

## Performance Assessment of the Storage and Warehousing Industry in India

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### Abstract

*This study is an attempt to analyse the performance of the storage and warehousing (S&W) Industry in India using the Annual Survey of Industries (ASI) unit level data for the years 2005-06 and 2009-10. It aims to bridge the gap in the current policy discourse regarding the development of this critical infrastructural sector by focussing on the supply side analysis, with special emphasis on the refrigerated S&W in the backdrop of (a) it being the dominant sub-sector in the S&W industry and (b) the lopsided state-level infrastructural gap assessed by the National Centre for Cold-chain Development constituting the demand-side analysis. The performance of the sector and its sub-sectors – non-refrigerated S&W and refrigerated S&W, are assessed in terms of critical financial and economic ratios. Further, inter-zonal variation in the performance of the refrigerated S&W sub-sector is assessed using the ANOVA tests on the key parameters. The study goes on to estimate the cross-sectional translog production function to capture the extent of factor substitutability between labour (L), capital (K) and energy (E) in the refrigerated S&W sub-sector. The analysis reveals that overall productivity and resource-use efficiency in the S&W industry and its sub-sectors has improved from 2005-06 to 2009-10. The zone-wise analysis carried out for refrigerated S&W reveals that there is significant variation in the performance of this sector across zones on account of differences in resource use efficiency, productivity of labour and capital, labour cost, and electricity use. Further, the estimated elasticity of substitution among different inputs for the refrigerated S&W sector turns out to be less than unity.*

### 1. Introduction

1.1 The Storage and Warehousing (S&W) industry is seen as a critical link in a country's overall logistics value chain, whose growth and modernization are imperative to overall economic growth. S&W units have evolved rapidly from the traditional four-walled *godowns*, to modern and sophisticated multi-purpose, non-refrigerated and climate controlled refrigerated (cold) stores which are equipped with modern facilities of collecting, segregating, sorting and storing agricultural perishable and non-perishable goods, raw materials and finished manufactured goods. In India, the S&W sector is evolving, albeit rather slowly, from a traditional business handling setup to becoming a critical link in an integrated logistics network.

1.2 The growth in S&W industry in India is primarily being driven by growing manufacturing activity, rising and changing pattern of domestic consumption, increasing international trade, the emergence of organised retail in the country and increasing private and foreign investments in infrastructure with the easing of government regulations. With the change in consumer demand in favour of high value products and horticultural crops, the importance of modern multi-purpose cold store warehousing has grown manifold. The number of cold stores and the total cold storage capacity has increased by nearly 50% and 60% respectively between 2004 and 2014.

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1.3 The National Centre for Cold Chain Development (NCCD, 2015) carried out a comprehensive demand-side analysis of the cold chain infrastructural capacity in India. The study estimates both the installed and required capacity across the different cold chain segments. The state-wise break-up of the installed as well as required capacity has been thus assessed to highlight the demand and supply mismatch. This analysis is of crucial significance in the context of a developing economy such as India which has a large population base to cater to, in the backdrop of their changing dietary habits and rising demand for perishable items. It is emphasised in this context that it is the lack of adequate storage facilities which result in loss of agricultural produce and acts as a major hindrance in ensuring the availability of good quality products for consumption during off-season period and stumbling block in realising the objective of food security.

1.4 The development of equipped infrastructural capacity in terms of storage facilities holds a key significance in addressing the issue of inflation of agricultural produce and stabilising their prices during the off-season. This paper aims to address the supply side aspect of the critical 'storage and warehousing' industry that has been largely ignored in the recently conducted NCCD (2015) study in the Indian context. It is to be noted here that the scope of this paper is more focused on but not restricted to, the refrigerated S&W sector of the overall S&W industry. It aims to provide a comprehensive analysis of the different sub-industry groups within the S&W industry. Such an analysis becomes significant in view of the factors such as growing population, rapid urbanisation and rise in per capita income that are driving the structural transformation of the food economy in the country. Further, it is imperative to understand the business environment of this industry and its evolution and growth in the past. This is crucial for understanding the nature of government intervention and designing policy instruments for attracting investment in this sector, to meet the capacity requirements in the times to come.

1.5 This paper is organised as follows. Section 2 lays out the objectives and scope of this study, followed by section 3 on data used. Section 4 presents a brief overview of the structure of the S&W industry in India, followed by detailed sectoral analysis in section 5 and inter-zonal analysis in section 6. Section 7 focuses on analysis of factor substitutability in the refrigerated S&W sector, followed by policy conclusions in section 8.

## **2. Objectives and Scope of the Study**

2.1 The main objective of this study is to understand the existing structure of the organised S&W industry in India. This is achieved by analysing its performance at all-India level based on key industrial financial and economic parameters. Given the growing dominance of the Refrigerated S&W sub-sector within the overall S&W sector in terms of its share in overall sector's value of output and value added, this study focuses on its performance across states by undertaking detailed zone-wise analysis (where states are categorised into six zones). The study also estimates cross-sectional translog homothetic and non-homothetic production functions to examine the estimated elasticity of substitution measures among factor inputs in the Refrigerated S&W sub-sector and draw inferences about the future impact of potential growth in this sub-sector on overall demand for labour and other inputs, possibilities of substitution between labour, capital and energy inputs and the challenges these may pose to sustainable growth in this sector. The study aims at highlighting key policy challenges and issues for addressing capacity constraints in this crucial infrastructural sector.

2.2 The scope of analysis is defined by the objectives laid out in this study and the data available. Data at five digit level is used for the sub-sectors of the S&W industry. See Table 1 for NIC-2004 and 2008 codes of the sub-sectors under the S&W industry as adopted in 2005-06 and 2009-10 five digit level data respectively.

2.3 Analysis of aggregates and critical financial and economic ratios calculated on the basis of unit specific information in ASI datasets is aimed at deriving:

- (i) Measures of resource use efficiency and overall productivity,
- (ii) Measures of different input intensities and input productivity,
- (iii) Contribution of various inputs to Net value added and their share in cost of production,
- (iv) Various financial ratios that capture the sector's financial performance such as the Debt rate and Profit rate,
- (v) Other ratios that provide a summary measure of the overall business environment and sectoral efficiency.

2.4 Such analysis is carried out for the years 2005-06 and 2009-10, at various levels, i.e. (i) All India level sectoral analysis of the S&W industry and (ii) Inter-zonal analysis of Refrigerated S&W industry, wherein state-level data is aggregated into data for six zones. Further, this study estimates a cross-sectional translog production function in order to ascertain input substitution possibilities in the Refrigerated S&W sub-sector for the year 2009-10. The methodology adopted is given in section 7.1 of this paper.

### 3. Data Used in the Study

3.1 This study deals with the organised segment of the S&W industry in India and carries out the analysis based on unit level data from the *Annual Survey of Industries* (ASI), brought out by the Central Statistics Office, Government of India. Data from ASI rounds of 2005-06 and 2009-10 are used to assess the performance of the sector over the five years period. Units belonging to the S&W industry at four digit level, categorized further into its sub-sectors at five digit level of NIC-2004 (in ASI 2005-06) and NIC-2008 (in 2009-10) classification are chosen for the study. All industrial parameters with monetary values are deflated using the wholesale price index of manufactured products (from the Ministry of Commerce and Industry, GOI) with 2004-05 as the base year. This study uses variable definitions given in ASI supporting documents and the tabulation procedures laid out are strictly adhered to in arriving at certain aggregates. These definitions and concepts as reported in ASI supporting documents and the definitions of derived ratios used in this study are given in Appendix I.

3.2 In 2005-06 and 2009-10 ASI data, there are a total of 410 and 381 units respectively as per block A of ASI schedule, belonging to the S&W industry in India. However, block B of ASI 2005-06 and 2009-10 does not contain certain required information<sup>2</sup> for as many as 41 and 42 units respectively. Thus, the total number of units in the ASI data for 2005-06 and 2009-10 considered for selecting the sample for the study reduces to 369 and 339 units

<sup>2</sup> Block B of ASI schedule provides information regarding the financial period for which a unit reports data in the ASI survey. In the absence of such critical information for 41 and 42 such units in ASI 2005-06 and 2009-10 data respectively, the analysis cannot be carried out for these units.

respectively. Further, for the sake of analysis, the study considers the sample to consist of only those units that were in operation (i.e. units with unit-status = 1, 17, 18, 19 and 20). Based on this criterion, the sample size is ascertained as 351 and 325 for 2005-06 and 2009-10 respectively. These units are classified across different sub-sectors of the S&W industry in India, i.e., a) *Non-refrigerated S&W*, b) *Refrigerated S&W (or cold storage)* and c) *S&W others*. For the year 2005-06, the number of units belonging to the 'Non-refrigerated S&W', 'Refrigerated S&W' and 'S&W Others' sub-sectors were 8, 315 and 28 respectively. For the year 2009-10, these numbers were 11, 293 and 21 respectively. The state-wise distribution of the chosen sample for ASI rounds 2005-06 and 2009-10 and its corresponding composition as per the ASI frame are shown in Table 2. It is noteworthy here that the 'Refrigerated S&W' (or cold storage) sub-sector is the dominant sub-sector within the S&W industry, accounting for approximately 90 per cent of the total units belonging to the S&W industry over the concerned period.

#### 4. Structure of the S & W Industry in India

4.1 Warehousing or storage refers to "holding and preservation of goods until they are despatched to the consumers"<sup>3</sup>. A large variety of commodities such as food grains, food products, pulses, spices, food stuffs, oilseeds, oils, sugar/ jaggery, fibres, seeds, feed /fodder, perishable commodities (such as fruits and vegetables), dairy products and miscellaneous items (such as pharmaceutical products) create demand for suitable storage facilities post-harvest or post-production or manufacturing.<sup>4</sup> The primary objective for storage is to make commodities available for final (or intermediate) consumption to meet consumers (or food processing industry) demand independent of time and space barriers, since the production of several commodities is seasonal in nature (mostly agricultural produce). Besides availability concerns, it is crucial to ensure that commodities are stored in suitable atmospheric conditions, to be sold for final (or intermediate) consumption as and when demand arises while maintaining their quality in the intervening period. However, with the advent of globalisation and strengthening of global supply chains and even the spread of organised retail chains and rapid growth of e-commerce, the role of warehouses has transformed far beyond just being the facilities relevant for holding inventories.<sup>5</sup>

4.2 Storage requirements could be temporary in nature or can be for short, medium or long term influenced to a great extent by the nature of product and its market conditions. On account of increasing demand for storage services spanning across wide range of commodities, the storage methods have evolved over time. Broadly speaking, these can be classified as: (a) traditional storage methods and (b) modern storage methods. Traditional methods include natural storage, artificial storage, ventilated storage and storage with ice refrigeration. Modern methods include storage with mechanical refrigeration, controlled atmosphere storage and modified atmosphere packaging (Rao, 2015).

4.3 In principle, warehouses can be classified into different types on the basis of criteria such as its stage in the supply chain, geographic area, product type, function performed, type of ownership, company usage (dedicated or shared-user), area, height

<sup>3</sup> [http://www.archive.india.gov.in/business/manage\\_business/warehousing.php](http://www.archive.india.gov.in/business/manage_business/warehousing.php), accessed on 15<sup>th</sup> June, 2016.

<sup>4</sup> This classification is in accordance to the warehousing industry.

<sup>5</sup> Besides inventory holding point, warehouses are now performing a variety of roles such as consolidation centre, cross-dock centre, sortation centre, assembly facility, trans-shipment point and returned goods centre (For details kindly refer to Rushton *et al.* 2014).

and equipment, subject to the availability of detailed information regarding these characteristics (Rushton, Croucher and Baker, 2014). In the Indian context, warehouses are generally classified on the basis of ownership type as - a) private, b) public, c) government, d) bonded and e) co-operative warehouses. Private warehouses are owned and managed by the manufacturers or traders for their own commodities. Public warehouses are the ones which are set up after obtaining the license from the government and provide storage services to public in general (such as manufacturers, wholesalers, exporters, importers etc.). In contrast to public warehouses, government warehouses are owned, managed and controlled by government at the central, state or local level and even by public corporations. Such warehouses deliver storage services to the government and private enterprises. Bonded warehouses are generally situated near the ports and are managed by the government or government agencies such as custom authorities. Cooperative societies own, manage and control the co-operative warehouses.

4.4 The ownership pattern and the organisation structure of units belonging to the organised S&W industry is skewed heavily in favour of wholly privately owned units and those that are Private limited companies or Partnership companies (ASI 2005-06 and 2009-10).

## **5. Sectoral Analysis of S & W Industry in India (2005/06 – 2009/10)**

The S&W industry remained buoyant during the 2005-06 to 2009-10 period. It witnessed an annual average growth rate of 51% in its profits, while Gross Value Added (GVA) per unit total output and GVA per unit total input grew at 18% and 32% per annum respectively depicting an improvement in overall productivity and resource use efficiency. It is, however, interesting to delve further and examine such critical aggregates and derived ratios at sub-sector level. This task is taken up in the following sub-sections. It may be noted that the sub-sector S&W (Others) comprises of units that are heterogeneous in nature and any analysis based on aggregates and derived ratios will not be very meaningful. Thus further in-depth analysis is undertaken for the non-refrigerated and refrigerated sub-sectors of the S&W industry in the sub-sections that follow. Table 3 provides sector-wise details, with all values expressed at 2004-05 prices.

### **5.1 Analysis of the Non-refrigerated S & W Sector**

5.1.1 Growth in this relatively smaller sub-sector over the 2005-06 to 2009-10 period has been phenomenal. Total output in real terms for this sub-sector increased from Rs 9.18 crores (cr.) in 2005-06 to Rs 59.02 cr. in 2009-10, registering an average annual growth rate of 59 per cent. The calculated GVA in real terms increased fourteen-fold from Rs 2 cr. to Rs 28 cr. at an average annual growth rate of 91 per cent during the same period. The ratio of GVA to total output more than doubled from 23 per cent in 2005-06 to 48 per cent in 2009-10, highlighting a significant jump in overall productivity. The ratio of GVA to inputs also registered an increase from 30 per cent in 2005-06 to 91 per cent in 2009-10, reflecting an increase in the efficiency of resource use in this sub-sector.

5.1.2 With respect to factor payments, the average wage per worker (on annual basis) increased from nearly Rs 30,000 in 2005-06 to Rs 49,000 in 2009-10, registering an average annual growth rate of 12 per cent. Debt rate (expressed as a ratio of outstanding loans to sum of invested capital and current assets) declined from 17 per cent to 9 per cent, while the Profit rate (expressed as a ratio of total profits to the sum of invested capital and

currents assets less outstanding loans) increased from a negative 7 per cent to 3 per cent, depicting a decline in reliance on borrowed capital and an increase in returns to the sector's owned capital.

5.1.3 The performance of this sector improved from 2005-06 to 2009-10 as reflected by an increase in all measures of factor productivity such as GVA to worker ratio, total output to worker ratio, GVA to fixed capital ratio and total output to fixed capital (see Table 3).

## 5.2 Analysis of the Refrigerated S & W Sector

5.2.1 Performance of this dominant sub-sector is of particular interest. The sector witnessed rapid growth as total output in real terms for this sector increased by nearly 30 per cent from Rs 950 cr. in 2005-06 to Rs 1200 cr. in 2009-10, registering an average annual growth rate of 7 per cent. Gross value added nearly doubled from Rs 300 cr. in 2005-06 to Rs 560 cr. in 2009-10, growing at an average annual growth rate of 17 per cent. The ratio of GVA to output increased from 32 per cent to 46 per cent during the same period, thus reflecting a more than 50 per cent increase in the overall productivity in this sector. Resource efficiency also improved with GVA to input ratio increasing from 47 per cent in 2005-06 to 84 per cent in 2009-10, registering an average annual growth rate of 16 per cent.

5.2.2 The average wage per worker (on annual basis) grew at annual growth rate of 8 per cent. Debt rate decreased from 37 per cent to 30 per cent while the Profit rate increased from 3 per cent to 8 per cent, registering an average annual growth in profit rate of 18 per cent. This depicts a decline in sector's reliance on borrowed capital and an increase in returns to its owned capital. Except a marginal decline in capital productivity measured in terms of output per unit capital, all the other measures of factor productivity such as GVA per worker, output per worker and GVA per unit capital have grown reflecting an improvement in overall factor productivity over the period under consideration (see Table 3).

## 6. Inter-Zonal Analysis of Refrigerated S & W Industry in India (2005/06 – 2009/10)

In this section, the analysis is focused on the Refrigerated sub-sector of the S&W industry and its performance across states categorised into different zones<sup>6</sup>. A recent study conducted by the National Centre for Cold Chain Development (NCCD, 2015) under the aegis of Ministry of Agriculture and Farmers Welfare, carried out a comprehensive demand-side analysis of the requirement of cold storage infrastructure in India. It provides the most recent and authentic information on the existing agricultural S&W capacity in the refrigerated segment in India and its spread across states. It estimates actual cold-chain capacity requirement for each state based on projected demand for agricultural goods and the existing infrastructural gap in terms of the required vis-à-vis actual capacity for this segment.

Broadly speaking, the development of agricultural S&W in refrigerated segment in India has remained concentrated in few Indian states. This gets reflected from the fact that as many as 10 states account for more than 90 per cent of the total installed capacity in this sector as of March, 2014. Further, if we rank these states on the basis of the installed capacities, Uttar Pradesh emerges as the leader (with a share of more than 40 per cent of

<sup>6</sup>The authors would like to thank suggestions from the Expert Panel during the 7<sup>th</sup> National Seminar on Industrial Statistics (held on 26<sup>th</sup> September 2016, Kolkata), where an earlier version of this paper was presented, on the viability of handling inter-state level analysis using the highly volatile data from ASI at five digit level of classification.

country's installed capacity), followed by states such as West Bengal, Gujarat, Punjab, Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Haryana and Karnataka (see Figure 1 and Table 4).

The growth of this sector has been primarily driven by proximity to production centres and not necessarily by actual demand for the agricultural goods in a particular state / region. This has resulted in lopsided growth of cold chain stores, with many states having cold chain capacity that well exceeds the actual requirement (for example, the installed capacity in Uttar Pradesh is 128 per cent of the actual required capacity, see Table 4). If the states are categorised into six zones based on climatic and geographical features, Zone 5 (comprising of the southern states of Andhra Pradesh, Tamil Nadu, Karnataka and Kerala) has installed capacity which is nearly twice the actual requirement for the zone (see Table 4). This calls for focused policy interventions to address the issue of such lopsided growth of cold storage capacity in the country.

At country-wide level, NCCD (2015) estimates total existing capacity of 31.8 million metric tonnes (MT) and a shortfall of 3.2 million MT. While a shortfall of 10 per cent in the existing cold chain capacity is not a formidable one to fill, it must be noted that ensuring enough cold storage capacity is only part of a successful integrated cold chain. The logistics network requires integrated use of farm-gate modern pack-houses, cold stores and reefer transportation to successfully control and regulate the perishability of farm produce. The shortfall in cold chain capacity exceeds the existing installed capacity by 100 per cent in states like Jammu & Kashmir, Himachal Pradesh, Bihar and some north-eastern states (see Figure 2).

In the backdrop of such uneven spread of cold chain capacity across different states and zones in the country, this section analyses inter-zonal performance of this refrigerated S&W sub-sector during the period from 2005-06 to 2009-10 on the basis of the key financial and economic indicators, to develop an understanding of the business environment of this dominant sector across different zones in India. The composition of the six zones into which all states have been categorised is clear from Table 4. Zones 1 to 6 comprise of states in North, East, West, Central, South and North-East India respectively. Clubbing of states into zones helps overcome to a certain extent, the expected volatility of data at five digit level of classification.

- (i) *Zone-wise analysis of Gross Value Added (GVA)*: The real GVA estimated for this cold storage segment at the all-India level increased from Rs 44,000 lakhs in 2005-06 to Rs 56,000 lakhs in 2009-10, registering an average annual growth rate of 6 per cent. However, the performance varies significantly across zones (see Table 5). GVA in the dominant zone 1, which accounts for more than 50 per cent of installed capacity, has been growing only marginally. While GVA in the eastern zone has been decreasing at 1 per cent per annum, zones 3, 4, 5 and 6 have all shown impressive growth in GVA. The performance of zone 3, which accounts for only 10 per cent of the installed capacity, is particularly impressive, as it contributes more than 40 per cent of GVA by the sector (see Figure 3). This zone, comprising of the western states of Rajasthan, Maharashtra and Gujarat has shown tremendous growth in GVA over the concerned period and has overtaken the erstwhile dominant North zone in terms of its contribution to overall sectoral GVA. The western zone has also shown

impressive growth in GVA per unit output and GVA per unit input, signifying rapid improvement in overall productivity and resource use efficiency. Productivity and resource use efficiency is seen to decline in the central zone and improve only marginally in zones 1, 2 and 6.

- (ii) *Zone-wise analysis of Input Cost:* At the all-India level for this sector, average annual wage per worker increased from Rs 31,000 in 2005-06 to Rs 42,000 in 2009-10, registering an average annual growth rate of 8 per cent. Similarly, average wage per worker increased in all zones under consideration, with the most rapid increase in zone 3, where the wage cost per worker jumped up by 30 per cent per annum (see Table 6). Rapid increase in wage cost may partly explain the declining labour-capital ratio in this sector. Given the nature of this service industry, it employs many contractual workers mostly for carrying out the loading/unloading of goods and stacking them in the storage facility. Even the permanent/regular employees are expected to take on multiple tasks.

Debt rate, defined as the ratio of outstanding loans to sum of invested capital and current assets, qualifies as an indicator of the level of indebtedness of an organisation/entity. As a result, the lower it is, better it is for an organisation implying lower dependence on borrowed capital for financing the investment. Debt rate declined for all zones except a marginal increase in case of zone 1. Share of capital cost (interest cost), represented by the ratio of total interest paid to cost of production increased in zones 1, 2 and 3, while it declined in zones 4, 5, and 6.

At the all-India level, profit rate (defined as ratio of profits to the sum of invested capital and current assets less outstanding loans) for this sector doubled from 13 per cent in 2005-06 to 26 per cent in 2009-10. However, this obscures the reality at zonal level. Negative profit rate in zone 5 in 2009-10 may be result of excess capacity, since this zone has nearly double the required cold-chain storage capacity. However, a negative profit rate in zone 2 in 2009-10 raises concern as negative profit rates imply lower returns to the owned capital and this could be a major stumbling block in encouraging the flow of capital to bridge the gap in the cold storage infrastructural capacity in zone 2.

- (iii) *Zone-wise analysis of Factor Productivity:* As expected, in this sector which has witnessed buoyant growth, productivity of labour (measured in terms of GVA or output per worker) and productivity of capital (measured in terms of GVA or output per unit capital) have grown in most zones over the concerned period (see Table 7). The growth has particularly been impressive in zone 3 on almost all measures of factor productivity. This explains the phenomenal growth in overall productivity and resource-use efficiency attained by this zone over the same period. Zone 5 is the exception where factor productivity declined significantly, which again can partly be explained by the presence of excess capacity.

## 6.1 Analysing difference in inter-zonal variation (ANOVA test)

6.1.1 ANOVA (analysis of variance) tests are conducted to detect if there is a statistically significant difference in the average performance of zones on certain critical ratios. These

tests are conducted for 2009-10 data on the refrigerated S&W sector. The ANOVA analysis results presented in table 8, are summarised below.

(i) While the average GVA per unit output does not vary significantly across different zones in India, average GVA per unit input varies significantly. Thus, it can be said that the extent of value added per unit of input differs across zones and this provides scope for further increase in overall resource-use efficiency in this sector as the laggard zones catch up with the more resource efficient ones.

(ii) Average productivity of capital varies significantly across zones when measured in terms of output per unit capital. Such significant difference in productivity of capital, however, does not result in significant difference in average profit rate. This may be a result of high cost of capital which dampens the profit rate for units which have higher capital productivity, but rely significantly on borrowed capital. The average debt rate does not vary significantly across zones.

(iii) Both average labour productivity and average wage rate differ significantly across different zones.

(iv) There is no evidence of significant difference in input intensities in production. This sector is characterised by capital and energy intensive technology and we find no significant difference in technology use across zones.

(v) In this energy-intensive sector, electricity accounts for nearly three-fourths of total expenditure on fuels consumed in 2009-10. Since expenditure on electricity also depends on per unit cost of electricity, which may differ from one zone to another, we test for difference in average electricity consumption as well as average electricity rate. Block-H of ASI schedule (i.e. indigenous input items consumed) reports annual figures of each unit's 'electricity purchased and consumed' both in physical units (in kWh) and value terms (in Rs), as well as 'electricity rate' (in Rs. Per kWh). Significant difference across zones in terms of both – electricity consumption and electricity rates are found to exist. The significant difference in electricity rate observed across zones may account for the significant difference in electricity consumption, besides other factors such as differences in capital productivity and differences in efficiency of resource use.

6.1.2 In view of the ANOVA results discussed above, it would be interesting to explore the substitution possibilities among factor inputs such as labour, capital and energy in the Refrigerated S&W sub-sector. The observed significant variation in the wages, electricity tariffs and capital productivity in this sub-sector across zones would assume significance, once it is determined how far the production technology allows an entrepreneur to choose optimal combination of these inputs given their cost. This exercise is taken up in the next section.

## **7. Analysis of Factor Substitutability in Refrigerated S&W Industry in India: Cross-Sectional Analysis**

In this section, we use cross-section data on 293 units under five digits level classification (NIC 2008 code number 52101) of the Refrigerated S&W sector in 2009-10, to estimate a three-inputs transcendental logarithmic production function (TPF) of the type:

$$\begin{aligned} \ln Y = & B_0 + B_K \ln(K) + B_L \ln(L) + B_E \ln(E) + \frac{1}{2} B_{KK} \ln(K)^2 + \\ & B_{KL} \ln(K) \ln(L) + B_{KE} \ln(K) \ln(E) + \frac{1}{2} B_{LL} \ln(L)^2 + \\ & B_{LE} \ln(L) \ln(E) + \frac{1}{2} B_{EE} \ln(E)^2 \dots\dots\dots(1) \end{aligned}$$

where Y is value of output and K, L and E are capital, labour and energy input respectively. Refer to appendix I for definitions of variables used in econometric estimation.  $B_0$  is the constant term.  $B_K$ ,  $B_L$  and  $B_E$  are first order partial derivatives.  $B_{KK}$ ,  $B_{LL}$  and  $B_{EE}$  are own second order derivatives,  $B_{KL}$ ,  $B_{KE}$  and  $B_{LE}$  are cross second order derivatives. Based on the estimates of the production function, Allen (partial) elasticities of substitution (AES) are computed for the three inputs K, L and E.

**7.1 Econometric Methodology**

7.1.1 The translog functional specification is more general, imposing relatively fewer *a priori* restrictions on the properties of the underlying production technology. It allows for linear terms (the first four terms in equation (1) that are those of a log-linear production function (Cobb Douglas) with a constant technology parameter), quadratic and interactive terms, variable scale elasticity and variable elasticity of substitution between factor inputs. The version of TPF given in (1) with interaction terms was developed by Christensen, Jorgensen, and Lau (1973), which can be estimated from a symmetric system of derived factor share equations. Under the assumption of perfect competition<sup>7</sup>, each input (*i*) is paid its value of marginal product ( $w_i = VMP_i$ ) and output elasticity with respect to any input equals the cost share ( $C_i$ ) of that input. Thus, we can get a system of factor share equations from differentiating the TPF with respect to each factor input,

$$\begin{aligned} \partial \ln Y / \partial \ln K &= B_K + B_{KK} \ln K + B_{KL} \ln L + B_{KE} \ln E = C_K \\ \partial \ln Y / \partial \ln L &= B_L + B_{LK} \ln K + B_{LL} \ln L + B_{LE} \ln E = C_L \\ \partial \ln Y / \partial \ln E &= B_E + B_{EK} \ln K + B_{EL} \ln L + B_{EE} \ln E = C_E \dots\dots\dots(2) \end{aligned}$$

Where  $\partial \ln Y / \partial \ln K = (\partial Y / \partial K) * (K/Y) = (VMP_K) * (K/Y) = (w_K * K) / Y I$ , which represents the average cost share of capital<sup>8</sup> denoted by  $C_K$ .

$B_{KK}$ ,  $B_{KL}$  and  $B_{KE}$  represent constant capital share elasticity with respect to capital, labour and energy input respectively. Average cost shares of K, L and E are assumed to add to one and cost share of capital is obtained as a residual (see Appendix I for definitions).

Coefficients in (2) are symmetric across equations due to Young’s theorem on partial derivatives applied to (1). Thus we have the following symmetry restriction on parameters,

$$\begin{aligned} B_{KL} &= B_{LK} \\ B_{KE} &= B_{EK} \\ B_{EL} &= B_{LE} \dots\dots\dots(3) \end{aligned}$$

<sup>7</sup> We assume competitive price taking in both the input markets and the output market. One may consider introducing market imperfections in to the empirical analysis, the analysis only gets more complicated without necessarily altering the intuition.

<sup>8</sup> Mostly in practice, share of capital input is derived as residual after subtracting labour and energy bills from value added. In such residual calculations, capital implicitly includes land and perhaps other inputs.

7.1.2 Simultaneous estimation techniques such as Seemingly Unrelated Regression Estimation (SURE) improve estimation properties over single equations estimation. TPF can be estimated under different nested hypotheses. In this paper, we proceed by verifying if the TPF is homothetic or not, and if it is linearly homogeneous or not. To do so, the following testable null hypotheses are set up:

$$\begin{aligned} B_K + B_L + B_E &= 1 \text{ (for constant returns to scale: linear homogeneous TPF)} \\ B_{KK} + B_{LK} + B_{EK} &= 0, \\ B_{KL} + B_{LL} + B_{EL} &= 0 \text{ and} \\ B_{KE} + B_{LE} + B_{EE} &= 0 \text{ (for homothetic TPF) } \dots\dots\dots(4) \end{aligned}$$

7.1.3 Imposing the restrictions for homothetic TPF typically improves estimation properties (Thompson, 2006). After choosing the appropriate model for the data, one needs to check for monotonicity and quasi-concavity of the production function. Monotonicity requires positive marginal products for each input and it is satisfied when the fitted cost shares of each input are positive. Quasi-concavity requires the bordered Hessian matrix (H) of estimated first and second order partial derivatives of the production function be negative semidefinite (Berndt and Wood 1975). These conditions may not be satisfied at all points in the input space. However, as long as the conditions are met for a large enough region, the translog specification provides a good representation of the underlying technology used in production (Goldar, 1999).

7.1.4 Allen elasticities of substitution (AES) are computed from the jointly estimated factor share equations (2). First, factor shares (output elasticities)  $C_K$ ,  $C_L$  and  $C_E$  are computed from the estimated parameters of the factor share equations. Further, AES between the  $i^{\text{th}}$  and  $j^{\text{th}}$  inputs is computed as:

$$AES_{i,j} = \sigma_{i,j} = |H_{ij}|/|H|$$

$$\text{where } H = \begin{bmatrix} 0 & C_K & C_L & C_E \\ C_K & B_{KK} + C_K^2 - C_K & B_{KL} + C_K C_L & B_{KE} + C_K C_E \\ C_L & B_{KL} + C_K C_L & B_{LL} + C_L^2 - C_L & B_{LE} + C_L C_E \\ C_E & B_{KE} + C_K C_E & B_{LE} + C_L C_E & B_{EE} + C_E^2 - C_E \end{bmatrix}$$

and  $|H_{ij}|$  is the cofactor of  $H_{ij}$  in matrix H.

Own price elasticity of demand  $\epsilon_L(i, i)$  and cross price elasticity of demand  $\epsilon_L(i, j)$  are calculated as follows:

$$\epsilon_L(i, i) = \frac{B_{ii} + C_i^2 - C_i}{C_i} \text{ and}$$

$$\epsilon_L(i, j) = \sigma_{i,j} * C_j ; \text{ for all } i, j = K, L \text{ and } E.$$

## 7.2 Empirical Results

7.2.1 There isn't sufficient evidence to reject the restrictions imposed for a homothetic production function or those imposed specifically for linear homogeneity (see Appendix II for results of coefficient diagnostic tests). Thus, the cost share equations in (2) are estimated without the restrictions on the production function (Model A) and with the

restrictions for homothetic and linear homogeneous production function (Model B) as laid out in (4), both subject to the symmetric parameters restrictions (3). The estimated parameters of Models A and B are reported in Table 9. All of them are significant at 1% level and there exists minor difference in the estimated parameters of Model A and B.

7.2.2 Monotonicity is satisfied at all points except 2.8% of the input space (see Appendix III for graphs of estimated input shares to confirm monotonicity).

7.2.3 Based on the estimates obtained in Table 9 and sample mean values of estimated cost shares, the AES along with own and cross partial elasticity of demand are computed, as reported in Table 10. The difference in estimates across Models A and B remain marginal. As expected, all own price elasticities of demand are negative but less than one. Demand curves for K and E are found to be relatively more inelastic than that for L.

7.2.4 Cross price elasticities are all positive implying that K, L and E are substitutes of each other in the production process. However, the degree of substitutability based on estimates of AES is found to be very low and hence the three inputs K, L and E are found to be weak substitutes for each other with all AES estimates being less than one. These are consistent with the findings of Goldar et al. (2013, 2014) which state that elasticity of substitution between K and L is less than one in majority of manufacturing and services sectors in the Indian economy. Thus, it would not be incorrect to say that the capital and energy intensive Refrigerated S&W sub-sector is characterised by poor input substitution possibilities. Mundra and Russel (2004) argue that in case of production function specifications with more than two inputs, one must adopt different elasticity of substitution concepts (such as dual Allen-Uzawa and Morishima elasticities) to infer about substitutability among inputs. However, in this paper, remaining within the scope defined by its objectives, we restrict ourselves to estimating only AES.

## 8. Policy Conclusions

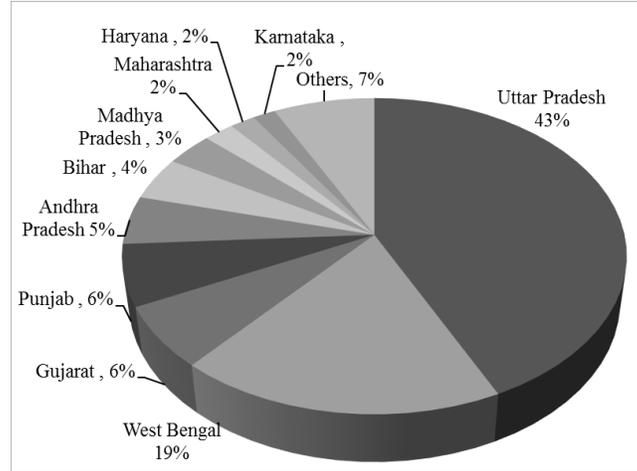
8.1 At the sectoral level, we find that both - non-refrigerated S&W and refrigerated S&W sectors have performed well in terms of key parameters analysed in this study. However, the in-depth zonal-level analysis of the refrigerated S&W reveals significant inter-zonal differences in some of the critical parameters such as resource use efficiency (GVA to inputs ratio), productivity of capital and labour, returns to labour, and electricity use (both in terms of electricity consumption as well as electricity rate). In view of this, it can be argued that policy interventions must aim to encourage the adoption of best practices in this sector while addressing the observed inter-zonal variation by standardising the business operations.

8.2 For the Refrigerated S&W sector, this study finds a downward trend in share of labour income in value added. Share of labour (L) in net value added (NVA) dropped by 6 per cent while number of workers per unit output measured in Rs. crores dropped by 5 per cent. During the same period, capital intensity measured in terms of capital per unit output and per worker has grown by 2 per cent and 8 per cent respectively. Though the sector is capital and energy-intensive, further capital deepening can have adverse implications for capital productivity in the presence of insignificant possibilities of substitution between different factor inputs. Given the low elasticities of substitution estimated using the translog production function, it would not be incorrect to argue that the potential future developments in this sector may not reverse the current trend of capital deepening in this

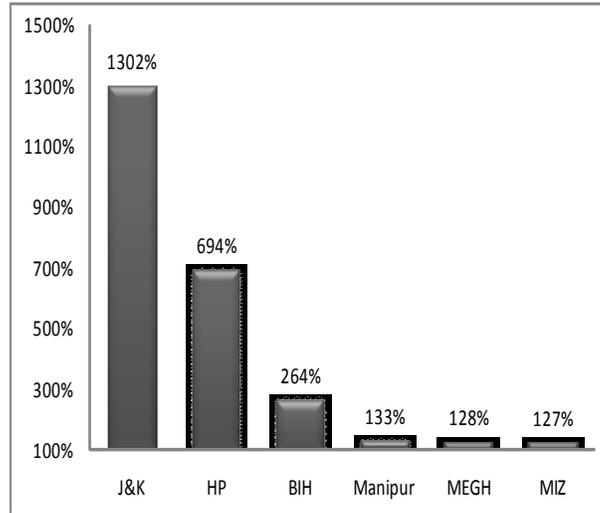
sector. Even if there is going to be an increase in demand for labour in this sector, it is expected to emerge especially for highly skilled labour, as day-to-day operations at the warehouse would become more mechanised to ensure competitiveness while keeping a check on the diseconomies of scale. The cross-sectional econometric estimation in this study cannot capture the impact of technical change on factor inputs proportions. This, however, remains an area of further research.

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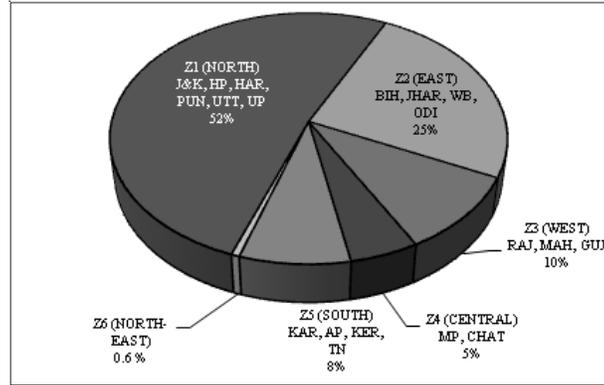
**Figure 1: State-wise Share in Existing Cold Stores Capacity (MT)**

Source: Authors' calculations based on NCCD, 2015.

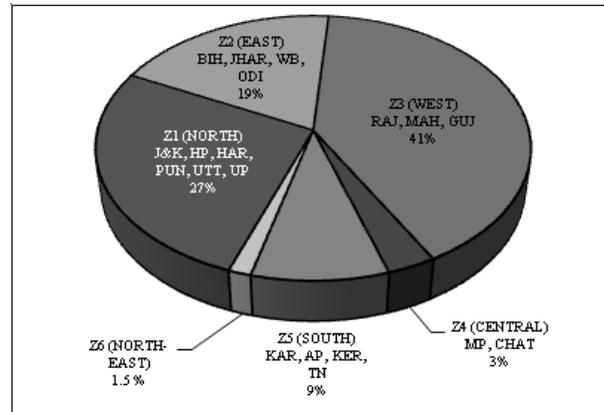
**Figure 2: Shortfall in Required Cold Chain Capacity (MT)**

Source: Based on data from NCCD, 2015

**Figure 3: Zone-wise share in (a) Installed Cold storage capacity (2014-15) and (b) GVA in Refrigerated S&W Industry (2009-10)**



(a)



(b)

Source: Authors' calculations

**Table 1: S&W Industry and its Sub-sectors**

Name of the Industry	Denoted in this study as	NIC-2004 Code	NIC-2008 Code
Warehousing and Storage Industry	S&W Industry	6302	5210
Warehousing and Storage (refrigerated)	Refrigerated S&W	63022	52101
Warehousing and Storage (non-refrigerated)	Non-Refrigerated S&W	63021	52102
Storage and Warehousing not elsewhere classified	S&W (Others)	63023	52109

**Table 2: State-wise Distribution of Units in ASI Sample and ASI Frame**

State	2005-06 ASI Unit Level Data								2009-10 ASI Unit Level Data							
	Sample				ASI Frame				Sample				ASI Frame			
	Non-Ref S&W	Ref S&W	S&W Others	Total S&W	Non-Ref S&W	Ref S&W	S&W Others	Total S&W	Non-Ref S&W	Ref S&W	S&W Others	Total S&W	Non-Ref S&W	Ref S&W	S&W Others	Total S&W
Punjab	2	10	0	12	10	37	0	47	0	5	0	5	0	20	0	20
Uttarakhand	0	6	1	7	0	6	1	7	0	2	0	2	0	5	0	5
Haryana	0	9	0	9	0	17	0	17	0	3	1	4	0	14	5	19
Delhi	0	1	4	5	0	1	13	14	0	1	0	1	0	5	0	5
Rajasthan	0	7	0	7	0	27	0	27	0	6	0	6	0	26	0	26
Uttar Pradesh	1	118	1	120	5	585	5	595	2	119	2	123	11	642	11	663
Bihar	0	22	0	22	0	104	0	104	0	15	2	17	0	78	11	89
Tripura	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Assam	0	7	0	7	0	8	0	8	0	5	0	5	0	14	0	14
West Bengal	0	60	5	65	0	255	17	272	6	55	5	66	27	252	22	300
Jharkhand	1	4	0	5	3	10	0	13	0	4	0	4	0	26	0	26
Orissa	1	6	0	7	4	20	0	24	0	6	0	6	0	27	0	27
Chattisgarh	0	4	2	6	0	9	5	14	1	2	0	3	6	11	0	17
Madhya Pradesh	0	10	0	10	0	48	0	48	0	6	0	6	0	38	0	38
Gujarat	0	6	5	11	0	20	19	39	0	8	3	11	0	44	18	61
Maharashtra	0	11	1	12	0	35	5	39	1	9	2	12	5	48	11	64
Andhra Pradesh	3	28	4	35	8	119	10	137	1	37	2	40	5	186	11	202
Karnataka	0	3	0	3	0	7	0	7	0	6	0	6	0	29	0	29
Tamil Nadu	0	2	5	7	0	2	17	19	0	3	4	7	0	19	14	32
All India	8	315	28	351	29	1310	93	1432	11	293	21	325	54	1482	101	1637
% of Total	2	90	8	100	2	91	6	100	3	90	6	100	3	91	6	100

Source: Authors' calculations

**Table 3: Sector-wise Critical Aggregates (at 2004-05 prices) and Derived Ratios (2005-06 and 2009-10)**

Sectors →	Non-Ref S&W			Ref S&W			S&W Total		
Variables ↓	2005-06	2009-10	CAGR (%)	2005-06	2009-10	CAGR (%)	2005-06	2009-10	CAGR (%)
Cost of Prod (Rs. Lakh)	815	3,068	39%	63,723	84,016	7%	107,925	177,272	13%
Fixed Capital (Rs. Lakh)	1,600	8,445	52%	86,800	124,251	9%	233,723	256,120	2%
Output (Rs. Lakh)	919	5,902	59%	95,367	123,839	7%	245,293	231,696	-1%
Input (Rs. Lakh)	709	3,092	44%	64,909	67,450	1%	175,611	105,167	-12%
GVA (Rs. Lakh)	209	2,810	91%	30,458	56,390	17%	69,683	126,529	16%

**Table 3: Sector-wise Critical Aggregates (at 2004-05 prices) and Derived Ratios (2005-06 and 2009-10) (Contd.)**

Sectors →	<i>Non-Ref S&amp;W</i>			<i>Ref S&amp;W</i>			<i>S&amp;W Total</i>		
Variables ↓	2005-06	2009-10	<i>CAGR (%)</i>	2005-06	2009-10	<i>CAGR (%)</i>	2005-06	2009-10	<i>CAGR (%)</i>
Profits (Rs.Lakh)	-118	423		3,130	14,850	48%	9,667	49,987	51%
Wages (Rs.Lakh)	111	548	49%	6,056	8,825	10%	7,573	12,610	14%
GVA/ Input (%)	30%	91%	32%	47%	84%	16%	40%	120%	32%
GVA/ Output (%)	23%	48%	20%	32%	46%	9%	28%	55%	18%
<b>Ratio to NVA</b>	2005-06	2009-10	<i>CAGR (%)</i>	2005-06	2009-10	<i>CAGR (%)</i>	2005-06	2009-10	<i>CAGR (%)</i>
Total Emoluments	220%	52%	-30%	54%	42%	-6%	53%	28%	-15%
Rent Paid	1%	2%	14%	1%	3%	47%	4%	8%	18%
Interest Paid	18%	23%	6%	30%	22%	-8%	20%	14%	-9%
Profits	-140%	23%		15%	33%	23%	23%	50%	21%
<b>Factor Remuneration Rates</b>	2005-06	2009-10	<i>CAGR (%)</i>	2005-06	2009-10	<i>CAGR (%)</i>	2005-06	2009-10	<i>CAGR (%)</i>
Wages / Workers (Rs.)	30,814	49,131	12%	30,973	42,247	8%	34,979	48,030	8%
Debt Rate (%)	17%	9%	-15%	37%	30%	-5%	24%	29%	5%
Profit Rate (%)	-7%	3%		3%	8%	28%	3%	15%	50%
<b>% Share in Cost of Production</b>	2005-06	2009-10	<i>Change (%)</i>	2005-06	2009-10	<i>Change (%)</i>	2005-06	2009-10	<i>Change (%)</i>
Workers	14%	18%	4%	10%	11%	1%	7%	7%	0%
Interest Paid	2%	14%	12%	10%	11%	1%	8%	8%	0%
Fuels Consumed	54%	54%	0%	41%	31%	-10%	29%	18%	-11%
Materials Consumed	9%	1%	-8%	17%	10%	-7%	24%	13%	-11%
<b>Factor Intensity</b>	2005-06	2009-10	<i>CAGR (%)</i>	2005-06	2009-10	<i>CAGR (%)</i>	2005-06	2009-10	<i>CAGR (%)</i>
Workers / Output in Rs. Cr.	39.16	18.89	-17%	20.51	16.87	-5%	8.83	11.33	6%
Workers / Plant	30	139	47%	102	108	1%	81.69	115.15	9%
Tot K / Output (Rs.)	1.68	1.36	-5%	1.25	1.41	3%	1.15	1.39	5%
Fixed K / Output (Rs.)	1.74	1.43	-5%	0.91	1	2%	0.95	1.11	4%
Fixed K / Workers (Rs. Lakh)	4.45	7.58	14%	4.44	5.95	8%	10.8	9.76	-3%
Fixed K / Tot K (%)	104%	105%	0%	73%	71%	-1%	83%	79%	-1%
Fuels Consumed / Workers (Rs. Lakh)	1.21	1.47	5%	1.34	1.26	-2%	1.46	1.22	-4%
Fuel Consumed / Fixed K (%)	27%	19%	-8%	30%	21%	-9%	14%	12%	-2%
<b>Factor Productivity</b>	2005-06	2009-10	<i>CAGR (%)</i>	2005-06	2009-10	<i>CAGR (%)</i>	2005-06	2009-10	<i>CAGR (%)</i>
GVA / Worker (Rs. Lakh)	0.58	2.52	44%	1.56	2.7	15%	3.22	4.82	11%
Output / Worker (Rs. Lakh)	2.55	5.29	20%	4.87	5.93	5%	11.33	8.83	-6%
GVA / Fixed K (%)	13%	33%	26%	34%	45%	7%	30%	49%	13%
Output / Fixed K (%)	57%	70%	5%	110%	100%	-2%	105%	90%	-4%

Source: Authors' calculations

**Table 4: State-wise Installed and Required Cold Chain Capacity (2014-15)**

State/UTs	ZONES	Installed Cold Chain Capacity (MT)	Capacity Requirement (MT)	Installed Capacity as % of Required Capacity
Uttar Pradesh	Z1	13,633,039	10,675,137	128
Punjab	Z1	2,004,778	1,693,408	118
Haryana	Z1	588,649	240,395	245
Delhi	Z1	129,857	40,122	324
Uttarakhand	Z1	84,545	72,931	116
Jammu & Kashmir	Z1	64,769	907,842	7
Himachal Pradesh	Z1	38,557	306,147	13
<b>TOTAL ZONE 1</b>		16,544,194 (52%)	13,935,982 (40%)	119
West Bengal	Z2	5,901,925	9,480,929	62
Bihar	Z2	1,406,395	5,123,982	27
Odisha	Z2	326,639	305,500	107
Jharkhand	Z2	217,280	24,951	871
<b>TOTAL ZONE 2</b>		7,852,239 (25%)	14,935,362 (43%)	53
Gujarat	Z3	2,030,873	2,239,476	91
Maharashtra	Z3	706,302.60	157,709	448
Rajasthan	Z3	480,032	53,395	899
Goa	Z3	7,705	2,271	339
<b>TOTAL ZONE 3</b>		3,224,913 (10%)	2,452,851 (7%)	131
Madhya Pradesh	Z4	1,097,168	1,867,179	59
Chattishgarh	Z4	427,766	513,830	83
<b>TOTAL ZONE 4</b>		1,524,934 (5%)	2,381,009 (7%)	64
Andhra Pradesh	Z5	1,577,828	530,925	297
Karnataka	Z5	526,752	210,313	250
Tamil Nadu	Z5	295,671	471,769	63
Kerala	Z5	78,355	45,874	171
<b>TOTAL ZONE 5</b>		2,478,606 (8%)	1,258,881 (4%)	197
Assam	Z6	119,652	71,996	166
Tripura	Z6	39,181	8,554	458
Meghalaya	Z6	8,200	18,704	44
Nagaland	Z6	6,150	8,675	71
Arunachal Pradesh	Z6	5,000	7,508	67
Mizoram	Z6	3,931	8,920	44
Manipur	Z6	2,175	5,062	43
Sikkim	Z6	2,000	2,621	76
<b>TOTAL ZONE 6</b>		186,289 (0.6%)	132,040 (0.4%)	141
<b>ALL INDIA TOTAL</b>		<b>31,823,700.60</b>	<b>35,100,662</b>	91

Source: Authors' calculations based on NCCD, 2015.

**Table 5: Zone-wise Gross Value Added in Refrigerated S&W Industry (2005/06 – 2009/10)**

ZONES	% Share in Installed Capacity	% Share in GVA		GVA (Rs. Lakh)	GVA (Rs. Lakh)	GVA / output (%)	CAGR*	GVA / input (%)		CAGR	GVA / input (%)		CAGR
		2009-10	2005-06					2009-10	2005-06		2009-10	2005-06	
Z1 (NORTH)	52	26.8	13,229	15,096	3%	38%	3%	44%	62%	3%	77%	77%	5%
Z2 (EAST)	25	18.9	11,285	10,690	-1%	31%	-1%	32%	45%	0%	46%	46%	1%
Z3 (WEST)	10	40.5	1,665	22,821	92%	18%	92%	72%	22%	41%	262%	262%	85%
Z4 (CENTRAL)	5	3.2	991	1,819	16%	46%	16%	24%	84%	-15%	31%	31%	-22%
Z5 (SOUTH)	8	9	3,054	5,109	14%	25%	14%	40%	33%	12%	66%	66%	18%
Z6 (NORTH-EAST)	0.6	1.5	234	856	38%	22%	38%	26%	28%	4%	35%	35%	6%
All India	100	100	30,458	56,390	17%	32%	17%	46%	47%	9%	84%	84%	16%

Note: \*CAGR stands for compound annual growth rate

Source: Authors' calculations

**Table 6: Zone-wise Analysis of Returns to Factor Inputs in Refrigerated S&W Industry (2005/06 – 2009/10)**

ZONES	wages / worker (Rs.)		CAGR	Debt Rate	Debt Rate	CAGR	Interest Cost (%)	Interest Cost (%)	CAGR	Profit Rate	Profit Rate	CAGR
	2005-06	2009-10										
Z1 (NORTH)	32,698	41,390	6%	28%	28%	2%	9%	13%	10%	3%	3%	-4%
Z2 (EAST)	31,427	44,328	9%	40%	40%	-4%	11%	15%	8%	1%	1%	-2%
Z3 (WEST)	16,949	48,939	30%	26%	26%	-16%	2%	5%	25%	8%	8%	30%
Z4 (CENTRAL)	30,415	61,767	19%	42%	42%	-5%	18%	4%	-29%	1%	1%	12%
Z5 (SOUTH)	34,149	39,072	3%	54%	54%	-3%	26%	13%	-16%	4%	4%	-7%
Z6 (NORTH-EAST)	22,355	17,719	-6%	87%	87%	-15%	26%	17%	-10%	24%	24%	34%
All India	30,973	42,247	8%	37%	37%	-5%	10%	11%	2%	3%	3%	8%

Source: Authors' calculations

Table 7: Zone-wise Analysis of Factor Productivity in Refrigerated S&amp;W Industry (2005/06 – 2009/10)

ZONES	GVA/ worker (Rs.lakh)		CAGR		Output/ worker (Rs.lakh)		CAGR		GVA / Fixed K (%)		CAGR		Output/ Fixed K (%)		CAGR	
	2009-10	2005-06	2009-10	2005-06	2009-10	2005-06	2009-10	2005-06	2009-10	2005-06	2009-10	2005-06	2009-10	2005-06	2009-10	2005-06
Z1 (NORTH)	1.43	1.88	7%	7%	3.73	4.32	4%	4%	37%	40%	2%	2%	95%	92%	92%	-1%
Z2 (EAST)	1.52	1.80	4%	4%	4.89	5.71	4%	4%	16%	29%	17%	17%	50%	92%	92%	16%
Z3 (WEST)	1.11	13.04	85%	85%	6.06	18.02	31%	31%	45%	97%	21%	21%	244%	134%	134%	-14%
Z4 (CENTRAL)	2.27	5.48	25%	25%	5.00	23.12	47%	47%	24%	52%	21%	21%	53%	220%	220%	43%
Z5 (SOUTH)	3.56	1.14	-25%	-25%	14.21	2.88	-33%	-33%	31%	23%	-7%	-7%	123%	59%	59%	-17%
Z6 (NORTH-EAST)	2.63	2.22	-4%	-4%	11.93	8.52	-8%	-8%	28%	89%	33%	33%	129%	343%	343%	28%
All India	1.56	2.70	15%	15%	4.88	5.93	5%	5%	24%	45%	17%	17%	75%	100%	100%	7%

Source: Authors' calculations

**Table 8: Analysis of Difference in Inter-zonal variation (ANOVA test)**

Difference in the Mean of ↓	MEASURE OF	Test Statistic (ANOVA F-stat)	p-value	Significant or not
1. GVA / Output	Overall Productivity	0.624	0.682	NO
2. GVA / Input	Resource Use Efficiency	2.808	0.017*	YES
3. GVA / Fixed K OR Output/ Fixed K	Productivity of Capital	1.661 2.416	0.144 0.036*	YES
4. GVA / Worker OR Output/ Worker	Productivity of Labour	3.051 2.41	0.011* 0.037*	YES
5. Profit Rate	Returns to Owned Capital	1.747	0.124	NO
6. Wages / Worker	Returns to Labour	3.727	0.003**	YES
7. Debt Rate	Ability to Repay Loans	1.399	0.225	NO
8. Fixed K / Output	Input Intensity (Depends On Technology In Use)	0.522	0.759	NO
9. Workers / Output		0.716	0.612	
10. Electricity Cons/ Output		0.508	0.769	
11. Electricity Cons	Electricity use	4.973	0.000**	YES
12. Electricity Rate		11.255	0.000**	YES

\* Significant at 5%; \*\* Significant at 1%.

Source: Authors' calculations

**Table 9: Seemingly Unrelated Regression Estimates (SURE) of the Translog Production Function**

Regressors	Model A		Model B	
	Coefficient	Std. Error	Coefficient	Std. Error
$B_K$	0.389	0.01	0.17	0.07
$B_{KK}$	0.172	0.003	0.174	0.004
$B_{KL}$	-0.043	0.002	-0.042	0.002
$B_{KE}$	-0.129	0.003	-0.118	0.005
$B_L$	0.224	0.009	0.238	0.041
$B_{LL}$	0.072	0.002	0.072	0.002
$B_{LE}$	-0.029	0.002	-0.03	0.003
$B_E$	0.389	0.011		
$B_{EE}$	0.157	0.004		
Included observations	280		280	

Source: Authors' calculations

Note: All coefficients are significant at 1%;

**Table10: Elasticities based on Estimated Translog Production Function**

Elasticity of Substitution		
	Model A	Model B
$\sigma_{KL}$	0.629	0.633
$\sigma_{KE}$	0.350	0.405
$\sigma_{LE}$	0.623	0.603
Cross Price Elasticity		
	Model A	Model B
$\xi(KL)$	0.132	0.133
$\xi(KE)$	0.126	0.146
$\xi(LK)$	0.346	0.348
$\xi(LE)$	0.224	0.217
$\xi(EK)$	0.193	0.223
$\xi(EL)$	0.131	0.127
Own Price Elasticity		
	Model A	Model B
$\xi(KK)$	-0.138	-0.133
$\xi(LL)$	-0.449	-0.449
$\xi(EE)$	-0.205	-0.229

Source: Authors' calculations

**Appendix I****Concepts and Definitions<sup>9</sup>**

Variable Name used in the paper	Corresponding Variable name and definition in ASI supporting document OR Definition of derived variables
Cost of Prod	<b>COST OF PRODUCTION</b> is the sum total of expenses incurred on employees in the form of wages/salaries, bonus, contribution to provident & other funds, workman & staff welfare, operating expenses, non-operating expenses (excluding insurance charges), insurance charges, rent paid for building, plant & machinery and other fixed assets, land on lease or royalties on mines, quarries and similar assets, interest paid, repair and maintenance of building, plant and machinery, pollution control equipment, other fixed assets, work done by others on materials supplied by the industrial undertaking, total indigenous items consumed as inputs (i.e. total basic and non-basic items from block H of ASI schedule), total imported items consumed as inputs (from block I of ASI schedule).
Fixed Capital OR Fixed K	<b>FIXED CAPITAL</b> represents the depreciated value of fixed assets owned by the factory as on the closing day of the accounting year. Fixed assets are those that have a normal productive life of more than one year. Fixed capital includes land including lease- hold land, buildings, plant and machinery, furniture and fixtures, transport equipment, water system and roadways and other fixed assets such as hospitals, schools etc. used for the benefit of factory personnel.
Fuels Consumed	<b>FUELS CONSUMED</b> represents total purchase value of all items of fuels such as coal, liquefied petroleum gas, petrol, diesel, electricity, lubricants, water etc. consumed by the factory during the accounting year but excluding the items which directly enter into the manufacturing process.
GVA	<b>GROSS VALUE ADDED</b> is arrived at by deducting total input from total output.
Input	<b>TOTAL INPUT</b> comprises total value of fuels, materials consumed as well as expenditures such as cost of contract and commission work done by others on materials supplied by the factory, cost of materials consumed for repair and maintenance work done by others to the factory's fixed assets, inward freight and transport charges, rate and taxes (excluding income tax), postage, telephone and telex expenses, insurance charges, banking charges, cost of printing and stationery and purchase value of goods sold in the same condition as purchased. Rent paid and interest paid is not included.
Interest Paid	<b>INTEREST PAID</b> includes all interest paid on factory account on loans, whether short term or long term, irrespective of the duration and the nature of agency from which the loan was taken. Interest paid to partners and proprietors on capital or loan are excluded.
Materials Consumed	<b>MATERIALS CONSUMED</b> represents the total delivered value of all items of raw materials, components, chemicals, packing materials and stores which actually enter into the production process of the factory during the accounting year. It also includes the cost of all materials used for the construction of building etc. for the factory's own use .It, however, excludes all intermediate products consumed during the accounting year. Intermediate products are those products, which are produced by the factory but are subject to further manufacturing.
Output	<b>TOTAL OUTPUT</b> comprises total ex-factory value of products and by-products manufactured as well as other receipts from non industrial services rendered to others, work done for others on material supplied by them, value of electricity produced and sold, sale value of goods sold in the same conditions purchased, addition in stock of semi- finished goods and value of own construction. Rent received and interest received is not being included from ASI 2001-02.
Profits	<b>PROFITS</b> = Net Income – (Wages + Bonus + Contribution to provident and other funds + Workman & Staff welfare expenses) Where <b>NET INCOME</b> = GVA – Depreciation – (Rent paid + Interest paid).
Rent Paid	<b>RENT PAID</b> represents the amount of royalty paid in the nature of rent for the use of the fixed assets in the factory.
Total Emoluments	<b>TOTAL EMOLUMENTS</b> is defined as the sum of wages and salaries, employers contribution as provident fund and other funds and workmen and staff welfare expenses.

<sup>9</sup>Sourced from ASI supporting documents provided with ASI unit level data. There is a standardized methodology for arriving at estimates of relevant variables and the tabulation procedures have been strictly adhered to.

Variable Name used in the paper	Corresponding Variable name and definition in ASI supporting document OR Definition of derived variables
Wages	<b>WAGES AND SALARIES</b> are defined to include all remuneration in monetary terms and also payable more or less regularly in each pay period to workers as compensation for work done during the accounting year. It includes (a) direct wages and salary (i.e., basic wages/salaries, payment of overtime, dearness, compensatory, house rent and other allowances) (b) remuneration for the period not worked (i.e., basic wages, salaries and allowances payable for leave period, paid holiday, lay-off payments and compensation for unemployment, if not paid from sources other than employers) (c) bonus and ex-gratia payment paid both at regular and less frequent intervals (i.e., incentive bonuses, productive bonuses, profit sharing bonuses, festival or year-end bonuses etc.) It excludes lay off payments which are made from trust or other special funds set up exclusively for this purpose i.e., payments not made by the employer. It also excludes imputed value of benefits in kind, employer's contribution to old age benefits and other social security charges, direct expenditure on maternity benefits crèches and other group benefits Travelling and other expenditure incurred for business purposes and reimbursed by the employer are excluded. The wages are expressed in terms of gross value i.e., before deduction for fines, damages, taxes, provident fund, employee's state insurance contribution etc.
Workers	<b>WORKERS</b> are defined to include all persons employed directly or through any agency whether for wages or not and engaged in any manufacturing process or in cleaning any part of the machinery or premises used for manufacturing process or in any other kind of work incidental to or connected with the manufacturing process or the subject of the manufacturing process. Labour engaged in the repair and maintenance or production of fixed assets for factory's own use or labour employed for generating electricity or producing coal, gas etc. are included.
Derived Ratios and other variables	
Debt Rate	OUTSTANDING LOANS / (INVESTED CAPITAL + CURRENT ASSETS)  Where <b>OUTSTANDING LOANS</b> represent all loans whether short term or long term, whether interest bearing or not, outstanding according to the books of the factory as on the closing day of the accounting year; <b>INVESTED CAPITAL</b> is the total of fixed capital and physical working capital; <b>CURRENT ASSETS</b> is the sum total of raw materials & components, packaging materials, fuels and lubricants, spares, stores and others, semi-finished goods/ work in progress, finished goods, cash in hand and at bank, sundry debtors and other current assets.
Fixed K / Output	FIXED CAPITAL / TOTAL OUTPUT
Fixed K / Tot K	FIXED CAPITAL / (FIXED CAPITAL + WORKING CAPITAL)
Fixed K / Workers	FIXED CAPITAL / WORKERS
GVA / Fixed K	GROSS VALUE ADDED / FIXED CAPITAL
GVA / Input	GROSS VALUE ADDED / TOTAL INPUT
GVA / Output	GROSS VALUE ADDED / TOTAL OUTPUT
Interest Cost	INTEREST PAID / COST OF PRODUCTION
Output / Fixed K	TOTAL OUTPUT / FIXED CAPITAL
Output / Workers	TOTAL OUTPUT / WORKERS
Profit Rate	PROFITS / (INVESTED CAPITAL + CURRENT ASSETS – OUTSTANDING LOANS)
Tot K / Output	(FIXED CAPITAL + WORKING CAPITAL) / TOTAL OUTPUT Where <b>WORKING CAPITAL</b> is the sum total of the physical working capital as already defined above and the cash deposits in hand and at bank and the net balance receivable over amounts payable at the end of the accounting year. Working capital, however, excludes unused overdraft facility, fixed deposits irrespective of duration, advances for acquisition of fixed assets, loans and advances by proprietors and partners irrespective of their purpose and duration, long-term loans including interest thereon and investments.
Wages / Workers	WAGES AND SALARIES / WORKERS
Workers / Output	WORKERS / TOTAL OUTPUT
Workers / Plant	WORKERS / NUMBER OF UNITS

Variable Name used in the paper	Corresponding Variable name and definition in ASI supporting document OR Definition of derived variables
<b>Definition of Variables used in Econometric Analysis</b>	
E	ENERGY INPUT proxied by ELECTRICITY CONS, Where <b>ELECTRICITY CONS</b> is number of units of electricity consumed in kilo watt hours (from block H of ASI schedule) Energy input is sourced from electricity, gas and petroleum products. However, while most units have provided information on electricity consumed, detailed information on use of gas and other petroleum products is missing for most units. Also, since electricity accounts for nearly 75% of total expenditure on fuels consumption, energy input is proxied by electricity used.
L	LABOUR INPUT measured as number of employees (WORKERS)
K	CAPITAL INPUT measured as value of fixed capital net of depreciation (FIXED CAPITAL)
Y	TOTAL OUTPUT
$C_E$	Average cost share of energy = (ELECTRICITY CONS * ELECTRICITY RATE) / OUTPUT
$C_L$	Average cost share of labour = WAGES / OUTPUT
$C_K$	Average cost share of capital = $1 - C_E - C_L$

**Appendix II****Wald test (coefficient restrictions)**

The Wald test computes the test statistic based on the unrestricted regression and it measures how close the unrestricted estimates come to satisfying the restrictions under the null hypothesis. The test statistic is Chi-square, whose value and associated probability (p-value) are listed below.

**Table 11: Wald Test Results**

Restriction imposed under the null hypothesis	Chi-square value	Probability	Conclusion
$BK + BL + BE = 1$	0.057	0.812	Do not reject the null hypothesis
$BKK + BLK + BEK = 0$	0.132	0.717	Do not reject the null hypothesis
$BKL + BLL + BEL = 0$	0.191	0.662	Do not reject the null hypothesis
$BKE + BLE + BEE = 0$	0.651	0.419	Do not reject the null hypothesis

**Appendix III****Testing Monotonicity of the estimated Translog Production function**