Section II: Chapter 6

Digitalization of Business Functions under Industry 4.0

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Abstract Despite the literature's support that the main function to be affected by the Industry 4.0 movement will be the operations function, the rapid incorporation of new technologies under firms promises to affect each departments of the business dramatically. This chapter intends to highlight the part of each function within Industry 4.0. Moreover, the chapter will determine the actualized benefit of transitioning towards Industry 4.0, separate from the recognized benefits under the literature. A content analysis of BIST Manufacturing revealed that 16 firms' were transitioning towards Industry 4.0 and actively addressed the outcome (benefits) of the applications. Items were subjected to a content analysis based on business functions (Theme 1), sub-categories of business functions (Theme 2) and the common actual benefit (Theme 3) by three different researchers. The unit of analysis, the identified benefits, were 232 items in total and spread across the operations (41%), strategic management (Cost and Competitive Advantage) (22%), technology and process development (15%), procurement and distribution (12%), human resources (8%) and marketing (2%) business functions.

Keywords: Annual Activity Reports, BIST, Industry 4.0, Business Functions, Manufacturing Firms, Digitalization.

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6.1. Introduction

The new Industrial Revolution, announced in 2011 at the Hannover Fair, initially began its integration into business functions through operations such as; failure prediction, production effectiveness and optimize planning/management activities (Rußmann et al. 2015), however, it has now become a part of all core business functions. Throughout vertical and horizontal system integration (Varghese and Tandur, 2014) the business functions have evolved from “raw materials acquisition” (Siemens, 2016) all the way to marketing, logistic, accounting, finance and customer relations. Recently, the Turkish Government launched a project-based incentive system in order to accelerate the shift towards Industry 4.0 under manufacturing firms, in turn creating incentive for analyzing existing Industry 4.0 applications/implementation activities. The main motivation of the chapter is to analyze the the Industry 4.0 transition from a business perspective of manufacturing sector. In line with this aim, we shall conduct a qualitative analysis on the annual activity reports of quoted BIST manufacturing firms. Kaldor (1957), describes the manufacturing industry as “the main engine” responsible for transforming demand into “growth”. Examining the relationship between national industrial development and economic growth, he argues that there is a strong positive relationship between GDP and industrial activity.

The above argument, coupled with the fact that (1) Industry 4.0 development is expected to largely target industrial production (Weyer et al. 2015), and (2) emerging technologies can have an impact on manufacturing approaches and businesses (Zhong et al. 2017) is motivation for including manufacturing firms under the sample. The activity reports were selected for the analysis as they provide audited information on the current and future activities of the organization. Under the analysis we downloaded and examined the 2017 quoted manufacturing firms’ annual activity reports. The reports were subjected to a content analysis to generate information on firms’ Industry 4.0 benefits in relation to the evolving business functions. The analysis was conducted by three coders simultaneously and each item was discussed before being coded in order increase the validity and reliability of the study. As revealed from the annual activity reports of BIST listed manufacturing firms, the chapter identified that, out of each business function, the strategy and operations functions have benefited extensively from the Industry 4.0 revolution. Moreover, the least affected business functions were marketing and human resource management. The chapter is structured as follows. Section 2 provides a literature review on the developmental stages of Industry 4.0 and its role under each business function. Section 3 details the research methodology and Section 4 debates the findings. Finally, Section 5 concludes.

6.2. Literature Review

6.2.1. The Stages of Development for Industry Revolutions

Humanity has transitioned through four different industrial revolutions. Beginning with the invention of machines in late 1700s, the first industrial revolution (Kagermann, Helbig, Hellinger and Wahlster, 2013). With the usage of steam power and engine in production, the door was opened for quicker and cheaper production (Allen, 2006; Karaköse and Yetiş, 2017). Production areas evolved, and small workshops shifted transformed into factories (Drath and Horch, 2014). Industry 1.0 revolution initially began in the Great Britain region due to the high wage rate, energy value, availability returns on inventions, and finally, the size of the current mining industry and legal rights of the inventor (Allen, 2006). Upon reaching this technological breakthrough, legal protection for workers increased. Moreover, as returns increased on investments, business owners were able to generate higher income to cover costs. This development reduced high wage rate for businesses by replacing most workers with machines (Allen, 2006). The core characteristic of Industry 1.0 was mechanization (Kagermann et al. 2013).

With the invention of these new machines, usage of steam and water power in manufacturing triggered increases in productivity (Allen, 2006; Voigtländer and Voth, 2006; Küçükkalay, 1997; Deane, 1979). The industrial revolution began within the manufacturing field, however their effects soon exceed the production areas and encompassed society as a whole. Even the population structure was not left unaffected. Citizens started to move to urban areas to work in factories (Labor, 1990; Deane, 1979; Blinder, 2006). Thus, the population (Tezge, 2010; Deane, 1979), living standards of people and aggregate welfare increased (Topleva, 2018). Contributing towards the betterment of society in the long run.

Industry 2.0 began towards the beginning of the 20th Century due to increased electricity usage in manufacturing (Atkeson and Patrick, 2001). Developments such as the usage of petroleum, chemicals, high explosives, telephones, and radios also signified the shift in the second industrial revolution age (Mokyr, 1998). Access to steel in the production area ultimately decreased production costs and in turn, increased the quality of products (Mokyr, 1998). With goods being shipped across the Atlantic to America directly, this opened the door for global trading and new alternative markets. Additional railroads were built, making the transportation of goods across long distances easier, subsequently decreasing costs (time and expenses) (Engelman, 2015). Taylorism principles were later incorporated into manufacturing factories. Assembly line, mass production (electrically powered) and labor division spurred important breakthroughs in manufacturing (Blanchet et al, 2014). In the second industrial revolution, cost of production decreased and productivity (Atkeson and Patrick, 2001), while production increased (Boyd and Crawford, 2012; Kagermann et al. 2013; Paul and Jonathan, 1991). Moreover, with the inventions of synthetic plastic, the core material employed for products shifted into plastics (Mokyr, 1998).

The second industrial revolution also affected the lives of citizens. With usage of steel in ship production, ships became more powerful and moved faster. People started to traveling long-distances to geographic areas, moreover interaction of people increased with new inventions; radios, telegraph and telephones (Atkeson and Patrick, 2001; Engelman, 2015; Mokyr, 1998). Social welfare, living standards, and the incomes of people increased (Engelman, 2015; Mokyr, 1998). Growth rate of the service industry increased due to changes in consumer preferences (Blinder, 2006). Moreover, fertilizers, chemicals and tractors were employed in the agriculture, which improved the amount of harvest, and decreased cost and time loss (Mokyr, 1998). Finally, countries became more interdependent and globalized.

Industry 3.0 began in the 1970s. Automation and information technologies (IT) became the core elements of the Industry 3.0 (Blanchet et al. 2014; Jazdi, 2014). In 1969, programmable logic controllers were invented, which allowed employees to digitally program the automation systems (Kagermann et al. 2013). Diminishing usage of fossil fuels and climate change triggered Industry 3.0. Sustainable growth and renewable energy topics became the focus of discussions by political leaders and company managers (Jänicke and Jacob, 2009; Rifkin, 2013). Invention activities continued during the third industrial revolution, high-speed railroads systems, inventions of the internet, fiber optic, satellite, cellular phones are a few examples of inventions during this age (Jänicke and Jacob, 2009). Not unlike the first two industrial revolutions, the third industrial revolution too brought about affirmative outcomes to manufacturing. More flexible and efficient production systems became possible through applications of automation (Kagermann et al. 2013) and controlling robots in production (Qin et al. 2016). Radio Frequency Identification Device (RFID) technologies gave the change for using product tracking programs during transportation and remotely controlling products in warehousing (Brettel, Friederichsen, Keller and Rosenberg, 2014). Moreover, companies started to develop prototypes of products more easily, due to additive manufacturing technology (Gibson, Rosen and Stucker, 2012). Usage of information Technologies expanded and the service industry still maintains this development and growth (Blinder, 2006).

Launched by the German Government in 2011, Industry 4.0 is referred to with various different names depending on the region. For example, “Industrie 4.0” in Germany, “Internet of Things (IoT)” in European Union countries (Kagermann et al. 2013) and “Made in China 2025” in China (Liu, 2016). Furthermore, Japanese use “Society 5.0”, which is the integration of Industry 4.0’s developments and society (Wang, Li, Yuan, Ye and Wang, 2016). Not unlike other governments, Turkey also attaches great importance to Industry 4.0. In 2016, TÜSİAD (Türk Sanayicileri ve İşinsanlari Derneği) published a report titled “Industry 4.0 in Turkey as an Imperative for Global Competitiveness” regarding the national position and vision on the movement (TÜSİAD, 2016).

The Industry 4.0 concept was defined as flexible control of manufacturing systems via usage of Cyber-Physical Systems (CPS) (Kagermann, 2015). CPS create a relation between the real and computer oriented world and all systems and devices can be monitored, coordinated and controlled without any stable control central (Rajkumar, Lee, Sha and Stankovic, 2010). Moreover, information can be exchanged between the real and virtual world in real time by computing and communication infrastructures (Kagermann et al. 2013). Technological developments in Industry 4.0 brings fast, disruptive and destructive (Blanchet et al., 2014) changes and effects the production fields (Gilchrist, 2016). It allows for better control and arrangement of manufacturing systems (Industrial Internet Consortium, Fact Sheet, 2013), real-time optimized flexible and dynamic systems (Kagermann et al. 2013) and so on.

However, technological developments of Industry 4.0 do not just affect the production areas, but also other business functions (Blanchet et al. 2014). Table 6.1 summarizes the information on the main core characteristics of the four industrial relations stages.

Table 6.1: Core Characteristic of Industrial Revolution Stages

Industrial Revolution Stages	Core characteristic
Industry 1.0	Mechanization (Kagermann et al. 2013).
Industry 2.0	Usage of Electric (Rosenberg, 1998)
Industry 3.0	Automation and information technology (Blanchet et al. 2014).
Industry 4.0	CPS (Kagermann et al. 2013, Rajkumar et al. 2010)

In the following section, the effect of Industry 4.0 on operations, strategic management (Cost/Competitive Advantage), accounting, finance, marketing and human resources management will be explored.

6. 2.2. Industry 4.0's Role under the Business Functions

Strategic management (Cost and Competitive Advantage): With the integration of Industry 4.0 under businesses, firms will slowly extend operations and become more large-scale (Kagermann, 2015; Rußmann, et al. 2015), increasing the level of competition (cost or otherwise) between transitioning and non-transitioning firms (Blanchet et al., 2014). The integrated technology will allow for more individualized production (Lasi, Fettke, Kemper, Feld and Hoffmann, 2014) and even contribute towards increasing customer trust levels for organizations (Harlamova and Kirikova, 2018). However, despite the professed multiple benefits of Industry 4.0, the current literature lacks coverage of these cost/financial and/or competitive advantages. Addressed under the strategic management function of businesses, these benefits are capable of setting the Industry 4.0 transitioning firms separate from the competition. By use of artificial intelligence programs and collected organizational data, the firms will be able to conduct accurate planning, organizing and evaluating tasks (Kagermann et al. 2013) in real and virtual environments. This information will be communicated by machines/systems to within/outside of the factory/stakeholder (Rußmann et al. 2015). These systems and the communicated information will allow managers to efficiently allocate and use resources (Jazdi, 2014), faster/supported decision making (Kagermann et al. 2013). Each function/activity within the business will be better coordinated, creating a clear corporate strategy (Kagermann et al. 2013). These integrated systems will ensure that the firm creates and sustains their competitive advantage (Stock and Seliger, 2016). Furthermore, the innovation speed within businesses will increase (Jazdi, 2014), and usage of smart systems will bring new advantages for companies boundaries (Schuh et al. 2014)- increasing value creation and evolving business models (Jazdi, 2014; Schuh et al. 2014).

Regarding the firms financial/cost advantage; increased production quality (quality enhancements) (Industrial Internet Consortium, Fact Sheet, 2013; Kagermann et al., 2013) will increase demand, and consequently, increase in sales volume (McAfee, Brynjolfsson, Davenport, Patil and Barton, 2012). Similarly, the following of new production trends will positively affect the financial bottom line. Improved quality will also aid in reducing manufacturing cost. Whether its preventative maintenance or production/operation costs per produced unit (Manyika et al. 2011). Preventative maintenance will also have the benefit of reducing machine breakdown, subsequently cutting back on associated losses; such as, loss of customer or electric expenses (Kagermann, 2015). Highly automatized production will also reduce the need for manpower on the production floor and online control/maintenance systems will reduce manager work-flow. Finally, repair expenses will go down as regular and monitored maintenance is conducted on new machinery. With increased level of communication between sales and production, the risk of unfulfilled orders will reduce and planning activities regarding raw material purchase and in-house transportation will become automatized (Lee, 2008). The ordering of new products and supplier communication will run smoothly, inventory/storage costs will reduce as smart factories will allow for optimized inventory management (Varghese and Tandur, 2014). New technology and increased monitory will reduce waste production, cutting back overhead costs. Finally, an optimized production process will allow for cutting back utility costs, such as, electricity and water. These items are a brief example of the benefits of transitioning towards Industry 4.0 and its effect on the cost and competitive advantage of firms.

Operations, Procurement and Distribution: One of the important benefits of Industry 4.0 is enhancing productivity (Gilchrist, 2016), while the shop-floor of firms is the most affected area from transitioning to Industry 4.0 (Schuh et al. 2014). This promises to benefit the productivity of operations through improved product development process (Kagermann et al. 2013), increased production speed/quality and lower defects and repair issues (Abbott, 2014; Kagermann, 2015). Moreover, these adaptations will enhance performance of engineering (Schuh et al. 2014) and usage of digital twin technology. A manager will be able to use an application to upload products to transport vehicles, whether or not they are physically located in the factory. They will also be able to makes changes or modifications in a virtual environment, observe these changes online and have access to information about possible problems (as it occurs) (Fiorentino, De Amicis, Monno and Stork, 2002). However, it is also argued that an increase in the speed of innovation has led to a reduction in the production life cycle (Schuh et al. 2014). Furthermore, production systems can be controlled remotely/digitally, allowing the systems to become more flexible. This provides workers with the ability to make last minute configuration and produce more individualized products (Kagermann et al. 2013).

The other advantages of Industry 4.0 are the increased connection and communication of machines (Lasi et al. 2014) through cyber-physical system. Moreover, the quality of production (Industrial Internet Consortium, Fact Sheet, 2013) and repair and defects cost (Varghese and Tandur, 2014) are several areas that will be affected positively due to the integration of smart systems. All systems will be integrated and will be open for in-house communication. These systems will be able to detect deficits or quality issues, which will allow them to take immediate action via use of artificial intelligence software- increasing the efficiency and effectiveness of factories (Industrial Internet Consortium, Fact Sheet, 2013; Rußmann et al. 2015).

Connection and communication between supply chain members will improve with these new technologies (IoT and CPS). Thereby, planning, ordering and transportation activities will be performed in more efficient ways by supply chain members. Thus, managers will be able to easily manage their supply chains (Kagermann et al. 2013). Besides supply chain management, logistics and transportation activities will be affected positively with the new technological developments. Some logistics and transportation decisions such as routes selection, controlling will be overtaken by smart systems. For example, all traffic lights will be connected each other, so that systems more efficiently create a transportation routes for truck (Kagermann, 2015). This will reduce the workload of human workers.

Finally, energy efficiency is one of the final benefits afforded by Industry 4.0 (Kagermann et al. 2013). With the help of "start-stop features" of machines and systems, the period of production breaks will decrease. Smart systems and robots dramatically reduce usage of energy, as 90 percent of energy expenses are consumed during production breaks (Kagermann, 2015).

Technology and process development: Digital manufacturing, network communication, computer and automation technologies are some of the technologies that are required to implement Industry 4.0 effectively (Zhou et al. 2015). With "CPS and IoT" technologies, all devices and systems will be able to automatically collect, analyze and interpret data. Moreover, these systems will be able to send and receive information from other devices and services. Data will be collectable through smart objects and systems, referred to as big data. However, this will also result in new emerging problems; such as, analyzing large data sources (Blanchet et al. 2014), organizing complex data (Weyer et al. 2015; Wu, Zhu, Wu and Ding, 2014), data storage (Manyika et al. 2011) and data protection (Blanchet et al. 2014). These issues need to be resolved in order to ensure efficient transition towards Industry 4.0. These technologies will not only contribute towards operations, but will also positively affect the business' reputation and image (Sung, 2018).

Cyber-security and data protection are seen as a core requirements of implementation of Industry 4.0 (Rußmann et al. 2015) because without data protection, effective integration of production systems/networks will not be possible. Hold backs resulting from fear of hacking will reduce firm willingness to share information, reduce connection /communication between activities (for smart objects, firms, stakeholder and customers). Service/product design also promises to be affected from technological development. For example, design of product can be made more flexible and easy with using high technological programs (Kagermann et al. 2013). Moreover, customers and stakeholders can be involved in production process through selecting the components to distribution phases (Blanchet et al.

2014). Also, 3-dimensional virtual objects (Paelke, 2014) give change to observe changes immediately without need to manufacture prototype (Fiorentino et al. 2002).

Marketing: New technological systems, referred to as embedded systems, give the ability to record, store and process data. With the integration of Industry 4.0, embedded systems will become more commonplace for firms/technology. All objects will, in time, be equipped with sensors/actuators, which will allow for them to easily connect to the internet, collect and analyze data (Lasi et al. 2014). Flexibility of the production systems (Shrouf, Ordieres and Miragliotta, 2014) and last-minute changes will become possible (Kagermann et al. 2013). Finally, different types of products will be more easily produced than before (Brynjolfsson, Hofmann and Jordan, 2010). This will also prompt the integration of consumers within the production systems.

The control of consumers (on products) will increase in the fourth industrial era. These individuals will determine components and ingredients of products based on their wants and needs (Blanchet et al., 2014: 9-11) and access more information on the product life-cycle (Jazdi, 2014; Stock & Seliger, 2016). Production will shift from mass customization to individualized production due to increased flexibility (Rußmann, et al. 2015).

Customers will be able to reach more detailed information about products; such as when/ where it is produced, how it is produced, ingredients of products. This will be possible due to unique product coding. Personalized medicine is one example for individualized production. These products are prepared based on patients' needs (Kagermann, 2015), taking into account the patients unique physical conditions. Industry 4.0/ IoT technology has allowed for the storage and analysis of consumers' preferences. Thus, comprehensive and continuous information about consumers can be accessible by marketers (Kagermann, 2015). Thus, the marketing function of businesses will be affected by the developments of fourth industrial revolution. With access to more detailed information about customers, the segmentation of the market and target customer selection will become more accurate.

Human Resource Management: With cyber-physical system, capabilities, abilities and functions of Artificial Intelligence and robots will be integrated in production, in turn affecting the employees work in the factory (Blanchet et al. 2014). Job design, work duties and employees' skills, which will shift and evolved for something more suitable for using technologies (Kagermann et al., 2013). Moreover, communication/integration between workers of the same/different departments will increase (Kagermann et al. 2013).

The division of labor, training and skills of employee will be changed due to Industry 4.0 and these changes will affect human resources department directly. The tasks required from each job will become more suitable for use of technology, employees will become more empowered with these new skill-sets. The employees will become more involved in comprehensive decision making, coordinating/managing their own jobs (Stock and Seliger, 2016). Moreover, career planning will need to become more flexible (Kagermann et al., 2013; Kagermann, 2015) and interdisciplinary (Kagermann, 2015; Stock and Seliger, 2016).

Moreover, the hiring procedure of employees in HRM will also change as the number of workforce goes down (Stock and Seliger, 2016) and the demand for high skilled employees goes up (Schuh et al. 2014). Demand for skilled workers' in mechanical and engineering sectors will increase (Kagermann, 2015). Thus, the human resources department will have to adapt to changes and focus on hiring workers who have the necessary skills to keep up with Industry 4.0 changes (software and information technology) (Rußmann et al. 2015).

6.3.2.1 Motivation and Aim of the Study

With the wide popularization of the topic- within not only Turkey but also a global context- policymakers, managers and researchers alike have started questioning the potential benefits of transitioning towards Industry 4.0. Coupled with the general importance of the manufacturing industry and its contribution towards country growth, the Turkish Government launched a project-based incentive system in order to hasten the shift towards Industry 4.0 under manufacturing firms. The main motivation of the chapter is to analyze the Industry 4.0 transition from a business perspective of manufacturing sector. Industry 4.0 is a new development that most countries (including the EU member states) are struggling with, or are planning to implement in the coming years. Moreover, as technological advances strongly dictates industrial productivity, in order to (1) ensure that firms adapt to the oncoming changes, (2) become more efficient and transparent; researchers, policy makers and managers alike are motivated to get ahead and focus on the new field of study. Thus, it is hoped that this chapter will aid in providing these interest groups with an in-depth look that will aid countries who are currently planning to go through with the switch.

Aiming to serve as a road map for countries wishing to improve their current Industry 4.0 planning by addressing the activities of transitioning firms, this chapter will detail the current practical application of Industry 4.0 under manufacturing firms. Overall, the study aims to clearly identify alternatives between Industry 4.0 activities and benefits. Considering the high cost associated with the digitalization movement, this is imperative for moving the Industry 4.0 debate forward.

In order to determine the firms' recognized/actualized benefit outcomes from transitioning towards Industry 4.0, a qualitative content analysis was performed on annual activity reports published in 2017; mapping and assessing existing evidence in order to analyze our research question, which is "What are the actualized Industry 4.0 benefits identified by transitioning listed manufacturing firms?".

Turkey's developing country status also provides the international literature with a unique perspective, as most countries that are close to completing their Industry 4.0 transition are currently “developed countries” with large budgets. The unique perspective and application offered by this chapter aims to fulfil a niche in the literature.

6.3.2. Sample Selection

6.3.2.1 Industry Selection

Despite the fact that all sectors and business functions/departments will ultimately benefit from the digitalization movement, the manufacturing industry is currently at the focus of the Industry 4.0. Promising to gain from the various technological advances, this industry is described as the “the main engine” responsible for transforming demand into “growth” (Kaldor, 1957). Examining the relationship between national industrial development and economic growth, the author argues that there is a strong positive relationship between GDP and industrial activity. Thus, Industry 4.0 development is (1) expected to largely target industrial production (Weyer et al. 2015), and (2) emerging technologies can have an impact on manufacturing approaches/businesses (Zhong et al. 2017). This is motivation for including manufacturing firms under the sample. Upon selection of the sample, information regarding the sector classifications were downloaded from the KAP (the Turkish Public Oversight Platform). The sample was categorized under the 9 sub-sector groupings of KAP.

6.3.2.2 Source Document Selection

In order to determine the Industry 4.0 transition status of the sample, the annual activity reports were employed. The annual reports were selected as the source document for the following reasons; (1) according to the Turkish Commercial Code the annual report must be audited. The information presented under the entirety of the report must be prepared without including misleading, extraordinary and untrue statements and must fairly reflect the company’s financial performance over a given period (TTC: 397). Thus, this had the benefit of increasing the reliability of the information provided under the source document. Moreover, (2) the publication of the annual reports are compulsory and allow for comparability.

All BIST listed firms are required to publish their annual activity reports alongside their financial statements and are made available on the official website of the organization. Thus, the existence of these comparable reports for each firm provide researchers with the unique opportunity of possessing data on the current and future ongoing of the organization. Thus, another reason for employing use of these annual activity reports are because (3) the reports are easily accessible under the official firm website. Finally, the most important reason for employing these annual reports are the fact that (4) they are considered as a modern advertisement/communication tool (Stanton and Stanton, 2002). These reports serve towards conveying detailed information regarding the current Industry 4.0 activities of the firm.

6.3.2.3 Country Selection

In light of the growing awareness for Industry 4.0, national governments have started adopting various programs to improve productivity/competitiveness of their industries (EU

Commission, 2017a). However, with only 28% of current EU Members implementing these changes, Turkey (as a developing, non-EU country), provides a rewarding setting for analyzing firms current Industry 4.0 application and implementation activities. Coupled with the fact that each country differs in regards to their target audience, budget amount, funding approaches, policy designs and implementation strategies- it is hoped that the "Project Based Incentive System" outlined in Turkey will hold particular importance for researchers and countries aiming to transition towards Industry 4.0. As a developing/candidate country, the information gained on Industry 4.0 applications in Turkey could contribute towards a better understanding within the international literature. The data collected from the study could, ultimately, be generalizable across different countries. Moreover, the fact that Turkey has taken the necessary steps in order to incorporate Industry 4.0 under its manufacturing industry, well before several EU member states, highlights the importance of this country analysis.

6.3.2.4 Sample Year

The annual reports prepared for 2017 was selected for the content analysis as it corresponds with the launch of the "Project Based Incentive System" which aims to aid manufacturing firms in transitioning towards Industry 4.0. Following the trend set by the German Federal Government (EU Commission, 2017b) the incentive system was launched by the Turkish Government in order to increase technological development, national competitive advantage and reduce the trade deficit. The initial announcement in 2017 resulted in a large number of firms willing to restructure their manufacturing processes and submitted project proposals (Ufuk2020, 2018) in preparation toward the 135 billion Turkish Lira incentive. Thus, the annual reports published for the year 2017 are only included in the sample, reflective of the current Industry 4.0 activities under Turkish firms.

6.3.2.5 Listed Firms

Only firms listed on BIST was included in the sample. The reason for this is the fact that firms quoted on the exchange need to mandatorily prepare and maintain financial reports. Thus, the information employed for evaluating the sample is consistently available. Moreover, listed firms are argued to disclose more information than non-listed firms. Not only are these firms striving towards fulfilling the minimum disclosure requirements, they are also more likely to provide quality voluntarily information. One reason cited for this under the disclosure literature is firm motivation to increase investor confidence (Raffournier, 1995). As a result, it was concluded that the listed firms on the exchange would be willing to provide more detailed information than non-listed firms in order to further communicate their intentions or activities with investors. Thus, these firms are more suitable for analyzing currently ongoing investments within firms.

6.3.3. Employed Qualitative Method

The source documents were searched via use of several keywords. Two of the authors managed this stage of this study in order to increase the internal validity of the analysis. Any activity pertaining to Industry 4.0 was determined by use of critical keywords, such as; “digitalization”, “4.0”, “Industry 4.0” and “smart factory”. The population (178 documents) were analyzed and 20 firms were identified as transitioning towards Industry 4.0. Table 6.2 provides the sub-sector distribution of the identified Industry 4.0 transitioning firms.

Table 6.2.: Transitioning Firms Identified under the Manufacturing Industry

Industry	**Count**	**Percentage**
Textile, Wearing Apparel and Leather	1	5%
Food, Beverage and Tobacco	3	15%
Chemicals, Petroleum Rubber and Plastic Products	5	25%
Fabricated Metal Products, Machinery and Equipment	8	4%
Wood Products and Furniture	1	5%
Non-Metallic Mineral Products	2	10%
Total	**20**	**100%**

The “Chemicals” sector makes up 25% of the sample. Transitioning firms were then categorized into themes, according to the methodology of Strauss and Corbin (1990). This stage of the analysis was conducted in the presence of all three researchers and the text was separated into actualized firms benefits from Industry 4.0 depending on the business function affected. Because of a lack of mention of Industry 4.0, the sample was reduced to 16 firms.

For the second stage of the analysis, the identified benefits were further separated into groups according to underlying categories/themes. These categories were determined employing use of the guiding principles presented under Tranfield, Denyer and Smart (2003). Under this stage, the researchers recorded evidence according to their business functions and themes. These business functions were determined with the aid of Brown (2008: 17-18).

As mentioned above, this portion of the analysis was conducted with all researchers present. Each individual theme/category was discussed in detail along with the identified benefits up for coding. Any ambiguous item was resolved with the vote of the third researcher. The final set of benefits coded reflect the joint review of all authors.

6.4. Findings

As mentioned above, each firm was individually analyzed and the Industry 4.0 actualized benefits/outcomes were coded under excel. This initial analysis yielded a total of 232 items from the 16 sample firms. The distribution of the identified items and their percentages are presented below under Table 6.3 along with the firms. The top 5 ranking firms (Vestel, Anadolu Isuzu, Türk Traktör, Tüpraş, Petkim) in the analysis constitute approximately 84 percent of actualized benefit items. The firms item dispersion is provided below under Table 6.3.

Table 6. 3. Firms and Dispersion of the items Referring Benefits of Industry 4.0

	Firms	Number of items	%
1	Vestel Beyaz Eşya ve Elektronik Sanayi ve Ticaret A.Ş.	70	30,17
2	Anadolu Isuzu Sanayi ve Ticaret A.Ş.	40	17,24
3	Türk Traktör ve Ziraat Makineleri A.Ş.	40	17,24
4	Tüpraş-Türkiye Petrol Rafinerileri A.Ş.	28	12,07
5	Petkim Petrokimya Holding A.Ş.	16	6,9
6	Kordsa Teknik Tekstil A.Ş.	6	2,59
7	Soda Sanayii A.Ş.	6	2,59
8	Pınar Su Sanayi ve Ticaret A.Ş.	5	2,16
9	Anadolu Cam Sanayii A.Ş.	4	1,72
10	Tat Gıda Sanayi A.Ş.	4	1,72
11	Ford Otomotiv Sanayi A.Ş.	3	1,29
12	Arçelik A.Ş.	2	0,86
13	Aygaz A.Ş.	2	0,86
14	Ditaş Doğan İmalat ve Teknik A.Ş.	2	0,86
15	Otokar Otomotiv ve Savunma Sanayi A.Ş.	2	0,86
16	Pınar Süt Mamülleri Sanayii A.Ş.	2	0,86
	Total	**232**	**100**

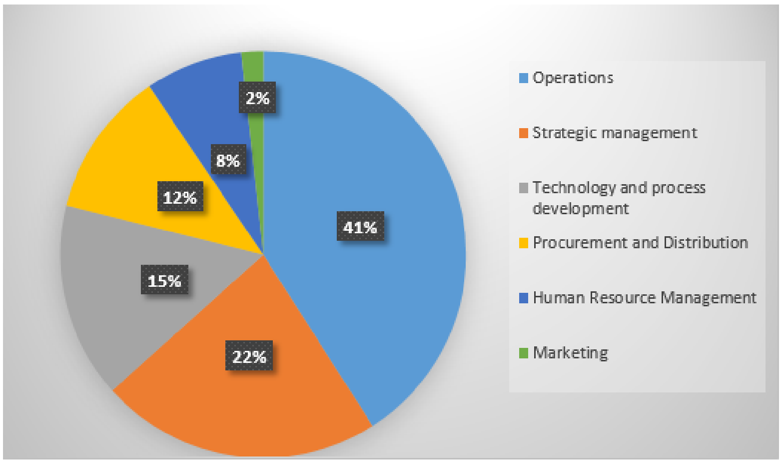

Figure 1. Business Functions Benefiting from Industry 4.0

As mentioned before, the information collected from the annual activity reports were grouped under six main business functions categories via use of the Brown (2008: 17-18). These categories are presented in Figure 1, employed as the coding and analytical framework of the study. The operations function largely (41%) benefited from Industry 4.0. However, the conducted analysis shows that multiple departments have also been affected by this transition. The dispersion percentages of the business functions are presented in Figure 1.

Following the level 1 analysis, the extracted data (sentences) from the annual reports were subjected to a second content analysis and separated into themes. These themes (level 2 and level 3) consisted of the expressions referring to actualized benefits of Industry 4.0 applications and the sub-categories for each business function activity. The processes or activities were coded simultaneously and at the discussions of the three researchers. The business functions, their sub-categories, benefits and frequency of items referring the common actual benefits are provided under Table 6.4.

Table 6.4. Business functions addressed in items referring benefits of Industry 4.0.

Business Functions (Theme 1)	**Sub-categories (Theme 2)**	**Benefits (Theme 3)**	**Frequency of items**
Operations	Developing Operation Process	Integration of Robotic-Based Systems into Manufacturing	6
		Reaching Efficient Production	6
		Business Process Improvement	4
		Improving Production Line Efficiency	4
		Improving Productivity	3
		Achieving In-house Communication	2
		Conducting Production Optimization	2
		Production Capacity Improvement	2
		Optimizing Order Procurements	1
	Quality, control and assurance	Conducting Continuous Assessment and Improvement	11
		Improving Production Monitoring	8
		Developing Remote Control Systems	5
		Development of Feedback Systems	2
	Managing production	Enhancing Error Detection	10
		Conducting Digitized Problem Solving	5
		Improving Maintenance Activities	4
		Effective Production Planning	1
	Producing goods	Improving Production Efficiency	15
		Improving Productivity	4
Strategic management (Cost and Competitive Advantage)	Gaining differentiation advantage	Enhancing Innovation Activities	4
		Gaining Competitive Advantage	4
		Improving Technological Infrastructure	3
		Reaching Alternative Markets	3
		Following Trends	2
		Improving Trade Performance	1
		Improving Workforce Competence	1
	Gaining cost advantage	Achieving Investment Efficiency	5
		Improving Production Efficiency	4
		Achieving Energy Efficiency	3
		Improving Logistic Activities	2
		Improving Maintenance Activities	1
		Improving Inventory Management	1
	Corporate strategy development	Achieving Sustainable Growth	3
		Improving Profitability	2
		Improving Stakeholder Relations	2
		Developing Business Models	1

		Developing Corporate Culture	1
	Coordinating activities	Achieving Cross-Department Harmony	4
		Reaching Operational Excellence	4
Technology and process development	Collecting and processing data	Conducting Data Analysis	5
		Conducting Data Collection	4
		Conducting Data Reporting	2
	Product or service designing	Achieving Rapid Prototyping	4
		Conducting Digital Designing	2
		Conducting Individualized Production	2
	Developing software	Developing Remote Control Systems	2
		Development of Robotic-Based Systems	2
		Conducting Maintenance	1
		Conducting Safety Management	1
	Cyber security improvements	Enhancing Data Protection	2
		Enhancing Network Protection	2
		Enhancing Protection Standards	2
	Developing process	Incorporating Technological Adaptation	3
		Improving Technological Infrastructure	2
Procurement and Distribution	Distribution	Integration of Robotic-Based Systems into Logistics	7
		Achieving Logistics Efficiency	5
		Achieving In-house Communication	1
		Conducting Safety Management	1
		Optimization of Logistics Activities	1
	Procurement	Improving Inventory Management	7
		Achieving Inventory Optimization	2
		Developing Remote Control Systems	2
		Achieving In-house Communication	1
Human Resource Management	Managing working conditions	Conducting Safety Management	6
		Improving Workforce Efficiency	3
		Improving Workplace Productivity	1
	Training	Improving Training Quality	3
		Achieving Technical Competence	2
	Managing human resources	Improving Workforce Efficiency	3
		Conducting Digital Planning	1
Marketing	Providing customer relations	Achieving Customer Involvement	1
		Improving Service Quality	1
		Increasing Customer Satisfaction	1
	Managing corporate image	Improving Corporate Trustworthiness	1
		Grand Total	232

6.4.1. Strategic Management (Cost & Competitive Advantage)

The number of items under the first sub-category, gaining differentiation advantage, is 18 and it accounts for seven percent of all items. Under this category, we see that firms take part in Industry 4.0 activities; such as, transferring into open innovation processes and increasing/accelerating innovation with smart manufacturing systems. As previous researchers confirmed, usage of smart systems within the business increases the speed of innovation with increasing value creation and evolving business models (Jazdi, 2014). Moreover, firms have attempted to strengthen their market position and sustain their competitive advantage among rival companies. One method of achieving this has been through increasing the technological advantage of the firm and making sure they are protected against disruptive technology by introducing a digital strategy.

While transitioning, firms have also attempted to reach alternative markets and have argued that Industry 4.0 integration protected them from the competitive power of the global market. One technological advantage has also been the adaption to the fast-moving world and following of production trends, increased productivity of the trade cycle and differentiated-qualified human resources. In terms of gaining a cost advantage, firms have achieved investment, production, energy efficiency; improved logistic, maintenance activity and inventory management. By use of this technology, firms have been able to analyze project costs, realized all projects with low costs (with the help of simulation analysis), decreased internal losses and manufacturing costs (with collaborative robotics), increased operational energy-saving, decreased lighting/heating costs, decreased transportation/logistics costs (with the help of factory stores that communicates with each other), decreased the cost of machinery breakdown maintenance and decreased inventory costs. The cost reduction effect of Industry 4.0 are supported by the literature (Lee, 2008; Varghese and Tandur, 2014).

The third sub-category is corporate strategy development and contains five benefits: achieving sustainable growth, improving profitability, improving stakeholder relations, developing business models, and developing corporate culture. Under their Industry 4.0 activities firms have maintained the firm's durability and sustainable growth, improved profitability, improved stakeholder relations by communicating the automation process with stakeholders. Moreover, they have enriched all stakeholders with new applications, created new productive business models and added value to the corporate culture. Thus the systems and the communicated information brought by Industry 4.0 will allow managers to allocate and use resources more efficiently (Jazdi, 2014), make decisions faster and supported (Kagermann et al. 2013) since each function/activity within the business will be better coordinated (Kagermann et al. 2013).

The last sub-category of strategic management (Cost and Competitive Advantage) function is coordinating activities which contains two actualized benefits: achieving cross-department harmony and reaching operational excellence. Concerning these activities, firms have integrated the marketing and production stages, planed sales according to manufacturing information collected from Industry 4.0 programs, and finally, achieved collaboration between the research & development and manufacturing departments. Ensuring that product development is conducted in a much more efficient manner.

6.4.2. Operations

The number of items that fall under developing operation process sub-category is 30 accounting for 13 percent of the total. This sub-category contains nine Industry 4.0 actualized benefits for firms, as listed under Table 6.4. Each theme and the activities leading to the actualization of these benefits are recognized below.

In order to achieve" integration of robotic-based systems into manufacturing" firms have had to automate their production processes and develop unmanned/fully automatic machines. This was conducted to lessen the manpower required for production and to reduce the number of errors in manufacturing. As stated under the literature by Varghese and Tandur (2014) the quality of production increases as repairs and defects decrease. Although this item is one of the most popularized benefits of Industry 4.0 under the literature, it is only mentioned 6 times out of the 232 actualized benefits. This could be a result of the high-costs associated with the integration of these fully automated robotic systems for manufacturing firms. The second highest actualized benefit under the Developing Operation Process activities is "reaching efficient production". By increasing competence in the manufacturing process, increasing the speed of production and working on time-efficiency via information generated from the installed digitalization programs; firms have actualized this benefit under their operations. Moreover, we see that firms have made innovative changes in business management by simplifying the operational processes and organizing a dynamic/continuous production plan via fourth industry revolution applications (improve business processes). To "improve productivity" firms have accelerated and shortened the production and manufacturing processes and to "improve the production line efficiency" they have increased their flexibility regarding production of goods. According to the information collected from the firms' annual activity reports, this has optimized the production processes of the sample firms.

During their Industry 4.0 transition, firms have also attempted to increase communication and integration between machines and the production department (achieving in-house communication). The data generated from this in-house communication ensures that each department is aware of the number of goods being produced or the level of raw material on hand. This allows for firms to efficiently plan the production of new orders and cut back on storage costs. Finally, firms have optimized demand/supplier order processes and increased production capacity while transitioning towards Industry 4.0. However, these constitute as a relatively small proportion (16%) of items under this sub-category.

The second operational function activity analyzed is "quality, control and assurance". The number of items mentioning benefits under this sub-category is 26 and accounts for 11 percent of the total. This sub-category contains four benefits: conducting continuous assessment and improvement, improving production monitoring, developing remote control systems, development of feedback systems, respectively. Under this category firms have enhanced production quality via use of augmented and virtual reality programs, standardized process quality (and also improved the visibility, speed, productivity and understandability of processes), detected errors and changes in the system with the help of Industry 4.0 programs (continuous assessment and improvement). Firms have also taken steps to increase monitoring on the production floor (improving production monitoring) and remotely followed performance by means of robotics (developing remote control systems). Finally, firms have developed online feedback systems in manufacturing and subsequently increased the production quality. This is in line with what is supported under the literature. Industry 4.0 improvements allow for production systems to be controlled remotely so that these systems will become more flexible and employees can make last minute configuration and produce more individualized products (Kagermann et al. 2013).

The third sub-category under the operations function is managing production activity with 21 items (9% of total). While transitioning under Industry 4.0 firms have taken proactive actions in order to intervene in malfunctionings, unplanned halts of production via use of 3-D prototyping and conducted multiple test to detect errors. Moreover, they have reduced the level of risk under production within the assembly line (enhancing error detection). The in-house communication implemented under operations has also contribution towards decreasing errors and increased instant decision-making. Maintenance activity were increased and conducted before machine breakdowns, ensuring timely production planning.

The final subcategory under operations is the production of goods. This category houses 19 items and makes up 8% of the total identified benefits. By incorporating industry 4.0 activities, firms have been able to improve production efficiency and productivity by integrating online feedback system, automatic leading and collaborative robot technology under operations. As mentioned in previous researches and as identified under our analysis (with 41% items from the total) production is the most affected area from Industry 4.0. Thus, it is not surprising that Industry 4.0 transitioning firms have enhanced their productivity through increased speed through performance engineering (Gilchrist, 2016).

6.4.3. Technology and Process Development

The first sub-category collecting and processing data contains three benefits: conducting data analysis, conducting data collection, and conducting data reporting. By integrating the Industry 4.0 activities under their operations, the sample firms have become technologically capable of advanced analytical analysis that allows them to monitor information through cloud computing. It has now become possible for these firms to obtain data about benchmarks, machine production and factory production through monitoring equipment. As mentioned before in the literature, "CPS and IoT" technologies brought by Industry 4.0 enable all devices and systems automatically collect, analyze and interpret data (Blanchet et al. 2014). The information generated from the technology allows for machines to communicate with each other, collect inputs through production and use this information to prepare production reports digitally.

The second sub-category product/service designing contains three benefits: achieving rapid prototyping, conducting digital designing, and conducting individualized production. Through these, firms have been able to conduct complex product testing via use of 3-D printers. These printers have allowed organizations to obtain their technological goals in a progressive, faultless and quick manner. This results from 3-dimensional virtual objects giving change to observe changes immediately without any need to manufacture prototype beforehand (Fiorentino et al., 2002; Paelke, 2014). Firms have also employed use of special simulations and virtual-reality programs to realize their projects. The flexibility afforded through industry 4.0 integration has increased the manufacturing of custom-made products per customer demand.

The third sub-category developing software contains four benefits: developing remote control systems, development of robotic-based systems, conducting maintenance, and conducting safety management. These activities have allowed for firms to manage all machinery, regardless of the location of factory and control automatic processing simultaneously. Manufacturing has progress to robotics/systems without human intervention. Moreover, collaborative robots that contains the ability to work with operators have been integrated into manufacturing. Finally, predictive maintenance and hot spots that permit workplace safety management have been integrated into operations.

The fourth sub-category cyber-security improvements contains three benefits: enhancing data protection, enhancing network protection, and enhancing protection standards. This has allowed for the protection of the company and corporate data from cyber-attacks (internal or external threats). Intranets/network security and technological infrastructure have been increased while maintaining cyber-security standards. This is in line with the literature as cyber-security and data protection are seen as main requirements of implementation of Industry 4.0 since data protection enables effective integration of production systems/networks throughout the business entity (Kagermann et al. 2013).

The fifth sub-category developing process contains two benefits: incorporating technological adaptation and improving technological infrastructure. These technological advancements have been adapted to not only the operations departments but all functions of the business; from sending the order to the supplier to shipping the final product to the customer.

6.4.4. Procurement and Distribution

The procurement and distribution function has two sub-categories including nine benefits referring to 27 items (12%). The first sub-category distribution involves five benefits: integration of robotic-based systems into logistics, achieving logistics efficiency, achieving in-house communication, conducting safety management, and optimization of logistics activities. As mentioned previously under the operations function, procurement and distribution too has incorporated advanced robotic based systems into their daily business activities. These activities consist of improving logistic operations by realizing “remote control in-factory” transfers and storing activities via robotics and utilizing unmanned transportation vehicles in materials’ transfers. This has increased in-house store communication and in turn, boosted the efficiency and productivity of logistic operations, while increasing the monitorability of outputs. Moreover, these integrated systems have also allowed for conducting better safety management by enabling in-factory transportation in a safer/planned manner

The second sub-category procurement contains four benefits: improving inventory management, achieving inventory optimization, developing remote control systems, and achieving in-house communication. By managing and controlling inventories online, firms have been able to create system orders automatically when their inventories shorten and have subsequently been able to cut back on inventory cost (via in-house factory communication). This has resulted in increased order speeds (improving inventory management) and optimized inventory management (via virtual reality training). Finally, the Industry 4.0 systems have made the monitoring of raw materials easier in the digital environment and this has allowed for automatic briefings to be generated on inventory ratios.

6.4.5. Human Resource Management (HRM)

HRM function accounts for eight percent of all items. By integrating Industry 4.0 under this business function, firms have been able to “conduct safety management” via increasing work safety standards with digital mapping. Moreover, firms have been able to increase job security in production and employee use of robots (instead of human workers) in risky situations. In order to improve “workforce efficiency” and “workplace productivity” they have started practicing ergonomic manufacturing and integrated Industry 4.0 applications in the back-office. The integration has also improved training quality and worker technical competence. This is because industry 4.0 facilitates employee empowerment which enables them involve in comprehensive decision making processes and coordinate/manage their own jobs (Schuh et al., 2014; Stock and Seliger, 2016). Moreover, skills (technical and inventory management) have been improved via use of virtual/augmented reality training operators, while workloads have been reduced with digital conversion projects and digital personnel planning.

6.4.6. Marketing

The final business function which has the least number of referred benefits of Industry 4.0 is marketing (4). The marketing function has two sub-categories including four benefits accounting for only 1,7 percent of all items. Firms addressing these actualized benefits under their operations have argued that, via transitioning towards Industry 4.0, they have been able to collect more feedback from their customers and improve service quality/customer satisfaction as a result. When comprehensive and continuous information about consumers becomes accessible, the segmentation and targeting activities are managed more effectively by marketing professionals (Kagermann, 2015). Finally, one firm has argued that Industry 4.0 has improved their corporate trustworthiness.

6.5. Conclusion

The analysis revealed that the sub-categories for each business function are as follows. Under the operations functions, the identified sub-categories are as; the operation process development, quality/control and assurance, production management. This business function is one of the most affected function from the implementation of Industry 4.0. The second most affected business function is strategic management (Cost and Competitive Advantage), which includes the following subcategories; gaining differentiation advantage, gaining cost advantage, corporate strategy development and coordinating activities. After the strategic management (Cost and Competitive Advantage) function, technology and process development is the third ranking function. The sub-categories are collecting and processing data, products or service designing, developing software, cyber-security improvements and developing process. The remaining identified business functions contain procurement and distribution, human resource management (managing working conditions, training and managing human resources) and marketing (providing customer relations, managing corporate image).

A limitation of this study is the current lack of transitioning Industry 4.0 firms under the Turkish manufacturing sector. Even though the growing importance of Industry 4.0 as been recognized by national governments and agencies, the transition towards this revolution is still ongoing. Thus, at this stage of implementation, the level of information available is lacking. As a future recommendation, the sample restrictions could be expanded to include non-listed firms operating in sectors other than manufacturing.

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