

**DRIVERS INFLUENCING THE INTENTION TO
ADOPT THE INTERNET OF THINGS BY
MANUFACTURING SMES IN PAKISTAN: AN
INTEGRATION OF THE TOE AND HOT-FIT
MODELS**

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UNIVERSITI SAINS MALAYSIA

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by

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LIST OF ABBREVIATIONS

AI	Artificial intelligence
B2B	Business to business
BIA	Business Impact Analysis
CMV	Common Method Variance
CR	Composite Reliability
CV	Convergent Validity
E-Commerce	Electronic Commerce
GDP	Gross Domestic Product
GPS	Global Positioning System
HOT fit	Human, Organization, and Technology-fit
HTMT	Heterotrait-monotrait ratio of correlations
ICT	Information And Communication Technology
IIoT	Industrial Internet of Things
IoT	Internet of things
IT	Information Technology
PLS	Partial Least Squares
RFID	Radio Frequency Identification
SEM	Structural Equation Modelling
SMEs	Small Medium Enterprises
SPSS	Statistical Package for Social Sciences
TOE	Technological, Organizational, Environmental
WSNs	Wireless Sensor Networks

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**PENDORONG YANG MEMPENGARUHI NIAT PENERIMAGUNAAN
INTERNET BENDA OLEH PKS PEMBUATAN DI PAKISTAN: MODEL
BERSEPADU TOE DAN HOT-FIT**

ABSTRAK

Kajian ini meneroka bagaimana perusahaan kecil dan sederhana (PKS) dalam sektor pembuatan merancang untuk menerima pakai teknologi Internet Benda (IoT). Penyelidikan ini menggabungkan dua kerangka teori, iaitu kerangka Teknologi-Organisasi-Persekitaran (TOE) dan teori padanan Manusia-Organisasi-Teknologi (HOT-fit). Selain itu, kajian ini meneliti bagaimana sokongan kepimpinan memoderatkan hubungan antara pemacu organisasi serta bagaimana penentangan organisasi memoderatkan pemacu berkaitan manusia. Sebanyak enam belas hipotesis telah dirumuskan untuk tujuan penyelidikan ini. Data telah dikumpulkan daripada 211 firma dalam sektor PKS pembuatan melalui kaedah tinjauan keratan rentas. Daripada hipotesis yang diuji, dua belas daripadanya telah disokong. Bagi niat untuk menerima pakai teknologi IoT, faktor peramal penting termasuklah kos, kelebihan relatif, kesediaan organisasi, budaya organisasi, inovasi organisasi, sokongan kerajaan, tekanan persaingan, dan kesan gelombang pengaruh. Sementara itu, kerumitan, tekanan daripada rakan dagang, serta isu keselamatan dan privasi tidak memberikan kesan yang signifikan terhadap niat untuk menerima pakai IoT. Kajian ini turut mengesahkan bahawa sokongan kepimpinan memainkan peranan sebagai moderator dalam hubungan yang dikaji. Namun, penentangan organisasi tidak memoderatkan kerjasama dalam kalangan kakitangan. Dapatan kajian ini memberi manfaat kepada pengurus, pihak pengurusan atasan, dan pembuat dasar kerana ia mengenal pasti bidang utama yang perlu diberi perhatian oleh PKS pembuatan untuk melaksanakan

teknologi IoT secara berkesan. Kajian ini juga mengisi jurang dalam literatur sedia ada dengan mengetengahkan perspektif manusia dalam niat untuk menerima pakai IoT, di samping mempertimbangkan faktor teknologi, organisasi dan persekitaran, sekali gus menyumbang kepada pemahaman yang lebih menyeluruh terhadap fenomena ini.

**DRIVERS INFLUENCING THE INTENTION TO ADOPT THE INTERNET
OF THINGS BY MANUFACTURING SMES IN PAKISTAN: AN
INTEGRATION OF THE TOE AND HOT-FIT MODELS**

ABSTRACT

This research explores how medium-sized and small enterprises plan to adopt Internet of Things (IoT) technology in manufacturing. This research integrates two theoretical frameworks combining the Technology-Organization-Environment (TOE) framework and the Human-Organization-Technology fit (HOT-fit) theory. Additionally, the study examines how leadership support moderates the relationships between organizational drivers, as well as how organizational resistance moderates human drivers. Investigation required sixteen formulated hypotheses in total. From 211 manufacturing SME sector firms, researchers gathered data. They did use a cross-sectional survey in order to gather data. Twelve of the hypotheses that were tested were supported. Regarding the intention to adopt IoT, important predictors were cost, relative advantage, organizational readiness, organizational culture, organizational innovativeness, government support, competitive pressure, and the bandwagon effect. Meanwhile, complexity with trading partner pressure along with security and with privacy had virtually no impact upon IoT adoption intention. The research did also confirm that support from leadership moderates the outcomes. Organizational resistance, however, does not moderate staff collaboration. This research findings benefit managers, top management, and policymakers because they pinpoint areas for manufacturing SMEs to focus efforts to adopt IoT technologies effectively. Notably, this research fills a gap that exists in the literature because it intends to adopt IoT for SMEs from a human perspective while considering technological, organizational, and

environmental factors so it contributes to a more thorough comprehension of this phenomenon.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter commences with the initial introduction to the research. To begin, it provides an overview of the research background, offering a concise insight into the manufacturing Small and Medium Enterprise (SMEs) sector in Pakistan. Following this, the problem statement is addressed in the subsequent section. From the identified problem statement, the research questions and research objectives are deduced. The significance of the research is then explored and categorized into both theoretical and practical significance. The concluding section of this chapter is dedicated to presenting the definitions of key terms.

1.2 Background of the research

Technology adoption refers to the decision reached to use innovation as the best available course of action (Rogers, 2003). Regarding the organizational context, technology adoption is associated with the acceptance and ultimate implementation of innovation (Abad-Segura et al., 2022). The research suggests that the advent of new technologies is helping firms enhance performance and reign in more environmentally friendly practices (Javaid et al., 2022; Quttainah & Ayadi, 2024). The increasing utilization and greater dependence on digital technology have resulted in significant changes in economic and social development (Sanaei et al., 2018). The information technology revolution has had an impact on all facets of business (Chase, 2016). As a fundamental business priority that features prominently in the strategic plans of nearly

all manufacturing companies at the heart of the digital era that is fast approaching, where nearly everything is interconnected via the internet (Farahani et al., 2017).

The digital revolution has converted the analogue world into a digital one. The fourth industrial revolution goes one step ahead of this transformation by focusing on automation and data exchange in manufacturing and production (Qiu et al., 2025). Fourth industrial revolution integrates innovative technologies such as artificial intelligence (AI), cloud computing, cognitive computing, cyber-physical systems (CPS), and the Internet of Things (IoT). These technologies enable smart factories and smart manufacturing, resulting in phenomenal efficiency and productivity gains in the industrial sector (Singh et al., 2025).

The IoT technologies are seen as being at the heart of the fourth industrial revolution and have tremendous potential for innovation and contributions for good for society (Nizetic et al., 2020). IoT is a global network that enables communication between humans, machines, and their interfaces using the internet, the revolutionary effects of which are recognized in all aspects of human life (Patel and Patel, 2016). According to current literature, IoT comprises networked sensors, software, and communication capabilities for data acquisition and sharing (Khan et al., 2024).

Besides, IoT is also defined as a "dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols, where physical and virtual components have unique identities" (Satar & Yusof, 2019). IoT is reported to have the potential to provide real value to businesses (Fortino et al., 2017). Implementation of the IoT presents a range of benefits such as transparency, traceability, flexibility, scalability, and adaptability that can be used to improve operational processes, reduce costs, and mitigate risks (Zhou et al., 2019).

Furthermore, the capabilities of IoT to aggregate massive amounts of data to improve product quality in the production process; hence, this satisfies the end-users' needs with higher reliability (Khan & Javaid, 2022; Shah et al., 2024).

Research indicates that it has been found that the quick evolution of technology in IoT has global implications (Afifi et al., 2021; Dutton et al., 2014; Rath & Jena, 2024). Figure 1.1 illustrates that as of 2024, the overall number of global IoT device installations was approximately 12.1 billion for short-range devices and 3.6 billion for wide-area devices and was estimated to experience more than three-fold growth by the year 2029. Technology innovation, increasing demand for smart solutions, and the position of IoT becoming increasingly prominent in enhancing operation efficiency across many industries are causes for this influx. Yet, with the quick uptake in IoT devices comes the need for cybersecurity and data privacy concerns to be addressed so that it can be safely and sustainably integrated.

According to recent studies, IoT can assist manufacturers in lowering waste, minimizing downtime, and making production more flexible (Rath et al., 2024; Zaidi et al., 2024). IoT enables manufacturers to make smarter decisions and enhance overall performance by providing real-time data and visibility into the manufacturing process (Tom, 2023). Building on the evidence in current literature, the integration of IoT into manufacturing, such as the development of sensor technologies and connectivity, is revolutionizing the sector by enabling improved operational efficiency (Rath et al., 2024).

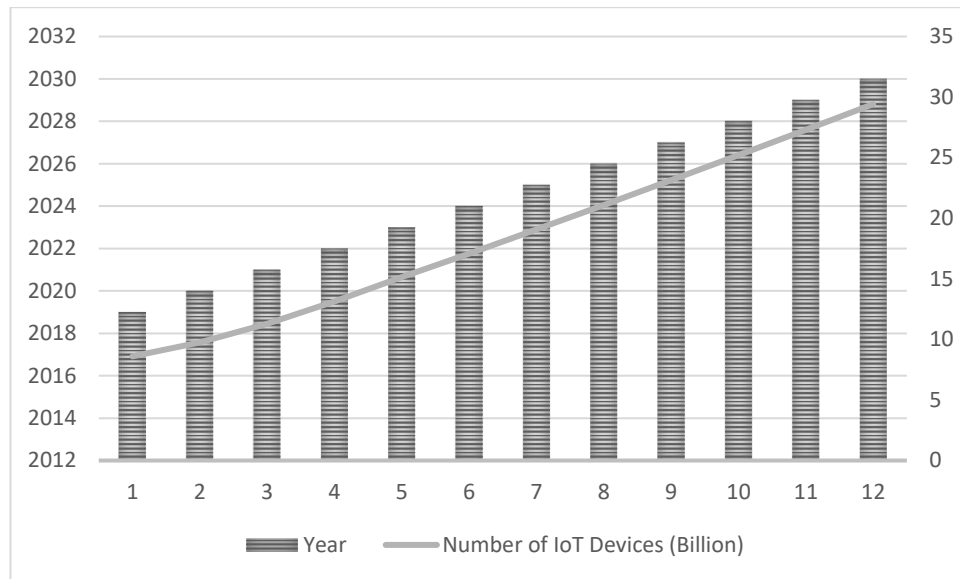


Figure 1.1 Emerging trend: Widespread IoT Device installations (Statista)

Rapid technology transfer, particularly to developing and underdeveloped countries, has become the focal point of discussions on industrial expansion and innovation (Al-Sulami et al., 2024). This transmission, according to scholars such as Alordiah (2023) & Kumar et al. (2020), is significantly influenced by governmental roles in establishing the regulatory policies of Industry 4.0, as well as the disparity of infrastructure development between developed and underdeveloped economies (Zanello et al., 2015). In Pakistan, although the services sector has been a major contributor to GDP and jobs, the manufacturing sector is plagued by productivity and export problems, with its contribution to gross domestic product (GDP) leveling off in recent decades (World Bank, 2021). These problems in Pakistan's manufacturing sector, including the slow pace of automation and low quality of infrastructure, point to the necessity of integrating IoT into its manufacturing setup for effective research and intervention (Nazir & Khan, 2022; Pakistan Today, 2023).

1.2.1 Pakistani Manufacturing Industries

Manufacturing sector is crucial for economic development and is the third largest, next only to the agriculture and services sector (Fakhar & Ali, 2023). Diversified sectors such as the engineering sector, textile, chemical, and agriculture-based sectors together form the industry of Pakistan's manufacturing sector (Pakistan Bureau of Statistics, 2023). To emphasize, Large Scale Manufacturing holds a stronghold of 74.3% of the sector's share, Small Scale Manufacturing subsidizes 15.9%, and sub-sector occupies 9.7% of the sector (Institute of Policy Studies, 2023).

The data given gives details about the proportion of Pakistan's GDP through manufacturing between 2012-2023 (see figure 1.2). GDP, being the sum total of the value of goods and services, a country produces, is a crucial measure utilized to measure economic performance. Starting at 21.3% in 2012, the share of manufacturing witnessed a overall decline through the subsequent years to reach as low as 18.15% in 2016. Despite there being a significant increase to 19.56% in 2019, it was not to continue, with the percentage dipping again to 17.52% in 2023. The consistent dip from 2019 to 2023 underscores the hard times experienced by the manufacturing sector. However, advances in digital technology have caused a profound effect on industrial processes (Sima et al., 2020). This change, commonly referred to as the "fourth industrial revolution," includes the embedding of digital technology into various manufacturing processes. IoT is one of the main driving forces behind this technology revolution (Peng et al., 2023).

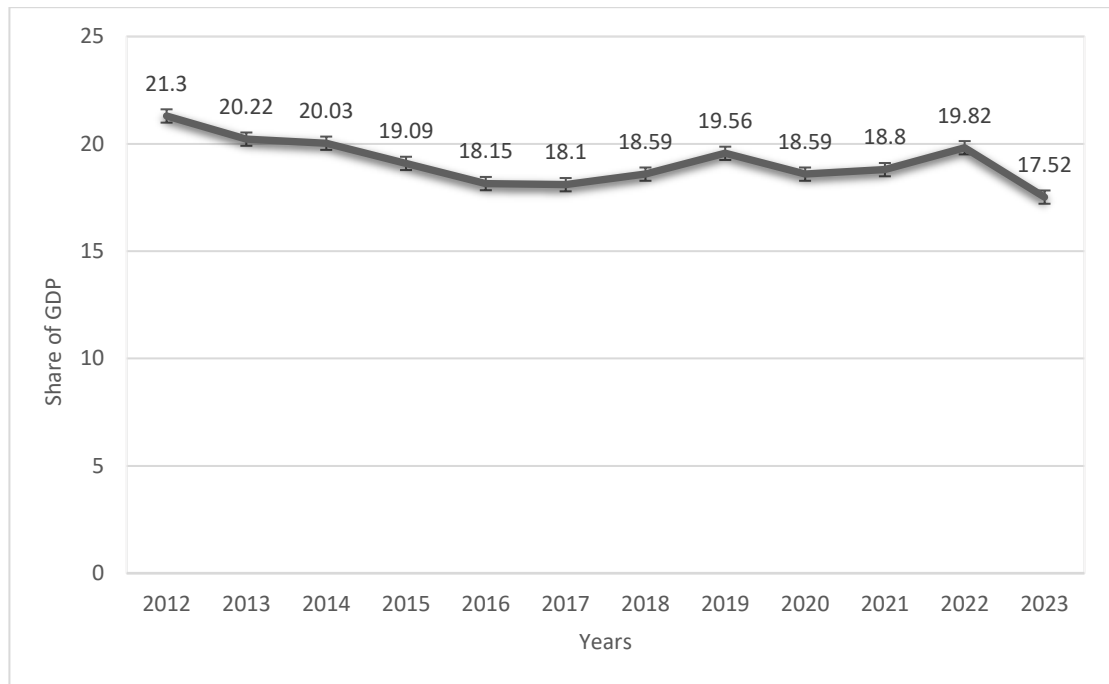


Figure 1.2 Pakistan Distribution of GDP across manufacturing sectors from 2012 to 2023

1.2.2 Geographical Distribution and Regional Disparities in Pakistan's Manufacturing Sector

According to Government of Pakistan, Bureau of Statistics (2013), the geographic distribution of Pakistan's manufacturing sector indicates a broad regional spread (see figure 1.3). Punjab, with the highest population and industrialized province, tops the manufacturing sector with 56.5% of the total number of manufacturing units. This is because of the infrastructurally well-developed area, vast industrial estates, and robust manpower of Punjab, which collectively ensure an ideal setting for manufacturing activity. Important cities like Lahore, Faisalabad, and Sialkot are hubs of variegated industries like textiles, sports goods, and surgical equipment.

Sindh, particularly Karachi, the port city, has 30.6% of the manufacturing sector. Karachi, being the financial center of Pakistan, possesses a number of large-scale industries like textiles, chemicals, and food processing. Its coastal location,

which is strategically placed, enables it to trade both domestically and internationally, which enhances its industrial growth. Khyber Pakhtunkhwa possesses 8.5% of the manufacturing sector. Although historically renowned for agriculture and natural resources, the province is now diversifying its economy to involve more manufacturing processes. Cities such as Peshawar and Hattar are turning into industrial centers with investments being placed in industries such as pharmaceuticals, food processing, and textiles. Balochistan, although having a vast geographical area and mineral resources, only has 3.4% of the manufacturing sector.

However, projects such as the China-Pakistan Economic Corridor (CPEC) are trying to address some of these ailments by introducing improved connectivity and investments in the region. These percentages highlight the imperative of regionally balanced development policies. More regionally balanced economic growth can be promoted by the government through targeted initiatives that enhance industrial infrastructure, provide investment incentives, and develop human capital in underrepresented provinces such as Balochistan and Khyber Pakhtunkhwa. By overcoming these imbalances, Pakistan can achieve a more broad-based and sustainable industrial development throughout the whole country.



Figure 1.3 SME Sector Contribution by Provinces

1.2.3 The Definition of a Small and Medium Enterprises (SMEs) and Operations

SMEs have been widely recognized as incubators of growth or anchor firms that are central to any country's long-run economic growth (Ahmad et al., 2022). The impact of SMEs on an economy can be categorized into three major domains: Trade, Technology, and Investment (Hussain, 2012). In these domains, SMEs play an active role in economic growth in the form of enhanced competition and innovation. Globalization has provided the entrepreneurial market, especially SMEs, with an opportunity to become international through participation in global value chains and international production networks (Purwaningsih et al., 2024). SMEs are significant sources of job creation in low-income economies (Hossin et al., 2023). Sharafat et al. (2014) stressed Pakistani SMEs as drivers of economic growth. Therefore, one of the key guidelines of SME policy in Pakistan is to align SME development with technological progress, human resource development, and marketing and blend them

with other policy areas such as labor, industrial, trade, and fiscal policies in the economy on a gigantic scale.

For SME growth promotion, the Small and Medium Enterprise Development Authority (SMEDA) was established in 1998 under the Ministry of Industries and Production (MOIP) as a central authority for the promotion and development of SMEs through various programs. The role of SMEDA must now be re-evaluated in the post-18th constitutional amendment scenario. There are presently, in 2021, approximately 5.2 million SMEs in Pakistan based on the provided definition (see Table 1.1).

Table 1.1 Definition of SMEs in Pakistan

Enterprise Category	Number of Employees	Criteria Annual Sales Turnover
Micro Enterprise (ME)	1-9	Less than PKR 150 million
Small Enterprise (SE)	10-49	Up to PKR 150 million
Medium Enterprise (ME)	50-249	Above PKR 150 million to PKR 800 million

Source: SMEDA Government of Pakistan.

Furthermore, 25% of manufactured goods' exports come from this sector, which contributes 35% to value-added production. Approximately 50% of SME activities fall in the trading. The sector contributes 22% of industrial SMEs, and 35% of rate accumulation in the manufacturing business (Ministry of Planning Development & Special Initiatives 2023). Recognizing the central role of SMEs toward financial inclusion, job creation, poverty reduction, and income generation, the Government of Pakistan (GoP) has committed significant efforts and resources to entrepreneurship development and supporting small and medium-sized enterprises.

In Pakistan's SMEs sector, food and beverages hold the highest share of manufacturing assets with 30% followed by textile mills with 22% and chemical and

chemical products with 6%. Basic metals, tanning rubber, paper, medical, other non-metal metallic mineral, and sports products have the remaining proportion, as together they account for 22% of the overall manufacturing sector of Pakistan. Moreover, 25% of manufactured goods exports are from this sector, and it represents 35% of value-added production (Table 1.2). Approximately 53% of SME operations are in the manufacturing, distribution, dairies sectors, and the hotel industry. The sector is represented by 20% of industrial SMEs, and 22% are in the service sector (PBS, 2011) .

Table 1.2 Contribution of Products in SME

Sector	% Share of financing to manuf. SMEs	% Share of financing to all SMEs
Food products and beverages	37	17
Textiles	22	22
Chemicals and chemical products	6	6
Apparel, readymade garments	4	2
Basic metals	4	2
Tanning and dressing of leather; manufacture of luggage and footwear	2	1
Rubber and plastic products	2	1
Paper, paperboard and products	2	1
Fabricated metal products	2	1
Medical, precision and optical instruments; watches and clocks	2	1
Other non-metallic mineral products	2	1
Sports goods	2	1

Besides that, SMEs also play an important role in enhancing the socio-economic status in Pakistan (Zafar & Mustafa, 2017). An enormous number of small organizations are struggling to promote health and education sectors in Pakistan. Furthermore, a massive number of small institutions struggle to decline poverty through increasing people's daily incomes below the poverty line. All these activities

have positively affected the financial growth of Pakistan by increasing trade, business innovation, poverty reduction, and utilization of local resources.

Additionally, SMEs have been part of the Pakistan economy for centuries, significantly adding to the per capita income and ushering a general enhancement of the quality of life of its citizens. Historically, SMEs contributed heavily to economic development through innovation, job creation, and productivity. For decades now, these companies have generated a higher number of jobs and generated economic activity in urban and rural areas, fostering broad-based economic engagement.

According to economic trends, the GDP per capita of Pakistan was \$1,407 in 2023, following an 11.47% decline from 2022. The decline comes after a development phase, where GDP per capita increased to \$1,589 in 2022, a 5.52% increase from 2021, which the situation reporting a 13.9% increase from 2020 (see in figure 1.4).

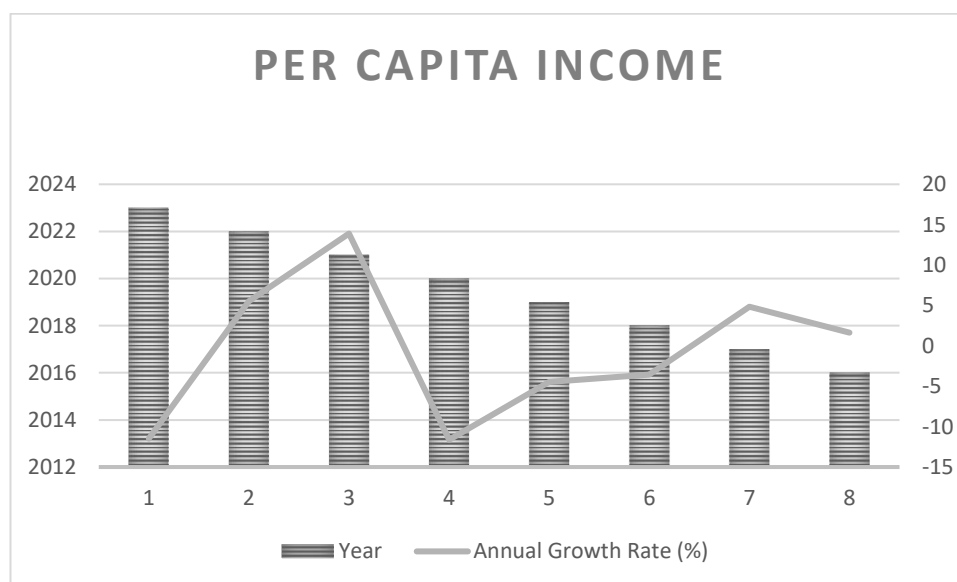


Figure 1.4 Per capita Income

1.3 Problem Statement

Since the last few years, Pakistan's competitiveness of the manufacturing sector has been going down. Although the manufacturing sector historically has been referred to as 2nd largest in Pakistan's development. Latest statistics indicate the services sector now leading, followed by agriculture, with the manufacturing sector ranking 3rd in GDP influences (World Bank, 2017; Pakistan Bureau of Statistics, 2023). The World Economic Forum's Global Competitiveness Index shows that Pakistan's ranking fell from 107 in 2018 to 110 in 2019, reflecting institutional weaknesses, infrastructure, and innovation. On economic terms, the share of the manufacturing sector in GDP has looked patchy at times. It was around 9.09% in 2000, 12.70% in 2005, and was a maximum of 14.79% in the year 2008. This record fell to 11.47% in 2020. The performance in manufacturing sector development has not been consistent. Following a 6.14% growth in 2008, the sector was constrained by -3.94% in 2009, thereafter poor development in the following ages 1.73% in 2010 and 2.61% in 2011. A drastic plunge of -7.80% took place in 2020, but the sector recovered with growth rates of 10.52% in 2021 and 10.86% in 2022. The speed may, however, not continue, and the segment over constrained by -5.29% in 2023. This indicates a notice insignia of decline in the segment's improvement technologies such as IoT, which could drastically stimulus the inclusive economic growth of the nation.

Past studies indicate that presently, there is low adoption intention of IoT in Pakistan (Ancarani et al., 2021; Jadala et al., 2021; Shah et al., 2024). Even though direct statistics on IoT adoption rates in developing countries are limited, internet penetration has generally been used as a proxy variable to estimate IoT adoption. This is based on the premise that higher internet access facilitates the use and installation of IoT technologies. For instance, Mandari (2022) emphasizes that the development of

IoT is subject to the omnipresence of internet access. Therefore, wherever some IoT uptake statistics are limited in specific locales, internet penetration rates can set a baseline context for the prospective IoT assimilation potential. At an adoption level of approximately 45.7% (Dataprot, 2024a), Pakistan is lagging far behind other South Asian countries like India, with a 52.4% (Statista, 2025), and while Sri Lanka has a more developed level of internet penetration at 69.9% (Dataprot, 2024b). The disparity suggests the sheer issues Pakistan has in developing its digital landscape and integrating new technologies. Conversely, countries such as Vietnam and Singapore have much greater adoption rates, with Vietnam attaining an 88.67% IoT usage in business and Singapore due to its Smart Nation program (Liu et al., 2021).

Consistent with this argument, results from early researchers indicated that numerous earlier studies have suggested the future researchers to look at the enabling drivers, namely, the contributed most the adoption choice is based on drivers in the organizational internal and external characteristics, and the technology characteristics (Howell & Higgins 1990; Kamble et al., 2021; Shah et al., 2024 Wu et al., 2025; Zhao et al., 2023). Most recently, academicians argued that many small businesses have not adopted innovative technologies due to their lack of knowledge of internal and external organizational characteristics, as well as the technological characteristics (Ghobakhloo & Ching, 2019; Ghobakhloo et al., 2022; Shah et al., 2024 Wu et al., 2025). This lack of awareness is a serious problem as it denies businesses the opportunity to benefit from IoT technologies (Jadala et al., 2021). Based on these needs, the present research aims to investigate how organizational internal and external strategic organizational characteristics of organizations like technology, organization, and environment (TOE) drivers can affect organizational adoption intention of IoT in Pakistan's manufacturing industry. In explaining this, the current research aims at such technological,

organizational, and environmental drivers identified through a focused literature review that can enhance intention to adopt IoT but have not yet been researched or lack a plausible explanation of the underlying process drivers that may affect the phenomenon.

For example, technological drivers such as the prices of Industry 4.0 technologies have been cited as a problem which can be the reason for worse performance overall (Rad et al., 2022). Nevertheless, few quantitative tests have been in place for this relationship to be shown quantitatively from the current literature. Besides, there are also studies that have negatively associated cost with intention to adopt (e.g., Haque, 2023; Hayat et al., 2024; Nguyen et al., 2024; Wong et al., 2020). Similarly, security and privacy entail protecting sensitive data and preventing unauthorized use, compromises, or misuses of data in IoT systems utilized in manufacturing and production SMEs. Besides, improved security and privacy was cited as one of the most important obstacles to IoT adoption. As a result of previous experience with technology, security, and privacy is a degree of firmness in taking an innovation (Strous et al., 2021). Secondly, relative advantage contribution is a fundamental drivers for intention to adopt IoT and some earlier researchers established that relative advantage is closely related to behavior when technology adoption is under consideration (Amini et al., 2023; Leong et al., 2023; Prabowo et al., 2024; Wang et al., 2024).

As a result, usability and usefulness reduce as organizational complexity increases (Ju et al., 2023). Actually, it has been argued that when the organizational system is intricate, employees will find it hard to employ a new technology with an intricate system and will be unable to value the utility of the new system (Chatterjee et al., 2021; Mwemezi & Mandari, 2024). Therefore, the present research

investigates this assumption to introduce novelty to existing literature on IoT adoption intention and proposes an apparent solution to existing real-world problems facing firm.

These same gaps are present in literature for organizational driver such as organizational culture because it is a critical determinant of new technology adoption in the organization. Organizational culture supports the main dynamic capabilities for organizations to cope with the digital transformation process (Warner & Wäger 2019). For example, as indicated by Morelli & Wang (2020), organizational culture is a management model that affects decision-making processes and working conclusions. The same in the same context, organizational readiness are the core values that identify the company's capability to modify existing resources in order to facilitate the effective adoption, utilization, and integration of the technologies supporting the implementation of new activities (Jais & Ngah 2023; Lokuge et al., 2019). Organizational readiness, as stated by some authors, is a significant determinant of the adoption and implementation of new technologies (Dewi et al., 2018; Ghallab et al., 2021; Setiyani & Rostiani, 2021). Non-significant direct organizational culture-organizational readiness and intention to adopt have been observed in earlier research (Ghallab et al., 2021; Maroufkhani et al., 2023; Bin Naeem et al., 2024).

This condition appears to outline the lack of availability of the capacity and propensity that facilitate the effectiveness of organizational culture and organizational readiness in developing intention to adopt of organizations. It is on this basis that the present research seeks to reduce these gaps and, concurrently, add to the existing body of knowledge by including leadership support as a moderator in order to examine how this moderating effect can be utilized to enhance the strength of relationships among organizational culture and organizational readiness and intention to adopt IoT.

Leadership support is particularly management values are aligned with the intention to adopt IoT, providing a supportive environment, and allocating sufficient resources for the adoption process (Bhattacharya & Wamba, 2018; Montani et al., 2017). Additionally, Lin & Sun (2018) identified that leadership is the most significant predictor of intention to use IT. Leadership support is demonstrated to be a critical driver for the successful adoption of emerging technologies, and literature has depicted that leaders play a decisive role in establishing the priority for adoption and allocating necessary resources (Ingebrigtsen et al., 2014; Oliveira et al., 2014). The investigation of this moderating effect moves the present research one step ahead of existing research.

Within the environmental characterises are the external drivers that influence the adoption of technology. An organisation is driven to adopt the new technology by competition pressure to enhance services, attain a competitive edge, or at least be competitive in the competitive market (; Al-Hujran et al., 2018). According to the latest research (Amini & Jahanbakhsh Javid, 2023; Hasani et al., 2023; Salah & Ayyash, 2024; Zhong & Moon, 2023), companies facing competitive pressure will adjust to new technologies at a higher speed. Although some have highly recommended government support aids in developing the proposal and execution of IoT applications based on creating a regulatory framework that eliminates the barriers to the adoption of IoT (Sarmiento et al., 2021), others have encouraged organizations the vast majority of organizations depend on their trading partners for the design and implementation of their IT operations (Gutierrez et al., 2015). Prior research illustrates how trading partner pressure is an important driver for IT adoption (Ocloo et al., 2020; Salah et al., 2024; Vang & Lind, 2023).

However, research shows that most adoption plans for IoT initiatives have failed. Despite significant results, there is quite a debate among researchers regarding the impact of TOE drivers on IoT adoption, and few have been able to reach any consensus (Gerritsen, 2018; Mubeen et al., 2023; Zhao et al., 2023). Also, new technology adoption is a complex phenomenon, and any single theory will be unable to explain all its dimensions (Sun et al., 2018). In spite of the strength of the TOE framework, researchers like Yadegaridehkordi et al. (2018) mention its weakness in addressing the impact of human resource drivers on technology adoption in firms in a holistic way. Most of the recent studies indicate that the human characteristics drive contributes a little in IoT development (Mu & Antwi-Afari, 2024). According to available research, the adoption of new advanced technologies is driven by organizational, technological, and human drivers (Satyroetal., 2024). Arguments have also been raised in some research that future research should involve other theories such as the HOT-fit theory (Wael AL-khatibetal., 2023).

Therefore, the research enlightens on human characteristics entails the in what way and capacity the staff have, by what means they oversee procedures in addition to rules, and just how open the firm to embracing new ideas and technologies. Organizational innovativeness is the ability of an organization to introduce new products to the market, diversify to new markets, and consistently enhance its services through the strategic incorporation of innovative processes and new technology uptake (Florida et al., 2001; Sayginer & Ercan, 2020). Furthermore, Sayginer & Ercan (2020) have contributed that previous innovativeness had a significant impact on adoption within the organizational environment. collaboration, whether within or across organizations, facilitates seamless sharing of resources, information, and best practice, towards the joint advancement of industries (Luo et al., 2016). Staff collaboration

results in a key driver of driving technical innovation (Tao & Hao, 2023). Earlier studies, however, had established non-significant direct relationships between organizational innovativeness and staff collaboration, and intention to adopt (Asiaei et al., 2019; Ghallab et al., 2021).

This condition seems to mark the absence of human related drivers that enhance the efficacy of organizational innovativeness and staff collaboration in fostering intention to adopt of organizations. Following the same line of reasoning, the present research seeks to close some of such gaps and at the same time add to the current literature by introducing organizational resistance as a moderator to determine how the moderating effect would help further strengthen the weakness of organizational innovativeness with collaboration and readiness to embrace IoT. In addition, as resistance is a possible hindrance, while research by previous researchers, the moderator function of resistance to change (Shaik et al., 2023). Previous studies suggested additional prediction that resistance would slow down the adoption process, hinder effective utilization of the system, and limit actualization of benefits (Bag et al., 2023). In addition, in recent research, Putro (2023) has also quoted that resistance to change is one of the issues that SMEs will face in adopting new technologies.

Comprehensive, encompassing all these drivers and examining the relationships between them, the present research aims to: (1) offer an innovative framework on theoretical theory of TOE extend with HOT fit theory, representing how strategic internal and external firm characteristics would assist in intention to adopt IoT; and (2) empirically validate the model in the manufacturing industry of Pakistan. This research seeks to improve the internal and external drivers such as technological, organizational, environmental and human in an effort to empower organizations to undergo intention to adopt IoT instead of concentrating on strategies to deal with a

single theory because most of the past studies did independently a TOE framework and HOT fit theory attributes (Amini et al.,2023; Mu & Antwi-Afari, 2024; Das et al., 2022; Salah & Ayyash, 2024; Tasnim et al., 2023; Trawnih et al., 2021). Thus, it offers a more comprehensive model of intention to embrace IoT, multidimensional approach, flexibility across sectors, and broader scope make it more able to cope with the shifting nature of the modern business environment.

1.4 Research Objectives

This section outlines the research objectives, emphasizing the critical need for studies on intention to adopt IoT within Pakistan's manufacturing SME sector. Currently, there is limited literature addressing IoT in the manufacturing sector of developing nations, with a predominant focus on large organizations. Furthermore, a comprehensive exploration of the various drivers influencing IoT adoption, including technological, organizational, environmental, and human drivers, is lacking. Consequently, this research aims to bridge these gaps by focusing on three key objectives: examining drivers of intention to adopt IoT in Pakistani manufacturing SMEs, investigating the impact of organizational and human drivers, and exploring the moderating effects of leadership support and organizational resistance on IoT adoption. Through these objectives, the research aims to provide a thorough understanding of intention to adopt IoT dynamics in the specific context of Pakistan's manufacturing SMEs.

- i) To examine the relationship between cost and intention to adopt IoT.
- ii) To examine the relationship between security and privacy and the intention to adopt IoT.

- iii) To examine the relationship between relative advantage and intention to adopt IoT.
- iv) To examine the relationship between complexity and intention to adopt IoT.
- v) To examine the relationship between organizational culture and intention to adopt IoT.
- vi) To examine the relationship between organizational readiness and intention to adopt IoT.
- vii) To examine the relationship between competitive pressure and intention to adopt IoT.
- viii) To examine the relationship between government support to adopt IoT.
- ix) To examine the relationship between trading partner pressure and intention to adopt IoT.
- x) To examine the relationship between the Bandwagon effect and intention to adopt IoT.
- xi) To examine the relationship between organizational innovativeness and intention to adopt IoT.
- xii) To examine the relationship between staff collaboration and intention to adopt IoT.
- xiii) To investigate the moderating effect of leadership support on relationship the between organizational readiness and intention to adopt IoT.
- xiv) To investigate the moderating effect of leadership support on the relationship between organizational culture and intention to adopt IoT.

- xv) To investigate the moderating effect of organizational resistance on the relationship between organizational innovativeness and intention to adopt IoT.
- xvi) To investigate the moderating effect of organizational resistance on the relationship between staff collaboration and intention to adopt IoT.

1.5 Research Questions

In line with the research objectives, specific questions have been formulated to guide the investigation and provide a structured framework for data collection and analysis.

- i) What is the relationship between cost and intention to adopt IoT?
- ii) What is the relationship between security and privacy and intention to adopt IoT?
- iii) What is the relationship between relative advantage and intention to adopt IoT?
- iv) What is the relationship between complexity and intention to adopt IoT?
- v) What is the relationship between organizational culture and intention to adopt IoT?
- vi) What is the relationship between organizational readiness and intention to adopt IoT?
- vii) What is the relationship between competitive pressure and intention to adopt IoT?
- viii) What is the relationship between government support to adopt IoT?

- ix) What is the relationship between trading partner pressure and intention to adopt IoT?
- x) What is the relationship between Bandwagon effect and intention to adopt IoT?
- xi) What is the relationship between innovativeness and intention to adopt IoT?
- xii) What is the relationship between staff collaboration and intention to adopt IoT?
- xiii) Does leadership support moderate the relationship between organizational readiness and intention to adopt IoT?
- xiv) Does leadership support moderate the relationship between organizational culture and intention to adopt IoT?
- xv) Does organizational resistance moderate the relationship between organizational innovativeness and intention to adopt IoT?
- xvi) Does organizational resistance moderate the relationship between staff collaboration and intention to adopt IoT?

1.6 Significance of the research

This research provides theoretical and practical contributions discussed in the following sections.

1.6.1 Theoretical significance

The contributions of the research are significant to the literature, particularly within the TOE framework. The current research creates several significant theoretical contributions.

Firstly, this research makes theoretical contribution to clarify drivers influencing the adoption choice of IoT technologies among manufacturing SMEs in Pakistan. Some researchers have made preliminary analysis of implementation obstacles or intention drivers to implement IoT based on macro views of technology, market, environmental issue, and economy (Nizetic et al., 2020; Zhang & Lee, 2023). Unfortunately, there has been less analysis of the influence of TOE drivers on the adoption intention of IoT in emerging economies compared to developed nations (Ahmetoglu et al., 2023; Zhao et al., 2023), with specific deficiencies in Asian-based studies (Gerritsen, 2018; Mubeen et al., 2023; Opasvitayarux et al., 2022), and particularly in South Asia (Zhang & Lee, 2023). Moreover, there is limited research on IoT challenges in manufacturing in emerging economies (Asadi et al., 2022; Peter et al., 2023).

From the theoretical perspective, previous work did not adequately explain intention to adopt IoT drivers (Brous et al., 2020). Ehiea & Chilton (2020) stated that not only is there a need to identify determinants of intention to adopt IoT in the manufacturing industry, but also to provide a roadmap for adoption. Furthermore,

Asadi et al. (2022) and Samaranayake et al. (2023) state that the understanding of drivers of intention to adopt IoT remains tentative, and therefore it is difficult for organizations to make decisions. Consequently, this research develops a conceptual framework that identifies and underscores the intention drivers for adopting IoT technologies by manufacturing SMEs.

Second, it is the desire of this research to uncover that TOE framework has its limitation since the drivers constructed by it have vagueness and generalization. It was suggested by prior studies that other theories such as the HOT-fit theory need to be employed in subsequent studies (AL-khatib et al., 2023). Furthermore, new technology adoption is a complex process, and a single theory cannot explain all its aspects (Sun et al., 2016; Cardozo et al., 2023). According to available research, the adoption of cutting-edge emerging technologies for transformation is determined by organizational, technological, and human drivers (Cardozo et al., 2023). Besides, most of the available research on IoT has primarily examined the effect of organizational drivers on the intention to adopt IoT. Therefore, it is important to conduct additional research on other variables, such as human variables, and examine their impact on intention to adopt IoT (Zhang & Lee, 2023).

This research extends the TOE model to encompass HOT-fit model determinants. The HOT-fit model and the TOE framework both explain technology adoption and both possess weaknesses. The HOT-fit model does not account for the setting of the environment, while the TOE framework is not providing the human driver with a direct focus. While the TOE framework has its strengths, scholars such as Yadegaridehkordi et al. (2018) note its weaknesses in adequately capturing the effect of human resource variables on technology adoption across organizations.