

ROLE OF ICT IN FOOD PROCESSING INDUSTRY: EVIDENCE FROM INDIA

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of the degree of Master of Philosophy in Applied Economics of the
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Centre for Development Studies

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CERTIFICATE

I hereby affirm that the work of this dissertation, “**Role of ICT in Food Processing Industry : Evidence from India**” being submitted as a part of the requirements of the M.Phil. Programme in Applied Economics of the Jawaharlal Nehru University, was carried out entirely by myself. I also affirm that it was not a part of any other programme of study and has not been submitted to any other Institutions/University for the award of any degree.

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Certified that this study is the bona fide work of Mr. Subal Danta carried out under our supervision at the Centre for Development studies, Thiruvananthapuram, Kerala.

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Dedicated to My Beloved Father

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ABSTRACT OF THE DESERTATION

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ICT is the convergence of two sets of technology, namely information technology and communication technology. The former deals with creating, sorting, retrieving, and processing information, and the latter deals with exchanging, transmitting, or broadcasting it. It is an all-encompassing term consisting of various devices, systems, and services used for data processing, telecommunications services, and equipment for data communication and transmission. By revolutionizing the exchange of information and reducing transaction costs, ICT facilitates the transition of an economy to a knowledge-based economy. In this information age, it is not easy to sustain and compete globally and domestically without this ICT. Empirically, the contribution of ICTs to the economy can be examined in two different but interrelated ways. The former talked about the ICT sector's growth and contribution to total output, generating employment and export earnings, whereas the latter talked about ICT diffusion or ICT use. Empirically it has also been proved that most countries are getting benefits both from ICT growth and ICT use. Most of the works have been carried out on the direct benefits of ICT to the economy, where literature concerning ICT diffusion is scanty. Again when it comes to the ICT diffusion, most of the work has been operated at the aggregate level. So, we have tried to see the role of ICT in the performance of the food processing industry of India. The role has been analyzed in two ways, the ICT adoption features and the impact of ICT adoption by taking information from the CMIE prowess database. In the first case, we have examined the role of firm-specific variables in the ICT adoption, and secondly, we have evaluated its impact on the total factor productivity. From the empirical model, with the help of the Probit model, it is found that the firm's age, size, and energy consumption negatively affect the ICT adoption of the FPI. Apart from these three

variables, all the other variables like ownership structure, types of goods produced, and raw materials & energy consumption do not significantly affect the ICT adoption as their results are insignificant. In the second objective, the study has tried to evaluate the impact of ICT on the total factor productivity of the food processing industry with the help of the Levinshon-Petrin method of productivity estimation. Taking the panel fixed effect model, in the empirical exercises, it has been found that ICT adoption by the food processing industry is positively affecting the TFP significantly. However, the firm's control variable age and energy intensity are not significantly affecting the TFP as per the estimated results.

Keywords: ICT, Food Processing Industry, Adoption, Probit model, Total Factor Productivity, Levinshon-Petrin

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List of abbreviations and Acronyms

ASI	Annual Survey of Industries
ASSOCHAM	Associated Chambers of Commerce and Industry of India
CMIE	Centre for Monitoring Indian Economy
DEA	Data Envelopment Analysis
DGCIS	Directorate General of Commercial Intelligence and Statistics
DPIIT	Department for Promotion of Industry and Internal Trade
EPWRF	Economic and Political Weekly Research Foundation
FDI	Foreign Direct Investment of India
FICCI	Federation of Indian Chambers of Commerce & Industry
FPI	Food Processing Industry
GFA	Gross Fixed Assets
GFC	Gross Fixed Capital
GFCF	Gross Fixed Capital Formation
GPT	General Purpose Technology
ICT	Information and Communication Technology
IT	Information Technology
ITES	Information Technology Enabled Service
KLEMS	K(C)apital Labor Energy Materials and Service
MPI	Malmquist Productivity Index
MoFPI	Ministry of Food Processing Industry
MSEs	Medium and Small scale Enterprises
NFA	Net Fixed Assets

NHB	National Horticulture Board
NIC	National Industrial Classification
NSSO	National Sample Survey Office
PIM	Perpetual Inventory Method
R&D	Research and Development
SFA	Stochastic Frontier Analysis
WPI	Wholesale Price Index

Chapter – I

Introduction

1.1. Introduction

Information and Communication Technology (hereafter ICT), as an integral part of the General-Purpose Technology (GPT), can affect economic efficiency in many ways. They are the attainment of trade of goods & services at low costs, scale economies, and comparative advantage (Harris, 1995). Further, it plays a prominent role in the reduction of transaction cost, efficient management of information, reduction of operational cost, and improvement of the business communications as well as reorganization of production and distribution of goods and services (Papaioannou & Dimelis, 2011). Many countries have benefited from the use of this technology for several years. The starting point of this widespread discussion and empirical studies on productivity growth, capital accumulation, and impact of new technology on economic growth started with the technological advancement of the US economy with the use of ICT (Jorgenson et al., 2000). Most of the literatures during the nineties have examined the significant role of ICT on the economic growth of the developed countries like the USA and the European Union (Inklaar et al., 2008). The information revolution of the United States benefited its economy to a greater extent and then spread to most countries around the globe (Gupta and Kumar, 2018). Further, the difference between the growth in productivity of the United States and Europe during that time can be explained by ICT as the former was getting more benefits than the latter out of this ICT investment (Giotopoulos et al., 2017). The last decade of the twentieth century has witnessed a significant technological change worldwide, driven by ICT.

ICT indicates the convergence of two technology sets: information technology and communication technology. The former represents information creation, while the latter demonstrates its transformation. It is an all-encompassing term that consists of a wide variety of devices, systems, and services used for data processing (information part of ICT) as well as telecommunications services and equipment for data communication and transmission (communication part of it) (Akarowhe, 2017). ICT generally includes three leading technologies: computer information, communication knowledge, and information technology. ICT, in most cases, is applied for the processing, exchanging, and managing of data, information, and

knowledge (Singh, 2012). It is an integral part of the general-purpose technology (GPT), which has a wide range of effects on the entire economy and reshapes the whole production and distribution systems (the information technology and innovation foundation, 2014). The contribution of ICT to an economy can be examined in two interrelated ways, namely ICT growth and ICT diffusion. The former represents the direct contribution to the economy, whereas the latter talks about the indirect contribution (Joseph & Abraham, 2007). It is also empirically argued that most countries benefit from both the direct and indirect benefits of ICT. Numerous works have been carried out to investigate the direct consequence of ICT on economic development domestically and globally. So, in this study, we have tried to determine the impact of ICT use on the firm's performance. ICT use is one of the influential drivers of enriched economic growth, organizational performance, and social transformation (Yunis et al., 2018). It is also diffused into nearly all the orbits of life (Joseph, 2002). Also, it brings benefits to the firms in terms of efficiency, effectiveness, innovation, growth, and competitive advantages (Consoli, 2012). World Bank (2006) has reported that "firms that use ICT grow faster, invest more, and are more productive & profitable than those who do not." So, ICT directly increases productivity, stimulates economic growth, and generates complementary innovations that help improve TFP and labor productivity. Further, it has been empirically proved that the return on digital investment (e.g. investment in ICT and innovation) is higher than the investment on any other physical investment (Chowdhury, 2006). It is also claimed that a small firm that has used ICT has a better competitive advantage than big non-ICT user firms. There is strong evidence that ICT is the driver of economic growth and the governments all over the country are motivating the small and medium enterprises (SMEs) to adopt the ICT for the production process. (Akomera, et al., 2012).

The growth and performance of food processing industries during the ICT revolution were also significant in many developing countries due to the export earnings, global and domestic industry restructuring, and the dietary issues of the economy (Wilkinson, 2004). Like other developing countries, the FPI in India also has enormous potential on various grounds. They are income and employment creation through the value addition via the availability of sufficient resources, adequate labor, technology, a vast market, and a good business atmosphere in the country (Ali et al., 2009). Moreover, it can be seen as one of the potential sources for driving the rural economy as it integrates both agriculture and the industrial sector (FICCI, 2010). It is one

of the labor-intensive industries that can absorb the massive skilled and unskilled labor from the rural and urban areas. So, it has enormous potential for employment and income generation (Kumar & Pattanaik, 2018). This emerging sector employed around thirteen million individuals directly & 35 million indirectly by 2012 (Rais et al., 2013). During the last five years, the sector has grown by 8.41 percent (average annual growth rate) against 3.45 percent in agriculture and 6.61 percent in the manufacturing sector at 2011-12 Prices (MoFPI, 2018-19). Agriculture and FPI will play an essential part in India to make the former sustainable and profitable because FPI has a significant linkage (both forward and backward) with the agricultural and industrial sectors (Dharni & Sharma, 2008).

1.2 Motivation of the Study

With the growing population, there is a parallel requirement for the increased production and processing of food to achieve food security in India. Further, the liberalization of the nineties has changed the nature of food intake and the country's food culture (Vepa, 2001). In order to meet this requirement, the FPI has to play a prominent role in this current situation (Bhandari & Vipin, 2016). The recent evolution and development of ICTs have strongly affected the small and medium scale industries of both developed as well as developing countries (Akomera, et al., 2012). So, this is an excellent opportunity for India to reap the benefits of this evolution of the information age. The level and structure of FPI of India mainly reflect the lack of productive augmenting technology and other drawbacks (Rais & Sharma, 2013). In order to address the above drawbacks, there is a requirement to get efficiency in the production & productivity of the FPI of India. The efficiency can be attained with an increase in output or a decrease in cost (Ali et al., 2009). Even though the FPI of India is growing, the sector remains underdeveloped compared to other manufacturing sectors as it cannot achieve its potential growth rate (Rais & Sharma, 2013). Even though the agricultural base in India is quite solid and massive, there is still a lot of food wastage, and most of the agricultural products are not processed fully. The processing of food to consumable standards is 80% in developed countries. In contrast, the total processing level in India has just reached 10%, which is very low compared to the former. Hence, India's food processing sector is relatively tiny, and its share in processed food exports worldwide is approximately 1.5 % (Bhuyan, 2010). Some studies also reveal that India is losing nearly seventy-five thousand crore to one lakh crore each year due to poor and inadequate post-

harvest management (Kachru, 2010). The short span of the shelf-life and perishable character of the food products instructs adequate and proper surveillance of the food product (Beshara et al., 2012). So, there is a vital requirement for a well-developed and efficient food processing sector that can enhance the processing level & value addition and help reduce wastage (Russ & Pittroff, 2004). In addition to the above, it can also promote crop diversification, ensure better returns to the farmers, generate employment opportunities, and increase export earnings (Ali et al., 2009). Apart from the above, this sector can also address critical issues of food security and inflation and provide wholesome nutritious food to the masses throughout the year (MoFPI, 2018-19). Thus, it ought to be more efficient and competitive to confront domestic and global competition, economic slowdown, and frequent transforming consumer requirements. India can become the world's food basket with the proper investment and attention to the food processing industries (Rais et al., 2013). Numerous works have been taken in order to show the impact of ICT on the firm performances in the developed countries (Rashiti et al., 2015). Again, in developing countries also, most of the large firm and industries have already getting the benefits of ICT use through various channels (Piget & Kossai, 2014). They are reduction in transaction cost, attainment of better organization structure and full information and other such factors (Rashitti & Ramdani, 2017). Moreover, big business house and other industries have already taken advantage of ICTs as far as the competition is concerned, and now the time has come to reap the benefit from the ICT by the food processing industries (Akomera et al., 2012).

1.3.Literature review

Existing empirical work on the role of ICT on firm performance can be categorized in two broad ways. They are ICT adoption and ICT adoption impact. A significant number of works have been carried out in both categories of work, which will be covered in further detail in the next part of the study. There is sufficient evidence that ICT can enhance the production and productivity of the firm and industry in several ways. It can enhance the firm's performance by reducing transaction costs, operational costs, efficient management of information, improvement of business communications, and reorganizing the production and distribution of goods and services (Papaioannou & Dimelis, 2010). So, an attempt has been made to give a broad overview

of the existing theoretical and observed literature to emphasize the role of ICTs on the firm's performance and the industry.

1.3.1. ICT and Productivity: A theoretical perspective

The devices, technologies, and production processes that we are endowed with are the product of the evolution and innovation of centuries of human beings. The recent ICT revolution started with the emergence of liberalization in the nineties, and India as a country has benefited from this revolution both in the form of ICT growth (direct benefit of ICT) and ICT diffusion (indirect benefit of ICT) (Erumban & Das, 2015). The evolution of this information age has become a significant determinant of the growth of most developed countries (Kosai & Piget, 2014). The rapid spread of ICT and decreasing price of all types of ICT equipment in the market have led to many countries' integration into the global scenario (Fransis & Susana, 2001). Also, the adoption of ICTs is one of the essential strategies to sustain and compete in the global market (Makanyeza & Ndvlu, 2016).

Grossman and Helpman (1991) said that technological progress is considered one of the crucial elements in the long-run economic growth as it plays the catalyst role in the growth. Improvement in the ICT with the ICT revolution can endow the economy with trading services at low cost, driving upward economic activities, trade specialization, the scale of economies, and comparative advantage (Harris, 1995). Using more and better tools in the production process is one of the best ways to increase productivity. In other words, the use of appropriate pieces of machinery, equipments, software & other such technologies help to improve the productivity of the firm and industry (Romer, 1990). As part of that technology, ICT leads to the capital deepening technology and leads to spillover in the economy, which ultimately increases the total factor productivity. The spillover may be endowed in the form of network externalities, better organizational setup, and transaction cost reduction (Erumban & Das, 2015). Hitt and Tambe (2006) have found that the technological spillover of the intra-industry out of the investment in information technology is the crucial driver of productivity growth. The existence of perfect information leads to zero transaction cost (Williamson, 1975), and a reduction in the information gap or asymmetric information can enhance the efficiency of the firms in terms of productivity as well as allocation of resources (Fransis & Susana, 2001 which can be obtained via the use of ICT by the firms (Grover et al. 2002).

To sum, the use of ICT can improve efficiency and productivity in many ways via; improving the efficiency in resource allocation, reducing the transaction cost, and technical up-gradation. Further, the disadvantages that arise to the isolated industry or firm which is in a remote area can be lessened through the rapid and extensive communication obtained through the use of ICT (Susanna Wolf, 2001).

1.3.2. ICT and Productivity: An empirical exercises

The pace of ICT revolution of the 90s was generally fueled by the tremendous production of semi-conductors technology and the implementation of globalization (Jorgenson & Vu, 2016). This ICT revolution brought acceleration to the economic growth and also changed the way of life of the human being both globally and domestically. A drastic change in the standard of living of the human being endowed with the use of this technology. The enhancement of this standard of living is mainly because of the rapid use of cellular phone, mobile phone, internet uses, and other such items (Grossman & Helpman, 1993). As a result, it became one of the essential components of human beings and economic growth. This ICT plays a prominent role both at country level and industry or firm level. In this age of information, it isn't easy to sustain and compete in the global and domestic market without using this crucial element in the production process (Joseph, 2002). Being a part of general-purpose technology, ICT can enhance production and productivity and stimulate economic growth through various ways. There may be hardly any country (both developed and developing) in this contemporary world that has not initiated any policy for its use of ICT. So, in the next section of the study, we will see how the use of ICT has played a prominent role in the firm's performance both at the global and domestic levels.

1.3.2.1 Global Context

Most of the developed countries already took advantage of this information and communication revolution during the nineties, when the role of the US economy was significant. The decline in the general price of computers and their equipment (ICT equipment) since 1995 (nearly 28% reduction between 1995 and 1998) has led to the growth in the US economy (nearly 0.46 percent annual growth since the 1990s). Along with the above, other technologies like software and communication equipment have also led to the growth of 0.30 percentage points during the same period. The US economy has experienced a new growth regime resulting from technological up-

gradation via increased labor and TFP (Jorgenson et al., 2000). Lee and Barua (1999) have studied the Italian manufacturing firms from 1978 to 1984 and argued that firm-level inefficiency could be reduced with the incorporation of Information technology (IT) in the production process. So, most of the literature on ICT diffusion accepted the positive and significant impact of ICT on output growth and productivity (Joseph, 2002).

In a cross-country analysis of thirty-six countries (both developed and developing) on ICT diffusion, Dewan & Kraemer (2000) found a substantial difference in the return on IT and non-IT investment. They have conducted this study by taking the cross-country production function of the IT and non-IT input to the economic growth of the countries from 1985 to 1993. The return on the IT investment is high and significant in the case of developed countries, whereas it is insignificant in developing countries due to infrastructural bottlenecks. By taking data from ninety-three developed and fifty developing countries, authors have observed that the use of telecommunication (as a part of ICT) has a direct influence on the technological efficiency of the firms (Thompson & Garbacz, 2007; Repkine, 2008). Another cross-country analysis also found a positive and significant relationship between capital deepening and growth in output per hour by taking the European Union KLEMS database for the time-period 1998 to 2007 of the ten European countries (Bresnahan & Trajtenberg, 1995). In the last half of the twentieth century, most developed and industrialized countries have witnessed the advancement of technological up-gradation, which widens the existing pattern of inequality into the digital divide with its counterparts (Castells, 1996). However, at the same time, the significant achievement of the few developing countries in the technical up-gradation has helped to narrow down the digital divide globally (Steinmueller, 2001).

Most of the studies on the use of ICT on the performances of the firm have been carried out by taking the Total factor productivity (hereafter TFP) and labor productivity into account. Additionally, various studies have been conducted to witness the influence of ICT on factor productivity other than TFP like Krueger (1993), Doms et al., (1997), Aghion et al., (1999), and Caroli and Van Reenen (2001) in case of British, French and US firms, respectively. It is claimed that ICT adoption by the firms improves the firm's productivity, labor productivity, and factor income. However, there is a substantial distinction between developed and developing countries. Literature reveals a persistent gap in productivity between IT-user and traditional firms.

Considerable investment in IT is linked with more significant productivity gain, as claimed by both firms and country-level studies (Dedrick et al., 2003). The majority of the studies launched from 1990 to 2014 demonstrate a direct association between ICT and the firm's productivity (Cardona et al., 2014).

There is an influential and direct association among the technology adoption and the performance of Small and Medium Enterprises (hereafter SMEs) in Tsunja (Piget & Kossai, 2014). Based on the above, there are also various studies in developing countries where it has been empirically proved that adoption of ICT by the firms and the industry has enhanced their productivity and production. The ICT adoption by the SMEs of Zimbabwe increased productivity and increased the firm's export capacity (Makanyeza & Ndvhou, 2016). In the case of Norway, the technological up-gradation in Salmon fish farming has led to an increase in their products locally and competition globally. Over the last decade, the industry has improved in knowledge skills, for which it has developed a global level of expertise (Sandvold, 2016). Locke (2004) investigated the influence of ICT adoption on the growth of SMEs in New Zealand. The study discovered that adopting and using the internet and phones directly affect SMEs' growth. The study also pointed out that SMEs must invest additionally in these technologies for higher profit. Chowdhury (2006) found that ICT investment helps SMEs expand their market share in the economy. By analyzing the impact of ICT on SMEs, Akemora, F et al., (2012) observed that though there are some barriers to adopting ICT by SMEs, its adoption has still enhanced SMEs' productivity. This productivity has been enhanced by locating customers' contracts and emailing them to supply raw materials in Ghana. By incorporating 587 large manufacturing firms in the United States from 1987 to 1994, Brynjolfsson and Hitt (2003) examine the relationship between the computerization of the firm and its impact on productivity and output growth. Their study found a significant impact in productivity in the long run compared to the short run. The above results are mainly because ICT use requires a complementary investment, which is impossible in the short run.

1.3.2.2 Indian Context

Several studies are carried out in the context of ICT use and productivity enhancement both at the macro & micro-level in the case of India as well. As a result, in the next paragraph, the role

of ICT and the industry's performance will be discussed by taking Indian manufacturing into account.

As explained earlier, investment in ICT equipment (as a proxy for ICT use) by the firms can enhance the efficiency, organizational setup, total factor productivity, and labor productivity by reducing the communication cost and enhancing substantial coordination (Erumban & Das, 2015). Chowdhury (2006) has articulated that acquisition in ICT can be a substitution for the investment in assets and labor, which can yield substantial returns to the businesses than other forms of investment. By considering the fish industries of the southern part of India, Robert Gensen (2007) has analyzed the impact of improvement in information (as a part of ICT) on the firm's performance and the welfare impact of the human being. As per his argument, information is critical and crucial for the efficient functioning of the market and the economy. Arnold et al., (2016) also found that telecommunication (as a part of ICT), banking services, transport, and insurance facilities of the firms positively affect the firm's productivity by taking the data for 4000 manufacturing firms from 1993 to 2005. Along with the firm performance, the impact of ICT has been carried out in the case of financial market-based measures. In one of the studies by Bharadwaj et al. (1999), it has been found that investment in the ICT positively and significantly affects the firm Tobin's q value. These estimated results indicate that the use of ICT in the firm increases the firm's value, as explained with the help of Tobin's q. The above claim has been made by taking firm-level data from the Indian manufacturing sector from 1988 to 1993. In addition to the above, the use of ICT in the firm enhances the firm's competitive power and future business capacity.

In addition to the aggregate level study, various works have also taken place at the firm level. One of the significant advantages of studying firm-level analysis in ICT adoption is incorporating firm heterogeneity concerning the adoption and performance of ICT use. It also allows incorporating the difference in the firm's organizational structure and skill composition. As a result, the present section will see ICT adoption and firm performance in detail at the unit level in the case of India.

By taking micro-level data from 900 firms for sixteen years (2000 - 2016) in Indian manufacturing firms, Khanna and Sharma (2018) explore the joint effect of ICT use and

innovation activities on labor productivity. Using the General Method of Moments, they have found that the investment in information technology (IT) and research and development (R&D) positively affects the labor productivity of the manufacturing firm. However, there are sector-level differences among them. The use of ICT helps enhance labor productivity and leads to the growth of TFP. By taking the primary information from 1000 Indian and Brazilian manufacturing firms, Commander et al., (2011) studied the effect of ICT on productivity. Using the ICT-augmented production function in their analysis, they found a positive association among ICT use and productivity among the manufacturing firms. Though there is a significant difference between the two countries regarding the firm's organizational capabilities and skill structure, the impact of ICT adoption is still the same on the manufacturing firms in both countries. By investigating the role of ICT and Public infrastructure on Indian manufacturing firms at the aggregate level for twelve years (1994 to 2008), Mitra & Sharma (2016) have found a positive and significant association between the ICT and infrastructure facility and productivity. However, there is a sector-level difference. Their empirical exercises show that chemicals, transport tools, and machinery enterprises perform the best in productivity. In contrast, textile and non-chemical product industries are the worst performers using ICT.

Adopting and using ICT in the firm enhances the productivity and output growth of large and organized firms and small and unorganized firms. Gupta and Kumar (2018) conducted a study on ICT use and unorganized firms' performance by taking the 67th and 73rd rounds of the NSSO survey. Their research found that ICT enhances the productivity of both large firms and small firms. In the case of an unorganized firm, the rate of increase in productivity is relatively low due to the inadequate basic infrastructure facilities. Empirically, it is concluded that the role of ICT in firm performance has been reflected in many ways, both in the case of organized and unorganized firms, through various channels. The central area of reflection is the increase in the TFP and labor productivity. Along with that, other multiple channels include better organizational setup, proper coordination among the agents of the production, reduction in the transaction cost, and better access to information.

1.3.2.3 ICT and Food Processing Industry

ICT has not only affected the performances of industry and firms but also affected the small scale enterprises like the Food Processing Industry (hereafter FPI). The FPI is coming under

SMEs and is subject to several difficulties like a high level of wastage, a low level of processing, and other such infrastructural bottlenecks. As a result, Singh et al. (2019) tried to find out the impact of ICT use in eradicating the above problem in the FPI. From their study, it has been found that ICT can play a significant role in enhancing processing levels and reducing agricultural wastage by providing proper coordination among the various agents of production. In another study of Navyashree & Bhat (2016) have analyzed the impact of ICT on SMEs by taking the FPI of India into account from 2010 to 2014. From their study, it has been found that the use of ICT, along with the size and age of the FPI, is positive & significantly affects the industry's sales growth. Armstrong et al., (2012) also analyze the impact of ICT on the value and supply chain of the agricultural sector. The successful integration of ICT into the supply chain can enhance the efficiency of the supply chain and food security in a revolutionary manner. So, ICT adoption in the agricultural sector and SMEs helps to enhance efficiency comprehensively. The adoption of ICT by the industry enhances productivity and provides valuable information, increases knowledge, improves performance, improves relationships with customers and suppliers, and increases efficiency and reduces the cost (Akemora F et al., 2012).

So, to sum it up, it has been empirically proved that the adoption of ICT in the industry affects the production and productivity of the industry in various ways, both domestically & globally. And also, the pattern of impact is the same both for aggregate industry level and firm level.

1.4 Research Gap

Most of the studies on ICT have been carried out in the case of the direct benefit of ICT on India's economic growth, and very few works on its indirect use, i.e., ICT diffusion. Again, when it comes to ICT diffusion or ICT-led growth, most of them are in the manufacturing sector at an aggregate level in India though there exist firm-level studies in the international context. The effect of ICT on the performance of various industries is manifold, as highlighted earlier. Empirically, it has been proved that the growth accounting exercise out of the technologies in aggregate and sector levels in the US and Europe shows a significant difference (Cardona et al., 2013). Empirically it is also claimed that the impact of ICT on the performance

has differed concerning time, region, and the type of industry involved (Papaioannou & Dimelis, 2011).

Further, the impact of ICT on firm-level analysis allows the incorporation of firm heterogeneity in the ICT investment on firm-level performances. In addition to the above, it also allows the incorporation of the difference in the firms' organizational capital and skill structure (Commander et al., 2008). Therefore, it would be fascinating to explore the consequence of ICT adoption in one of the vital industries of the manufacturing sector, the FPI. It also plays a prominent part in the context of the Indian economy. Again, few works have been carried out at the disaggregated level of the FPI concerning ICT (ICT) based on small and medium-scale enterprises.

1.5 Research questions

From the empirical exercise, it has been proved that the majority of firms and industries have benefited from technological development mainly through ICT. based on the above literature, the present study will raise two fundamental questions:-

- ❖ What are firm specific variables that are required to adopt ICT in the food processing industry in India?
- ❖ How the adoption of ICT has affected the performance of the food processing industry of India?

1.6 Major Objectives

To address the above two basic research questions, the present study is based on the following two major objectives:

- ❖ To analyze the adoption features of ICT of the food processing industry in India.
- ❖ To analyze the impact of ICT adoption on the productivity of the food processing industry in India.

In this context, the present study is looking at the adoption and performance of ICT in the food processing industries of India. The first objective of the study will look into, how the adoption of ICT is affected by the firm-specific variables in the food processing industries of India. In

addition to that, the second objective will focus on the impact of ICT adoption on the firm performance i.e. how the firms get benefits from the use of ICT in the food processing industries of India.

1.7 Data Sources and Methodology

The proposed study will rely on the Centre for Monitoring Indian Economy (hereafter CMIE) Prowess database to infer two objectives. Prowess is a database of the economical execution of Indian, listed, and unlisted companies. The annual descriptions of individual companies are the primary base of this database. Prowess also has a domain representing the NIC-2008 category for the firms. Firm-level details on net expenditures towards software, net asset on computers and IT systems, communication tools, software charges, and IT-enabled service charges are gathered from the Prowess database for investigation. It also gives information on salaries and wages, exports, net fixed assets, net sales, and year of incorporation, which is crucial for the analysis. The study will also use the data from the Annual Survey of India (ASI) published by the National Sample Survey Office (NSSO), India. This database is one of the essential bases disseminated by the government of India for industrial statistics of the organized industrial sector. It enables proper data collection established on suitable sample designs. It ensures timely dissemination of statistical details to evaluate the organized manufacturing sector's composition, growth, and structural dynamics. In addition to the above, information has also been collected from the EPWRF database for industry-level data. Further, various reports from the Ministry of food processing of India (MoFPI) and the Ministry of Small and Medium Scale Enterprise (MSME) of the Government of India have been considered to see the status and progress of the FPI in India. The methodologies that have been used for the two objectives have been discussed in detail in their respective chapters.

The succeeding sections of the study have been categorized into four major chapters. The second chapter of the study gives a brief overview of the food processing industries of India and their status, performance and growth, and various problems faced by the sectors. The role of firm-specific variables in adopting (or incurring) ICT has been discussed in detail in the third chapter of the study. The fourth chapter of the study talks about the productivity enhancement of the food processing industries using ICT. Finally, the fifth chapter of the study gives the concluding remarks, policy suggestions, and limitations of the study.

Chapter-II

Overview of Food Processing Industry in India

2.1. Introduction

The emergence of food processing industry is essential in most developing countries, mainly due to the industry restructuring, dietary issues, and export earnings (Wilkinson, 2004). Historically, it has been claimed that Indian people have a strong demand for fresh and unprocessed food compared to their western counterparts (Ali et al., 2009). There is a growing demand for processed food in developing countries with time. The primary reasons for this changing demand for food culture are urbanization, modernization, and changing lifestyle of the people (due to globalization) (Wilkinson, 2004). Further, other factors include the emergence of middle-income and high-income groups in the economy (with the increase in income of the people), changing demand for the food culture of the masses, and interest of the human being in experimenting with the new and different types of products (Vespa, 2000). As a result of this, the food processing industries in India also evolved and developed remarkably after globalization like other developing countries of the world. Like other developing countries, the FPI in India has an enormous prospect in terms of revenue and employment generation through value addition. This is mainly because of the availability of adequate resources, sufficient labor, technology, vast demand, and a favorable business atmosphere in the country (Ali et al., 2009). Also, it can be considered as one of the potential sources for driving the rural economy as the sector integrates both agriculture and the industry (FICCI, 2010) and has the highest both forward and backward linkages. Improvement in this linkage plays a crucial role in reducing wastage and enhancing the value addition of the agricultural produces.

Food processing means transforming natural components into food or other value-added forms. It handles the clean reaped produce & butcher animal products (Rais et al., 2013), covering a wide range of food items. This wide range of products covers meat and meat, fish, fruits and vegetables, vegetable oil, milk, milk, grain milling, animal products, bakery products, sugar processing, and so on (NIC-2008, fig - 1). This food processing sector can be broadly divided into two broad categories, namely, primarily processed food and value-added processed food (Rais et al., 2013). Primary processor or manufactured process mainly includes transforming the

raw food like agricultural produce, fisheries, and another such natural produces into the edible and commercial form, and secondary (or value-added) process refers to the addition of the value in those produces with the help of processing unit. In other words, the former refers to the transformation of raw ingredients into consumable forms and later refers to the high level of adaptation and modification with a certain amount of value addition. So, to sum up, food processing industries comprise both primary processes and the value-added process. There are two broad meanings and definitions of food processing industries, given by the National Industrial Classification (2008) and India's Ministry of FPI (2018-19), shown in detail in the following table. From the above two definitions, the present study is based on the meaning and explanation given by the national industrial classification (2008).

Table 2.1: NIC Classification of Food Processing Industries

Sl. No.	NIC 3-digit code	Sectors
1	101	Processing and Preserving of Meat
2	102	Processing and Preserving of Fish, Crustaceans, Molasses
3	103	Processing and Preserving of Fruits and Vegetables
4	104	Manufacture of Vegetables & Animal oil and Fats
5	105	Manufacture of Dairy Product
6	106	Manufacture of grain mill products, starches, and its products
7	107	Manufacture of other food products
8	108	Manufacture of prepared animal feeds

Source: NIC, 2008

Table 2.1(b): Classification of food processing industries by MoFPI

Sl. No	Sectors
1	Processing and Refrigeration of certain agricultural products (milk powder, infant milk food, malted milk food, condensed milk, ghee, and other dairy products), poultry and eggs, meat, and meat products.
2	Processing of fish (including canning and freezing);

3	Fruit and vegetable processing industry (including freezing and dehydration);
4	Food grains milling industry
5	Specialized packaging for the FPI
6	Beer including non-alcoholic beer
7	Alcoholic drinks from non-molasses base
8	Aerated water and soft drinks

Source: Ministry of Food Processing Industries, 2018-19

2.2. Growth and Performance of the FPI

Before going into the details of the ICT adoption and firm performance of the food processing industries of India, it is essential to know about its growth, performance, value addition, export earnings, and foreign direct investment in this sector. The variables mentioned above can play a crucial role in adopting ICT in the FPI. So, this section of the study is devoted to examining the above variables. Since it is challenging to get systematic single-sourced information on the food processing industries of India, we have taken information from various sources like the government ministry and department, business associations, and other sources. For which it is not easy to compare one data set with others. Given these constraints, an attempt has been made to give a broad overview of the food processing industries of India. In countries like India, food processing industries play a significant role in the economy as it connects both agricultural sectors and the industrial sector (sector with maximum forward and backward linkages). In other words, it comprises four distinct major subsectors, namely - the agricultural inputs sector, agricultural products sector, processing sector, and marketing and trading sector. This food processing sector has a vital function in India in contributing to GDP, GVA, employment generation, export earnings, and agricultural waste reduction.

Table-2.2 talks about the growth & performance of the FPI by taking GVA into account. GVA is the value addition made by any industry or firm to their respective economy. The GVA of the FPI can play an important role in the adoption of ICT. So, it is essential to have prior information about the growth & performance of GVA of FPI. The growth rate of GVA in the FPI is depicted in the nominal form in table 2.2 (a) and in percentage form in 2.2 (b). The following table-2.2 indicates that the GVA of the food processing sector has increased over time from 1.3 lakh crore to 2.08 lakh crore (in nominal value, and from –11.72 percent to 8.90 percent (in percentage

share) during 2012-13 to 2018-19. The overall GVA also increased from 85.46 lakhs crores (5.42 %) to 128.03 lakh crores (6.04%), whereas the GVA of the manufacturing sector has increased from 14.87 lakh crore (or 5.45%) to 23.17 lakh crores (or 5.80 %). So, it can be observed that the food processing sector is growing at a higher rate than the manufacturing industry. This sector is also performing better than the agricultural sector, with a record growth rate of 21.6 % during 2011-12. So, it can be considered one of the essential industries of the manufacturing sector, which has immense potential in the economy of India. Based on the above empirical evidence, there is a higher probability of adopting ICT in this food processing sector.

Table – 2.2 (a): Growth and Performance of Food processing Industries (through GVA)

Activity (Nominal Value)	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
GVA-India	85.46	90.64	97.12	104.92	113.28	120.74	128.03
GVA-MF	14.87	15.61	16.84	19.04	20.55	21.90	23.17
GVA-FPI	1.30	1.30	1.34	1.61	1.79	1.91	2.08

Source: MoFPI, 2019-20

(in lakhs crore)

Table – 2.2 (b): Growth and Performance of Food processing Industries (through GVA)

Activity (In Percentage)	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
GVA-India	5.42	6.05	7.15	8.03	7.97	6.59	6.04
GVA- MF	5.45	4.97	7.90	13.06	7.93	6.57	5.80
GVA- FPI	-11.72	0.39	3.08	20.15	11.18	6.70	8.90

Source: Ministry of Food Processing Industries, 2019-20

(in percentage)

GVA-Gross Value Added

MF- Manufacturing Sector

FPI – Food Processing Industries

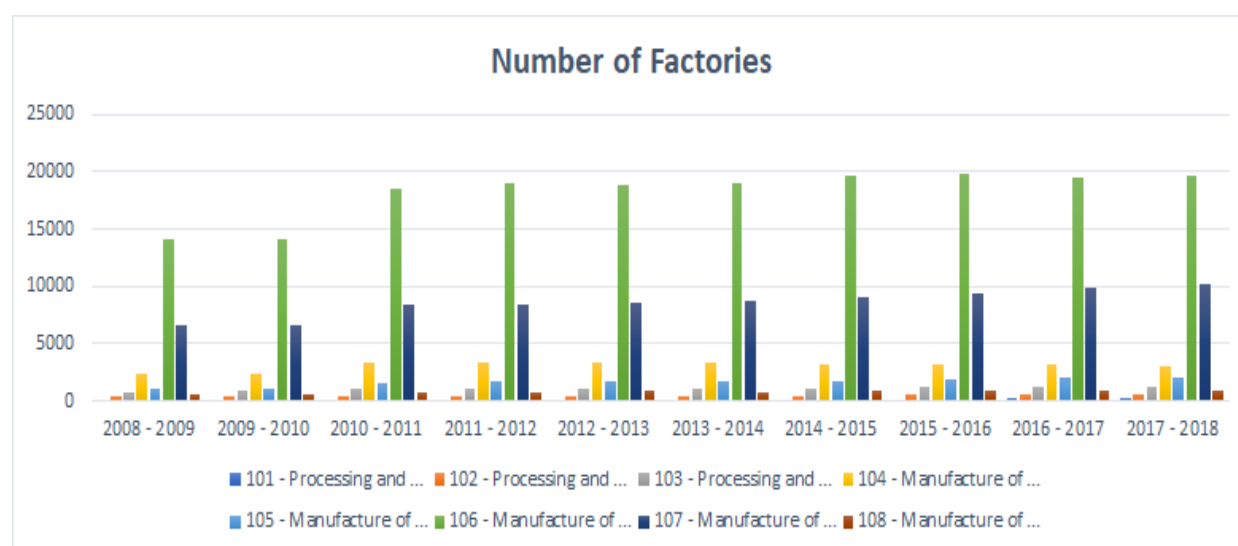
After analyzing the importance of the FPI in the Indian economy, an attempt has been made to see the growth and performance of the FPI. . Next, a passage has been devoted to seeing the various issues (specifically wastage and other such bottlenecks) faced by this food processing sector. Based on the current information, the investigation is restricted to the organized food processing sector from 2008-09 to 2017-18. To see the growth and performance of this sector, we have taken four significant variables: the number of factories, the total number of persons engaged, gross value added (GVA), and gross fixed capital formation (GFCF). The analysis of the growth & performance of the above variables is crucial regarding the adoption of ICT by this FPI. For which, we have taken information from the EPWRF database from 2008-09 to 2017-18 at the three-digit level for the FPI. Along with the above variables, total export, total FDI inflow, and gross fixed capital formation of the food processing sector also play an important role in adopting ICT. For which information on the total export, FDI, and gross fixed capital formation has been taken from the Directorate General of Commercial Intelligence and Statistics (DGCIS) Department for Promotion of Industry and International Trade (DPIIT) and the Annual Survey of Industry (ASI), respectively. The detailed analysis of each variable is explained below..

a. Number of Factories

The first and foremost characteristic to give a broad overview of the FPI is the number of factories that have been established in various parts of India. One can analyze the growth and performance of this sector by considering the number of food processing units. The expansion in the number of FPI in India is a recent phenomenon due to the demand for processed and preserved food that has evolved recently, as explained earlier. The number of factories, which can represent the proxy for the industry's size, can play a crucial role in adopting ICT. Higher the number of food processing units, there is a higher probability of adopting ICT. It can be seen from the figure that all the 3-digit eight sectors follow a similar pattern of growth over the years. The growth of all eight sectors reflects the food culture of the people of India. Further, it can be observed that the number of factories in the manufacture of grain mill products and starches & its products is increasing over the time and it is highest throughout the year (nearly 20,000 units)

followed by the manufacture of the other food products (nearly 10,000 units). Most Indians generally prefer rice and wheat as their primary diet, as a result, the number of milling factories in this industry remains at the top of the list compared to the other sectors of the FPI of India (Vepsa, 2010).

Figure-2.1: Number of factories in various sectors of FPI



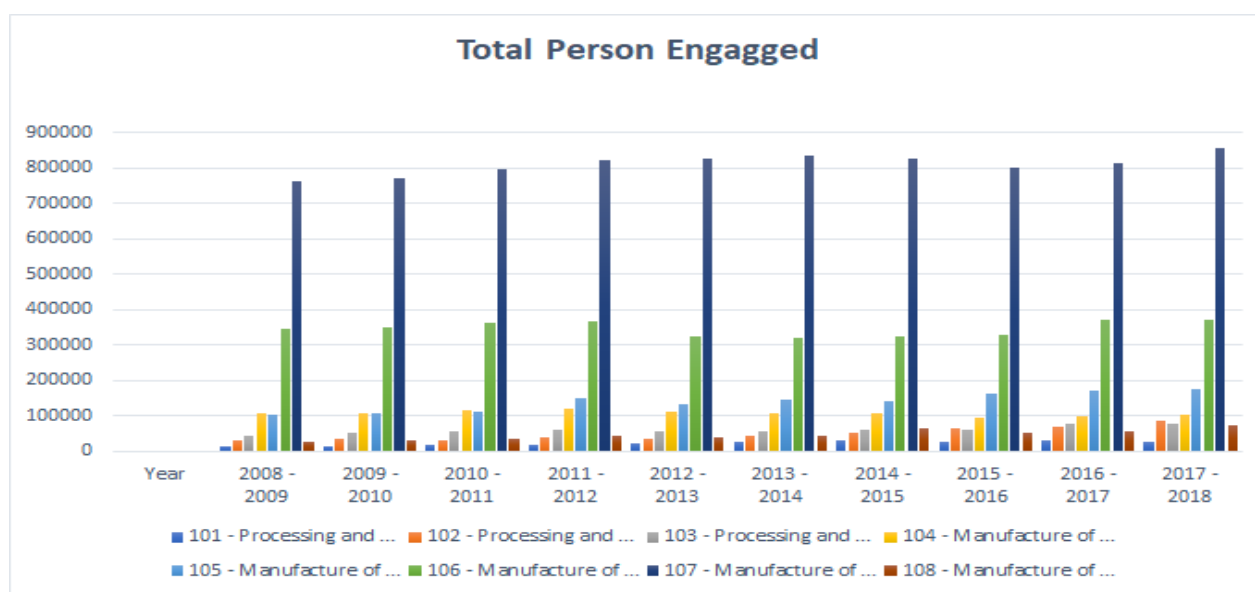
Source: Calculated from EPWRF

b. Total Person employed in FPI

After analyzing the number of the food processing industries in the country, in this section, we have seen how the organized food processing industries have been employing people over the years. Like the total number of factories, total employment generated by the FPI also plays an essential role in adopting ICT. There might be a positive association between the number of the person engaged in FPI and ICT adoption by it. To see this, we have taken the data from the EPWRF database from 2008-09 to 2017-18 to analyze the total number of persons engaged in India's organized FPI at a three-digit level (starting from 101 to 108). From the fig-2, all the eight sectors of the FPI have followed the same pattern of growth over the years concerning the number of persons engaged in the industry. This growth pattern is similar to the growth in the number of factories explained earlier. Among the eight sectors of the FPI in India, the manufacture of other food products (107)

employs the highest number of people, followed by the manufacture of cereal mill, starches (106), and the producer of dairy products (105). It is the processing and preservation of the meat sector of the industry which is employing a lesser number of workers in most of the years of analysis. The size of any sector/industry is highly correlated with the number of people engaged in that industry. In other words, the sector that is higher in size (size in terms of the number of factories) employs a higher number of people as the sector is one of the labor-intensive sectors. Further, the size of this sector is related to the taste, preference, and food culture of that particular economy, as has been explained earlier (Vepsa, 2010).

Figure-2.2: Total persons engaged in various sector of FPI



Source: Calculated from EPWRF

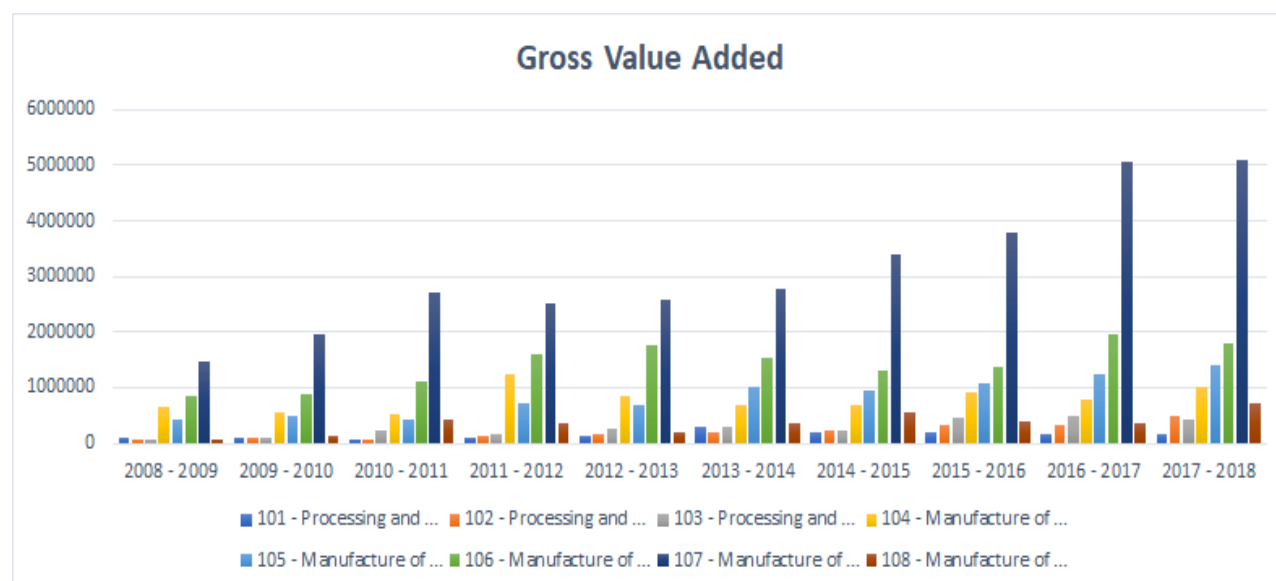
c. Gross Value Added

After employment, the next important feature which needs to be analyzed to see the overview of the FPI is the gross value added (hereafter GVA). GVA is nothing but the gross value contribution of any industry or sector to their respective economy. In technical terminology, it is the gross output minus gross input. The analysis of the GVA of the FPI can give a better picture of the contribution of this sector to the Indian economy. The analysis of GVA of the FPI is essential owing to ICT adoption as there exists a positive association between these variables. To

see this, we have taken the information from the EPWRF database for the period 2008-09 to 2017-18. From figure- 3, it can be seen that the manufacture of other food products (107) is adding the highest value to the economy, followed by the manufacture of cereal mill, starches (106), and the manufacture of dairy products (105). So, the sector providing a higher level of employment contributes to a higher level of GVA. The possible reason might be the size of the firms, and larger firms may contribute the higher gross value added. Therefore, in this case, the larger sector of the FPI is contributing a higher value addition to the economy than that of smaller sectors.

If we make a year-wise analysis of GVA of the FPI to the economy, then we find that contribution of GVA to the economy increases over the years except for 2012-13 and 2013-14 for all sectors. The reason behind this slowing down from 2012 to 2014 may be the decline in the agricultural production of India (Kumari et al., 2020). During this time, the country had witnessed a severe drought due to scanty rainfall in most of the agriculturally dominated states of India. As per the Indian Meteorological Department Pune (2013) report, 64 percent of the Indian districts, i.e., four hundred out of six hundred and twenty-seven districts had experienced drought. Despite these years, the overall GVA of the sector has been increasing as the sector is growing gradually..

Figure-2.3: Gross Value Added of FPI

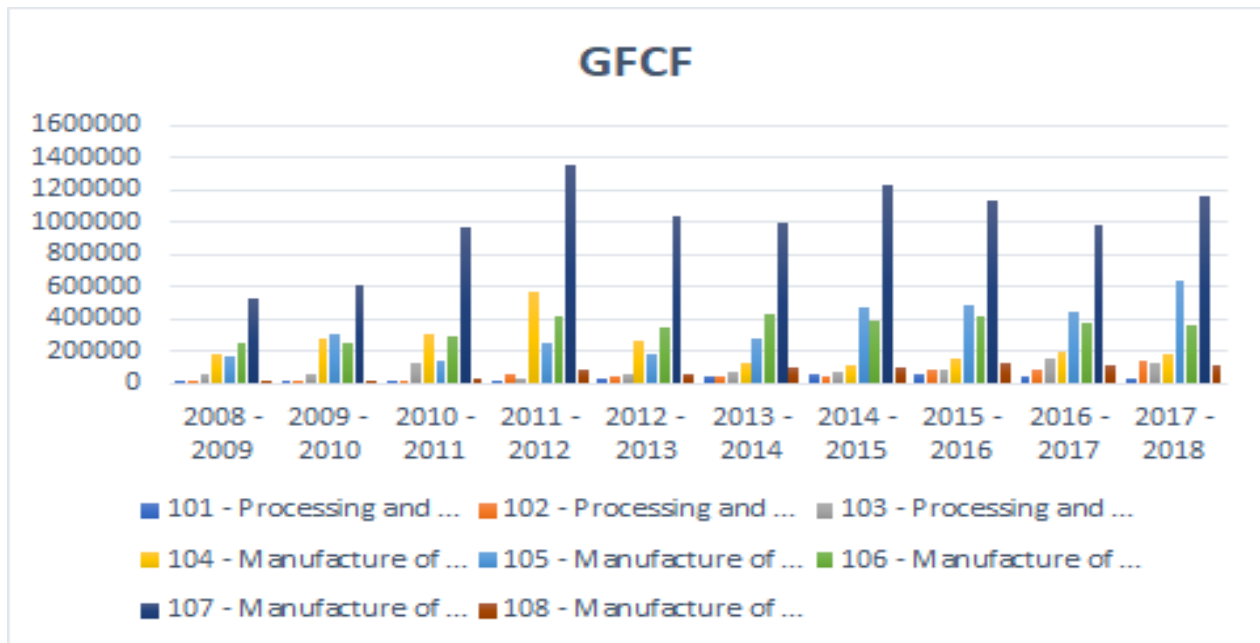


Source: Calculated from EPWRF

d. Gross fixed capital formation of Food Processing Industries

Gross fixed capital formation (hereafter GFCF) is the crucial variable that needs to be analyzed after GVA to see the overview of the FPI of India. GFCF is the acquisition of producers' assets minus fixed assets produced by a firm or industry. It is otherwise known as the Investment of any firm or Industry. GFCF of the FPI can give a broad picture of producer acquisition of the assets. This GFCF is also yet another critical variable for the determination of ICT by the FPI. We have taken the same data source and the time as the previous three variables to analyze the above. It can be observed from the figure-2.4 that the manufacture of other food products (107) is forming highest gross fixed assets followed by the manufacture of cereal mill, manufacture of dairy products (105) and the starches (106) like in the case of the total person engaged and GVA. The logic behind this kind of picture is that the bigger the firm's size, the higher will be the GFCF than that of its counterpart. The higher the volume of GFCF higher the probability of ICT adoption in the FPI. Like the gross value added, the year-wise analysis of GFCF shows the same pattern of growth. Lack of adequate rain in most of the states from 2012 to 2014 might lead to the reduction in the GFCF of the FPI for all eight sectors..

Figure-2.4: Gross Fixed Capital Formation of FPI



Source: Calculated from EPWRF

e. Fixed capital in registered FPI

The firm's fixed capital is yet another crucial variable in examining the overview of the FPI. Fixed capital of the FPI is the assets that have been owned by it. It comprises plant, machinery properties, and other things used in the production process several times. Fixed assets and firm size are directly associated, which means more prominent size firms have a higher amount of fixed capital than small firms. Furthermore, the size of the firm and ICT adoption is positively associated. So, the firm's fixed capital and ICT adoption are positively related. Data has been taken from the Annual Survey of India (hereafter ASI) from 2007-08 to 2017-18 for fixed capital of the FPI. Like other variables, as explained earlier, the fixed capital of the food processing industries has been growing over the years, starting from 2007-08 to 2017-18. It can be seen that the fixed capital has increased from 68335 crores (18.93 in percentage) in 2007-08 to 245063 crores (08.41%) in 2018-19, as shown in the following table. When the fixed capital of the registered food processing industries is concerned industry is not performing well. The growth rate of the fixed capital has been decreasing over time. During 2007-08, it was 18.39 percentages which declined to 8.41% in 2017-18. This decline is mainly attributed to the size and structure of the industry. As most of the food processing units are small and mainly labor-intensive, there is less fixed capital in the units than other manufacturing sector units.

Table –2.3: Fixed Capital of FPI

Sl. No	Year	Fixed capital (in crores)	Growth rate (in %)
1	2007-08	68335	18.93
2	2008-09	81156	18.76
3	2009-10	99482	22.58
4	2010-11	120705	21.33
5	2011-12	145038	20.16
6	2012-13	158865	09.53
7	2013-14	168380	05.98
8	2014-15	191984	14.01
9	2015-16	206339	07.47
10	2016-17	226043	09.54

11	2017-18	245063	08.41
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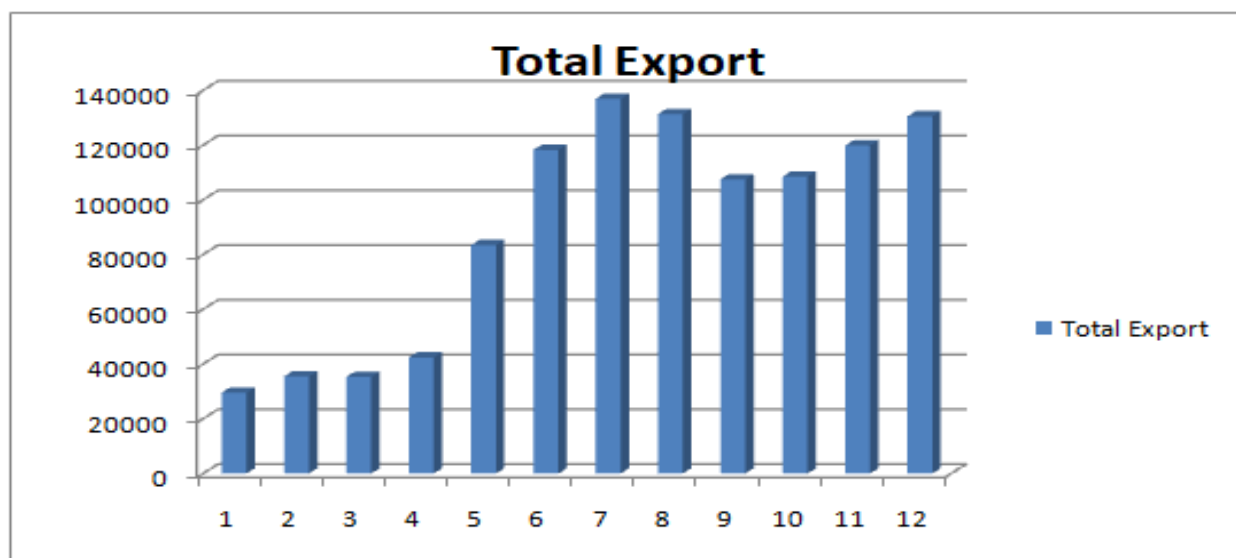
Source: Annual Survey of Industries

Total number of factories, total person engaged in various sector of the FPI, GVA, GFCF and GFA can represent the size of the industry. Both theoretically and empirically it has been claimed that size is one of the crucial element in the determination of ICT. There exist a positive association between the size and ICT adoption of the firm. For which the study has analyzed the above-mentioned variables in details.

***f.* Export of Food Processing Industry (Export of the major food products)**

The agricultural sector mainly dominates the Indian economy, and historically we have benefited a lot from this sector. Though the share of agriculture to India's gross domestic product has decreased to 13 percent recently from more than 50% during the implementation of the first five-year plan, the sector still plays a significant role. Along with the ICT adoption, the export of any economy or country plays an important position in growth, employment generation, and balance of payment correction. Moreover, there is a positive association between export and the variables mentioned above. A higher amount of export can insist the food processing firm adopt more and more ICT. As an agrarian economy, India has contributed significantly to the global economy in terms of its agricultural product export. To see the export performance of agricultural produce and processed food, we have taken information from the Director-General of Commercial Intelligence and Statistics (DGCIS) for 2007-08 to 2017-18. The contribution of India towards the global economy through the export of processed food can be discussed from the following figure (figure- 5). We can observe from the figure that total export value increased from 29,581.72 crores in 2007-08(denoted by 1 in figure- 5) to 1, 30,506.52crores in 2018-19 (denoted by 12 in figure-5). The major items in the export baskets of processed food comprise processed foods, vegetables, groundnut, guru gram, juice, milled cereals, alcoholic beverages, and edible oil. There is a decreasing trend in the export of agricultural products and processed food during 2015 & 2016, mainly due to decreased overall agricultural production. The primary reason for this reduction in export during this period is the heavy drought and reduction in agricultural production in most agricultural states. Therefore, we can conclude that India has a strong base in the export of both agricultural as well as processed food products as it comprises a major chunk of the global trade in the export of agricultural and allied products..

Figure-2.5: Total agricultural export



Source: Caclculated from DGCIS, GoI

g. Foreign Direct Investment in FPI

Another essential variable to see the overview of the food processing industries is the foreign direct investment. Like the other sectors of the economy, the food processing sector is also attracting investment from abroad. The inflow of FDI might substantially influence the adoption of ICT in the FPI. Higher the magnitude of the FDI can push to ensure a more significant amount of ICT expenses in the FPI. Based on the available information from DPIIT from 2007-08 to 2017-18, we have given a brief overview of India's FDI in the FPI. As per the norms of the DPIIT, there can be 100% of the foreign direct investment through automatic route in the food processing sectors except the sectors belonging to the Micro and Small Enterprises (MSEs). The following table explains the FDI inflow in the food processing industries of India for the period 2007-08 to 2018-19. It can be observed that FDI inflow (in terms of crores rupees) has increased from 279.01 crores rupees in 2007-08 to 46831.302 crores rupees in 2018-19 except for 2011-12. There was a slight decline in FDI inflow due to the decrease in agricultural production during 2011-12 due to heavy drought. The decline in production did not attract FDI in the food processing sector. According to the press information bureau, Government of India, the inflow of FDI to this sector has decreased to 46831.302 crores (32% reduction) in 2018-19, which was 67457.002 crores in 2017-18. The FDI inflow increased to 67422.76 crores in 2019-20 from

46831.302 crores in 2018-19. These hikes in FDI generally occur mainly because of the implementation of 100% FDI in the food processing sector through an automatic route.

Table –2.4: Foreign Direct Investment in FPI

Sl. No.	Year	FDI (In crore)
1	2007-08	279.01
2	2008-09	455.59
3	2009-10	1314.23
4	2010-11	858.03
5	2011-12	826.16
6	2012-13	2193.65
7	2013-14	25106.78
8	2014-15	38455.35
9	2015-16	37707.18
10	2016-17	54208.39
11	2017-18	67457. 002
12	2018-19	46831. 302

Source: DPIIT, GoI

All the above variables analyzed earlier might have an essential role in adopting ICT in the FPI. All the variables can positively enhance the adoption of ICT in the FPI. So, It is crucial to have brief information about the above before going into the ICT adoption in the FPI in the succeeding chapter. To conclude, most of the variables of the food processing sector have been growing over the years, starting from 2007-08 to 2017-18. From 2012 to 2014, there was a slight downward trend in all the variables. This slight decline in the growth rate is mainly due to the heavy drought (due to scanty rainfall) that we witnessed in most of the agriculturally dominated states. This chapter of the study is restricted to the organized sector only, where we have analyzed each variable by taking the information from the organized food processing sector. Due to the unavailability of the data, the study hasn't incorporated the growth and performance of the unorganized food processing sector.

2.3. Major issue of the sector

Though India has a substantial agricultural base, the wastage level is very high due to the poor post-harvest management and lack of basic infrastructural facilities. Due to this, India loses nearly 3-16% of the total produced annually. This wastage can occur starting from harvesting to the consumer plate (Balaji & Arshinder, 2016). As per the report of the Central Institute of Post-Harvest Engineering and Technology (CIPHET, 2019), 6% of the cereals, 8% of the pulses, and 10% of the oilseeds are getting wastage annually due to poor post-harvest management. India is the 2nd highest producer of fruits & vegetables after China. However, regarding fruit and vegetable waste, India is losing nearly 15-16% of its total produce annually (NHB, 2019). Due to its significant share of wastage, India has become one of the major agricultural wasters of the world (ASSOCHAM, 2013). Again, India's processing level is also deficient compared to the other countries as the country has recently achieved ten percent of processing of their total harvest and for which the country is losing nearly one lakh crore in monetary terms annually. Again, developed countries have achieved 80 percent of the processing level of their total produces, whereas India has recently achieved 10 percent of the processing level. Lack of infrastructural facilities like storing, sorting, grading, packaging, and transferring produces from one place to another require proper and adequate post-harvest management. To address the above issues that the FPI has faced and attain 5% of total wastage (from 15%) & 30 % of total processing level (from 10%), ICT can play a significant role. So, in this regard, the FPI can play a prominent role with the help of ICT because an improved and adequate amount of technology use can enhance the supply chain management, which can help in the reduction of wastage (Singh et al., 2019). This technology can also enhance the processing level in the food processing industries (Parwez, 2013). The majority of the issues in food processing industries are the results of poor post-harvest management and a lack of proper supply chain management that can be overcome with the use of ICT in the food processing industries.

2.4. Conclusion

The main objective of this section was to give a broad overview of the food processing sector by taking into account the growth and performances of its few variables. As a result, we have taken the number of factories, total employment, gross value added, GFCF and gross fixed assets for all the eight sectors of the industry from 2008-09 to 2017-18. These variables might have critical

implications concerning ICT adoption in the FPI. All the variables explained above can have a positive association with ICT adoption. From the variables mentioned above, it is found that all variables follow the same pattern of growth except for 2012-13, as explained earlier. This means that apart from 2012-13, all the sectors grew over the year, from 2008-09 to 2017-18. Also, the manufacture of other food products has played a dominant role among all the eight sectors for the entire sample regarding the growth and performance of the FPI.

Along with the above, we have also taken the export of the major agricultural produces and FDI of the entire FPI to see the sector's growth and performance. These two variables also play an essential role in adopting ICT, like the above variables. Export of the major agricultural & processed food and FDI of the FPI also show upward trends like the variables mentioned above except for 2012-13. There was a downward trend in 2012-13 for all the variables due to the shortfall in the agricultural produces. This decline in the agricultural produces mainly because of the scanty rainfall due to adverse monsoon in most of the agricultural states of India. Though the sector is growing and India has a substantial agricultural base, we are still endowed with a considerable amount of wastage and a low level of processing compared to the other developed countries. Based on the above empirical evidence, ICT can play a critical role in reducing agricultural wastage & enhancing the processing level. As a result, we are looking at the role of firm-specific variables regarding ICT adoption in the next chapter of this study..

Chapter- III

Determinants of ICT adoption by FPI in India

3.1. Introduction

In the previous chapter, we analyzed the growth, performance, and significance of the FPI in India. It has been seen that the performance of FPI in India has shown a rising trend in the recent years. Several factors might have contributed for this encouraging trend. The adoption of ICT can be a major factor therein. So, in this chapter we have tried to analyze the role of firm-specific variables in the adoption of ICT in FPI of India. There is a growing consensus in the literature that ICT are the major determinants of firms' productivity. ICT also plays a vital role in enhancing output growth (Hiller & Siedschlag, 2011). Before going into the productivity analysis of the firm using ICT, which is the subject matter of the next chapter, it is crucial to examine the factors that may affect ICT adoption. One of the major benefits of making firm-level studies is looking at the firm heterogeneity and its impact on the ICT expenses. Other benefits include capturing industry-specific effects, year-specific effects, product variation of the firms in the same industry, and other such factors. Analyzing the determinants of the ICT adoption at the firms' level is essential both from the researchers' and policy makers' point of view in this era of information. Therefore, an attempt has been made, in this chapter, to see the role of firm-specific variables in incurring ICT expenses in the FPI.

The next section of the study briefly explains the existing work on the firm's determinants of ICT expenses (role of firm-specific variables) at the global and domestic level, followed by its data sources & methodology, variables construction, empirical model, estimated results and a conclusion.

3.2. Determinants of ICT adoption: A theoretical perspective

There is relatively few mainstream economics literature that has modeled the firm's and industry's adoption of technology and innovation. The Epidemic model is one of the classic models that capture a company's technology and innovation adoption characteristics. This epidemic model assumes that adoption of new technology or innovation adoption is based on the availability of knowledge and information about that technology (like an epidemic) among adopters, as well as other learning elements (Mansfield 1963 a, b). The other learning factors in

this adoption process are exogenously determined, and the path of diffusion is primarily determined by cost reduction and product quality improvement (Stoneman & Diederer 1994). This Epidemic model of technology adoption basically depends upon the rate of spread of information about that technology among the adopters. There exist a positive association between the rate of spread of information and technology adoption. According to this model's prediction, the adoption rate of any new technology will increase with the decrease in the adoption risk (Battisti & Stoneman, 2005). Another set of literature explains the Rank Model. This Rank model is based on the return on using the new technology. So, there is a direct association between adopting the new technology & innovation and its return. As per the model, an early adopter of the new technology will get a higher return on its use than the later adopters (David, 1969; Davies, 1979; Ireland & Stoneman, 1986). This model often incorporates firm-specific variables (such as age, size, structure, and other variables) in adopting new technology & innovation. Other models, such as the Game-theoretic method, ordered model, and stock model, also have captured technology adoption by the firm and industry.

3.3. Determinants of ICT adoption: Empirical Perspectives

Taking insights from the above studies, we try to examine the effect of firm characteristics on the adoption of ICT. There are several empirical studies which focus on the issue of firm heterogeneity and its role in adopting new technology such as ICT. Corrado et al., (2017) have investigated the various channel of investment of intangible assets on firm productivity to see the ICT adoption. By taking European Union KLEMS database from 1998 to 2007, they found that ICT intensity and complementarities between ICT capital and intangible capital have affected output elasticity to a greater extent among the firms. This work has been carried out by taking the ten European countries into account. Further, the authors also observed that the investment in the intangible capital has directed to an enhancement in the factor income (output elasticity) of the non-R&D intangible capital. Commander et al., (2011) have taken the quality of infrastructure and labor regulation of the country as the exogenous variables to determine the adoption of ICT among the firm. Their study has figured out that the poorer infrastructure facility and improper labor regulations are closely associated with the lower level of productivity in the ICT capital investment. They also pointed out that more inadequate infrastructure facilities in India and

Japan are significantly related to the lower return on ICT use. Poorer infrastructure facilities are positively associated with a lower return on both ICT capitals and traditional (non-ICT) capital. Infrastructure acts as an essential part of enhancing the productivity and economic growth of the nation with the use of ICT capital. A study has observed that the effect of computerization on productivity generally takes time as the impact depends on the time-consuming investment like investment in the organizational inputs (Brynjolfsson & Hitt, 2003).

Along with complementing organizational input, a drastic decline in the price of ICT equipment during the 90s also played a crucial role in the computerization of firms. The initial phases of computer introduction can detect lower productivity as the new technology demands skills advancement and workplace reorganization (Bresnahan et al., 2002). It has also been observed that the diffusion of ICT has a long-term positive effect and short-term negative effect on the economic growth of Tsunina due to its infrastructural bottleneck (Kallal et al., 2021). Thus, ICT investment will likely drive jointly with managerial changes and enhance the firms' skill mix. Khanna and Sharma (2018) found the complementarities between the investment in information technology (IT) and research and development (R&D) in the enhancement of the labor productivity of thenine hundreds manufacturing firms for the period 2000 to 2016. Many other scholars (Hempell, 2003 & Mohnen et al., 2018) also pointed out the complementary interrelation between the investments of ICT capital with investment in additional intangible capital. As mentioned earlier, the firm's innovation and R&D expenditure, labor composition (skilled and unskilled), and nature of leadership also play a crucial role in adopting ICT in small and medium scale enterprises of 3500 firms (Giotopoulos et al., 2017). Acharya (2016) found three possible ways where the use of ICT can enhance productivity. Among all the ways, the first two ways are the complementary use of ICT and intangible capital like investment in R&D, and the third is the externalities arising from ICT use.

Several studies have been carried out on the firm-specific characteristic and technology adoptions to see this relationship. This part will see how the firm-specific variables (or features) affect ICT adoption in their respective firms. From a survey of one thousand five hundreds Italian manufacturing firms in 2001, Fabiani et al., (2005) examined the role of firm characteristics and environmental features (of the firm) in adopting ICT. Their analysis found that the firm-specific variables like size, capital, workforce, and presence of the large firm in the locality are the major determinants of the ICT adoption, and ownership structure (domestic or

foreign ownership firm) plays a role in it. Another study reveals that uneven patterns among firms, individuals, and spaces play a major role in adopting new technology. From an analysis of Irish manufacturing firms from 2001 to 2004, it has been found that the young, highly skill-intensive, and export intensive located in the urban area are using the ICT more extensively than those who are not (Haller & Siedschlag, 2011). By considering firm-specific characteristics and other such variables, Alberto & Fernando (2007) have found that size, ownership structure, and skill structure of labor (whether skilled or unskilled labor) plays a prominent role in adopting ICT. Many other studies also found the significant role of the location of the firm, previous innovation activities (Domenech et al., 2014), the composition of the labor force, subcontracting, the export intensity of the firm (Giunta & Trivier, 2011) in the adoption of ICT.

From the above theoretical and empirical literature, it is shown that numerous factors determine the adoption of ICT. It can be seen that better infrastructural facilities, proper labor regulation, and various policy implementation can have a better opportunity to adopt and use the ICT at country level. However, at the firm level, firm having large size, more experienced, foreign ownership, higher profit, and advantageous location can have a higher probability of incurring more ICT expenses. Moreover firm producing perishable product are also more likely to adopt ICT as compared to their counterpart.

3.4. Methodology, data, and variables construction

3.4.1. Empirical Model

Theoretically and empirically, it has been proved that several factors determine ICT adoption by a firm. So, an attempt has been made to see the function of firm-specific features in adopting ICT in their respective firms. Based on the above evidence and hypothesis, we identify the role of firm characteristics in adopting/incurred ICT expenses by estimating the following model. Based on the data constraints, we are not taking any of the theoretical models (which have been explained earlier); instead, we have taken the role of firm-specific variables exclusively to determine the ICT in the FPI of India.

We have employed the Probit model to examine the function of firm-specific variables in adopting ICT. As the dependent variable is binary in nature (zero or one), the Probit model is the

appropriate model to identify the determinants of the ICT expenses of the food processing industries of India.

Model

$$Probability(Y_{it}=1) = F(X_{it}\beta) + \epsilon_{it} \dots\dots\dots(3.1)$$

Where β represents the vector of parameters that needs to be estimated, and X represents the vector of explanatory variables such as age, types, structure, size, energy, raw materials, profits, assets of the firms. The final Probit regression equation can be discussed as follows.

Final probability model

$$Probability(ICT = 1) = \beta_0 + \beta_1 age + \beta_2 types + \beta_3 structure + \beta_4 sales + \beta_5 energy + \beta_6 raw materials + \beta_7 profit + \beta_8 assets + \epsilon_{it} \dots\dots\dots (3.2).$$

3.4.2. Data source and variable description

This chapter of the study is entirely based on the CMIE prowess database. This base is the primary source for the time series information on the annual performances of 40,000 companies since the 1990s. It covers unit-level data on net expenditures towards software, net expenses on computers & IT systems, communication equipment, software charges, and IT-enabled service charges from the prowess database. The above includes wages, exports, net fixed acquisitions, net sales, and incorporation year with the NIC 2008 classification. So, the study has taken information for both ICT expenses and firm-specific variables from this database. In order to examine the determinants of ICT adoption, the study has used only the firm-specific variables, owing to the data constraint of other variables.

The study's primary objective is to see the role of firm-specific variables on ICT adoption in the FPI. So, in the empirical model, we are looking at whether a firm is incurring ICT expenses or not. The decision variable is binary (qualitative response) in nature, which takes the value 0 or 1. If a firm adopts the ICT, the outcome variable is one; otherwise, it is zero. In order to measure the above, we have used the Probit model of estimation. By taking the help of this Probit model we can analyzed the ICT adoption of the FPI.

In order to examine adoption features, cross-sectional information of 215 observations of various firms has been taken into account for the year 2005. These 215 observations comprise all the eight sectors of the FPI (3-digit industry), starting from 101 to 108. We have taken 2005 as the

year of analysis as the firm has started giving its information on the ICT expenses this year. Therefore, we assume that firms have adopted ICT in their production process since 2005. If a firm were opting for ICT in 2005, then that firm would be an ICT adopter firm for years to come. So, in this way, we have tried to find out the adoption features of ICT in the FPI of India. This is the only way to see the role of firm-specific features in adopting ICT by the FPI. In this study, we have 215 observations for the analysis with their firm-specific variables for 2005. Each observation in the sample is entirely based on the available data in the Prowess like ICT expenses, total sales, salaries & wages, gross fixed assets, energy, raw materials, and profit. Based on the ICT expenses of the firm, the total observations have been broadly divided into two categories, namely, adopter and non-adopter, and further analysis have been done accordingly.

3.4.3 Variable Description:

To understand the determinants of ICT adoption by food processing firms, we have considered firm-specific variables as the determining factors. The details of the variables are presented in Table 3.1.

Table- 3.1: Description of the Variables

Sl. No	Variables	symbols	The definition used in the Study
1	ICT Expenses	ictexp	Telephone expenses + IT and ITES services + Software Charges + IT enabled services
2	Firm Size	size	Gross fixed assets of the firm
3	Firm Age	Age	Year of analysis (2005) – Initial year of incorporation
4	Structure	struct	Ownership structure of the firm i.e, Foreign or Domestic
5	Types	Types	Types of goods produced i.e perishable or Non-Perishable
6	Profit	profit	Total amount of profit earned by the firm
7	Energy	enrg	Total amount of fuel and electricity consumed by the firm
8	Raw Materials	rm	Total amount of raw materials consumed by the firm

Source: CMIE Prowess

Size: Sales represent the firm's size, which plays a significant role in adopting any technology. Apart from the sales, many kinds of literature have taken gross fixed assets (GFA), net fixed assets (NFA), and gross fixed capital (GFC) as the proxy for determining the firm's size. Studies in the literature have found a positive association between the firms' size (sales/GFA/NFA/GFC) and the adoption of technology by them. In other words, larger the sales, GFA, NFA, and GFC of the firms, the higher the probability of adopting the technology (Basant et al., 2006; Lal. K 2004). In this study, we have taken GFA to measure the firm's size. GFA also represent the proxy for the firm's size like sales, net fixed assets, and gross fixed capital. This GFA is also an important variable that can determine the adoption of the technology by the firms. According to the literature, there exists a positive association between the GFA of the firm and technology adoption. This relationship indicates that the higher the GFA, the more the chance to adopt the technology (Casson & Singh, 1993). Many other pieces of literature also argued that the larger the firm's size, the higher the probability of adopting new technology and innovation (Schumpeter, 1934). Because large firms are efficient and take the risk of technology adoption in their production process compared to their counterpart.

Age: The firm's age is one of the crucial determinants for ICT adoption by firms. Two different kinds of arguments prevail in the literature that exhibits the relationship between the age of the firms and the adoption of technology by them. One set of literature argues the positive relationship, whereas another piece of the literature reveals the negative relationship between the firm's age and ICT adoption. The positive relationship indicates that when the firm gets older, there is a higher probability that they will go to adopt technology as they are more experienced, wealthy, and can take the risk (Basant et al., (2006) Lal. K (2004)). On the other hand, the negative relationship indicates that younger and new firms go for the adoption of the technology as they are evolved in the age of information and are more digitalized than aged firms. So, there is a higher probability that they will go for the adoption of the ICT (Gambardella and Torrisi (2001), Murphy and Siedschlag (2015)).

Types: After the firm's age, the nature of the goods (perishable or non-perishable) produced also plays a vital role in adopting the technology. The intensity of adoption of ICT by the perishable goods-producing firm is higher than that of the non-perishable producing firm, as evident in the existing studies (Prakash et al., (2015), Bagchi et al., (2018)).

Structure- The firm's ownership structure (domestic or foreign) also has a vital role in adopting ICT. From the literature, it has been found that the firms owned by the foreign entity are more prominent for adopting new technology and innovation than their counterpart because the foreign-owned firms are more modernized, digitalized, and innovative (Haller & Siedschlag, 2015).

Energy: Energy consumption is another important variable that plays a crucial role in adopting technology by firms. Existing studies on the relationship between the firm's energy consumption and the adoption of the technology have found a negative association between these two variables. This negative association means that the adoption of technology and any such kind of innovation reduces expenses on energy, for which there is an inverse relationship between the adoption and energy consumption. In other words, ICT plays a crucial role in the management of the energy consumption of the firm. The use of more and more ICT in the firm can enhance the energy efficiency of the firms (Laura-Diana Radu, 2016).

Raw Materials: Further, adopting any technology depends on what kind of raw materials a firm is consuming. The literature shows a negative association between ICT adoption and raw materials consumption like energy consumption. Adopting ICT by the firm reduces raw materials consumption to a greater extent (Laura-Diana Radu, 2016). As a result, there is a negative relation between ICT adoption and raw materials consumption.

Profit: There is much literature on the relationship between ICT adoption and profit level. Most of the literature has found a positive and significant relationship between these two variables which means the probability of ICT adoption will be higher with the increase in profit of the firms (Lal. K, 2004).

3.5. Estimation procedure

The study's primary goal is to examine the firm-specific variables and their impact on the incurring of ICT expenses. ICT expenses in the model are defined as the sum of the total amount of telephone expenses, IT and ITES services, software charges, and IT-enabled services. The details of the construction of other variables, apart from the total ICT expenses, have been given in table 3.1. Further, all the variables have been normalized by taking their respective price indices (deflated with the Wholesale Price Index). We have used the Probit estimation to see the firm-specific variables and their role in incurring ICT expenses. As mentioned earlier, the study

has estimated the probability of incurring ICT expenses as a function of firm size, age, ownership structure, raw material consumption, gross fixed assets, and energy consumption.

3.6. Descriptive Statistics

Table 3.2 briefly explains the sample of the food processing industries of India for the year 2005. The firm that has not reported or had zero ICT expenses is categorized as a non-adopter firm, and a firm with a positive amount of ICT expenses is called an ICT adopter firm. It is essential to see the detail of ICT expenses and determine variables for the year 2005 as we are looking at the ICT adoption in the FPI. To do so, we have two sets of summary statistics. The first set of statistics talks about the ICT expenses, whereas other statistics sets discuss the deterministic variables of the ICT expenses.

Table 3.2: Summary statistics of ICT expenses

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
totalicte	215	0.003746	0.007775	0	0.052588
telephone	215	0.003571	0.007756	0	0.052588
ites	90	0	0	0	0
software	90	8.35E-05	0.000568	0	0.004508
itenabled	90	0.000334	0.001712	0	0.013523

Source: Calculated from the Prowess

(in millions)

It can be seen from Table 3.2 that there is a total number of 215 observations for the year 2005. Of them, 90 observations (41.86%) have adopted the ICT, whereas the remaining 125 (58.14%) have not adopted it. Regarding the total ICT expenses, the average ICT expenses are 0.003746 million, ranging between zero minimum and 0.052588 million maximum. The average telephone expense consists of 0.003571 million, software expenses consist of 8.35E-05 million, and IT-enabled expenses are 0.000334 million. No firm has incurred any expenses on ITES services for 2005, as depicted in the above table. As we have incorporated both adopter and non-adopter firms into our analysis; hence the minimum ICT expenses and their composition are coming to zero.

Table- 3.3: Summary statistics of firm-specific variables

Variables	Observations	Mean	S.D	Minimum	Maximum
Industry	215	105.707	1.719242	101	108
types	215	0.12093	0.326807	0	1
structure	215	0.023256	0.151067	0	1
Age	215	28.93488	25.61132	3	115
realsales	215	23.85827	52.59119	0.00601	567.6472
realwage	215	2.325943	4.016865	0.003005	24.94922
realenergy	215	0.72787	1.608812	0.001533	15.17747
realrm	215	14.67084	63.90019	0.001258	718.6676
realprofit	215	0.941632	3.638737	-12.7683	22.51657
realgfa	215	9.120563	18.66331	0.013834	143.5315

Source: Calculated from the Prowess (in millions)

The above table shows that the sample for 2005 comprises all the eight categories of industries (starting from three-digit 101 to 108). Further, the sample consists of both the perishable and non-perishable goods-producing firms (types of the firm) and domestic and foreign firms (ownership structure). The average sales of the firm are 23.85827 million, whereas the average wage and average energy consumption are 2.325943 and 0.72787 million, respectively. In addition to the above, the average raw materials consumption is 14.67084 million, whereas the average profit is 0.941632, and the average gross fixed asset is 9.120563 million. The other details of the variables have been given in detail in Table 3.3 above.

3.7. Estimated Results:

Table-3.4: Results of Probit Estimation

Variables	Model -I (Probit)
Age	-0.018 *** (0.0047283)
Type	0.248 (0.301284)

Structure	- 0.336 (0.814591)
Size	-0.161 *** (0.037961)
Energy	-0.7318 ** (0.3969667)
Raw materials	-0.001 (0.00307)
Profit	0.0350 (0.11837)

Source: Author's own calculation (* Significant at 10%, ** Significant at 5%, *** Significant at 1%)

In the above table, telephone expenses accompanied by other ICT expenses have been considered as the proxy for ICT adoption. This ICT adoption depends upon the age, types, structure, energy consumption raw materials consumption and profit of the firm as shown in the above table. Estimated results from the above Probit model can be discussed in details as follows.

The relationship between the age of the firms and the adoption of ICT by them is negative and significant. This means that old/traditional/experienced food processing firms are not likely to adopt the ICT. Instead, it is the new and young firms who are more likely to adopt ICT. This result implies that the firms evolved recently in the age of information are, opting for technology in their production process than experienced & aged firms. This finding is also supported by the previous literature (Gambardella & Torrasi, 2001; Haller & Siedschlag, 2015). Regarding the firm's size, the coefficient is negative at a significant level. This indicates that small-sized firms are more likely to adopt ICT in the FPI. This might be the case that large-sized firms have already adopted the ICT, and small firms are now opting for it. As a result, we have been endowed with the above-estimated results. Surprisingly this is not in line with the existing literature on the relationship between size and ICT adoption of the firm. The relationship between energy consumption and ICT adoption is negative and significant. This estimated result indicates that the energy efficient firms are more likely to adopt ICT than its counterpart. Like the estimated results of the variable age, this variable also supports the existing literature.

The coefficient for the variable that explains the types of goods produced by the firm is insignificant. This implies that nature of the goods produced by firms does not have any significant role in determining ICT adoption. Further, there is no such evidence in the model for the firm's ownership structure in determining ICT adoption as the coefficient is insignificant. As per the existing study, foreign-owned firms are more prone to ICT adoption than their domestic counterparts. However, in this study, we have endowed with the negative and insignificant results regarding the firm's structure and ICT adoption. The result also shows that raw materials and profits of the firm do not have any significant role in determining ICT adoption as it come insignificant. As per the existing literature thereexists a positive relationship between raw materials consumption and ICT adoption of the firm. But in this study the coefficient is coming negative but at an insignificant level. Again, most of the studies found a positive and significant relationship between the profit and ICT adoption of the firm. In our model, it is also coming positive, as mentioned in the above table but at an insignificant level. As a result, we can conclude that the estimated results on the profit with the ICT adoption do not support the existing literature on it.

3.8. Conclusion

There are many pieces of literature on the use of ICT and its determinants at the aggregate level, and various studies have taken various approaches to investigate the determinants of ICT. In most of the studies, firm-specific variables are significant and positive with the adoption of ICT at the aggregate level. Keeping that in mind, we have investigated the role of firm-specific variables in adopting ICT by taking the food processing industries into account. As the FPI of India is small (in terms of its sales, GFA, GFC) as compared to other industries of the manufacturing sector, most of the standard relationships of the firm characteristic variables and ICT adoption are not holding in this industry. The estimated results show that the age and size of the firm are affecting negatively at a significant level to the ICT adoption of the FPI. This means those younger and smaller firms adopt ICT more than their counterparts in the FPI. The relationship between energy consumption and ICT adoption is becoming negative and significant. The estimated result between these two variables indicated that energy-efficient firms are adopting ICT. Apart from these variables, all the other variables like types of good produced, raw materials consumption, and profit of the firm do not significantly affect the ICT adoption as their results are

insignificant. All these are not supporting the existing literature on the relationship between firm-specific variables and ICT adoption. We have been endowed with the above results because of unique features of the FPI that are small in size, lack basic infrastructural facilities, and other such bottleneck. Because adoption of ICT in the firm requires a minimum size and proper infrastructural facilities. Therefore, as proved in our study, we can conclude that the standard relationship between the ICT uses with its determinants which generally holds at the aggregate level in various industries is not holding goods in the FPI of India. .

Chapter-IV

Impact of ICT on performance of FPI

4.1. Introduction

After knowing the adoption features of ICT, in the previous chapter, the next essential task is to analyze the effect of ICT on the performance of the FPI of India. As a result, in this chapter, we have examined the impact of ICT adoption on the firm's performance by considering India's food processing industry. ICT (hereafter ICT) has two significant but interrelated roles in the economy: the growth of ICT and ICT use. The former represents the direct benefit of ICT, whereas the latter talks about the indirect benefits of ICT (ICT diffusion/ICT use) in the economy (Joseph & Abraham, 2007). In the era of globalization, every firm and industry use ICT equipment (or makes ICT investments) in their production process directly or indirectly. It is not easy to sustain and compete in the globalized economy without ICT. Empirically it is also proved that the tremendous productivity growth of the USA and European Union after the 90s is mainly because of the growth of ICT equipment production and ICT use in their production process (Acharya, 2016). Theoretically and empirically, it is evident that ICT has led to productivity & economic growth. Therefore, in this chapter, we will see how ICT adoption impacts the firm's performance. ICT use can be estimated in net expenses towards its telephone, software, internet charges, IT and ITES services, IT-enabled services, and broadband services. Apart from the above, different pieces of literature have taken different measures to evaluate this ICT adoption. In our study, we have brought the telephone expenses, software charges, IT and ITES services, and IT-enabled services of the FPI as the representative for ICT use. On the other hand, the performance of the firms with the use of ICT can be estimated in terms of its total factor productivity, labor productivity, and enhancement of efficiency, better organizational structure, and proper coordination among the agents of production. The next section of the chapter gives a comprehensive overview of the existing works on the impact of ICT adoption on the performance of the firms, followed by data sources and methodology, variables construction, and summary statistics for the estimation. The final part of the chapter calculated the total productivity from ICT of the food processing industries of India, followed by a concluding remark.

4.2. ICT and Firm's Performance: Theoretical and Empirical evidence

As proved in most theoretical papers, using ICT leads to the enhancement of TFP & efficiency of the producing unit. So, the firm's performance with ICT use can be broadly measured either through productivity or change in efficiency. The production function technique can examine the TFP with ICT use. In contrast, efficiency change can be evaluated through Stochastic Frontier Analysis (SFA) or Data Envelopment Analysis (DEA). Firstly, Nishimizu & Page (1982) designed a methodology to decompose the TFP to technological change & efficiency change by taking the data from Yugoslavia. This has been carried out by specifying a trans-log production function in the parametric technique of Aigner and Chu (1968) and Trimmer (1971). Further, Fare et al. (1989) developed the above method to calculate the efficiency through Malmquist Productivity Index by considering the non-parametric technique. This productivity index is calculated from the percentage of distance function, where productivity is defined as the net difference in the technical efficiency and technological changes. This technical efficiency is generally measured with the help of distance function from the technology frontier of the firm or industry.

On the other hand, technological change indicates a shift in the production function. One of the significant problems in constructing the above model is the assumption of constant return to scale and ruled out of the scale effect. However, Fare et al., (1989) later constructed their decomposition method to capture the scale effect of the productivity. This model also experienced internal inconsistency due to the incorporation of the CRS in the production process. Finally, Ray and Desil (1997) have developed a model based on the efficiency change and variable return to scale to avoid the problem of inconsistency.

To sum up, the impact of ICT on a firm's performance can be examined in two forms. They are productivity analysis and efficiency analysis. Out of the two, this study is confined to productivity analysis only as efficiency analysis of ICT use requires a different and new type of analysis. Again, Due to Prowess's data constraints, we have been confined to productivity analysis of ICT use. So, the next section of the study will briefly illustrate the role of ICT on the firm's performance.

4.2.1 Related literature:

This section provides a brief overview of how ICT has led to increased TFP and other performance changes in various countries, sectors, industries, and firms. Many studies have been conducted to see the effect of ICT on the firm's performance. Different pieces of literature have taken different types and components of ICT as a proxy for ICT use.

Numerous studies at the micro and macro levels have been carried out to examine the relationship between ICT expenses and total factor productivity. One of the studies by Li et al. (2022) found a substantial positive relationship between ICT use and TFP. They have claimed the above argument by taking the listed manufacturing firms of China from 2000 to 2019. Another study on the relationship between the ICT and TFP also found a positive association by taking the Italian manufacturing sector into account (Castiglione & Infante, 2010). Haller and Lyons (2019) did a firm-level panel study from 2006 to 2012 in Ireland's service and distribution sector. They looked into the impact of broadband service on the total factor productivity. Their study found that broadband use has led to the enhancement of the TFP in the information and communication, administration, and supportive services. By analyzing the role of R&D and ICT (both direct and indirect effects of the ICT) on the TFP growth in some of the industries of Sweden, the authors found a positive association between the R&D and ICT and total factor productivity. It is also pointed out that there is an influential association between ICT use and TFP in the long run, which is not valid in the case of the short run (Edquist & Henerkson, 2015, 2017). With the help of the Business Environment and Enterprise Performance Survey, Botric et al., (2017) have examined the determinants of post-transition productivity in some countries. Their study found that ICT also plays a predominant role along with the other variables like investment in R&D & human capital, competition, and trade. A cross-country investigation has been carried out across the 38 countries to see the role of ICT on TFP and externalities effect. Their studies found that ICT has led to the generation of the externalities, which ultimately ends with the enhancement of TFP with the presence of the digital divide (Huret al., 2005). Using an advanced estimation procedure covering non-stationarity, endogeneity, and reverse causality, Mitra et al., (2011) studied Indian manufacturing by taking the data from 1994 to 2008. Their analysis found that ICT use has not improved the productivity of the core sectors of the manufacturing sector adequately. The primary rationale behind such lousy performance in the

infrastructure sector is the infrastructural bottleneck. This infrastructural bottleneck primarily hampers the productivity of the manufacturing sector.

Against this backdrop, the study's main objective is to empirically investigate the effect of ICT investment on the firm's productivity. The central hypothesis is that investment in ICT equipment has a substantial and positive impact on productivity. In other words, higher investment in ICT will lead to a higher level of productivity, given the other inputs.

4.3. ICT and Productivity: Methodology

One of the primary objectives of economic research is to find out the causal relationship between the economic variables. There are many methods in the economic literature to find out this kind of relationship. The relationship between input and output comprises the central segment of the research like construction of labor productivity, total factor productivity, and other such things. In this section of the study, we have tried to determine the relationship between ICT and total factor productivity. So, it is essential to know the various methods from the existing literature to measure TFP before computing it. Below, we have analyzed several methods the authors employed to construct the TFP.

TFP is the net transformation in output due to per unit total change in input. It captures all the measures that comprise the improvements in efficiency and technology (Fabricant, 1959). There are three primary methods to measure the TFP of the firm/industry/country. This TFP method is an improvement over the partial productivity method because it measures the net change in output due to change in per unit of input (Kalashami et al., 2020). For this section of the study, we have tried to analyze the few methods that have evolved into measuring it. They are the *Production function approach*, *Growth accounting approach*, and *Non-parametric approach*. Both the production function and growth accounting approach are parametric methods, whereas the latter is a non-parametric method. The main objective of the parametric method is to measure productivity, whereas the non-parametric method computes the efficiency through DEA and SFA (Saikia, 2014). Based on the availability of information on the ICT expenses and other firm-specific variables, this study is restricted to the production function approach.

The method of estimating output from the given level of input is historical, which started in the 1800s using several pieces of literature. The most frequently used method to see the productivity impact of ICT at the firm level is the production function framework, where ICT expenses can be treated as unique inputs. With the advancement in productivity measurement, it is possible to distinguish between ICT expenses and other inputs and their respective effect on productivity growth (Cardona & Kretschmer, 2013). As a result, this study has tried to see the impact of ICT capital on the productivity growth of the food processing industries of India with the help of simple production function techniques.

Therefore, the present study has used the production function approach to see the impact of ICT adoption on the firms' productivity. The firm is assumed to produce the output (Y) by using several inputs, namely, capital (K) and labor (L) with the current level of technology (T). Improvement in technology can enhance the productivity of both traditional inputs, as explained above, and ICT input.. Output can be increased by increasing any inputs, as mentioned earlier, given the constant return to scale or increasing return to scale. However, to increase productivity, we need to increase the level of technology along with the other inputs. Given the above condition, food processing industries in India can also enhance their productivity by investing more in the ICT expenses and R&D expenditure than in traditional inputs and other such factors. In the line of the above literature, the production function approach has been used to see the impact of ICT on the firms' productivity. This approach is one of the widely used techniques to construct the firms' total productivity. This methodology is also an improvement over the case study approach. This case studies approach required a detailed analysis of the technology's introduction, diffusion, and growth path, which is not required in the case of the production functions approach of the productivity estimation (Griliches, 1979). In the case of production function, the firm generally produces its output with the help of conventional input (like labor, raw materials, energy and other such inputs) and ICT inputs.

In this section of the study, we have investigated the impact of ICT expenses on the TFP of the food processing industries of India. Here, the production function comprises both net fixed assets and ICT expenses. By incorporating the ICT expenses, we can analyze their significant impact on TFP. Based on the above theoretical and empirical evidence, we assume that the use of ICT in the FPI will enhance total factor productivity.

4.4. Data source and Variables construction

For the measurement of TFP of the firms, we have entirely relied on the CMIE prowess database. As mentioned earlier in the previous chapter, CMIE Prowess is a significant destination for the time series information on the financial performances of the 40,000 both listed and unlisted companies since the 1990s. It covers unit-level data on net expenditures towards software, net expenses on computers & IT systems, communication equipment, software charges, and IT-enabled service charges from the prowess database. The above includes wages, exports, net fixed acquisitions, net sales, and incorporation year with the NIC 2008 classification. For both the ICT expenses and firm-specific variables, data has been taken from this major source of information on the Indian food processing industries.

To examine the effect of ICT on the productivity of the FPI, we have constructed thirteen years of unbalanced panels from 2005 to 2018. The main reason behind choosing this period (2005 to 2018) is the availability of data from the Prowess database. From 2005 onwards, food processing industries started reporting their annual expenses on ICT. A total of 1323 observations in the panel have been considered to see the impact of ICT on the firm's productivity. The above sample has been taken into account based on their availability of data in the Prowess, like reporting the variables on ICT expenses, total sales, salaries & wages, net fixed assets, energy, raw materials, profit, and other such firm-specific variables.

Table- 4.1: Variable constructions

Sl. No	Variables	symbols	Definition used in the Study
1	ICT Expenses	ictexp	Telephone expenses + Software Charges + Internet charges + ISPS and other charges
2	Output	output	Total sales of the firm
3	profit	profit	Total profit of the firm
4	Labor	lab	Total amount of labor employed
5	Energy	enrg	Total amount of fuel and electricity consumed by the firm
6	Raw Materials	rm	Total amount of raw materials consumed by the

			firm
7	Capital	cap	Net fixed asset of the firm

Source: constructed from the prowess

As mentioned in the previous chapter (chapter-3), we have used the same procedure to construct the variables. ICT expenses of the firm are constituted of telephone expenses, software charges, internet charges, and ISPS & other services. Total sales of the firm have measured the output of the firm. On the other hand, variables on profit, raw material consumption energy consumption have been measured by taking the total amount of profit raw materials consumption and energy consumption respectively. The total number of labor has been obtained by dividing the total amount of wage of the firm by the average wages received in the industry obtained from the ASI. All the variables mentioned in the table 4.1 are deflated with their respective price indices. We have taken the log value of net fixed assets (hereafter NFA) for capital construction (Pattanayak & Thangavelu, 2014). This Net fixed asset has been normalized by taking its log value. Log value of net fixed assets has been taken into account as the proxy for the capital for the construction of TFP. We have not constructed the capital series for the estimation of TFP as the study required continuous data on the gross fixed assets, which is not available in the prowess database. For which, like many other studies, this study is also taken the net fixed assets as the proxy for the capital

The perpetual inventory method (hereafter PIM) is one of the appropriate methods for constructing capital series to measure TFP (Sharma and Mishra, 2012). However, the PIM method is more suitable for extended and continuous time-series data (Parameswaran, 2009). It will be challenging to construct capital series with the help of PIM due to the unavailability of continuous data and the presence of missing variables in the Prowess. As a result, it will be convenient to take the NFA as the proxy for capital for the construction of TFP. Capital series can be a better representative of capital than that of GFA and NFA for the estimation of TFP. Using a capital series as the proxy of capital can give more accurate results than other proxies of capital. But owing to the data constraints we have used the NFA as the proxy for capital.

4.5. Summary statistics

From the summary statistics, we can have a brief idea about the firm-specific variables of the food processing industries of India, which have been taken into account for the estimation of

total factor productivity. We have deflated all the variables with their respective price indices for comparison. As a result, all the variables are in one common form, i.e., real variable form.

Table- 4.2: Summary statistics of the variables

Variable	Observations	Mean	Std. Dev.	Min	Max
Output	1,323	15.60926	1.637819	7.139701	20.30393
labour	1,323	4.93031	1.451438	0.470997	10.1365
ICT	1,323	8.41503	1.303945	6.79532	15.93513
Capital	1,323	4.298646	12.60206	.0107656	213.3485
Energy	1,323	11.74366	1.531438	6.7495	16.22516
Material	1,323	15.18056	1.882952	7.234454	19.57744

Source: Authors own calculation

The average output produced is 15.6 million, with a maximum of 20.3 million and a minimum of 7.1 million, as shown in table 4.2. The average number of labor employed is 5, with a maximum of ten and a minimum of one labor. The average total ICT expenses of the firm are 8.4 million, with a maximum of 15.9 million and a minimum of 6.7 million. Similarly, the average expenses for capital, energy, and raw materials consumption are 4.2 million, 11.7 million, and 15.1 million, respectively, as explained in the above table.

4.6. Estimation Procedure

The empirical exercise of the study is based on the Cobb-Douglas production function. In this production function, the input capital comprises traditional and ICT capital. The net fixed asset is the proxy for the traditional capital, as seen in the previous studies (Lu et al., 2016). In contrast, ICT expenses have been incorporated as the proxy for ICT adoption. The basic Cobb-Douglas production has been enumerated in equation one as follows,

$$Y = A K^{\alpha} L^{\beta} \dots\dots\dots(1)$$

Equation 1 represents the basic Cobb-Douglas Production with two variables Where,

Y = Total output produced by the firms

A = TFP

K = Capital used in the production process

α = coefficient of the capital

L= Labor employed in the production process.

β =coefficient of the Labor

From the above, the TFP has been estimated to see the impact of ICT. For which, we have specified the following model,

$$TFP = \beta_0 + \beta_1 ICT_{it} + X_{it} + \epsilon_{it} \dots\dots\dots (2)$$

TFP represents the total factor productivity, and ICT_{it} represents the ICT. The variable ICT in the above equation (2) is one of the significant determinants of the total factor productivity, expressed as the total ICT expenses incurred by the food processing industries. X_{it} represents the other control variables, such as age and the energy intensity of the firm. These control variables, age (Aubert & Crepon, 2003) and energy intensity (Sahu & Narayanan, 2011), might impact the firm's total factor productivity. Here the firm's age is calculated by distinguishing the year of analysis and the year of incorporation.. On the other hand, the variable energy intensity is estimated as a proportion of total energy consumption to the firm's gross sales. Finally, ϵ_{it} represents the error terms which is not directly observable. The model specified in equation (2) is subject to the problem of simultaneity as the input, and unobservable productivity shocks are correlated to each other. With this issue, the estimation of the model through ordinary OLS will give biased and inconsistent results. There are various approaches (specific models) in the literature to address this issue of endogeneity, namely, Instrumental Variables regression, System Generalized Method of Moments, Olley-Pakes Method (1996), and Levinson & Petrin Method (2003a). .

Based on the existing model above, we have used the Levinson-Petrin (2003a) method (hereafter LP method) to estimate the total factor productivity. This Levinson-Petrin method is one of the advanced methods that can capture the issue of endogeneity to estimate total factor productivity. In addition to that, it is also an extension of the Olley & Pakes (1996) method for productivity estimation. This method is one of the significant methods for addressing unobservable productivity shock with the help of inputs in the production compared to others. As a result of which, this advanced method of productivity estimation has been taken into account for the computation of productivity. In the first stage, we have estimated the TFP with the help of this advanced method, and in the next stage, we have evaluated the impact of ICT on TFP.

We have built an unbalanced panel data set of the thirteen years (2005-2018) for the food processing industries of India for estimating the TFP. After estimating the TFP through the LP method of estimation with the help of the Cob-Douglas production function technique, the next

important task is to see the impact of ICT on the total factor productivity. In order to see the impact of ICT on TFP, we have used the panel fixed-effect model owing to the requirement of the Hausman test.

4.7. Empirical Result

In the existing literature, there are many methods to estimate the impact of ICT on TFP. Based on the data constraints and considering the endogeneity problem, we have used the LP method of TFP estimation. Apart from that there are other benefits as well in using this method for estimating productivity as has been explained above. There are two ways in the LP method where one can measure productivity. In the first case, the dependent value is gross value-added, whereas in the second case, the dependent variable is the firm's gross revenue (Levinshon & Petrin 2003a). Based on the availability of data from the prowess, we have taken the second way of LP method, where the outcome variable is the gross revenue of the food processing industries. The following section of the study has discussed the estimation procedure followed by its estimated results.

Table-4.3: Estimated results of LP method of productivity

Variables	Coefficients
Labor	0.2263*** (0.02550)
Capital	0.07613* (0.06929)
Materials	0.5835*** (0.09190)

Source: Author's own calculation

(* Significant at 10%, ** Significant at 5%, *** Significant at 1%)

To estimate productivity, we have taken the gross revenue as the outcome variable along with labor and raw material. In this LP method, we have taken labor as the free variable and capital as the state variable. Also, we have taken the raw materials as the proxy variables to estimate the same. From the estimated results, as shown in table 4.4., it is found that all the variables, namely labor, capital, and raw materials, are positively related to the outcome variable. Labor and raw materials are significant at one percentage level, whereas capital is significantly related at ten

percentage level. Finally, with the help of these coefficients, the TFP of the FPI has been calculated with the help of the Levinson-Petrin method as explained earlier.

Table-4.4: Impact of ICT on the Productivity

Variables	Fixed effect model	Random effect model
ICT	0.0945*** (0.01783)	0.0630*** (0.01444)
Age	0.0064 (0.00532)	0.0072*** (0.00148)
Energy intensity	-5.00489 (0.22238)	-4.42926*** (0.20337)

Source: Author's own calculation (* Significant at 10%, ** Significant at 5%, *** Significant at 1%)

In the second stage of regression (in table-4.5), we have estimated the panel regression for both the fixed and random effect model as the data are in panel form. The main reason behind choosing this model is to see the effect of ICT on a firm's TFP after constructing TFP in the first regression stage. We have taken TFP as the dependent variable which is dependent on the firm's ICT expenses in these models. Further, we have taken the age and energy intensity of the firm as the control variables. These variables might have some impact on the firm's total factor productivity. Empirically and theoretically, it has been proved from the majority of the studies that a direct association exists between ICT and the TFP of the firm (Abraham& Joseph, 2007). From our estimation, as shown in table 4.5, both the fixed and random effect models reveal a positive effect as the coefficients are positive & significant at one percent. These results indicate that an increase in the use of ICT (or incurring ICT expenses) enhances the productivity of the FPI. The use of a significant amount of ICT in the firm can reduce the transaction cost and enhance the TFP of the FPI through proper coordination & organizational structure among the agents of production. The estimated age coefficient is positive but significant in random effect model & insignificant in fixed effect model, whereas that of energy intensity is negative but insignificant in fixed effect model and significant in fixed effect model. We have carried out the estimated results of the fixed effect model of the panel regression as per the direction of the Haussman test results. Along with the requirement of the Haussman test, there are also other benefits to using the fixed-effect model as this model incorporates and addresses some

estimation issues. The primary benefit of using the fixed effect panel model is that it handles the problem of omitted variables and controls for the unobserved industry-specific time-invariant effect. It also fixes the potential correlation between these effects and some of the independent variables in the model (Eakin & Douglas 1992). From the table, it is shown that ICT has a direct influence on TFP. In line with the existing literature (Ramirez et al., 2019), this study also shows a positive association between the ICT expenses and the total factor productivity. Various factors can enhance productivity, whether it is TFP or the labor productivity of the firm. Among them, ICT adoption plays a significant role (Zwick, 2003). There are numerous ways where ICT can enhance the TFP of the firm, as explained earlier. It can be argued that the estimated results support the existing theoretical and empirical works on the ICT adoption and performance of the firms.

4.8. Summary and conclusion

After examining the determinants of ICT in the previous chapter, we have analyzed its impact on FPI. Hence, in this chapter, we have analyzed the impact of ICT on the TFP by taking FPI into account. Several studies have taken place at the aggregate level to see the impact of ICT, but literature is scanty at the disaggregated level. Empirically it also proved that the impact of ICT performs differently in the different industries. As a result, we have analyzed its impact by considering the FPI of India. Hence, we have estimated the TFP with the Levinson-Petrin method, owing to an endogeneity issue in the model. After estimating TFP in the first stage, we have examined the influence of ICT on the estimated TFP in the second stage. From the existing literature, it has been found that ICT significantly affects productivity, as has been evident in the manufacturing sector. We have found the same results at the disaggregated level from our empirical analysis, which means ICT adoption has a positive and influential function in enhancing TFP. This estimated result of this study also supports the existing study on the role of ICT and productivity at the aggregate level. So, we can conclude that incurring ICT expenses positively affects the TFP in the FPI of India. .

Chapter- V

Conclusion

5.1. Introduction

ICT indicates the convergence of two technology sets: information technology and communication technology. The former represents information creation, while the latter demonstrates its transformation (Mukherji, 2013). ICT has two significant and interrelated roles to play in the economy. They are ICT use on one hand and ICT diffusion on the other hand. Most of the studies on ICT have been carried out in the context of direct benefits of ICT, whereas very few works have been on the indirect benefits of ICT or ICT diffusion. Again, when it comes to ICT diffusion or ICT use majority of the work has been done at the aggregate level. The impact of ICT on the performance of different industries is different, as claimed empirically. For this, we have analyzed the impact of ICT on the performance of the FPI of India.. The entire study comprises five chapters, including the introduction and conclusion chapter. We have taken two major objectives in order to undertake the above study. The first objective talks about the adoption features of the ICT of the firm, whereas the second objective talks about its impact. The major findings of both objectives can be discussed as follows.

In the first objective, we have examined the role of firm-specific variables in the adoption of ICT in the FPI of India. Diverse studies have taken various strategies as well as different firm-specific variables in order to estimate the adoption features of the firms. Owing to the data restraints of the Prowess database, we have taken age, size, structure, types, energy consumption, and raw materials consumption of the firm to see the role of these variables in the adoption of ICT in the FPI in India. In order to see the ICT adoption attributes, we have taken the Probit model of computation. From the estimated results, we have endowed with the following results. The empirical model found that the firm's age, size, and energy consumption negatively influence the ICT adoption of the FPI. Apart from these two variables, all the other variables do not significantly impact the ICT adoption as their results are insignificant.

Theoretically and empirically, it has been proved from the preceding chapter that ICT has led to the enhancement of TFP, labor productivity, and overall growth. The use of ICT enhanced

productivity and economic growth in developed countries and developing countries, as demonstrated by the cross-country analysis of various studies. In addition to the above, it is also verified that ICT has led to productivity growth at aggregate or industry level and unit level or firm level. So, it can be concluded from the above that the use of ICT in the economy affected the economy's overall growth through various channels. With the background of the above facts, in the second objective, we have tried to find out the consequence of ICT on the firm performance of the FPI. For this, we have constructed an unbalanced panel of 1323 observations. In order to examine the impact of ICT on firm performance, we have computed the TFP with the help of the Levinson-Petrin method in the first stage. The primary rationale behind the LP method of productivity estimation is the endogeneity issue in the ICT expenses variable. In the second stage of the investigation, we have analyzed the influence of ICT on the estimated TFP through panel regression (both fixed effect and random effect model). We have taken TFP as the dependent variable in the panel regression, which depends on the firm's ICT expenses. The study has used the age and energy intensity of the firm as the control variables as these variables might have some influence on the TFP of FPI. We have taken the fixed effect model results based on the Hausman test condition out of fixed and random effect models. From our empirical exercises, it has been found that ICT adoption by the FPI is positively impacting the TFP at a significant level. However, the firm's control variable age and energy intensity do not significantly affect the TFP as the calculated results are insignificant in the empirical exercises.

5.2. Limitation of the study

Though we have analyzed the role of ICT in the FPI through its adoption features and impact of its use still, the study has the following limitations, which can be discussed as follows.

One of the major obstacles to carrying out the function of ICT in the Industry or firm in this country is the availability of data. CMIE Prowess is the only primary source concerning the information ICT expenses of the manufacturing firm. Apart from the Prowess, no other secondary source provides information on it. When it comes to the proxy for the ICT expenses, only four or five variables can be taken as the proxy for the ICT expenses, which is available only in the Prowess database. Apart from that, no other such variables can be taken as the proxy for the ICT expenses. In addition to the above, one of the significant problems in the CMIE

Prowess is the presence of missing variables. There are ample of missing variables in the Prowess database; as a result, it is difficult to undertake such kinds of studies.

We know that there are eight sub-sectors, starting from 3-digit 101 to 108, in the FPI of the manufacturing sector. Different sub-sectors have different ICT adoption features for which their role concerning ICT use may differ accordingly. The unavailability of a significant amount of data in each sub-sector from the prowess database restricts the study of the FPI only at an aggregate level without any decomposition of it. Another limitation of the study is the construction of the capital series to estimate total factor productivity. Some studies have used capital series, while others have used the normal deflation to normalize the variable capital in the computation of total factor productivity. As the present study has used an unbalance panel where there is no continuous availability of observation on the capital, the study has limited to the normal deflation of the capital with the help log variable to normalize the variable capital. Another limitation of the study is the efficiency analysis of the ICT use. Some of the studies regarding ICT use have been carried out both in the efficiency and productivity analysis. However, the present study is restricted to the productivity analysis only due to data constraints. Because efficiency analysis of ICT use required a different and new set of analyses, this study is limited to productivity analysis only.

5.3. Policy Suggestions

Our empirical exercise conducted the adoption feature of ICT and its impact on the TFP in the FPI of India. It has been found from the empirical exercise that small-sized, energy-efficient firms and firms that evolved recently (young firms) are going for the ICT adoption. So, policies should emphasize the promotion of ICT adoption among those variables mentioned above as they significantly affect the ICT adoption in the FPI. Secondly, it is also empirically proved that ICT adoption in the FPI led to the enhancement of TFP. So, policymakers should promote ICT use among the food processing firms by providing adequate means of infrastructure and other such facilities. To sum, policymakers should focus their policy on both adoption & use phases in order to strengthen the FPI. We can reduce agricultural wastage and enhance processing levels by adopting the above measures in the FPI.

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