tradable sectors is useful to reflect upon the factor requirements of the economy in a more realistic manner.

At a sector level, a comparison between the labour and capital coefficients is helpful to inform the relatively higher capital intensity of nearly all sectors.[8] The only noted

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[7] Figures correspond to the year 2013-14.

[8] Henceforth in the paper, factor coefficients refer to the expanded coefficients as obtained from the SIO model upon inclusion of their interactive effect with the non-tradables.

exceptions are agriculture and allied, manufacturing nec, and education as using more labour than capital in a unit of sector output (refer column (4) of Table 2).

The computations of factor proportions, using the SIO modelling in the paper, show that the expanded labour coefficient for the tradable group increases by 7% over the direct labour coefficient, while the increase is higher by 10% in case of the expanded capital coefficient of the group (Table 2).[9] The higher capital and labour coefficients are attributed to the use of three key non-tradable across all tradables. These are trade¸ electricity, gas and water supply and transport and storage. Within the three dominant non-tradable inputs, the trade sector has notable high capital and labour proportions when compared with the electricity and transport and storage sectors, and also in comparison to the remaining non-tradable sectors. Also, the relatively higher capital proportion for each of the before mentioned three non-tradables has contributed to greater expansion in capital proportions of the tradables. Therefore, their inclusion contributes to improved estimates of factor proportions, which, in turn, makes the assessment of factor requirements more realistic for policy and planning.

Comparison against the group average is helpful to mark the sector as the one which uses a given factor more intensively. The sector-wise expanded factor coefficients for all 18 tradable sectors are reported in Table 2 (refer column (2) and (3)). Only six sectors have labour coefficients exceeding the benchmark group average of 0.174. These are agriculture and allied, mining, manufacturing nec, financial service, business service, education ((refer column (5) of Table 2). Likewise, agriculture and allied, mining, non-metallic mineral products, financial service and business service are identified as the five capital intensive sectors. It is intriguing to note that the capital intensive sectors of the economy span beyond the conventional secondary manufacturing products such as non-metallic mineral products; to also include primary and tertiary sectors such as the agriculture, mining, financial services and business services.

Table 2: Sector-wise Expanded Factor Coefficients, Tradables

Sector Name	*Expanded factor coefficient*		*Factor with greater use**	*whether Labour intensive***	*whether Capital intensive****
	Labour	***Capital***			
(1)	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***
Agriculture and allied	0.459	0.387	Labour	intensive	intensive
Mining	0.196	0.559	Capital	intensive	intensive
Processed food	0.096	0.146	Capital		
Textile and leather	0.142	0.181	Capital		

[9] For brevity, only expanded coefficients are reported in the Table.

Sector Name	*Expanded factor coefficient*		*Factor with greater use**	*whether Labour intensive***	*whether Capital intensive****
	Labour	***Capital***			
(1)	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***
Wood products	0.174	0.194	Capital		
Paper, printing and publishing	0.152	0.159	Capital		
Coke and petroleum products	0.009	0.184	Capital		
Chemical products	0.075	0.247	Capital		
Rubber and plastics	0.073	0.160	Capital		
Non-metallic mineral products	0.118	0.268	Capital		intensive
Basic metal products	0.067	0.196	Capital		
Machinery nec	0.076	0.144	Capital		
Electrical equipment	0.130	0.209	Capital		
Transport equipment	0.099	0.236	Capital		
Manufacturing nec	0.187	0.118	Labour	intensive	
Financial service	0.279	0.571	Capital	intensive	intensive
Business service	0.263	0.342	Capital	intensive	intensive
Education	0.542	0.232	Labour	intensive	
Tradables (average)	0.174	0.252			
Increase over direct coefficient	7.0	10.3			

Notes: * Factor with greater use is Labour if Col (2)> Col (3); Capital otherwise.

** A sector is considered labour intensive if it has an expanded labour coefficient more than that for the average expanded labour coefficient of the tradable sectors as a group

** A sector is considered capital intensive if it has an expanded labour coefficient more than that for the average expanded capital coefficient of the tradable sectors as a group

Source: Authors' computations.

6. Conclusions

Quite often, the factor proportions are studied for either labour or capital separately, or in a comparative framework. The research interests are generally driven by factor abundance or scarcity. In this paper, we are interested to re-assess the factor proportions for all the tradable sectors of Indian economy for a recent period for which the data is

available in an economy-wide framework. The focus is on tradables which are more likely to register expansion in output, export and FDI.

The methodology followed for the analysis provides a refinement over the existing estimates of factor proportions. The SIO approach adopted in the paper recognises that relative factor intensity of production of any given commodity is not only determined at the ultimate stage of production, it is also important to account for factor proportions at the intermediate stage. The separation of sectors into tradables and non-tradables allows for improved estimates through inclusion of the impact of expansion of non-tradables on tradables, an issue unaddressed before.

The analysis confirms an underestimation of factor proportions, if only the direct factor usage is taken into consideration. It also provides a benchmark for comparison of the sector-wise factor proportions. It is insightful to note that most tradable sectors have higher capital coefficients than the corresponding labour coefficients. The observation for the not so capital intensive tradables only underscores on the greater capital requirements across sectors.

The finding on the relatively high capital share in the not-so capital intensive sectors not only contributes to the debate on the share of labour but also provides insights and inputs for polices based on the relative factor proportions. Depending upon the sector-wise factor proportions, growth can result in varying factor shares at aggregate level which can further be influenced through greater integration with the world, whether through the channel of trade or through investment.

The observation of greater proportion of capital makes a case for policy intervention to align the present level of skills with a different spectrum more suited to capital-intensive sectors. The industrial policy should aim to address the price distortions, which are irreversible in the context of capital; and skill deficit. An industrial policy supportive to labour productivity will be helpful in increasing substitutability between capital and labour, while improving labour intensity through increased job prospects in modern and dynamic production.

Although we have sincerely attempted to capture the roundaboutness in production structure issues, the scope of the present research prevents us from simultaneously dealing with non-tradables. Nonetheless, we are mindful of the limited scope and suggest future work in this direction. s. Given the primarily time-static nature of the present paper, it becomes necessary to also see the dynamism in labour shares over time and space. This is intended as a follow up exercise to the present paper. As an immediate follow-up of the present research, an evaluation of factor proportions vis-a-vis structure of the economy is work-in-progress.

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