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Antecedents of Bottom-Up Operations Strategy Formation*

Cem Mercikoğlu[1], Arnd Huchzermeier[1], Serden Özcan[1]

ABSTRACT

Purpose: This paper's purpose is to deepen our understanding of what drives bottom-up operations strategy formation – that is, continuous improvement activities at the front line – with a particular focus on operations strategy understanding. That way, it aims to contribute to the awareness of management quality in manufacturing – a cornerstone of national competitiveness.

Methodology: We examine the antecedents of individual Kaizen generation by frontline employees, drawing on the well-established Motivation-Opportunity-Ability framework and focusing on the dimension of ability – that is, understanding operations strategy. Survey data on 217 frontline employees, working in 17 teams on 11 different production lines, were "triangulated" with their team leader assessments and the plant's archival records. We tested the hypothesized relationships via analyses that incorporate both structural equation modeling and multiple regression techniques.

Findings: Our results suggest that employees typically overestimate their understanding of the plant's operations strategy and that productivity is driven more by an objective than a subjective understanding of that strategy. We also find that incremental innovation is facilitated by supervisor support, employee engagement, and an employee suggestion scheme; in contrast, neither autonomy nor selected control variables (e.g., age or seniority) has a significant effect.

Originality: Our findings and the unique metrics we developed for better management of strategy understanding should help managers increase the productivity of their operations and thus the competitiveness of their respective firms.

Keywords: Operations Strategy Understanding, Supervisor Support, Employee Engagement, Continuous Improvement.

JEL Codes: M11, M54, J24.

Aşağıdan-Yukarıya Operasyon Stratejisi Oluşumunun Öncülleri

ÖZET

Amaç: Bu makalenin amacı, özellikle operasyonel strateji anlayışına odaklanarak aşağıdan yukarıya operasyon stratejisi oluşumunun – yani ön cephedeki sürekli iyileştirme faaliyetlerinin – öncüllerine dair anlayışımızı derinleştirmektir. Bu şekilde, ulusal rekabetçiliğin temel taşlarından biri olan üretimde yönetim kalitesi konusundaki farkındalığa katkıda bulunulması amaçlanmaktadır.

Yöntem: Bu çalışmada, Motivasyon-Fırsat-Yetenek teorisinden yararlanarak ve yetenek boyutuna, yani operasyon stratejisini anlamaya odaklanarak, üretim hattındaki çalışanların bireysel Kaizen üretiminin öncülleri incelenmiştir. 11 farklı üretim hattında 17 ekipte çalışan 217 üretim çalışanından elde edilen anket verileri, ekip liderlerinin değerlendirmeleri ve fabrikanın arşiv kayıtları ile "üçgenlenmiştir". Varsayılan ilişkiler hem yapısal eşitlik modellemesi hem de çoklu regresyon tekniklerini içeren analizler yoluyla test edilmiştir.

Bulgular: Sonuçlarımız, çalışanların fabrikanın operasyon stratejisini anlama derecelerini olduğundan fazla değerlendirdiklerine ve üretkenliğin bu stratejinin öznel olarak anlaşılmasından ziyade nesnel olarak anlaşılmasıyla sağlandığına işaret etmektedir. Ayrıca, artımsal inovasyonun amir desteği, çalışan bağlılığı ve çalışan öneri sistemi tarafından kolaylaştırıldığı; buna karşın ne otonominin ne de seçtiğimiz kontrol değişkenlerinin (örneğin, yaş veya şirket kıdemi) önemli bir etkiye sahip olmadığı tespit edilmiştir.

Özgünlük: Bulgularımız ve strateji anlayışının daha iyi yönetilmesi için geliştirdiğimiz özgün ölçütler, yöneticilerin üretim operasyonlarının verimliliğini ve dolayısıyla şirketlerinin rekabet gücünü artırmalarına katkı sağlayacaktır.

Anahtar Kelimeler: Operasyon Stratejisi Anlayışı, Amir Desteği, Çalışan Bağlılığı, Sürekli İyileştirme.

JEL Kodları: M11, M54, J24.

* This study is derived from the PhD dissertation titled "Bottom-up Operations Strategy Formation and Competitiveness" which is conducted by Dr. Cem Mercikoglu at WHU-Otto Beisheim School of Management under the supervision of Prof. Dr. Arnd Huchzermeier and Prof. Dr. Serden Ozcan.

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1. INTRODUCTION

An important change in the global economic landscape in recent decades is that the world's economic center of gravity has shifted eastward. The shift is expected to continue. Dobbs et al. (2012) from McKinsey Global Institute predict that by 2025 it will be in Central Asia – just north of where it was in 1 AD and in 1000 – coming full circle. Huang (2021) from Allianz Research also reports that the destination is to the east – and will remain so during the decade (Figure 1).

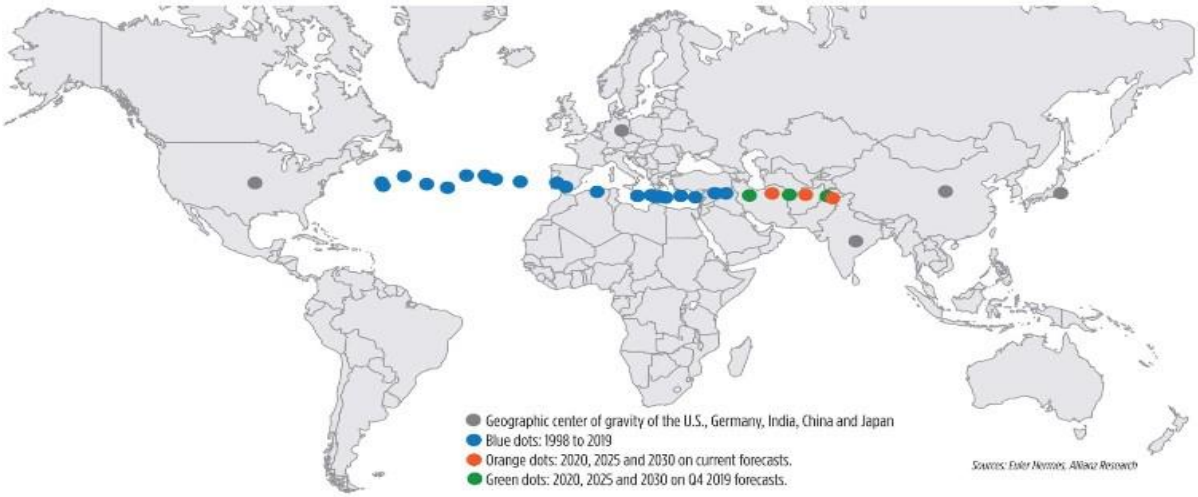


Figure 1. World Economic Center of gravity (Adapted from Daughters, 2021)

Other sources report similar expectations. For example, PwC (2017: 5-6) forecasts that the E7, the group of seven largest emerging economies, could grow on average twice as fast as the advanced economies (G7) by 2050 and increase their share of global GDP from 35 % to almost 50 %, while the shares of G7 and EU-27 will decline significantly. Similarly, Orlik and Van Roye (2020) argue that emerging economies will overtake advanced economies in 2042 and that 60 % of global GDP will be generated by them by 2050. Business intelligence firm CRU Group (2020) believes that the world in 2050 will be largely unaffected by the COVID-19 pandemics and that Asian economies will grow the most in the next 30 years, while Europe will shrink in relative size. So there seems to be a consensus that the East will become significantly more important in the foreseeable future. This will force Western executives engaged in international business to adjust their overseas strategy accordingly, or to begin developing such a strategy if they have not already done so. Ultimately, it is likely to be difficult – if at all possible – for a Western company to achieve high growth rates in the West alone without having a foot in the emerging economies, particularly in the East.

Türkiye is one of these emerging economies. As is the case in many countries around the world, its economic agenda focuses on productivity and innovation. Improved productivity in Türkiye benefits not only the national economy but also many other countries around the world, including the EU, which are increasingly looking to the country as a manufacturing hub – especially in the post-pandemic world where supply chain resilience is more important than ever. A natural consequence of this is that the competitiveness of European firms will depend more on Turkish productivity. Therefore, any contribution to increasing Turkish productivity directly benefits the European economy – the largest consumer of "Made in Türkiye". In addition, smarter use of resources benefits the "green transformation", an issue that will remain on the agenda for decades to come – with Türkiye aiming for net-zero emissions by 2053. In view of all these considerations, our attention turns to the question of how to further increase Turkish productivity.

In essence, productivity and innovation are interrelated, and the former – especially *labor* productivity – becomes evident as a result of the latter – especially *process* innovation. Greenspan (2013: 164) interprets innovation as a key determinant of productivity's growth rate. Owing to the increasing pace and complexity of business environments, organizations no longer compete on processes per se but rather on the ability to improve processes continuously (Anand et al., 2009). That development explains the strong relevance of a focus on continuous improvement, known as Kaizen. The Japanese word Kaizen is defined as a "company-wide process of focused and continuous incremental innovation" (Bessant et al., 1994) and is usually considered the opposite of Kaikaku, or radical change. In Japanese management philosophy, Kaizen is an "umbrella" concept that encompasses a unique set of management methods and involves the participation of everyone with the goal of continuous improvement. The prevailing mindset is that nowhere in the organization should there exist a place where some kind of improvement does not occur on any given day (Imai, 1986: 5). In that sense, human capital plays a big role in moving the business forward.

Nonetheless, many executives immediately associate productivity enhancement with tangible assets (e.g., physical assets or technology), which are necessary but not sufficient. For such assets to be fully utilized, they must be complemented by the intangible assets to which our work is dedicated. Despite these assets being no less effective, they are underutilized: factors such as management support, workers' understanding of operations strategy, and employee engagement merit great attention. This is succinctly highlighted by Peters (2010: xxi) with the words "Hard is soft. Soft is hard". Our work is an endeavor to raise awareness of the overlooked soft levers of productivity.

One way to increase productivity is to improve the quality of management. Two prominent studies in this area are World Management Survey (Bloom and Van Reenen, 2007) and Organizational Health by McKinsey (Gagnon et al., 2017). The former study, which measures the quality of management practices in different countries and industries, found that differences in management practices accounted on average for about 30 % of the total factor productivity differences both between countries and within countries across firms (Bloom et al., 2016), and that one standard deviation increase in management quality is associated with about a 10 percent increase in productivity (Scur et al., 2021) – a good figure for many economies around the world. Similarly, the latter study concluded that health, which is a measure of an organization's performance on 37 different management practices, explains up to 50 % of performance variation between companies, and healthy companies deliver a threefold total return to their shareholders (Dagan et al., 2020). In short: management practices play an important role in an organization's performance – and ultimately in a nation's competitiveness.

Unfortunately, Türkiye scores relatively poorly on management quality (Carpio and Taskin, 2019). More specifically, more than half of Turkish manufacturing firms were found to be worse managed than firms in even the lowest quartile in the United States. Perhaps even worse is the finding that, compared to managers from all other countries, Turkish managers are the least aware that their management practices are poor (Carpio and Taskin, 2019).

The main objective of our work is to contribute to Turkish productivity. What motivated us to do so have been the facts that (i) Turkish industry is a laggard in terms of management quality – as mentioned above – and is currently unable to capitalize on the resulting productivity gains, (ii) only 11% of Turkish executives in a survey stated that their strategies are being executed as planned (Aki, 2016), resulting in lower value creation in around 90 % of companies, and (iii) there is a large productivity gap between KOBIs (small and medium-sized enterprises in Turkish parlance) and large firms, with the former, which accounts for 99% of Turkish industry, being only about one-sixth productive as the latter, which accounts for a mere 1 % of the industry (Dünya, 2017) – an imbalance that is a big obstacle on the road to becoming a global economy and should definitely be addressed. We aim to tackle all these problems by focusing attention to the soft side of productivity.

Our research deals with antecedents of bottom-up operations strategy formation, i.e., continuous improvement activities on the shop floor, with a particular interest on *operations strategy understanding at worker level* – a management practice that is in most cases neither appreciated nor properly measured. In regard to such understanding, workers can be classified into one of the four possible groups (Figure 2).

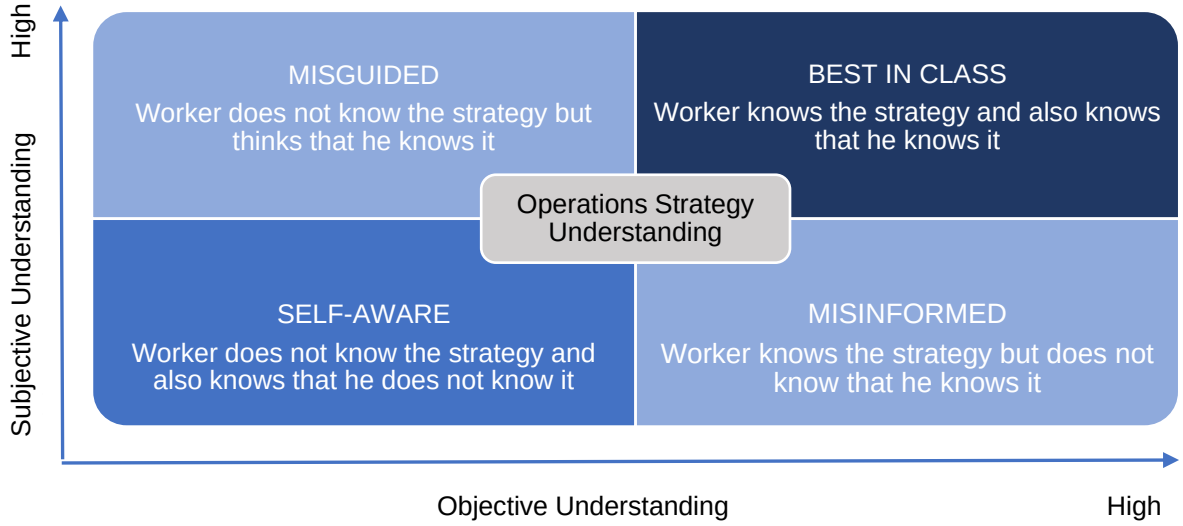


Figure 2. Clusters of strategy understanding (Huchzermeier et al., 2019)

There are a number of studies in the literature that have investigated the role of the same and/or similar constructs to ours, such as managerial support and autonomy, on organizational performance, including innovativeness and entrepreneurship in the Turkish context (e.g., Bulut et. al., 2009; Fis and Cetindamar, 2009; Gümüslüoglu and Ilsev (2009); Ulusoy et. al., 2015). However, this study is unique in the sense that it goes beyond the constructs already studied and brings a new one, namely operations strategy understanding, to the scene. To the best of our knowledge, this is the first study to empirically investigate the effects of objective and subjective operations strategy understanding on incremental innovation, i.e., individual Kaizen performance, in the Turkish manufacturing industry.

The rest of this paper proceeds as follows. Section 2 addresses the background and the research model; literature review and our methodology are presented in (respectively) Sections 3 and 4. In Section 5 we present the analysis and the findings, and Section 6 addresses workers' understanding of operations strategy. We conclude in Section 7 with a summary discussion of our results, managerial insights, limitations of the study and avenues for future research.

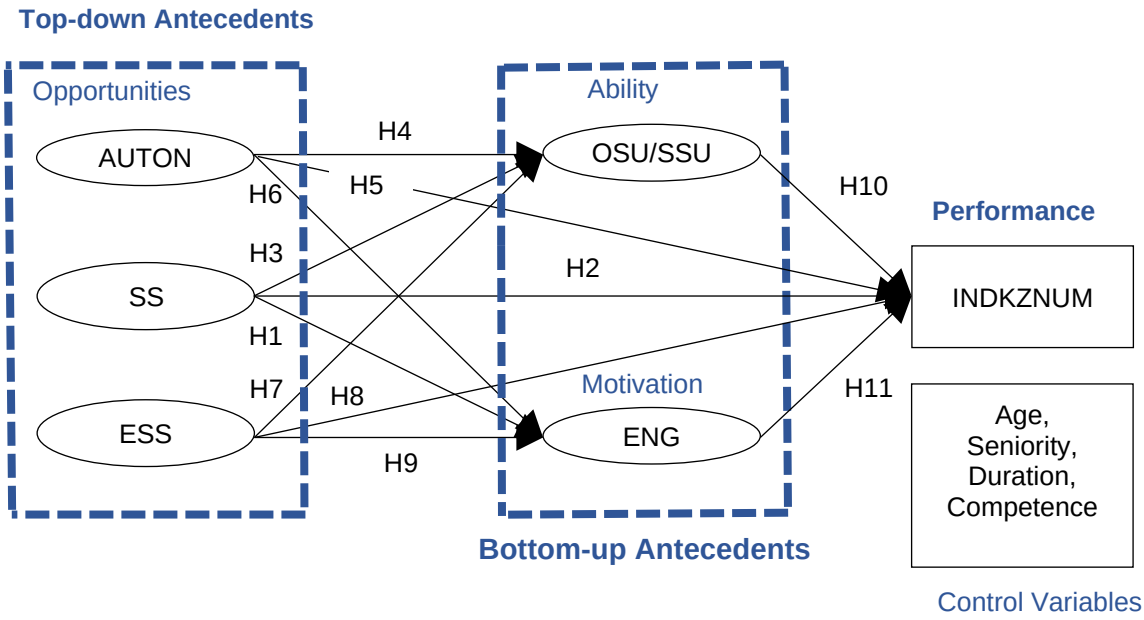
2. THE MODEL

A widely used theory to explain behavior or performance at the individual level is the MOA model. The basic idea of the model is that performance is a function of motivation, opportunity, and ability. That is, P = f (M, O, A) holds. The origins of the model go back to Vroom (1964: 197-199) who contented that performance is a function of ability and motivation. Later, Blumberg and Pringle (1982), arguing that existing theory does not provide a strong and consistent prediction of job performance, added "opportunity to perform" as a third dimension and replaced the other two dimensions with "capacity to perform" and "willingness to perform" which have a broader scope. According to the authors, capacity to perform refers to the "physiological and cognitive capabilities that enable an individual to perform a task effectively" and includes the effects of individual's knowledge, skills, intelligence, age, state of health, level of education, endurance, energy level, and similar variables. The second dimension, willingness to perform, consists of "psychological and emotional characteristics that influence the degree to which an individual is inclined to perform a task" and includes the effects of motivation, personality, attitudes, values, task characteristics, job involvement, perceived role expectations, need states, self-image, and related concepts. The proverb referred to by Purcell et al. (2003: 6) underscores the willingness aspect perfectly: "You can lead a horse to water but you can't make him drink". The third and newly added dimension, opportunity to perform, goes beyond the individual's immediate task environment and "consists of the particular configuration of the field of forces surrounding a person and his or her task that enables or constraints that person's task performance and that are beyond the person's direct control". Thus, to perform well, employees need resources such as information and technology, and their potential is limited by the level of support they receive from other key people, including colleagues and supervisors (Sterling and Boxall, 2013). Overall, performance is collectively shaped by the partial contributions of these three dimensions (Blumberg and Pringle, 1982).

The MOA framework has been used, inter alia, as a basis for explaining work performance and has been utilized in knowledge sharing in Operations Management (Siemsen et al., 2008). In our proposed research setting, the synthesis of "opportunities", which we measure through autonomy, supervisor support, and employee suggestion system, and "motivation", which we assess through employee engagement, along with "ability", which we evaluate through operations strategy understanding, culminates in behavior that supports the strategy in a bottom-up manner and that we quantify by the number of individual Kaizen contributions. In this regard, our conceptual framework looks as illustrated in Figure 3, with an overview in Table 1. Top-down antecedents are contextual, i.e., environmental, factors provided to employees by management, while bottom-up antecedents consist of personal antecedents brought by employees. In this sense, performance is the result of collaboration between both parties.

Table 1. Model content at a glance

Inputs	*Construct(s)*	*Data source*	*Data type*
Opportunity (O)	Supervisor Support	Employees	Primary
	Autonomy	Employees	Primary
	Employee Suggestion System	Employees	Primary
Motivation (M)	Employee Engagement	Employees	Primary
Ability (A)	Objective Operations Strategy Understanding	Team Leaders	Primary
	Subjective Operations Strategy Understanding	Employees	Primary
Output	*Metric*	*Data source*	*Data type*
Performance (P)	Individual Kaizen numbers	Archival records	Secondary
Control Variables	*Variables*	*Data source*	*Data type*
Variables	Age, Seniority, Duration, Competence	Archival records	Secondary



AUTON: Autonomy, ENG: Employee Engagement, ESS: Employee Suggestion System, INDKZNUM: Individual Number of Kaizens, SS: Supervisor Support, OSU: Objective Operations Strategy Understanding, SSU: Subjective Operations Strategy Understanding

Figure 3. Conceptual framework of hypotheses (Adapted from Scholz et al., 2021: 9-10)

3. LITERATURE REVIEW

The causal link between HR practices and performance outcomes is often referred to as the "black-box problem" because it is not actually known just how and why HR practices affect performance (Purcell et al., 2003: 3). A basic component of the HR–performance link is line management, or team leaders. Almost all HR policies and practices are implemented by and through team leaders, and there are differences in how they are implemented by those leaders (Purcell et al., 2003: 74). What Purcell et al. (2003: 75) refer to as "front-line leadership" – such team leader behaviors as sharing information with employees, responding to their suggestions, being fair, and addressing operations problems – makes the job and workplace both satisfying and motivating, which in turn leads to discretionary behavior and better performance (Purcell et al., 2003: 39-71). The importance of line managers is highlighted also in some other sources. Holbeche and Matthews (2012: 79) argue that employees' relationship with their supervisors determines how committed and willing they are to make discretionary effort, while immediate managers, who most workers view as their employers (Wong et al., 2010: 27), influence work life and play an important role in the level of engagement a worker has (Robinson et al., 2007: 19; Macey and Schneider, 2008). In addition, Maslach et al. (2001) contend that social support plays an important role in engagement and its absence is associated with burnout – with lack of support from the supervisor being particularly important. Using the Job Demands-Resources (JD-R) model and considering supervisor support as a job resource, Hakanen et al. (2006) find that job resources are positively related to engagement. Our first hypothesis is accordingly as follows.

Hypothesis 1 (H1): Supervisor support is positively correlated with employee engagement.

Supportive supervision – whereby leaders are responsive to employees' feelings and needs, provide informative feedback, promote skill development, and encourage employees to voice their concerns – is expected to increase creative achievement; in contrast, controlling or restrictive supervision is likely to reduce it (Oldham and Cummings, 1996). According to the componential theory of creativity (Amabile, 2012), creative responses require a social work environment characterized by (among other things) supervisors who encourage the development of ideas. In a similar vein, employees' ratings of supervisory encouragement are significantly linked to creativity (Amabile and Gryskiewicz, 1989). There is ample empirical evidence that better management enhances productivity. For example, Bloom et al. (2017) found that management practices used on the frontlines matter for productivity, and that every 10 % increase in a plant's management score calculated based on a particular set of practices – which they call "structured management" – was associated with a 14 % increase in the labor productivity. In a similar vein, a 1-point increase on a 5-point management score, equivalent of moving from the bottom third to the top third of the sample, corresponded to a 23 % increase in productivity (Bloom et al., 2012). Further evidence comes from Loch et al. (2003: 198) who showed that firms with management quality have higher production

improvement rates including unit cost. In their study of the effect of supervisors on worker productivity, Lazear et al. (2015) found that supervisor quality varies widely and that the effects of supervisors on worker output are large and significant. According to the authors, if a supervisor who is in the bottom 10 % of supervisor quality is replaced by a supervisor who is in the top 10 %, a team's performance increases by more than when a team of nine employees is expanded by one. Finally, management support was found to have a positive impact on innovative performance in a sample of Turkish firms (Alpkan et al., 2010). We are motivated to form our second hypothesis.

Hypothesis 2 (H2): Supervisor support is positively correlated with continuous improvement activities.

Not every generated idea is relevant to operations strategy. For employees to generate strategically relevant ideas, i.e., those that can at least be accepted as Kaizens, they need to know where to divert their efforts – especially mentally. This is where the line of sight comes into play. "Line of sight (LOS) is an employee's understanding of the organization's goals and what actions are necessary to contribute to those objectives. To translate strategic goals into tangible results, employees must not only understand the organization's strategy, but must also accurately appreciate the actions aligned with realizing that strategy" (Boswell et al., 2006). If employees do not understand the company's strategic goals, they may develop their own goals, which might lead them to work on objectives that are less important or even antithetical to the company's strategy (Boswell et al., 2006). A lack of commitment to the strategy by teams at the middle and lower levels is often why strategy implementation fails (Ateş et al., 2020). A prerequisite for employee commitment is a good understanding of the organization's goals and of individuals' responsibilities for achieving them (Kumar and Pansari, 2016) – a point Pietersen (2010: 157) highlights by referring to Nietzche's saying "People will do almost any *what* if you give them a good *why*". Therefore, organizations must create both an understanding of and a commitment to the strategy among those tasked with implementing it (Ateş, 2014: 52). It is the responsibility of especially middle- and low level managers to communicate and clarify the strategy to subordinates and interpret it as part of their daily operations (Ateş, 2014: 52). Boswell and Boudreau (2001) state that "supervisors play a crucial role in the communication of group, division, and organizational goals to their employees, as well as managing their performance toward those goals. Thus it would seem that supervisor-subordinate relations have an influence on developing line of sight". Studies confirm the importance of supervisory communication. If the organization fails to communicate the strategy to the employees, and if this communication is not received and accepted on their part, perception gaps occur, leading to poor execution (Cocks, 2010). Loch (2008) considers under-communication to be the most common weakness, noting that strategy cascading – dialogue on the business strategy and breaking it down into smaller sub-goals and sub-objectives – makes goals and objectives clearer and more meaningful to employees, which increases motivation and commitment. Finally, supervisory communication and training facilitate a better understanding of strategic principles (Parker et al.,1997). These considerations lead to the next hypotheses, as follow.

Hypothesis 3a (H3a): Supervisor support is positively correlated with objective strategy understanding.

Hypothesis 3b (H3b): Supervisor support is positively correlated with subjective strategy understanding.

In this study, we adopt Hackman and Oldham's (1975) definition of autonomy: "the degree to which the job provides substantial freedom, independence and discretion to the employee in scheduling the work and in determining the procedures to be used in carrying it out". Pfeffer (2018) contends that autonomy serves as a kind of learning mechanism: when people have freedom in the work they do, they can learn better when seeing the connection between their actions and the consequences. In this way, employees gain a degree of mastery over the work and thereby come to understand better what they must do in order to achieve desired results. With regard to the subjective dimension of strategy understanding, Biggs et al. (2014) show that the construct of job control – which includes autonomy – is highly correlated with perceived strategic alignment, which in our case corresponds to subjective strategy understanding. In addition, Scholz et al. (2021: 21) report a statistically significant effect of autonomy on perceived strategic alignment. In light of all these studies, we hypothesize as follows.

Hypothesis 4a (H4a): Autonomy is positively correlated with objective strategy understanding.

Hypothesis 4b (H4b): Autonomy is positively correlated with subjective strategy understanding.

Autonomy is a factor known to influence business outcomes. Unlike corporate strategy, operations strategy can be shaped more by operational, i.e., shop floor, staff than by managers (Wheelwright, 1984). It is formed through an iterative process that integrates competitive priorities, objectives, and action plans, some of which are brought about in top-down planning and some of which emerge bottom-up (Kim et al., 2014). According to Sting and Loch (2016), operations strategy involves multiple initiatives – related to both technology and process development – simultaneously and is inherently complex. Such complexity cannot be managed by a single person who understands all the decisions. Therefore, decisions and innovative

activities must be distributed among several actors in the organization, each of whom has only partial knowledge (Sting and Loch, 2016). Mintzberg and Van der Heyden (1999) view top management as a metaphor and argue that top management stands on top of nothing more than an organization chart. In their view, good management operates in a web, that is, an interconnected network of functions, and in a web anyone can be the management. This way of thinking is similar to the concepts of "X-teams" (Ancona and Bresman, 2007: 222), which argues that any specific leader is incomplete, and "Blue Ocean Leadership", which favors distributed and empowered leaders at all levels of the hierarchy (Kim and Mauborgne, 2014), as well as "emergent strategy", which is defined as realized strategies from lower levels that were never intended in the beginning (Mintzberg, 1978). In this sense, autonomy can be expected to contribute to improvement. A relation is observed between autonomy and employees' inclination to improve operations (Kim et al., 2014; Sting and Loch, 2016). And according to Amabile et al. (1996), people work more creatively when they are free to decide *how* to do their work. All this accounts for our next hypothesis.

Hypothesis 5 (H5): Autonomy is positively correlated with continuous improvement activities.

The Job Characteristics Model is a work design theory which posits that jobs can be redesigned to enhance employee motivation and productivity (Hackman and Oldham, 1975). It focuses on five core job dimensions: skill variety, task identity, task significance, feedback, and *autonomy*. These dimensions create the three psychological states, which in turn, influence personal and work outcomes, including internal motivation and satisfaction – which are closely related to engagement. Thus, autonomy makes work internally motivating.

In his seminal book entitled *Drive*, Pink (2009: 110-112) argues that "control leads to compliance; autonomy leads to engagement" and "Living a satisfying life requires more than simply meeting the demands of those in control. Yet in our offices and our classrooms we have way too much compliance and way too little engagement. The former might get you through the day, but only the latter will get you through the night". Gino (2016) reaches a very similar conclusion about the prevalence of compliance: only less than 10 percent of more than 1,000 employees she surveyed from a variety of industries reported working in companies that regularly encourage nonconformity – in addition to another survey's finding that nearly half of 2,000 employees working in a wide range of industries said they regularly feel they have to conform, while more than half of them said that people in their organizations do not question the status quo. According to her research, when employees express their authentic selves at work, i.e., when they are provided with autonomy, employee engagement increases. As a proponent of employee rebellion, she argues that leaders should allow and even encourage "constructive nonconformity" in their organizations – a term she defines as "behavior that deviates from organizational norms, others' actions, or common expectations, to the benefit of the organization".

The benefits of autonomy are also presented in some other sources. According to a study conducted by Chirkov et al. (2003), there is a correlation between autonomy and overall well-being in some countries, including Türkiye. Similarly, declining job satisfaction in the United Kingdom is reported to be mainly due to the lack of individual autonomy at work (Krueger, 2005), while Baard et al. (2004), who studied first-line employees at an investment bank, found that (i) employees whose supervisors provided "autonomy support" had greater job satisfaction and (ii) this higher job satisfaction translated into better job performance. Pfeffer (2018) states that low job control leads to job stress and anxiety, which are causes of burnout, which is the opposite of engagement (Schaufeli et al., 2002). Especially striking in Pfeffer's (2018) paper is the "MBA" style of management used by one company: "management by absence". Bakker et al. (2004) find that job resources, including autonomy, are *negatively* associated with *disengagement*, and Gallup (2020: 16) reports that employees are 43% less likely to suffer from high levels of burnout when they have job autonomy (although too much autonomy can also be a burnout risk by leading to excessive ambiguity). The cited findings give rise to the following hypothesis.

Hypothesis 6 (H6): Autonomy is positively correlated with employee engagement.

An organization's journey to full continuous improvement capability is a learning process (Bessant and Francis, 1999) consisting of six levels, with level 0 being "no continuous improvement activity" and level 5 being "the learning organization". Establishing a structured idea management system is a behavior for level 2 - "structured and systematic continuous improvement". The transition from level 2 to level 3, "strategic continuous improvement", is crucial (Bessant and Francis, 1999). In this regard, it can be argued that the employee suggestion system is an important practice on the way to becoming a learning organization.

A well-designed suggestion system is characterized by a variety of features, such as encouraging the submission of suggestions, a fair evaluation process, a quick response to submissions, and appropriate rewarding. An effective employee suggestion system helps align employees' goals with the organization's priorities (Fairbank and Williams, 2001). Feedback on employee suggestions serves as an opportunity for employees to identify and correct errors, thereby improving the quality of future ideas (Verdinejad et al.,

2010). In a similar vein, Bassford and Martin (1996: 6) claim that the employee suggestion system is a win–win–win–win situation for the parties involved: the company, employees, customers, and investors. One of the benefits is increased communication, since a formal employee suggestion system encourages employees to talk to their supervisors and colleagues about the tasks they perform and how they can improve on them – which should contribute to a better objective strategy understanding. Therefore, we hypothesize as follows.

Hypothesis 7a (H7a): An employee suggestion system is positively correlated with objective strategy understanding.

As mentioned above, setting up an employee suggestion system is a key practice for companies that aim to become a learning organization (Bessant and Francis, 1999). Bell (1997) mentions that "the real goal [of an employee suggestion system] is to generate as many ideas as possible, and, over time, to improve the quality of the suggestions through feedback and encouragement." Feedback helps "reduce the discrepancy between current and desired understanding" (Hattie and Timperley, 2007). Hence an employee suggestion system can be expected to increase subjective understanding of strategy. In addition, Scholz et al. (2021: 21) find a statistically significant relationship between structured idea management processes and perceived strategic alignment. Thus we posit the following variant.

Hypothesis 7b (H7b): An employee suggestion system is positively correlated with subjective strategy understanding.

An employee suggestion system is an effective tool for creating a lean culture, and its absence can result in management forgoing enormous improvement potential – as much as 80% (Robinson and Schroeder, 2009). Companies without such a system thus settle for a relatively small portion of their total improvement potential. Furthermore, companies that have implemented a suggestion scheme frequently find that suggestions markedly improve both the quality and quantity of production (Frese et al., 1999). Hence we formulate the next hypothesis.

Hypothesis 8 (H8): An employee suggestion system is positively correlated with continuous improvement activities.

The closeness of frontline employees to operational problems and their knowledge of operations give them an edge in providing the best possible solutions (Deming, 2000: 79-82; Tucker, 2007). To exploit workers' knowledge and to tap into their creativity, an infrastructure, such as an employee suggestion system, must be in place which makes it possible for employees to voice their ideas (Loch, 2008; Anand et al., 2009). An effective suggestion system signals management's interest in creative ideas and helps companies retain their most creative workers, who might otherwise leave the company or establish their own businesses (Fairbank and Williams, 2001). In terms of the JD-R model (Bakker and Demerouti, 2007), the suggestion system can be viewed as a job resource; and job resources enhance engagement. We accordingly propose the following.

Hypothesis 9 (H9): An employee suggestion system is positively correlated with employee engagement.

Shop floor workers cannot engage in bottom-up operations strategy formation without an understanding of that strategy (Loch, 2008). Huckman and Staats (2011) provide anecdotal evidence that workers who are not aware of the strategic goals of their work unit cannot contribute to those goals, while Gagnon et al. (2008) provide empirical evidence that strategically knowledgeable workers demonstrate strategic commitment and engage in strategically supportive behaviors. These considerations lead to our next hypothesis.

Hypothesis 10a (H10a): Objective strategy understanding is positively correlated with continuous improvement activities.

In their study on the alignment between students' perceived understanding of some technical biological terminology and their performance – defined as the ability to provide correct and complete definitions of the terms – Zukswert et al. (2019) find that students overestimated their understanding. Along the same lines, Caspi et al. (2006) cite studies (e.g., Gordon, 1991; Ward et al., 2002) that cast doubt on self-assessment as a good predictor of true competence. For instance, Khan et al. (2001) find a weak relationship between participants' self-assessed knowledge and their test scores. Young et al. (2002) likewise report that physicians' self-assessed understanding of seven terms used in evidence-based medicine was noticeably different from an objective assessment, with an 8% predictive value of a positive self-rating for one term but 0% for the remaining six terms. In light of these negative findings, we hypothesize as follows.

Hypothesis 10b (H10b): Subjective strategy understanding is *not* positively correlated with continuous improvement activities.

Schaufeli et al. (2006) find that engagement is positively associated with innovativeness. Bailey et al. (2015) observe that many studies examine the link between engagement and performance; overall, researchers conclude that there is a positive relationship between engagement and the outcomes of individual-level performance. Some example studies to mention, all conducted using the UWES-9 instrument, include Agarwal et al. (2012), who found a positive relationship between engagement and innovative work behavior, Bakker and Bal (2010), who demonstrated that engagement was positively related to weekly job performance, Gorgievski et al. (2010), who demonstrated that engagement was positively associated with task performance and the innovativeness level of employees, Bakker and Xanthopoulou (2013), who provided support for the positive association between engagement and creativity of principals as assessed by their teachers, and Shimazu et al. (2012), who demonstrated a positive relationship between engagement and changes in job performance (Bailey et al., 2015). Hence we offer our final hypothesis.

Hypothesis 11 (H11): Employee engagement is positively correlated with continuous improvement activities.

Boudreau et al. (2003) contend that Operations Management and Human Resources Management are closely related and cannot exist without each other at a fundamental level. They argue that better integration brings greater value and point to the value of connecting the two disciplines. Utilizing the Human Resources Management literature helps to expand knowledge in the field of Operations Management by shedding light on issues that tend to be treated as “black box” in Operations Management. Our research is an endeavor to illuminate this black box (Boudreau et al., 2003). In that regard, we responded to their call for further research by focusing on human resource-related determinants of operational performance, which we measured by the number of voluntary process improvements made by shop floor employees at an award-winning Turkish furniture manufacturer.

4. METHOD

4.1. Measures

We use a shortened version of the Utrecht Work Engagement Scale (UWES-9) to measure employee engagement. The Turkish version of that scale is publicly available on Schaufeli’s official website (wilmarschaufeli.nl). We measured autonomy using Spreitzer’s (1995) self-determination scale. To measure subjective operations strategy understanding, we used Biggs et al. (2014). To assess objective operations strategy understanding, we asked workers to write down three goals of their lines for 2019. To measure supervisor support, we followed Frese et al. (1999) and Madjar et al. (2002). Questions related to employee suggestion systems were adapted from Konecny and Thun (2011). Data on our model’s dependent variable (viz., the number of individual Kaizens due to employees from the beginning of the year until the survey date), as well as on the control variables (i.e., age, seniority, duration, and competence), were extracted from the plant’s archival records by the lean office director. All items were measured on a 7-point Likert-type scale, and none was reverse-coded.

4.2. Data

Workers and team leaders provided our primary data: the worker survey and team leader evaluations. The worker survey included workers’ self-assessments of how well they thought they understood the operations strategy – what we call *subjective* operations strategy understanding – as well as handwritten responses to the open-ended question of what three goals of their lines are. Based on the latter responses, we then asked the corresponding team leaders to anonymously rate the actual, or *objective*, operations strategy understanding of workers to whom those leaders had directly communicated the lines’ goals. So as not to violate the principle of anonymity, we removed all other data and showed the leaders only the goals that the workers had written. The secondary data we use were provided by the lean office director; he provided us with archival records of workers’ Kaizens and all other worker-related data on age, seniority, duration, and competence.

We used the so-called forward-backward translation method (Brislin, 1970) to translate – from English to Turkish – the scales of autonomy, employee suggestion system, supervisor support, subjective strategy understanding, and objective strategy understanding. No translation was needed for the engagement scale because we used the original Turkish translation provided by Schaufeli. The translated draft was then reviewed by the lean office director, who suggested a few small adjustments (reflecting the plant’s internal jargon) to help better convey the intended meaning. The survey’s final version was informed by a pre-test involving three workers. Following agreement on that version, the lean office made hard copies for distribution to the workforce. The three workers who participated in the pre-test were excluded from the survey.

The data were collected between August 3 and August 7, 2019. That time window was chosen mainly to avoid stopping production at the plant – though it also served as a prudent ex ante measure to mitigate

common method bias, as explained later. Thus, workers were given the survey questionnaire at the end of their shift on August 2 (Friday) and were asked to fill it out at home over the weekend. Some workers were unable to finish within that time frame, so the deadline was extended to August 7. The completed questionnaires were delivered by the workers themselves into a closed drop box placed (on August 5) in the middle of the shop floor by the lean office, which then returned all documents to the researchers via ground mail. Apart from this operational support (the distribution and collection of questionnaires), the lean office was not otherwise involved in the survey process. At the time of the survey, there were 453 workers on the payroll, 395 of whom participated in the study; thus 87% of the shop floor workforce was covered. Datapoints with deviant components (blank responses, two different responses for any given question) were eliminated. The result was 235 datapoints that could be used for analysis, and all 15 of the plant's lines were represented. At this stage, we took the additional step of examining the *distribution* of the average number of individual Kaizens across the lines. We found that three lines – machine maintenance, quality, and product development – were outliers (see Figure 4). The workers on these lines are arguably "specialists" and thus differ from ordinary frontline workers – whom we should prefer to survey – in the sense of performing some kind of expert work. We therefore considered these three to be "expert lines" and so the analysis excludes all the experts (15 workers in all) on those lines. In addition, we excluded the plant maintenance line because all three of its workers had, by design, *not* been given competency grades by the plant management. (The practice of not grading competencies applied also to the machine maintenance line, which we had already excluded.) These steps yielded a final set of 217 datapoints from 17 teams working on 11 different lines under the supervision of 17 team leaders. According to Boomsma (1983), a sample size of at least 200 datapoints is sufficient for analysis based on structural equation modelling.

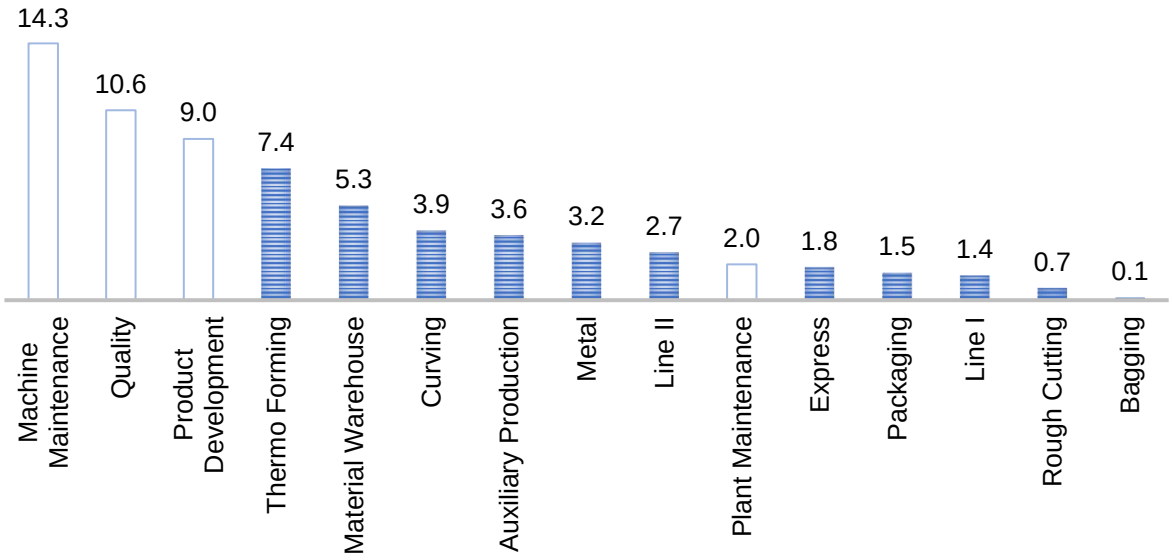


Figure 4. Average number of individual kaizens per employee across all lines

5. FINDINGS

5.1. Analysis

For the analysis, we used the *lavaan* package in R (Rosseel, 2012). We started by performing a confirmatory factor analysis (CFA). Since multivariate normality tests using the *MVN* package in R (Korkmaz et al., 2014) indicated multivariate *non*-normality in our data, which would violate the CFA's maximum likelihood assumptions, we applied the Satorra–Bentler (1994) correction. We then examined reliability and construct validity, both convergent and discriminant. Because we have two different models – one each involving subjective and objective strategy understanding, with all other variables remaining the same – we conducted two separate analyses for reliability and validity. One of the manifest variables of the engagement construct (namely, the last question in Schaufeli's UWES-9) had a factor loading below the 0.50 threshold, so we removed it from the construct. Our data meet all the requirements for reliability and construct validity for both models (see Tables 2-7).

Table 2. Questionnaire items

Item	*Std. factor loading (std.all)*
Supervisor Support (SS)	
My team leader discusses with me my work-related ideas in order to improve them	0.779
My team leader gives me useful feedback about my ideas concerning the workplace	0.848
My team leader encourages me to give suggestions	0.852
Giving suggestions is appreciated by my team leader	0.848
Employee Suggestion System (ESS)	
Management takes all product and process improvement suggestions seriously	0.787
We are encouraged to make suggestions for improving performance here at [company name]	0.765
The lean office tells us why our suggestions are implemented or not used	0.724
Many useful suggestions are implemented here at [company name]	0.772
Autonomy (AUTON)	
I have significant autonomy in determining how I do my job	0.837
I can decide on my own how to go about doing my work	0.815
I have considerable opportunity for independence and freedom in how I do my job	0.855
Employee Engagement (ENG)	
At my work, I feel bursting with energy	0.912
At my job, I feel strong and vigorous	0.929
I am enthusiastic about my job	0.857
My job inspires me	0.784
When I get up in the morning, I feel like going to work	0.732
I feel happy when I am working intensely	0.752
I am proud of the work that I do	0.642
I am immersed in my work	0.544
I get carried away when I am working	†
Subjective Strategy Understanding (SSU)	
I have a clear understanding of my line's goals	0.751
I am aware of how my day-to-day work aligns with my line's goals	0.820
I have a clear understanding of how my workgroup helps my line achieve its goals	0.707
It is important to me to help my line achieve its goals	0.767
Individual Kaizen Number (INDKZNUM) – numerical data from archival records	*1.000*

Note: Item marked by a dagger (†) was dropped after the initial CFA and reliability tests.

Table 3. Convergent and discriminant validity after (before) trimming: Subjective strategy understanding

	Alpha [0.7]	*CR [0.7]*	*AVE [0.5]*	*SS*	*ESS*	*AUTON*	*ENG*	*SSU*	*INDKZNUM*
SS	0.90 (0.90)	0.90 (0.90)	0.69 (0.69)	1.00					
ESS	0.84 (0.84)	0.84 (0.84)	0.58 (0.58)	0.28 (0.28)	1.00				
AUTON	0.87 (0.87)	0.87 (0.87)	0.70 (0.70)	0.20 (0.20)	0.18 (0.18)	1.00			
ENG	0.92 (0.91)	0.92 (0.91)	0.62 (0.54)	0.21 (0.21)	0.29 (0.29)	0.18 (0.18)	1.00		
SSU	0.83 (0.83)	0.84 (0.84)	0.57 (0.57)	0.36 (0.36)	0.26 (0.26)	0.10 (0.10)	0.37 (0.38)	1.00	
INDKZNUM				0.02 (0.02)	0.00 (0.00)	0.00 (0.00)	0.03 (0.03)	0.01 (0.01)	1.00

Notes: Minimum thresholds suggested by Hair et al. (2014: 619) in brackets. Off-diagonal values represent square correlations between constructs. Values in parentheses are those *before* trimming.

Table 4. HTMT ratios for model with subjective strategy understanding after (before) trimming

	SS	*ESS*	*AUTON*	*ENG*	*SSU*	*INDKZNUM*
SS	1.00					
ESS	0.53 (0.53)	1.00				
AUTON	0.45 (0.45)	0.42 (0.41)	1.00			
ENG	0.47 (0.46)	0.54 (0.53)	0.44 (0.44)	1.00		
SSU	0.60 (0.60)	0.52 (0.52)	0.33 (0.33)	0.67 (0.67)	1.00	
INDKZNUM	—	—	—	—	—	—

Note: Values in parentheses are those before trimming

Table 5. Questionnaire items (Subjective strategy understanding replaced with objective strategy understanding)

Item	*Std. factor loading (std.all)*
Supervisor Support (SS)	
My team leader discusses with me my work-related ideas in order to improve them.	0.788
My team leader gives me useful feedback about my ideas concerning the workplace.	0.853
My team leader encourages me to give suggestions.	0.847
Giving suggestions is appreciated by my team leader.	0.842
Employee Suggestion System (ESS)	
Management takes all product and process improvement suggestions seriously.	0.789
We are encouraged to make suggestions for improving performance here at [company name].	0.765
The lean office tells us why our suggestions are implemented or not used.	0.724
Many useful suggestions are implemented here at [company name].	0.770
Autonomy (AUTON)	
I have significant autonomy in determining how I do my job.	0.837
I can decide on my own how to go about doing my work.	0.817
I have considerable opportunity for independence and freedom in how I do my job.	0.854
Employee Engagement (ENG)	
At my work, I feel bursting with energy.	0.920
At my job, I feel strong and vigorous.	0.936
I am enthusiastic about my job.	0.850
My job inspires me.	0.778
When I get up in the morning, I feel like going to work.	0.726
I feel happy when I am working intensely.	0.749
I am proud of the work that I do.	0.632
I am immersed in my work.	0.534
I get carried away when I am working.	†
Objective Strategy Understanding – assessed by team leaders as a single-item scale	
Please write down three goals of your line/department for 2019.	1.000
Individual Kaizen Number (INDKZNUM) – numerical data from archival records	*1.000*

Note: Item marked by a dagger (†) was dropped after the initial CFA and reliability tests.

Table 6. Convergent and discriminant validity after (before) trimming: Objective strategy understanding

	Alpha [0.7]	*CR [0.7]*	*AVE [0.5]*	*SS*	*ESS*	*AUTON*	*ENG*	*OSU*	*INDKZ NUM*
SS	0.90	0.90	0.69	1.00					
	(0.90)	(0.90)	(0.69)						
ESS	0.84	0.84	0.58	0.28	1.00				
	(0.84)	(0.84)	(0.58)	(0.28)					
AUTON	0.87	0.87	0.70	0.20	0.18	1.00			
	(0.87)	(0.87)	(0.70)	(0.20)	(0.18)				
ENG	0.92	0.92	0.61	0.21	0.29	0.18	1.00		
	(0.91)	(0.91)	(0.54)	(0.21)	(0.29)	(0.18)			
OSU				0.01	0.00	0.00	0.03	1.00	
				(0.01)	(0.00)	(0.00)	(0.03)		
INDKZNUM				0.02	0.00	0.00	0.03	0.03	1.00
				(0.02)	(0.00)	(0.00)	(0.03)	(0.03)	

Notes: Minimum thresholds suggested by Hair et al. (2014: 619) in brackets. Off-diagonal values represent square correlations between constructs. Values in parentheses are those before trimming.

Table 7. HTMT ratios for model with objective strategy understanding after (before) trimming

	SS	*ESS*	*AUTON*	*ENG*	*OSU*	*INDKZNUM*
SS	1.00					
ESS	0.53	1.00				
	(0.53)					
AUTON	0.45	0.42	1.00			
	(0.45)	(0.42)				
ENG	0.47	0.54	0.44	1.00		
	(0.46)	(0.53)	(0.44)			
OSU	—	—	—	—	—	—
INDKZNUM	—	—	—	—	—	—

Notes: Values in parentheses are those before trimming.

How well the specified model reproduces the observed covariance matrix is assessed by model fit. The model need not exhibit an acceptable fit in terms of all reported criteria; yet it should, of course, satisfy many criteria. We calculated the initial CFA indices for both models, which were acceptably good at the global level (Table 8).

Table 8. Goodness-of-fit statistics for both models

	χ^2/df	*Robust RMSEA*	*Robust CFI*	*Robust TLI*	*SRMR*
Model with *objective* strategy understanding	1.87	0.071 [0.059–0.083]	0.928	0.914	0.051
Model with *subjective* strategy understanding	1.90	0.076 [0.065–0.087]	0.908	0.893	0.058

Notes: χ^2/df is the ratio of the chi-square statistic to degrees of freedom (i.e., the normed chi-square). A normed chi-square value of no more than 2 indicates a good fit; a value greater than 2 but of no more than 3 indicates an acceptable fit (Schermelleh-Engel et al., 2003).

An RMSEA value of between 0.05 and 0.08 (inclusive) indicates a reasonable fit. "One would not want to employ a model with a RMSEA greater than 0.10" (Browne and Cudeck, 1993). The associated 90% confidence intervals are given in brackets. CFI values above 0.90 are usually associated with a model that fits well (Hair et al., 2014: 580). A TLI value greater than 0.90 is acceptable (Morhart et al., 2009). A SRMR value of 0.08 or less indicates an acceptable fit (Hu and Bentler, 1999).

5.2. Common Method Bias (CMB)

Next we analyzed common method bias. In a pro-active effort to prevent CMB ex ante, we took several measures.

(i) Pre-testing the survey to improve its items, as explained previously.
(ii) Informing workers about the study's purpose (viz., to improve the plant's competitiveness through their support), which encourages self-disclosure.
(iii) Asking workers to take their time and to answer honestly.

(iv) Informing respondents that there are neither "right" nor "wrong" answers; also, asking them to leave no question unanswered and to give only one response to each question.
(v) Conducting the survey anonymously, which should mitigate bias due to social desirability; giving assurance that individual responses will be used only for research purposes and will be seen only by us as independent researchers.
(vi) Using different sources for independent and dependent variables, which should mitigate self-reporting bias.
(vii) Avoiding both reverse-coded items (which have been shown to induce method bias) and "double-barreled" items.
(viii) Providing a survey window that allows for a different context (here, the respondent's home environment) and breaks, which should mitigate location-related effects.
(ix) Not measuring the dependent and independent variables simultaneously: the dependent variable comprises the cumulative sum of continuous improvement activities from the beginning of 2019 to the survey date, whereas the independent variables reflect workers' current states of mind and perceptions as of the survey date. This approach should mitigate the measuring context's time-related effects.

Note also that we refrained from conducting the survey online because the lean office director advised us that workers were accustomed to the offline format and so most of them would have difficulty completing a survey online. All the measures that we adopted should have served to reduce the possibility of common method bias. In particular, collecting measures of different constructs from different sources is recommended as the best strategy to avoid or mitigate CMB (Chang et al., 2010) – a strategy that our design followed. We evaluated common method bias using Harman's single-factor test. The largest components accounted for only 39.3% and 38.5% of the variance in the models with (respectively) subjective and objective strategy understanding. Since these values are acceptably low, we conclude that our pro-active measures were largely effective and therefore view our analyses as *not* being compromised by common method bias.

5.3. Structural Equation Model (SEM)

For the SEM analysis described here, we used the *lavaan* package in R (Rosseel, 2012). First we performed a square-root transformation of the outcome variable in order to reduce non-equal variance of residuals (i.e., heteroscedasticity). This transformed outcome variable was then used as the base outcome for our main analysis.

5.3.1. SEM Results with Objective Strategy Understanding

Initial CFA fit indices were reasonably good at the global level with chi-square/df = 1.87, robust CFI = 0.928, robust TLI = 0.914, robust RMSEA = 0.071, and SRMR = 0.051 (where CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean square error of approximation, and SRMR = standardized root mean residual). Both robust CFI and robust TLI are above 0.90. All manifest items have a factor loading of at least 0.5 (cf. Hair et al., 2014: 632), and all constructs possess construct validity. Overall, 7 of the 11 hypotheses are significantly and positively supported (as indicated by the bold arrows in Figure 5). Our analysis confirms the existence of three principal drivers of continuous improvement performance: objective strategy understanding, employee engagement, and supervisor support.

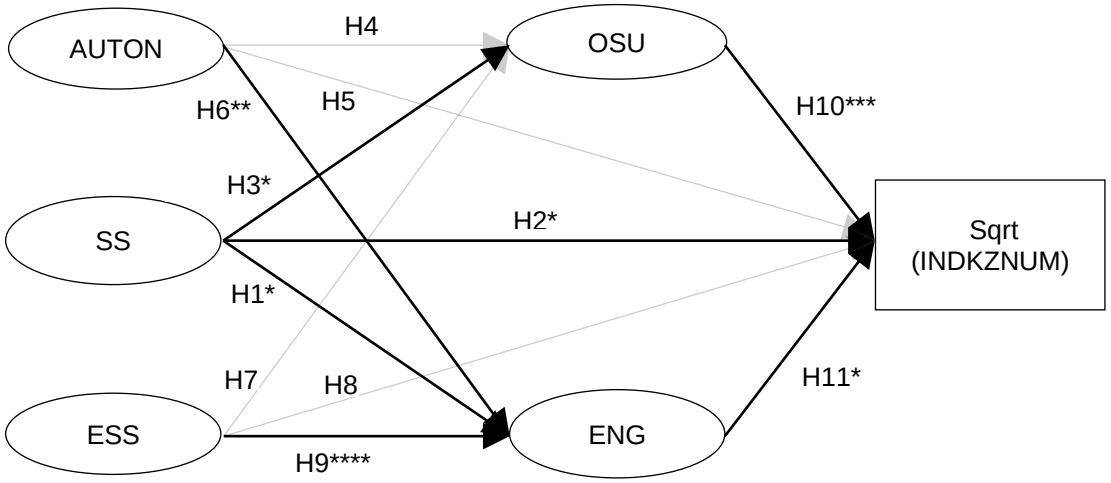


Figure 5. SEM framework for Objective Strategy Understanding with Square-Root-Transformed outcome variable (*p < 0.1, **p < 0.05, ***p < 0.01, ****p < 0.001)

5.3.2. SEM Results with Subjective Strategy Understanding

To discover what role, if any, is played by perceived rather than actual strategy understanding, we replaced objective strategy understanding with its subjective counterpart. The initial CFA fit indices were reasonably good at the global level: chi-square/df = 1.90, robust CFI = 0.908, robust TLI = 0.893, robust RMSEA = 0.076, and SRMR = 0.058. All manifest items have a factor loading of at least 0.5, and all constructs possess construct validity. In total, 7 of the 11 hypotheses are significantly and positively supported (the bold arrows in Figure 6). This confirms that subjective strategy understanding is *not* a contributor to continuous improvement performance.

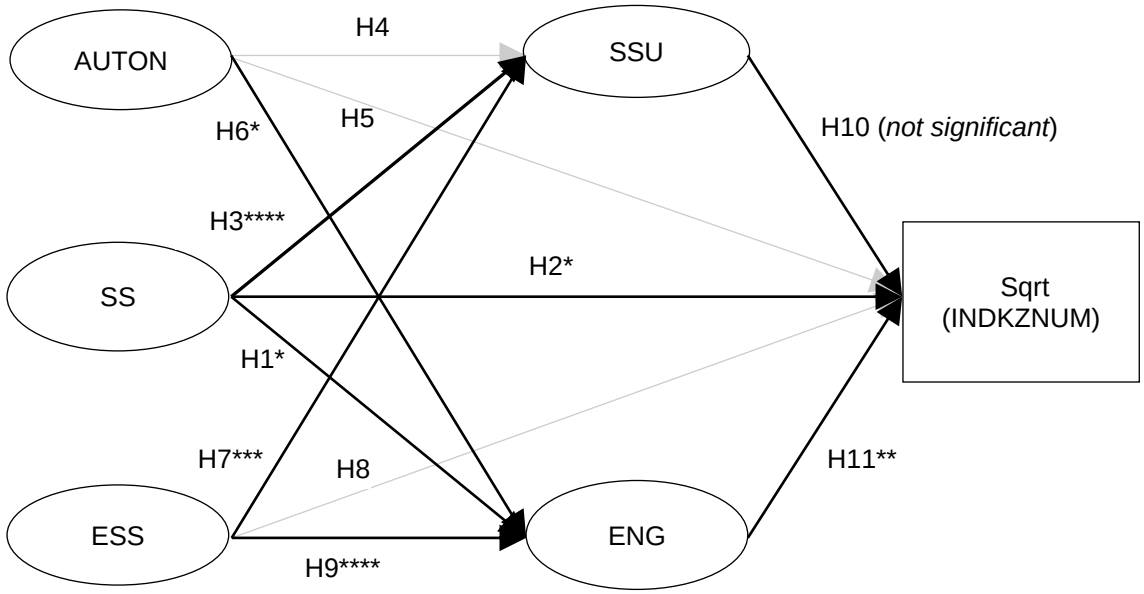


Figure 6. SEM framework for Subjective Strategy Understanding with Square-Root–Transformed outcome variable

5.4. Robustness Check

We analyze the robustness of our SEM results by way of multiple regression. In this context, we regressed the outcome variable (individual Kaizen performance of frontline employees) on the main constructs of interest including strategy understanding. For the analysis, we used the *lm()* function in R.

To maximize the exclusion of confounding effects in our analysis, we used fixed effects and control variables. Face-to-face interviews that we conducted with workers on the shop floor revealed that some lines systematically offer many opportunities for Kaizen while others offer few or none at all; we therefore decided to treat lines (i.e., work stations) as fixed effects. For this purpose, we asked the lean manager to group the shop floor's 15 lines according to their systemic advantageousness for promoting individual Kaizens. The result was four distinct clusters: unfavorable, neutral, favorable, and very favorable (see Figure 7).

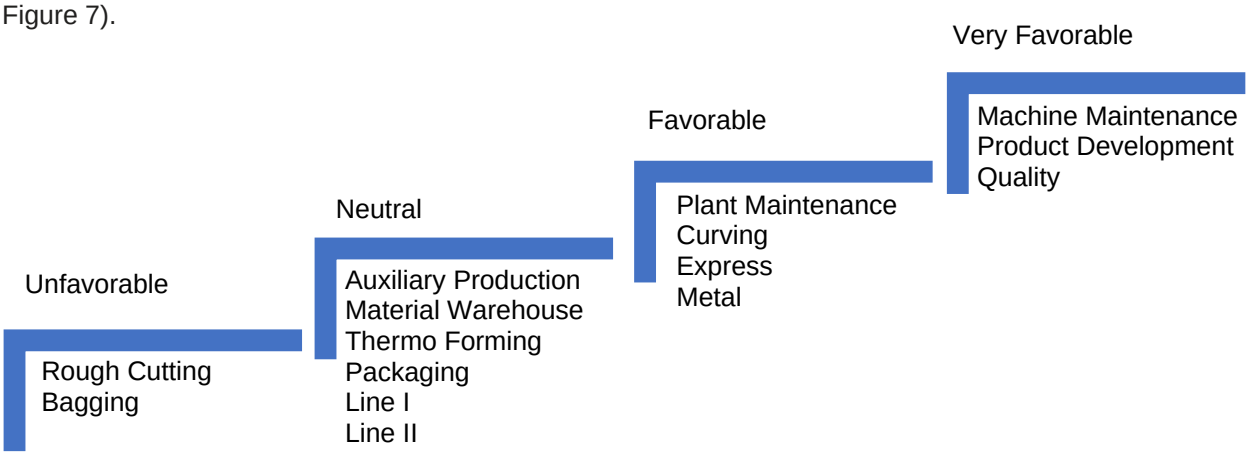


Figure 7. Systemic favorability of production lines for continuous improvement

The interpretation of this clustering is that a line classified as favorable (e.g., the metal line) is systemically more advantageous and thus offers employees more opportunities for process innovation than does a neutral or unfavorable line (e.g., resp., thermo forming or rough cutting). As explained in Section 4.2, the three "expert lines" (all classified as very favorable) as well as the plant maintenance line (which is classified as favorable) are not included in this study. This leaves three categories – unfavorable, neutral, and favorable – that enter the regression equation as fixed effects. In short, our data set includes 217 workers working on 11 lines in three different advantageousness categories.

Our regression analysis augments the SEM analysis in the sense that we could include line fixed effects and control variables. The chief motivation is to understand what role our constructs – in particular, operations strategy understanding – play in incremental innovation (i.e., continuous improvement activities). To deepen our knowledge, we expanded the study by including both objective and subjective types of strategy understanding. The independent variables in our model are SSAVER, ESSAVER, AUTONAVER, ENGAVER, SSUAVER, and OSU, which are (respectively): the arithmetic mean of workers' responses in the survey for supervisor support, employee suggestion system, autonomy, engagement, subjective strategy understanding, and a worker's operations strategy understanding as objectively assessed by the team leader. Our regressions also include line fixed effects and control variables. We take "unfavorable" as the reference category for fixed effects, and for control variables we use age, seniority, duration, and competence. Age refers to the age of workers, seniority indicates how long a worker has been at the plant, and duration is the period of time that workers have been supervised by their current team leaders. The plant's competence matrix informs our competence variable, which captures how capable a worker is of performing line-related tasks. Our statistical results follow.

5.4.1. The Results of Multiple Regression

The regression analysis identified four factors that were most predictive of an employee's number of individual Kaizens: the three independent variables supervisor support (coefficient: 0.12, $p < 0.1$), employee engagement (coefficient: 0.20, $p < 0.05$), and objective strategy understanding (coefficient: 0.08, $p < 0.1$) along with line fixed effects (coefficient for neutral: 0.75, coefficient for favorable: 0.86; both $p < 0.01$). None of the control variables was statistically significant. The R-square of the model was 0.127, and the p-value was 0.005. Next, for the sake of comparability with our SEM analysis, both the line fixed effects and the control variables were excluded from the regression equation. In this case, Kaizen performance was shown to be driven by the same three independent variables: supervisor support (coefficient: 0.12, $p < 0.1$), employee engagement (coefficient: 0.16, $p < 0.1$), and objective strategy understanding (coefficient: 0.11, $p < 0.05$). Here the model's R-square was 0.075 and the p-value was 0.01 (see Table 9).

Table 9. Multiple regression results

	Supervisor Support		*Employee Engagement*		*Objective SU*		*Line Neutral*		*Line Favorable*	
	Est.	*p-value*	*Est.*	*p-value*	*Est.*	*p-value*	*Est.*	*p-value*	*Est.*	*p-value*
Included	0.12	0.09*	0.20	0.03**	0.08	0.07*	0.75	0.007***	0.86	0.005***
Excluded	0.12	0.07*	0.16	0.08*	0.11	0.05**	excluded from analysis			

Notes: The dependent variable is the square root of the number of individual Kaizens. Only significant variables are shown. SU = Strategy Understanding. "Included" (resp., "Excluded") means that line fixed effects and control variables are both included in (resp., excluded from) the regression equations. *p < 0.1, **p < 0.05, ***p < 0.01,****p < 0.001

Both findings – with and without line fixed effects and control variables – are consistent with our original SEM analysis, whereby Kaizen performance was found to be driven mostly by supervisor support, employee engagement, and objective strategy understanding.

6. WORKER UNDERSTANDING of OPERATIONS STRATEGY

The focus of our research is worker operations strategy understanding, and we were able to assess both subjective and objective understanding at the individual level. As showed by the SEM and subsequent regression analyses, objective (resp., subjective) understanding does (resp., does not) appear to have a significant effect on continuous improvement.

Recall that, at the individual level, a gap in understanding is likely at any company; Figure 8 shows the gap at the plant. We use the collected data to conclude that two losses (Loss 1 and Loss 2) could reduce the effectiveness of strategy deployment in the plant (Figure 9).

If we treat our Likert scale as an interval type and compare the summated subjective understanding score to the objective understanding score, then one could argue that the output is only about 35% of the input. In other words: frontline employees appear to have internalized, on average, barely more than a third of the knowledge that management expects of them. It follows that these workers lack nearly *two thirds* of the "raw material" needed to generate Kaizens. Considering that the plant has already won awards for

productivity, these results underscore just how great is the potential of hidden productivity in the country's industries.

So far we have shown (i) that it is the objective understanding of operations strategy that matters for productivity in operations and (ii) that workers have an inflated view of their understanding. The latter finding supports Dunning et al.'s (2004) assertion that faulty self-assessments are widespread and that people tend to overestimate their abilities; it also echoes the previously cited work of Zukswert et al. (2019), who finds that students generally overestimate their understanding of specialized terminology. A similar study is that of Bloom et al. (2012), who report that 79% of more than 8,000 firms in 20 countries self-assessed their management practices as above average – which, of course, is mathematically impossible. Bloom and colleagues found no correlation between these self-assessments and their own objective evaluations.

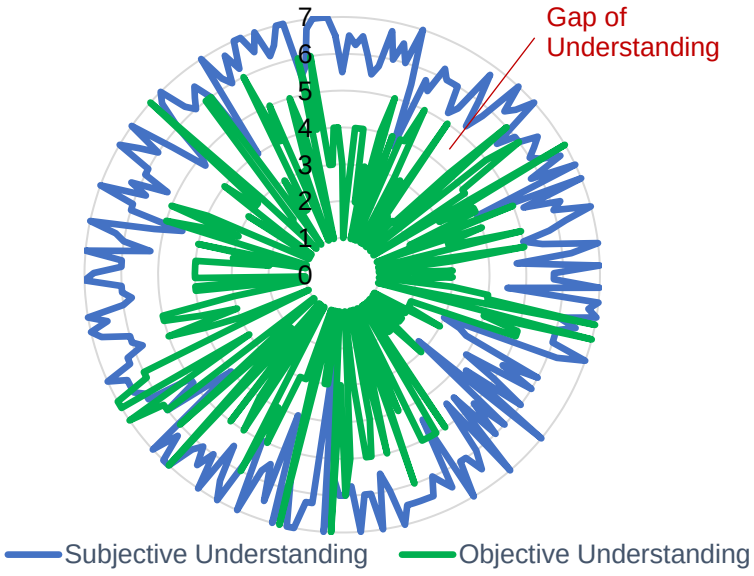


Figure 8. Workers' Operations Strategy Understanding (n =217, assessed on a Likert scale of 7)

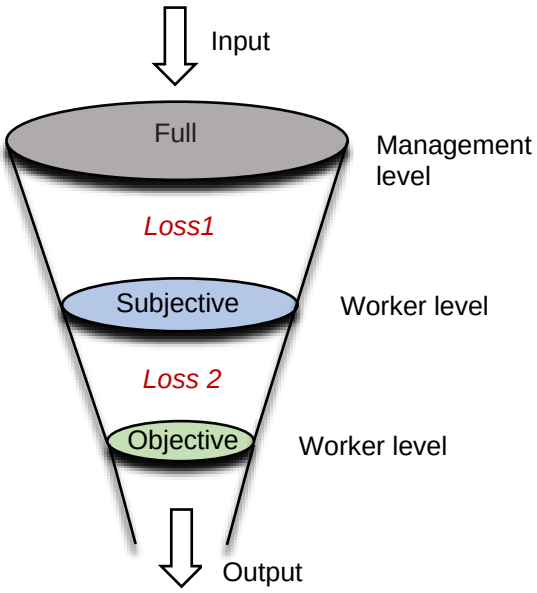


Figure 9. Erosion of operations strategy understanding

The output of a cascading process largely relates to what portion of employees' strategy knowledge is relevant for continuous improvement. It is probably fair to say that all available knowledge beyond the core strategy knowledge is of little use to Kaizens. Although output can indicate the plantwide effectiveness of strategy cascading, its shortcoming is that output says nothing about the *distribution* of understanding in the workforce. So even when the output from two different teams or business units is the same, the respective workforce's distribution across different clusters of operations strategy understanding may be quite different. Hence we cannot rely on output alone when waging the "battle for strategy understanding". Output can measure the intensity of understanding and can suggest how deeply strategy knowledge is embedded in the average employee's mind, but it offers no clue as to how widespread such knowledge is in the minds of the workforce. Figure 10 plots the range of strategy understanding at the plant of this study and also the distribution of understanding among its workers. For subjective understanding (SU), we took the arithmetic average of all four questions that informed our construct of subjective strategy understanding. If s ≤ SU < s+1, then subjective understanding was considered to be s ($1 \leq s \leq 7$).

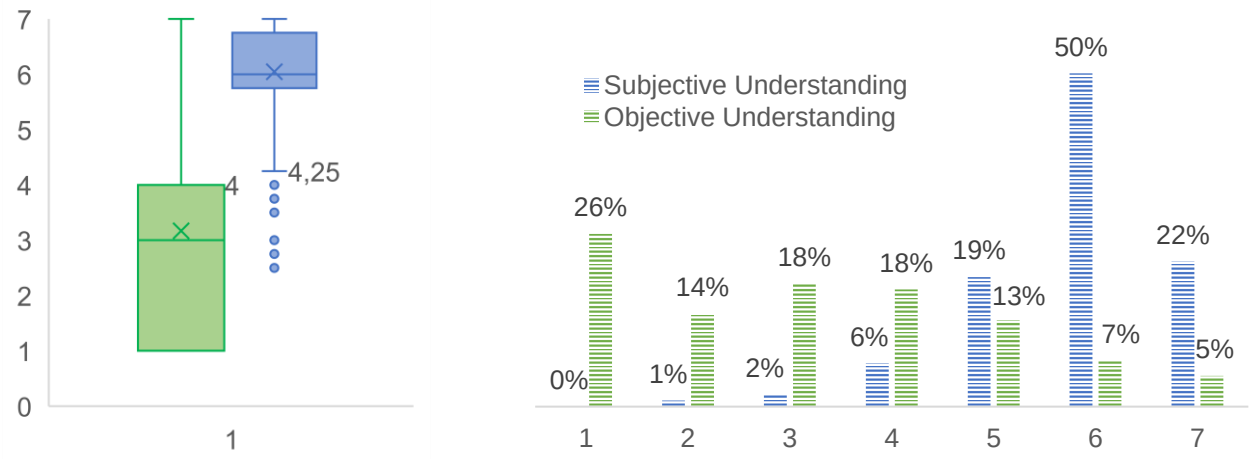


Figure 10. Range and distribution of understanding

As can be seen from both graphs in this figure, there is a discrepancy between the distribution of employees' self-assessments (blue) and that of the team leaders (green): the former is strongly left-skewed while the latter is moderately right-skewed. More precisely, even the upper quartile value of objective assessments (4) is *less* than the minimum subjective assessments (4.25, excluding outliers). This discrepancy corresponds to Loss 2, or the gap between what one thinks one knows and what one actually knows. The *knowledge gap* consists of this loss together with Loss 1, or the gap between complete knowledge and the knowledge one thinks one has acquired. The presence of these gaps suggests that the plant suffers from a human-related productivity loss, possibly due to poor communication. Therefore, objective understanding – and thus manufacturing productivity – can still be improved. So that operations managers will have additional weapons in this battle, we developed two metrics for them to consider (Table 10).

Table 10. Mathematics of operations strategy understanding

Metric	Formula	Value	Definition
Prevalence of Objective Strategy Understanding (POSU)	Equation 1	24%	The ratio of the workforce that has an adequate level of objective strategy understanding (the "core group") to the total workforce
Accuracy of Strategy Cascading (ASC)	Equation 2	27%	The ratio of employees in the clusters that "know themselves" to the total workforce

Notes: Cluster A, Best in Class (n=53 datapoints); Cluster B, Misinformed (n=0); Cluster C, Self-Aware (n=6); Cluster D, Misguided (n=115). The difference between Σ = 217 and the clusters' total corresponds to the sum of OSU = 4 (n=38) and SSU = 4 (n=5). The ASC would include datapoints for which OSU = SSU = 4, except that our data set contains no such datapoint.

$$\frac{(A+B)}{\Sigma} \quad (1)$$

$$\frac{(A+C)}{\Sigma} \quad (2)$$

The first metric, the *prevalence of objective strategy understanding* (POSU), is defined as the percentage of employees who can (irrespective of their self-assessment) adequately explain the operations strategy. At the plant, this core group amounts to 24% of the workforce. Kaplan and Norton (2005) claim that, on average, 95% of a company's employees are unaware of (or do not understand) its strategy; by that standard, the plant of this study is a model case. The second metric we propose concerns the accuracy of strategy cascading, where by "accuracy" we mean consistency between perceived and actual knowledge at the individual level. These cases are captured in Figure 2's "self-aware" and "best in class" clusters (i.e., those populated by knowledgeably self-aware individuals). The value for the plant on this metric is 27%, which means that almost three of every four employees in this study – with the "misguided" cluster being by far the most represented – exhibit knowledge asymmetry with regard to strategy: they think they know either more than or less than they actually do.

7. CONCLUSION and DISCUSSION

The aim of this study was to improve our understanding of the antecedents of bottom-up operations strategy formation – namely, of continuous improvement activities in manufacturing and with particular consideration given to operations strategy understanding. Drawing on the well-known MOA framework, we used both structural equation modeling and multiple regression to gain insights.

7.1. Implications for Research

This study contributes to the literature in a number of ways. First, we adopt Blumberg and Pringle's (1982) MOA framework to treat autonomy, supervisor support, and an employee suggestion system as opportunities that are provided top-down (i.e., by management). Both the SEM and multiple regression results indicated that all three factors contributed to the formation of a bottom-up operations strategy. To be precise, supervisor support makes both a direct and an indirect contribution to employee performance, and the other two have an indirect influence on it. This result contrasts with the findings of some other studies. For example, Scholz et al. (2021: 21) found a direct positive relationship between an "opportunity", namely structured idea management processes in their case, which respectively correspond to employee suggestion system in our setting, and behavior supporting strategy formation which is their measure of performance as a counterpart to our measure of continuous improvement ideas, i.e., kaizens. We also found that "ability", i.e., objective strategy understanding, is positively correlated with performance, i.e., kaizens. However, as contrary to us, Knies and Leisink (2014) found a negative effect of employees' "ability" on performance, i.e., extra-role behavior. In this regard, our results should be interpreted with caution. On the other hand, it is also noteworthy to mention that, in terms of the interrelationships between MOA variables, Knies and Leisink (2014) came to the same conclusion as we did, in the sense that individual employee characteristics (i.e., ability and motivation) have a direct effect on performance, while job characteristics (i.e., autonomy) have an indirect effect on it through motivation.

Second, we documented a discrepancy between objective and subjective strategy understanding at the employee level. In particular, employees overestimate their knowledge of strategy; this finding is in accordance with claims from previous work (Bjork, 1999) that people frequently mis-assess their own competencies. Third, we showed that objective strategy understanding is positively associated with continuous improvement activities, although the same cannot be said for subjective strategy understanding. Thus objective but not subjective strategy understanding seems to be decisive for efficiency gains. Here we refer back to Scholz et al. (2021: 21), who have not had objective strategy understanding in their model but, in contrast to us, reported a significant positive link between perceived strategy alignment, i.e., subjective strategy understanding, and behavior supporting strategy formation, i.e., kaizen performance. Fourth, as regards to the main antecedent of strategy understanding, supervisor support turned out to be the major driver of both objective and subjective strategy understanding. A suggestion scheme does not help employees understand strategy, but it does make them believe that they do. There are grounds for arguing that autonomy does nothing to help employees understand strategy, either objectively or subjectively. Overall, the most reliable – indeed, the only – mechanism for ensuring strategy understanding is support from the supervisor.

This paper's fifth contribution is to show that employee engagement is affected by all three of our model's exogenous constructs: supervisor support, employee suggestion system, and autonomy. The standard coefficients indicate that, regardless of whether subjective or objective strategy understanding is being considered, employee engagement is clearly most affected by employee suggestion system; supervisor support is not as influential, and autonomy is even less so. However, as a relatively contrasting example, in their research based on MOA model Beltrán-Martin and Bou-Llusar (2018) found that motivation is not only driven by opportunities but also abilities. Referring to social exchange perspective (Blau, 1964: 91), the authors note that employees may view the opportunities they are given as a signal from management that it cares about them, and therefore may feel compelled to reciprocate by making greater efforts, i.e.,

higher engagement. This argument could also apply to this study. Incidentally, engagement is the only construct in this study with which autonomy is significantly associated.

Sixth, we established that – regardless of the estimators used and the method of analysis – no statistically significant relationship exists between autonomy and strategy understanding (either subjective or objective) or between autonomy and incremental innovation (i.e., H4 and H5 were not supported). Surprisingly, autonomy proved beneficial only for employee engagement and contributed neither to strategy understanding nor to Kaizen performance. This contrasts with Scholz et al. (2021: 21) who found a significantly positive relationship between autonomy and perceived strategic alignment which corresponds to the subjective strategy understanding in our setting. In our opinion, this unexpected result might be related to Turkish culture. Aycan et al. (2014: 49) point out that it is questionable whether the job characteristics of the Job Characteristic Model (Hackman and Oldham, 1975) are effective in increasing motivation and satisfaction to the same extent in *all* cultural contexts. So, contrary to the original theory, "enhanced" jobs did not yield the same positive effects on motivation and business outcomes across cultures (Aycan et al., 2014: 49). Our results exemplify the business outcome aspect of that claim. The authors argue that managers in fatalistic cultures refrain from providing enriched jobs, e.g., with autonomy, as they assume that the nature of employees is constant and cannot be changed. Managers in collectivistic cultures, on the other hand, use job enrichment because they view it as their obligation to employees (Aycan et al., 2014: 49). According to INSEAD (2021: 263), the survey question "In your country, to what extent does senior management delegate authority to subordinates?" was answered with an average response of 4.37 [1 = not at all; 7 = to a great extent] in Türkiye, ranking 65th out of 134 countries (Denmark ranked 1st with 6.02, Chad ranked 134th with 2.81). In addition, Robert et al. (2000) found that culture moderates the relationship between autonomy and job satisfaction – something very similar to engagement. In a study of the relationship between societal culture dimensions and HRM practices, the strongest association was found in the function of "internal communication" (Papalexandris and Panayotopoulou, 2004) – which is necessarily a prerequisite for objective strategy understanding, which in turn is at the core of incremental innovation – as we have shown in this study.

Finally, our regression model results reveal that the lines themselves also matter. All else equal, an employee working on a favorable line (i.e., one conducive to innovation) can be expected to generate more Kaizens than an employee working on a neutral or unfavorable line. Hence we conclude that stations at which processes are relatively sophisticated and fluid (as in the case, e.g., of new furniture design) offer more opportunities for improvement than those with straightforward processes – such as simply putting nuts and bolts into a plastic bag, which is the primary task on the bagging line.

7.2. Implications for Managers

The research presented here suggests that leaders who seek a workforce that generates Kaizens should focus on seven core areas. First, employees cannot deliver Kaizens without an objective strategy understanding; subjective understandings are insufficient. We have shown that employees overestimate their level of understanding, which inevitably leads to an understanding gap. This gap is a hidden enemy of the firm's bottom line, and we believe that it should be considered a distinct form of "*waste*" in Lean Management. At best, it leaves some potential for improvement untapped; at worst, it hinders overall execution because employees may be rowing the boat in different (perhaps even opposite) directions. Hence management should address the causes of any understanding gap and strive to minimize it, which means that objective understanding must be as high as possible. Our findings suggest that neither job autonomy nor employee suggestion scheme leads to objective understanding – instead, it is supervisor support that brings this understanding to life. It follows that persistent communication and explanation by team leaders, especially during periods in which strategy may need to change frequently, is extremely important. To ensure that these communication efforts bear fruit, strategy understanding should be regularly monitored at the employee level with the goal that all employees become of the "best in class" type (Figure 2). The two metrics discussed in Section 6 can factor into the performance appraisal criteria of team leaders. Management might even consider making all leader ratings public throughout the facility, thereby encouraging leaders to support their teams even more (i.e., inducing constructive competition among leaders). In addition, the distribution of workforce across the clusters of understanding (Figure 2) should be a regular agenda item at board meetings. All in all, our method serves as a tool for managers to measure and manage communication losses, which silently eat up profits.

Second, employee engagement is another contributor to productivity. It is therefore crucial for managers to have engaged employees. Our research confirms that the three hypothesized factors – supervisor support, autonomy, and an employee suggestion system – all play a role in employee engagement. According to the structural model's standardized coefficients and p-values, a suggestion system emerges as the strongest driver of engagement. Although it does not directly lead to Kaizens, it increases productivity indirectly through employee engagement. Managers should therefore view a suggestion system not as a

cost but rather as an investment in the company's future. The third area worth highlighting is supervisor support, which played the leading role among the three opportunities provided top-down by management. Such support contributes to bottom-up strategy formation not only directly but also indirectly (through objective strategy understanding and employee engagement). Hence managers should ensure that the support provided by team leaders is always maximized. Toward that end, subordinates' ratings of perceived supervisor support could be included as a criterion in the team leaders' performance appraisal system; the ratings could also be disclosed, which might spur team leaders to give their subordinates even more support. Fourth, the regression analysis revealed that the line in which an employee works will affect the number of individual Kaizens that worker generates. Thus managers should be aware that a worker with a high number of Kaizens need not be a better employee than some other worker with fewer Kaizens, since the difference could be due to the line's favorability for innovation. For this reason, expecting all employees to deliver the same number of Kaizens (the plant's current practice) is probably not the best approach. Adjusting the target number of individual Kaizens by line would be more appropriate and so might contribute to perceived fairness at the plant.

The fifth area that merits close attention concerns the distribution of individual Kaizens. In this case, the machine maintenance department has the highest number of individual Kaizens per employee. For a plant where Total Productive Maintenance (TPM) is implemented, as it is at the plant of this study, we argue that the higher the number of suggestions from the maintenance department, the less developed the TPM activities – that is, the higher the *potential for improvement* in the name of autonomous maintenance. Therefore, plant managers should keep an eye on the share of suggestions from maintenance in the total suggestion pool. To prevent the dominance of maintenance, or (more generally) to achieve a more balanced distribution of Kaizens in the plant, managers could introduce an internal limit such that the number of suggestions from maintenance cannot exceed a stipulated percentage of all suggestions. The advantages of this approach are improving the management of Kaizen concentration risk, promoting a more effective use of TPM, and developing more leaders distributed across the facility. Sixth, the regression result shows that none of our four control variables (age, seniority, duration, competence) plays a meaningful role in the productivity game. We therefore caution managers against falling prey to status-related misconceptions, such as that older employees are less Kaizen-savvy than younger ones, or that employees with more "competency points" will produce more process innovations than their colleagues with fewer points. In sum, the four characteristics for which we controlled are not predictive of incremental innovation, in contrast to objective strategy understanding, employee engagement, and supervisor support.

Seventh, management must bear in mind that strategy deployment tools are not necessarily efficient communicators. Given the plant management's reported use of strategy cascading tools (e.g., Hoshin Kanri), our findings suggest that employing such tools cannot reasonably be supposed to guarantee an adequate strategy understanding. We recommend, at the least, that managers involve team leaders in the strategy development process. With respect to Loss 1 (cf. Figure 9), that approach could reduce the erosion of understanding and thus improve the quality of strategy understanding at the employee level (the "output" in that figure). Finally, it is almost certain that adaptations to strategy will become more frequent over time, given, for example, ever-increasing competition and the current ramifications of the Green Revolution, i.e., the carbon border adjustment mechanism. Each round of adaptation requires a comprehensive understanding at the individual level, usually from the ground up. As organizations navigate a post-pandemic world where much of the work is done in a distributed or "gig" way, workers' objective understanding of strategy will become more critical – and a greater differentiator – than ever.

7.3. Limitations and Avenues for Future Research

Like most studies, ours has some limitations that nonetheless point to avenues for future research. Our setting is a good case for multilevel SEM, with team leaders representing one level and workers another. Yet because the number of workers per team leader was statistically insufficient, we could not undertake multilevel modeling (i.e., account for fixed effects) with SEM – although we were able to do so with multiple regression. In future studies with a large number of workers, the multilevel approach could also be integrated with SEM. In our model, the dependent variable is the individual Kaizen performance of frontline employees. There are three types of Kaizens in the plant: Kobetsu, individual, and group. Kobetsu Kaizens are initiated solely by management and so do not involve voluntary actions on the part of employees; thus voluntary performance is the sum of individual and group Kaizens. However, we could not reliably determine how much an individual employee contributes to a group Kaizen activity; hence we did not include group Kaizens and considered only individual Kaizen performance. Voluntary performance also includes individual Kaizens that are ultimately not submitted to the suggestion system, but this behavior could not be incorporated into the analysis because no such data are kept at the plant. Future research should consider both aspects, if possible. Line fixed effects are an essential input for our regression analysis. When we interviewed the workers, some stated that there were no (or very few) opportunities for Kaizen on their lines. This state of affairs was usually attributed to the task being simple and routine, such as putting screws

and bolts into a small plastic bag. We therefore augmented the analysis by accounting for the lines' favorability, or systemic appropriateness. In classifying the lines according to their favorability, we relied on the information provided by the lean office director.

Given that industrial excellence requires organizational alignment, future research could examine strategy understanding beyond the shop floor level. For that purpose, it would be worth exploring the role that operations strategy understanding plays in the effectiveness of support and other primary activities of the value chain. Looking at the supplier side could yield some interesting results. As operations and finance are closely linked, the impact of strategy understanding on some key financial metrics (e.g., return on investment) should also be investigated. The same is true for companies that operate many business units around the world, as is the case with some Turkish conglomerates. For example, even if autonomy seems to be a minor factor for the employees of a business unit in Türkiye, it can be an indispensable factor for the employees of a subsidiary of the same business unit abroad. Examining the productivity factors of a particular company in different cultures should provide useful insights into the motivation of local employees and the development of managers worldwide. Finally, since many managers rely on technology to increase productivity, it follows that we need to do more research to examine how human capital compares to technology – and the relative importance of both in increasing productivity.

Author Contributions
Cem Mercikoğlu: Literature Review, Conceptualization, Methodology, Data Curation, Analysis, Writing-original draft *Arnd Huchzermeier*: Modelling, Writing-review and editing *Serden Özcan*: Modelling, Writing-review and editing.

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It was declared by the authors that the tools and methods used in the study do not require the permission of the Ethics Committee.

Ethical Statement
It was declared by the author(s) that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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DMAIC Cycle for the New Product Launch Process: FMEA and DOE Applications for Built-in Oven

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ABSTRACT

Objective: Six Sigma-SS and the DMAIC-Define, Measure, Analyze, Improve, Control cycle are employed to enhance the success of the launch of a new built-in oven with a digital panel.

Method: Following the define and measure phases, to identify and eliminate potential failures, Failure Mode and Effect Analysis-FMEA is conducted and control plans were composed during the analyse phase. In the improvement phase, the Risk Priority Numbers-RPNs obtained through FMEA and recommendations were listed. Using Design of Experiments-DOE, the lifespan of bulbs in ovens was maintained at the target value while reducing procurement costs. In the control phase, the results of validation experiments and the gains were reported.

Findings: After reporting the RPNs related to high-risk failure modes and providing improvement recommendations, DOE and Analysis of Variance were employed to determine which type of oven and brand of bulb could be used. If implemented, the expected annual savings are approximately 20,000 Euros.

Originality: This article focuses on an integrated approach for a product that is set for a new launch. It aims to improve design and production processes using the SS while also targeting cost reduction in procurement processes. To the best of our knowledge, no similar study has been encountered in the literature.

Keywords: Six Sigma, Built-in Oven, Design of Experiment, Failure Mode and Effect Analysis.

JEL Codes: C12, C19, M11, M21.

Yeni Bir Ankastre Fırını Devreye Alma Sürecinde TÖAİK Döngüsü: HTEA ve DT Uygulamaları

ÖZET

Amaç: Altı Sigma Metodolojisi ve TÖAİK-Tanımla, Ölç, Analiz Et, İyileştir, Kontrol Et döngüsü ile ilk kez piyasaya sunulacak olan dijital panelli ankastre bir fırın lansmanının başarısını artırmak hedeflenmiştir.

Yöntem: Tanımlama ve ölçme aşamasını takip eden analiz aşamasında Hata Türü ve Etki Analizi-HTEA ile muhtemel hata kaynakları belirlenip elimine edilmeye çalışılmış, kontrol planları oluşturulmuştur. İyileştirme aşamasında, HTEA ile elde edilen Risk Öncelik Sayıları (RÖS) ve iyileştirme önerileri listelenmiştir. Deney Tasarımı (DT) ile ankastre fırınlarda kullanılan ampül ömrünü hedef değerde tutarak satın alma maliyetlerini düşürmek amaçlanmıştır. Kontrol aşamasında doğrulama deneylerinin sonuçları ile elde edilen kazançlar raporlanmıştır.

Bulgular: Yüksek riskli hata türlerine ilişkin RÖS ve iyileştirme önerileri raporlandıktan sonra DT ve Varyans Analizi ile hangi fırın tipinde hangi marka ampülün kullanılabileceği tespit edilmiştir. Uygulamaya geçilmesi halinde beklenen yıllık kazanç yaklaşık 20.000 Euro civarındadır.

Özgünlük: Bu makale; henüz seri üretime geçmemiş ve yeni devreye alınacak olan bir ürün için, Altı Sigma yaklaşımı ile tasarım ve üretim süreçlerini iyileştirirken, satın alma süreçlerinde de maliyeti azaltmayı hedefleyen bütünleşik bir yaklaşıma odaklanmaktadır. Bilindiği kadarıyla literatürde benzer çalışmaya rastlanmamıştır.

Anahtar Kelimeler: Altı Sigma, Ankastre Fırın, Deney Tasarımı, Hata Türü ve Etki Analizi.

JEL Kodları: C12, C19, M11, M21.

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1. INTRODUCTION

SS is a problem-solving and quality improvement philosophy that can be applied in various industries. The DMAIC cycle is a structured problem-solving approach widely used in SS methodology (Antony and Banuelas, 2002; Girmanová et al., 2017). This methodology aims to identify waste, eliminate defects, and increase customer satisfaction.

The phases of DMAIC are systematically connected and continuously monitor the process according to the Deming PDCA (plan-do-check-act) cycle. Through these phases, the process is defined in detail, data is gathered, causes of defects are analyzed, and solutions are processed, tested, and implemented (Cheng and Kuan, 2012; Matthew, 2011; Singh et al., 2017; Smętkowska and Mrugalska, 2018).

The five steps of DMAIC are summarized below (Ahmad et al., 2018; Monica and Beata, 2018; Karamustafaoğlu and Sontay, 2018: 224):

Define- the problem is defined based on the voice of the customer (VOC) and what is critical to quality (CTQ). The problem statement is developed, and the goals for improvement are established. *Measure*-data is collected to understand the current state of the process. The process is mapped out, and key metrics are identified and measured. *Analyze*-potential root causes of the problem are identified through data analysis. The vital few causes are determined, and possible solutions are generated. *Improve*-solutions are tested to eliminate the root causes of the problem. The best solution is selected and implemented, and the process is improved. *Control*-the improved process is verified and validated to ensure that it is stable and meets the desired quality standards. Standard procedures are established, and continuous monitoring is performed to ensure that the process remains in control.

This paper proposes a step-by-step DMAIC procedure for a new product (digital-display built-in oven) launch process. Various basic and advanced tools and techniques were used to improve performance and product quality. In the *Define phase* of the project, workflow was utilized to visually represent the steps of a process. After analyzing the production process in detail, the problem has been described and the defects have been identified. In the *Measurement phase*, potential failure modes were identified, and decisions were made on what the severity (S), occurrence (O), and detection (D) values would be. RPN is determined by these three risk parameters (Kaoudom et al., 2019). RPNs were utilized to determine the most critical failures in this phase. In the analyze phase, tools such as Pareto, fishbone and why-why analysis were used to detect root causes and identify the necessary actions for preventing those failures. In the *Improve phase*, corrective actions were recommended and the RPNs were recalculated for comparison. DOE was also used to optimize the life span of bulbs and identify the factors that had the greatest impact on lifespan. General Linear Model-GLM and regression models were utilized to analyze and understand the relationship between variables. In the *Control phase*, control plans were created to monitor improvements and ensure standardization. The validation experiments of DOE studies are also examined in this phase.

Although SS methodologies have been commonly applied in the household appliances industry, this paper involved specific design considerations, manufacturing processes, and quality control measures that were tailored to a new built-in oven with a digital display. The goal is to eliminate or reduce failure modes causing poor product quality, reduce procurement costs, meet customer expectations, and improve product quality. All of these objectives are closely associated with the concept of productivity. Therefore, the SS methodology has been chosen for improvement efforts in this firm. The study proposes an integrated approach aimed at improving design and production processes, concurrently focusing on reducing costs in procurement processes through supplier evaluations.

The sections in the study were organized as follows: Introduction provides an overview of the study's purpose and objectives. The second part of the study provides information about the DMAIC cycle and reviews existing literature and research relevant to the topic. Section three (a case for digital-display built-in oven) describes the research design, data collection methods, and analysis techniques employed in the study. It presents the findings of the study, including data analysis and interpretation. Conclusion summarizes the key findings and their implications of the study.

2. THEORETICAL BACKGROUND AND LITERATURE REVIEW

As mentioned before, SS methodology focuses on reducing waste and variability in manufacturing processes, which can lead to improved quality, increased productivity, and reduced costs. The DMAIC cycle is a key aspect of SS, which is used to identify and solve problems. Each stage of the SS methodology is supported by a range of corresponding tools and techniques, including statistical process control and DOE. By leveraging these techniques, practitioners have a diverse set of tools at their disposal to improve critical processes and drive improvements in quality and efficiency (Pepper and Spedding, 2010). SS techniques include basic tools-histograms, Pareto, fishbone and control charts, and advanced tools- DOE, Taguchi, Response Surface Methodology (RSM) and multiple regression analysis (Uluskan, 2016).

DMAIC is a widely used process improvement methodology in the manufacturing sector, and has been applied in various industries to address a range of problems including household appliances (Atmaca and Grines, 2013; Uluskan, 2019; Uluskan and Oda, 2020; Yetimler, 2018), food (Banuelas et al., 2005), textile (Ajmera et. al, 2017; Demirtas et al., 2022; Lingam et al., 2015; Mukhopadhyay and Ray, 2006; Prasad et al., 2020;), automotive (Gijo et al., 2014; Kaoudom et al., 2019; Kaushik et al., 2012; Kumar et al, 2007; Pugna et al., 2016), and the others (Antony et al., 2008; Cheng and Kuan, 2012; Costa et al., 2019; Ehie and Sheu, 2005; Natarajan et al., 2013; Sokovic et al., 2005; Sontay and Karamustafaoğlu, 2017; Prabu et al., 2013; Putri et al., 2018).

Experimental design strategies such as RSM, Taguchi or DOE play an important role for the improve phase of the SS projects. DOE is a highly effective technique for identifying the most important variables (factors) that impact process output, and determining their corresponding levels for optimal performance (Antony, 2002; Goh, 2002; Uluskan, 2019). In essence, DOE is a systematic approach to understanding the relationships between the various factors that can influence a process output (Ryan, 2005).

In the following studies, SS projects were carried out with RSM, Taguchi or DOE:

Kumaravadivel and Natarajan (2013) proposed DMAIC with RSM to minimize defects in sand-casting processes, resulting in optimized casting parameters and reduced rejection rates. The DMAIC methodology has been applied in a study focused on eliminating defects in the spray-painting process (Srinivasan et al., 2014). They used Taguchi robust design, ANOVA and multivariate regression to identify optimal conditions in the pretreatment process (Uluskan, 2019). used statistical process control techniques (Gage R&R, pareto, fishbone, SIPOC diagrams, control charts and process capability analysis) and DOE in improve phase for the electrostatic powder coating process.

FMEA is used for identifying and eliminating potential failures of a product or process. FMEA is typically used during the design phase of a product or process, but it can also be used in the measurement and improvement stages of the DMAIC cycle. Kaoudom et al. (2019), Lingam et. al. (2015), Pugna et al. (2016), Putri et al. (2018) have used FMEA in DMAIC cycle.

Additionally, the effectiveness of several Lean SS methodologies and quality tools such as value stream map (VSM) and systematic layout planning, flow mapping (Lingam et al., 2015; Nagi and Altarazi, 2017; Prasad et al., 2020), SIPOC diagram, Measurement System Analysis-Gage R&R, Process Capability Analysis, Cause-Effect diagrams, Hypothesis tests, Control Charts (Kaushik et al., 2012; Kumar et al, 2007), 5S, Kanban, Kaizen, Poka-Yoke (Demirtas et al., 2022; Prasad et al., 2020; Saleeshya et al., 2012) SMED (Utkun and Güner, 2012) and TPM (Ahmad et al., 2018) within the DMAIC methodology framework, were explored for improving the quality.

As different from other researchers, our paper focuses on an integrated approach, aiming to enhance design and production processes through the SS methodology, with a concurrent focus on reducing costs in procurement processes. To our knowledge, there is no equivalent study found in the existing literature.

3. A CASE FOR DIGITAL-DISPLAY BUILT-IN OVEN

This section provides a comprehensive overview of the research design, data collection methods, and analysis techniques used throughout the investigation. The section also presents the study's findings, encompassing the data analysis process and its corresponding interpretation.

3.1. Define Phase

This article describes improvement efforts using the DMAIC cycle for a new built-in oven that is currently in the commissioning process. To address potential failures and risks in the touchscreen display on the oven door and other critical components before transitioning to mass production, a study has been initiated. The improvement studies were conducted by a team of five engineers, including machine, industrial, and materials engineers, working in the R&D laboratory, quality, and production departments. After analyzing the workflow in detail, FMEA and DOE studies have been started at measure and improve phases. The goal of FMEA is to reduce design changes before mass production and to prevent high scrap rates. DOE studies have also been carried out to ensure that the bulbs used in built-in ovens are low-cost and long-lasting.

The company operates in the durable consumer goods industry. It manufactures, sells, markets, exports, and provides after-sales services for washing machines, dishwashers, dryers, refrigerators, freezers, cookers, full-size and built-in ovens. 90% of the products are exported, and 10% are used in the domestic market.

The manufacturing process of the built-in oven begins with the storage of sheet metal in the warehouse (Figure 1). The raw materials are then transferred to the production line, where computer numerical control

(CNC) metal-forming presses are used to shape the cavity frame. These presses allow for easy bending of the sheet metal or plate with the help of simple fixtures. After spot welding, the metal surface points are joined together. Subsequently, the oven cavities are loaded onto hangers to undergo the enameling process. During enameling, one or more layers of enamel are applied to the pre-prepared cavity. Following that, the cavities are subjected to firing at a temperature ranging from 780°C to 850°C, allowing the enamel to securely adhere to the surface through the application of heat (as shown in Figure 2). Subsequently, the cavities, now coated with enamel, are transported to the assembly area using hangers. Simultaneously, the spalla pieces are affixed and secured to the door glass using an adhesive. Once the adhesive has dried, the door glasses are transported to the assembly area. Additionally, panels obtained from external suppliers are also transferred to the assembly area.

The assembly line is initiated with the control of cavity enamel. Subsequently, nuts are installed for interior rack assembly, and door glass hinges are placed. These steps are followed by resistor assembly, motor fan insulation and assembly, and fan blade assembly. Next, the rear resistor and rear resistor protection sheet are assembled. Afterwards, the cavity is covered with an insulation sheet. Once the oven chassis base is assembled, the right and left chassis parts are joined together. Finally, the fan cover and thermostat bulb holder are assembled. Before the panel assembly, a quality check is conducted on the digital screen and cables. Once verified, the cables are installed, and the digital screen is securely fixed in place using silicone sealant. Following that, the light bulbs and panel are assembled, and labels are attached for identification and information purposes. After the assembly of the inner racks, the oven tray is checked and placed in position. Then, the thermostat switch is inspected and installed. Once the ventilation plate, temperature limiter, and cooling fan are assembled, the top chassis is secured to the sides by screwing, thus closing the body. Then, the oven door is assembled, and the inner glass is installed, if necessary, followed by the installation of the gasket. The gap between the glass and panel is checked and adjusted as needed. After the barcoding process, electrical and panel tests are conducted. The oven is wrapped with protective foam and packaged before being transferred to the warehouse for storage and shipment.

Figure 1. Workflow of built-in oven (adopted from Yetimler, 2018)

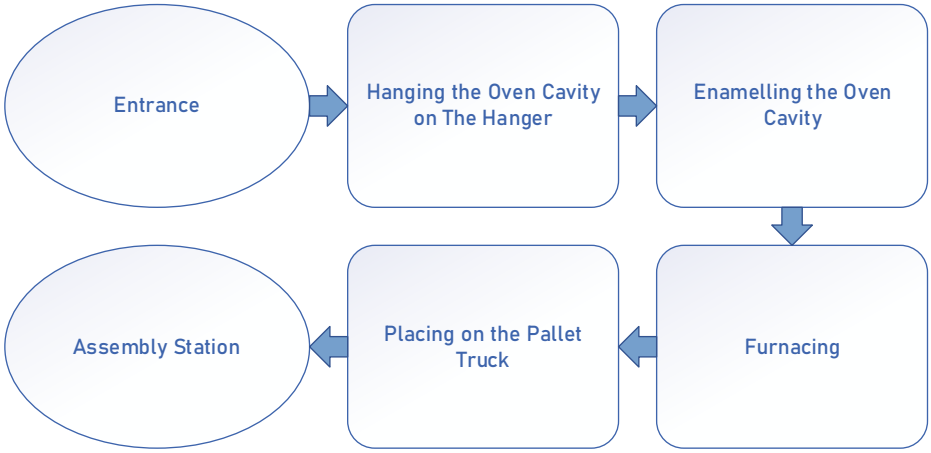

Figure 2. Workflow of cavity (adopted from Yetimler, 2018)

3.2. Measure Phase

Since the digital display built-in oven is still in the commissioning phase, FMEA studies were carried out during pilot production. Possible failure modes, effects and causes of failures are determined. Severity, probability, and detection scores for the failures were calculated. High risk failure modes and RPNs of the failure modes have been listen in Table 1.

Table 1. Failure Modes and Risk Priority Numbers

Code	*Failure Modes*	*RPN*
F1	Long cable harness	315
F2	Failure to data cable enclosure	315
F3	Improper fixing of the door handle	245
F5	Failure to install the door front frame properly	245
F6	Improper assembly of sheet metal	225
F7	Failure to install the filter properly	189
F8	Visual defects on the touchscreen	175
F9	Failure to mainboard	175
F10	Damage to the inner glass	147
F11	Damage to the monitor during the spalla fixing process	147
F12	Damage to the monitor and its parts mounted on the door group	147
F13	Failure to hinges	135
F14	Enamel problems in cavity	105
F15	Failure to mount the monitor protector to the door group properly	105
F16	Failure to data cable	105

After determining RPNs, measurement and analyses were conducted using basic quality tools for the identified high-risk failures. These efforts were sampled for the cavity enameling process in this paper. Defective cavities received from the enameling cannot be used in the assembly line and are scrapped. This leads to loss of time, labor, and increased costs. In order to reduce the number of defective cavities, the process has been thoroughly examined. Data has been collected for one month on the cavities that are scrapped after enameling, and a Pareto analysis has been conducted (Figure 3).

As seen from the Pareto diagram, the most significant cause leading to scrap is impact, accounting for 78.1% of the total. Out of the 919 scrapped cavity, 718 are due to impact-related issues. Following that, enamel buildup accounts for 7.7%, high enamel thickness for 7.3%, enamel burn for 2.4%, and other reasons for 4.5% of the total scraps.

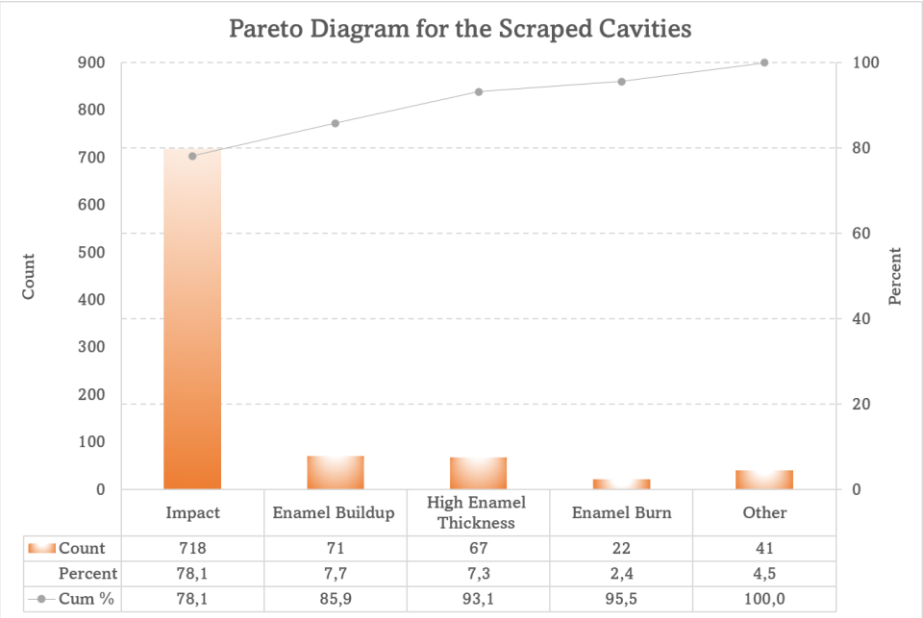

Figure 3. Pareto Diagram for the scraped cavities

The impact and buildup issues have been further examined in detail using a Cause-and-Effect diagram (Figure 4). This diagram, also known as a Fishbone or Ishikawa diagram, helps identify the root causes contributing to the observed problems. By understanding the underlying factors causing impacts and buildup, proper actions can be taken to mitigate these issues and reduce the number of scraps. Suggestions for the impact and buildup problem are given in the following section.

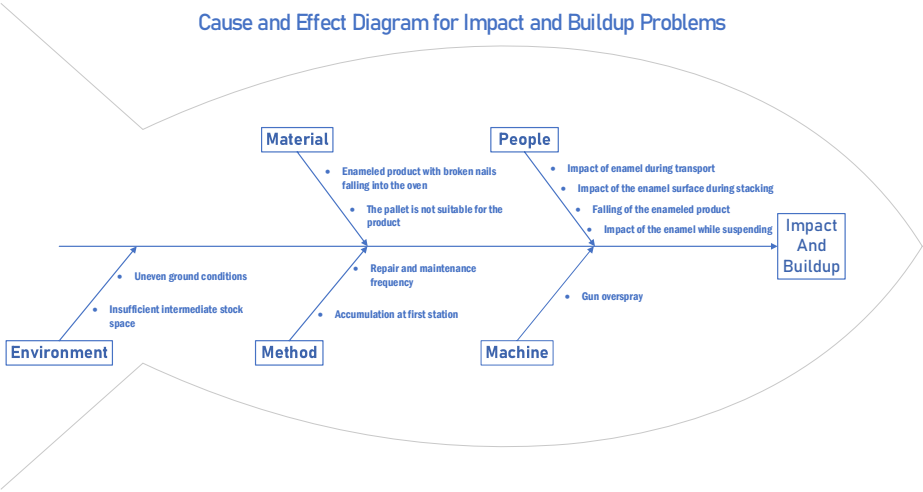

Figure 4. Cause-Effect Diagram for impact and buildup problems

3.3. Improve Phase

This phase contains FMEA and DOE studies. Actions have been taken for high-risk failures, which are identified based on their RPN scores. The corrective actions and the revised RPNs thereafter are listed in the improve phase (Table 2).

Furthermore, based on the revised FMEA forms for processes with high RPN values and planned improvement studies, control plans have been developed (please see Yetimler, 2018). For one of the processes with a high RPN value, which is the enameling of the oven cavity, quality tools have been utilized to target the reduction of scrap rates. The analysis of cause-effect diagram has revealed the following actions contributing to the improvement efforts:

- To prevent the cavities from falling into the furnace during enameling, operators have been informed and warning signs have been added to the panels, emphasizing the need for careful handling while hanging the cavities on the furnace hooks.

- Uneven floor conditions have been identified as a cause of cavities receiving impacts during transportation. It has been determined that floor improvement work is necessary to address this issue.
- Insufficient storage space leads to storing the cavities in proximity, increasing the chance of collision during transportation. It has been recognized that a new storage area is required to avoid collision.
- It is recommended to use a suitable rack for storing the cavities while they are waiting to be transferred from the enameling to the assembly line.
- Excessive enamel spraying from the gun results in buildup defects. To address this issue, operators have been trained for application. They also informed to perform more frequent and meticulous maintenance and repair of the enamel gun.
- The cavities can also receive impacts during the transportation and stacking after the enameling process, due to factors such as falling or collisions. Therefore, improvement suggestions have been provided for the transportation method. Prior to the improvements, stacking was done on wooden pallets, and transportation was carried out using these pallets. However, the wooden pallet can cause impacts during stacking and transportation. To prevent impacts resulting from contact between the cavities or external sources, a more protective transportation vehicle has been recommended.
- In the recommended cart, the cavities will be surrounded by vertical profile material to protect them from external impacts. For ease of use, the top part of the profile will have detachable slats. Additionally, the bottom part of the cart will be designed to protect the front frame of the cavities from external impacts while also providing a convenient placement for the cavities. Furthermore, considering the possibility of impacts during stacking, it has been observed that the inner surfaces of the transportation vehicle should be covered with a soft material.
- The use of heat-resistant material, such as polyamide, is recommended for the transportation carts considering that the cavities are placed on the carts at an average temperature of 80°C after coming out of the 800°C furnace. Polyamide is known for its excellent heat resistance and durability, making it suitable for this application.
- By considering the cost of 125 transportation carts required by the operation and comparing it with the monthly scrap cost, it has been determined that the business will recoup the investment in 5 months.

To evaluate the bulbs from the new supplier and the existing bulbs used in the company, a DOE strategy has been decided upon. The objective is to conduct lifespan tests on the bulbs and evaluate the results. The goal is to find suppliers who can provide the required quality and performance at a lower cost.

During the improvement studies, it was determined that if the new bulb brand can be used in all voltage ranges and in all brand ovens, an estimated annual savings of approximately 80,000 Euros can be achieved. To achieve this goal, a supplier evaluation was conducted by operating the bulbs from the new supplier in different models of ovens and at different voltage levels, while observing the results of lifespan tests. This evaluation aimed to assess the compatibility and performance of the bulbs in various operating conditions and ensure that they meet the required standards for reliability and longevity.

The new bulbs from the alternative supplier and the existing bulbs used by the company were tested in 3 different types of ovens and at 3 different voltage levels in a 2 replicated (36 samples) experiment. The factors and their levels are encoded as shown in Table 3. During the experiments, lifespan tests were conducted by setting the voltage values to 230, 250, and 270 volts. These different voltage values represent the company's customers in different countries. 230 volts is the designated voltage for products offered in the Turkish market, while 250 and 270 volts are designated for the French and British markets, respectively. The bulbs are expected to complete 1000 hours of operation to pass the lifespan test successfully.

Table 2. RPNs after improvement

Failure Mode	*Definition*	*Improvement Efforts*	*RPNs after improvement*
F1	Long cable harness	The R&D department has recommended implementing cable fixation in specific regions. This involves securely fastening the cables to prevent movement or dislodging, reducing the risk of damage or malfunction.	105
F2	Failure to data cable enclosure	The short length of the conduit used to protect the data cable is causing damage to the cable. To address this issue, it has been requested that the R&D department update the technical specifications and communicate with the supplier to extend the length of the conduit.	105
F3	Improper fixing of the door handle	To improve the ease of proper adhesive application for the oven door handle, it has been determined that the existing convenience needs improvement. After consultation with method engineers, a more functional convenience has been designed.	49
F5	Failure to install the door front frame properly	Consultation with method engineers has taken place to improve the frame bonding method. In addition, the production engineers have created a maintenance plan for the apparatus used in frame bonding.	63
F6	Improper assembly of sheet metal	The problem of assembly issues arises from the necessary mounting holes either not being drilled or being drilled incorrectly. This issue has been discussed with the R&D department, and after technical drawing updates RPN has been reduced.	75
F7	Failure to install the filter properly	During the assembly of the parasitic filter onto the sheet metal, it has been observed that the operator faces difficulty in performing this task. The challenge stems from the instability of the sheet metal onto which the filter is being attached. The failure is attributed to a lack of convenience in the process. To address this issue, method engineers have developed a new convenience that improves the ease of assembly. By implementing this improvement, the RPN associated with the assembly operation has been reduced.	63
F8	Visual defects on the touchscreen	A visual inspection instruction has been added to the control plan to examine visual defects on the touch screen.	75
F9	Failure to mainboard	The mainboard can sometimes arrive at the assembly line from the supplier faulty or may not be properly installed by the operator, resulting in potential damage and non-functionality of the board. To address these issues, it has been requested to ensure control over the storage and transportation conditions from the supplier. Additionally, training has been provided to the operators regarding this matter.	21
F10	Damage to the inner glass	To prevent damage to the glass during the inner glass assembly process, a visual form has been created.	63
F11	Damage to the monitor during the spalla fixing process	During the fixing process, it has been anticipated that the cables on the monitor may be at risk of damage, which can potentially lead to malfunctions. To address this issue, the R&D department has introduced a tape in the technical drawing, and the cables are now secured with the tape. Additionally, an improvement project has been initiated for the spalla fixing robot.	49
F12	Damage to the monitor and its parts mounted on the door group	To prevent any damage to the components during the assembly of the door assembly group, maintenance plans have been created by the production engineers for the fixtures used.	49
F13	Failure to hinges	The inability of the hinge legs to lock properly results in the door not closing correctly. This issue stems from design flaws in the Soft Close mechanism. The R&D department has made improvements to the Soft Close mechanism, resulting in a reduction in the RPN.	45
F14	Enamel problems in cavity	Detailed studies have been conducted regarding this matter, and the findings can be summarized in the measure and improve phase.	35

Table 2. (*Continued*)

Failure Mode	*Definition*	*Improvement Efforts*	*RPNs after improvement*
F15	Failure to mount the monitor protector to the door group properly	To prevent any damage to the monitor, a visual guide should be created. This guide will provide instructions on how to handle the monitor properly to ensure its safety and integrity.	35
F16	Failure to data cable	After the improvement efforts in the process, the data cable is now securely fixed onto the oven without any bending. This ensures that the cable remains straight and properly connected, reducing the risk of damage or disconnection.	35

Table 3. Factors and coded levels

Factors	*Coded Levels*		
Oven type (A)	X	Y	Z
	{1 0}	{0 1}	{-1 -1}
Bulb brand (B)	Current	New	
	{-1}	{1}	
Volts (C)	230	250	270
	{-1 1}	{0 -2}	{1 1}

In the conducted 36 experiments, the lifespan of each bulb was measured in hours, and the results were recorded. The lifespan test results of the existing and new brand bulbs were analyzed using ANOVA. Considering that the oven model, bulb brand, and voltage variables are categorical, GLM was employed for the analysis. The analysis results are summarized in Table 4 and Table 5.

According to the variance analysis results shown in Table 4, the F-value is 81.70 and the p-value (Prob > F) is less than 0.05, indicating that the model is significant at a 95% confidence level. It is observed that the main factors A, B, C, AB, AC, BC, and ABC, as well as their interactions, are also significant (p-value < 0.05).

Table 4. ANOVA results

Source	*Sum of Squares*	*df*	*Mean Square*	*F Value*	*p-value*	
Model	1.124E+006	17	66141.65	81.70	< 0.0001	significant
A-model	44364.67	2	22182.33	27.40	< 0.0001	
B-bulb	4.303E+005	1	4.303E+005	531.57	< 0.0001	
C-voltage	4.128E+005	2	2.064E+005	254.96	< 0.0001	
AB	18432.67	2	9216.33	11.38	0.0006	
AC	13253.33	4	3313.33	4.09	0.0157	
BC	1.292E+005	2	64614.33	79.81	< 0.0001	
ABC	75978.67	4	18994.67	23.46	< 0.0001	
Pure Error	14572.00	18	809.56			
Cor Total	1.139E+006	35				

In Table 5, the "R-Squared" value is calculated as 0.9872, and the adjusted R-squared value is 0.9751. Both values are close to 1, indicating a high percentage of variance explained by the main factors and interactions in the model. The predicted R-Squared value is also close to the others.

The regression equation obtained for the lifespan test is provided in Equation 1.

$$Y = 1097 + 47.17A_1 - 37A_2 - 109.33B - 130.75C_1 + 5.92C_2 - 30.83A_1B + 8A_2B - 12A_1C_1 + 0{,}5A_2C_1 - 9.33A_1C_2 - 8.17A_2C_2 + 71.92BC_1 - 8.42BC_2 + 35.83A_1BC_1 - 29.67A_2BC_1 + 14.83A_1BC_2 + 25A_2BC_2 \quad (1)$$

The calculations in the regression equation have utilized the dummy variables from Table 3.

To express it more clearly, in Equation 1, it is written as follows:

$A_1 = 1$ and $A_{2=}0$ (for the X model oven), $A_1 = 0$ and $A_{2=}1$ (for the Y model oven), $A_1 = -1$ and $A_{2=} - 1$ (for the Z model oven), $B = -1$ (for the current bulb), $B = 1$ (for the new bulb), $C_1 = -1$ and $C_{2=}1$ (for 230 volts), $C_1 = 0$ and $C_{2=} - 2$ (for 250 volts), $C_1 = 1$ and $C_{2=}1$ (for 270 volts)

For example, for the existing bulb in X model oven at 230 volts, the lifespan is calculated as Equation 2.

Lifespan = 1097 + 47.17(1) – 37(0) – 109.33(-1) – 130.75(-1) + 5.92(1) – 30.83(1)(-1) + 8(0)(-1) – 12(1)(-1) + 0.5(0)(-1) – 9.33(1)(1) - 8.17(0)(1) + 71.92(-1)(-1) – 8.42(-1)(1) + 35.83(1)(-1)(-1) – 29.67(0)(-1)(-1) + 14.83(1)(-1)(1) + 25(0)(-1)(1)= 1525,01 hours (2)

Table 5. R^2 values

Statistics	*Values*
Std. Dev.	28.45
Mean	1097.00
C. V. %	2.59
PRESS	58288.00
R-Squared	0.9872
Adj R-Squared	0.9751
Pred R-Squared	0.9488
Adeq Precision	31.811

Upon examining the residual plots in Figure 5, it can be observed that the assumptions of normality and constant variance are met. The independence of residuals has been verified by conducting the Durbin-Watson Test statistic, confirming that there is no correlation among the residuals.

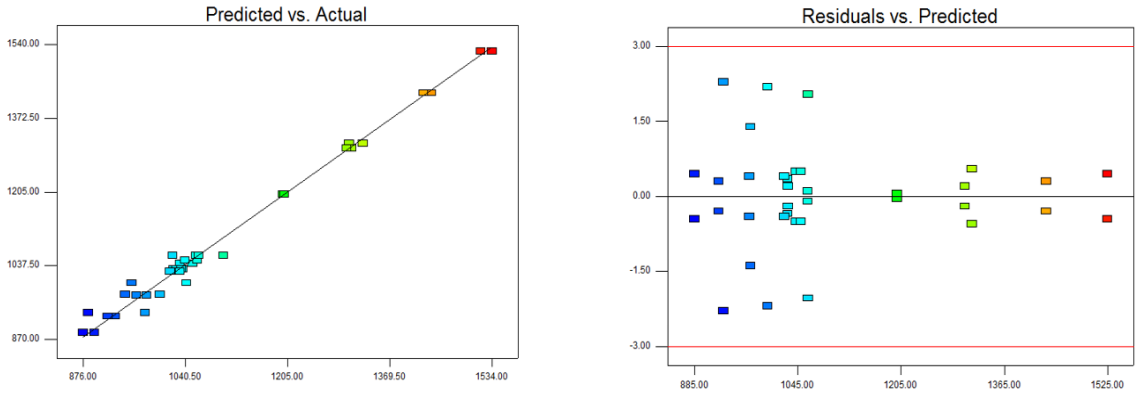

Figure 5. Residual analyses

When the voltage value is 230, in all oven models, both the new and existing bulb brands have exceeded the target value of 1000 hours. It is observed that the lifespan of the existing bulb brand is longer compared to the new one (Figure 6).

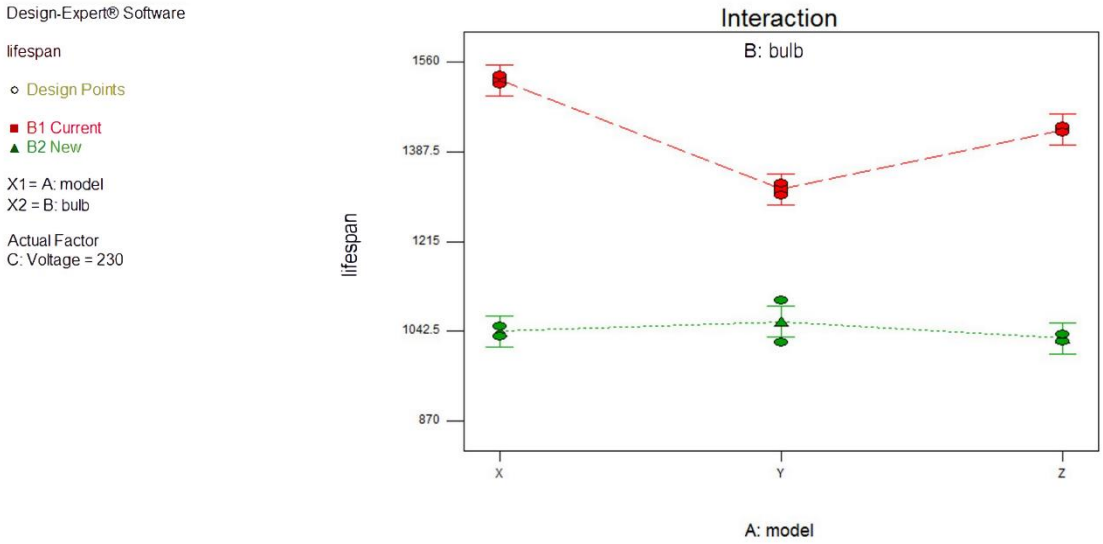

Figure 6. Interaction plots (230 Volts)

When the voltage value is 250, the existing bulb has successfully passed the lifespan test in all oven models, while the new bulb has exceeded the target value in the Z model. The lifespan of the bulbs is longer for the existing bulb in X and Y model ovens, while the new bulb brand has a longer lifespan in the Z model oven. (Figure 7).

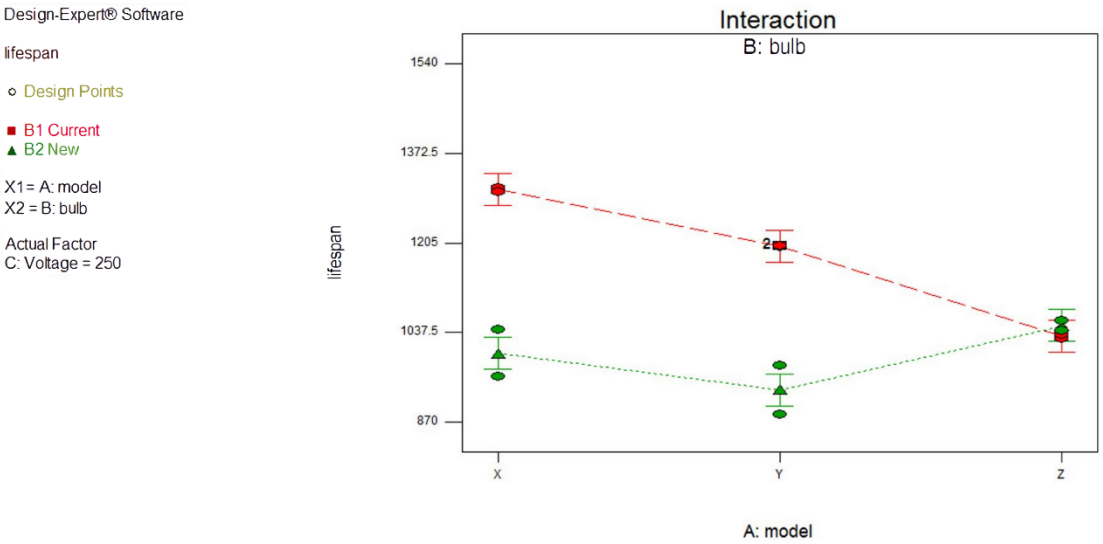

Figure 7. Interaction plots (250 Volts)

When the voltage value is 270, it is clearly observed from Figure 8 that the products tested using the existing bulb brand have a longer lifespan.

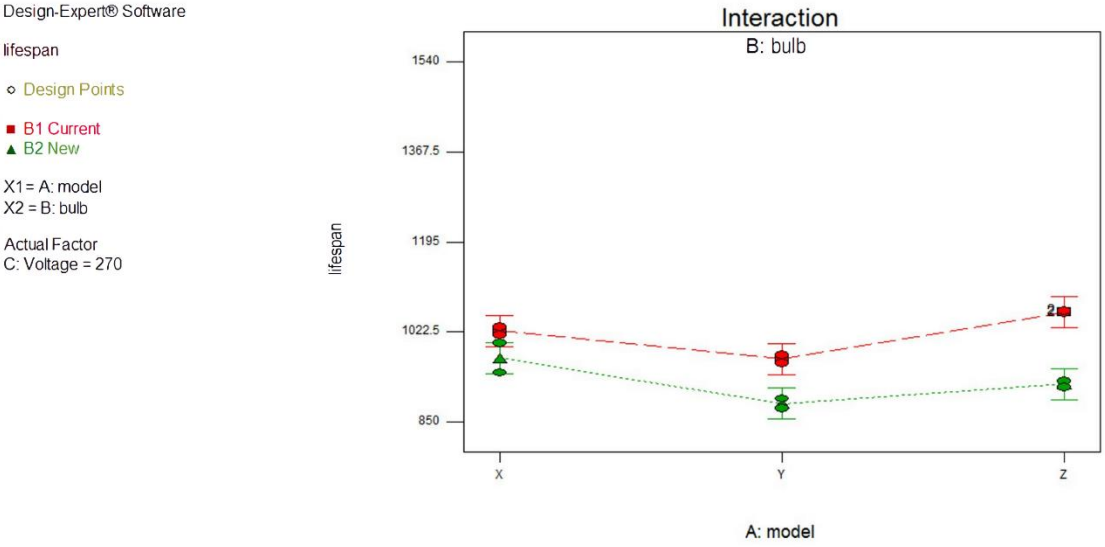

Figure 8. Interaction plots (270 Volts)

After examining the interaction between factors, optimization studies were conducted, and local best solutions were obtained. When the predicted lifespan values of the proposed solutions were examined, the following results were obtained:

- At 230 volts, the lifespan of the new bulb exceeds the target value of 1000 in X, Y, and Z model ovens.
- At 250 volts, only in the Z model oven, the lifespan exceeds the target value.
- At 270 volts, the new bulbs do not reach the target value.
- These findings indicate the optimal conditions for each voltage and oven model combination in terms of the lifespan of the bulbs.

3.4. Control Phase

To validate the local best solutions, verification experiments were conducted. X, Y, and Z model ovens were operated at 230 volts, while the Z model oven was operated at 250 volts, and the lifespan values were recorded. When examining Table 6, the predicted results are presented in column 4, the prediction intervals at a 95% confidence level are presented in columns 5 and 6, and the results of the verification experiments are presented in column 7.

Table 6. Validation results

A	*B*	*C*	*Predicted Lifespan*	*Lower PI (%95 CI)*	*Upper PI (%95 CI)*	*Validation Results*
{1 0}	{1}	{-1 1}	1042	968,79	1115,21	1053
{0 1}	{1}	{-1 1}	1061	987,79	1134,21	1026
{-1 -1}	{1}	{-1 1}	1029	955,79	1102,21	1011
{-1 -1}	{1}	{0 -2}	1050	976,79	1123,21	1032

Based on the results of the validation experiments, when using the new bulb in X, Y, and Z model ovens at 230 volts, and in the Z model oven at 250 volts, the lifespan exceeds 1000 hours. The results obtained from the experiments fall within the lower and upper limits of the prediction intervals. Based on these findings, it is evident that the predictions are reliable.

In these scenarios, the new bulb brand can be used successfully in X, Y, and Z model ovens at 230 volts, as well as in the Z model oven at 250 volts. However, it is not recommended for use in X, Y, or Z model ovens at 270 volts (Table 7). The situations where the new bulb brand can be used are indicated by the (+) symbol, while the situations where it cannot be used are indicated by the (-) symbol.

Table 7. The usability of the new bulb brand

	Volts		
Oven Type	*230*	*250*	*270*
X	+	-	-
Y	+	-	-
Z	+	+	-

As shown in Table 7, the new bulb brand can only be used in X, Y, and Z model ovens in the Turkish market. It can also be used in the Z model oven for the French market. For X and Y model ovens in the French market and X, Y, and Z model ovens in the UK market, it is recommended to use the existing bulb brand. In this case, the estimated annual savings would be around 20,000 Euros instead of 80,000 Euros.

4. CONCLUSION

In today's business landscape, SS has gained significant popularity among organizations across different industries. It primarily emphasizes enhancing production processes to drive improved profitability for the company. Attaining the SS level necessitates a deep understanding of the factors contributing to process variability, conducting thorough cause-and-effect analysis, and assessing associated costs. By employing DMAIC, one of the quality improvement methodologies utilized within the SS framework, organizations can enhance their ability to effectively respond to emerging issues and improve overall process efficiency.

This study demonstrates that organizations can achieve greater success by adopting SS for products that are in the process of being launched, along with the associated improvement efforts. By implementing SS methodologies and DMAIC cycle, organizations can effectively enhance the quality and performance of new products, leading to improved customer satisfaction and business outcomes. The systematic approach provided by SS enables organizations to identify and address potential issues early on, resulting in smoother product launches and increased chances of success in the market.

The implementation of the proposed solutions can result in various benefits not only for the company itself but also for other stakeholders involved in its operations:

- *For the company:* By adopting these solutions, the company can avoid penalties for non-compliance with agreements, reduce production costs, increase productivity, and consequently decrease the amount of work in progress.
- *For customers:* The implementation of these solutions can lead to increased customer satisfaction by improving timeliness and ensuring timely delivery of products or services.
- *For employees:* The solutions can enhance employee comfort and improve organizational efficiency, potentially eliminating the need for overtime work and creating a more balanced work environment.
- *For other entities:* The implementation of these solutions can enable the company to handle a higher volume of orders during peak periods, maximizing business opportunities and benefiting other entities involved in the industry.

In summary, the proposed solutions offer a range of benefits that extend beyond the company itself, positively impacting customers, employees, and other stakeholders in terms of compliance, cost reduction, productivity improvement, customer satisfaction, employee well-being, and increased business opportunities. Introducing employees to SS techniques and establishing a SS culture in small and medium-

sized manufacturing businesses can lead to an increase in similar initiatives and the elimination of wastes. By implementing SS, these organizations can improve their operational efficiency, enhance product quality, reduce waste and defects, and ultimately achieve higher customer satisfaction. Additionally, the adoption of SS methodologies promotes a data-driven and problem-solving mindset among employees, fostering a culture of continuous improvement and innovation. This, in turn, can contribute to the overall success and competitiveness of the organization in the market.

Improvements have been made specifically for a new built-in oven with a digital panel, and efforts related to the production processes of other products are not within the scope. However, by extending similar initiatives throughout the organization and establishing a corporate culture, it is possible to enhance the efficiency of processes. The inability to establish a corporate culture and awareness is one of the major barriers for organizations.

In sectors outside the household appliance industry, where inefficiencies and high defect rates are prevalent, similar initiatives can be undertaken by employing statistical tools aligned with quality objectives in future.

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Compliance with Ethical Standards
It was declared by the authors that the tools and methods used in the study do not require the permission of the Ethics Committee.

Ethical Statement
It was declared by the authors that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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VERİMLİLİK DERGİSİ
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The Effect of Capital Structure on Profitability: Evidence from the Turkish Manufacturing Companies

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ABSTRACT

Purpose: This study analyses the relationship between capital structure and profitability levels of manufacturing industry companies operating in Türkiye between the years 2006-2020.

Methodology: The relationship between capital structure and the profitability of Turkish manufacturing industry companies was analyzed using the standard error estimator proposed by Driscoll and Kraay (1998). In this context, sub-panel data models were created.

Findings: The findings showed that capital structure changes (short-term debt, long-term debt, and total debt) in the manufacturing industry are negatively related to both return on assets and return on equity.

Originality: It is thought that this study will contribute to the existing literature in terms of better understanding the relationship between the changes in the capital structure decisions of the manufacturing industry companies operating in Türkiye, both their return on assets and their return on equity, taking into account their sub-sectors.

Keywords: Profitability, Return on Assets, Return on Equity, Capital Structure, Debt, Manufacturing Industry, Driscoll-Kraay Panel Data Model.

JEL Codes: G32, L6, O14.

Sermaye Yapısının Kârlılığa Etkisi: Türkiye İmalat Sanayi Şirketlerinden Kanıtlar

ÖZET

Amaç: Bu çalışma, Türkiye'de faaliyette bulunan imalat sanayi şirketlerinin, 2006-2020 yılları arasında, sermaye yapıları ile karlılık düzeyleri arasındaki ilişkiyi analiz etmektedir.

***Yöntem*:** Türkiye imalat sanayi şirketlerinin sermaye yapıları ile karlılıkları arasındaki ilişki, Driscoll ve Kraay (1998) tarafından önerilen standart hatalar tahmincisi kullanılarak analiz edilmiştir. Bu kapsamda alt panel veri modelleri oluşturulmuştur.

Bulgular: Bulgular, imalat sanayi sektöründe sermaye yapısı değişikliklerinin (kısa vadeli borçlar, uzun vadeli borçlar ve toplam borçlar) hem aktif karlılığı, hem de özkaynak karlılığı ile negatif ilişkili olduğunu göstermiştir.

Özgünlük: Türkiye'de faaliyette bulunan imalat sanayi şirketlerinin, alt sektörleri de dikkate alınarak, sermaye yapısı kararlarındaki değişimlerin gerek aktif karlılıkları gerekse özkaynak karlılıkları ile ilişkisinin daha iyi anlaşılması açısından bu çalışmanın mevcut literatüre katkı sağlayacağı düşünülmektedir.

Anahtar Kelimeler*:* Kârlılık, Aktif Getirisi, Özkaynak Getirisi, Sermaye Yapısı, Borç, İmalat Sanayi, Driscoll-Kraay Panel Veri Modeli.

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1. INTRODUCTION

Efficiency refers to the methods that positively affect the results of operations in a company that produces goods or services by using the factors of production. In detail, it describes positive situations that are revealed by measuring and rationing the economic results, rather than just about increasing production or being suitable for productivity (İleri, 1999). Debt financing is also a component of production. The efficiency of debt financing can only be recognised provided that it reflects positively on business income or expenses, thus increasing the profitability of the company. In other words, a financial manager should consider loan features such as maturity, cost, etc. in debt financing. The decisions made taking these factors into account can positively or negatively affect the profitability of the company.

Financial management has three basic functions: financing decision, investment decision, and dividend decision. Within these, the financing decision or function requires a finance manager to decide on an appropriate mix of alternative sources of financing. To this end, a finance manager identifies all available sources of finance and evaluates them based on various quantitative and qualitative variables. He then chooses the ones that best suit the needs of the company. When we look at the lower-level decisions of the Financing Decision, three basic decisions or functions can be mentioned: Determining the Capital Structure, that is, the ratio of various resources in the total capital of the company. Determination of the Cost of Capital, i.e. calculating the cost and total cost of each resource as a weighted average Cost of Capital. Leverage analysis, i.e. analyzing the financial risk associated with a particular financing plan, providing profitability to shareholders in terms of earnings, and choosing plans accordingly (Sana et al., 2017: 25)

Capital structure is an important part of financial decisions that affect the value of the firm, leading to changes in the EBIT and market value of shares. There is a relationship between the capital structure, the cost of capital, and the value of the firm. The purpose of an effective capital structure is to maximize the value of the firm and reduce the cost of capital. There are two main theories that explain the relationship between capital structure, cost of capital and firm value: the traditional approach and the modern approach. On the basis of these two concepts, which will be explained in the following section, they argue that different capital structures are more suitable for firms (Paramasivan and Subramanian, 2009: 50). The most basic resources that companies can use to finance their assets are internal financing resources, expressed as equity, and external financing resources, expressed as debt. Companies generally use a mix of internal and external sources of finance, or a mix of equity and debt (Nassar, 2016). All choices made by companies among financing options, also referred to as capital structure decisions, can have negative as well as positive effects on the income and profits of the companies. The increase in company revenues and profits can also contribute positively to company value. Companies' financing decisions involve establishing the appropriate mix of resources. The composition of these resources is formed by taking into account parameters such as favorable maturity conditions, appropriate interest cost and additional costs. When the internal resources obtained as a result of the activities of the companies are excluded, it is understood that the financing decisions are a preference between debt and equity. Capital structure choices should serve the purpose of minimizing the cost of capital, which also helps to maximize company value.

Despite numerous theories developed to explain the capital structure of firms, scholars have yet to find a single optimal capital structure model. The lack of consensus on the relationship between capital structure and performance still drives practitioners to prioritize this area of financial management. This study examines the effect of capital structure of manufacturing companies on the performance in Türkiye. To be more specific, the purpose of this study is to measure the effect of increasing or decreasing the weight of the debt financing option of manufacturing companies, as well as the impact of maturity structure on their return on assets and return on equity. Based on the data in the balance sheets of Turkish manufacturing industry companies, empirical research has been conducted to examine and reveal the relationship between the company's leverage ratios and performance. To act within this framework, first of all, 15 years (2006-2020) data from 22 subsectors in the Turkish Manufacturing Industry were obtained from online databases and made suitable for analysis.[3] In the next step, the panel data methodology was applied and the results obtained were compared with theoretical expectations and similar studies in the literature. In regression analysis, two main profitability indicators, return on assets (ROA) and return on equity (ROE) were used as dependent variables. As for independent variables, it is used as the ratio of short-term debt

[3] In this study, Entrepreneur Information System (GBS) data of the Ministry of Industry and Technology of the Republic of Türkiye were used. Entrepreneur Information System (EIS, 2023) refers to the information system created based on Article 388/B of the Presidential Decree on Presidential Organization No. 1 dated 10/7/2018. For the data obtained within the scope of the analysis, publicly available data at www.gbs.sanayi.gov.tr was used. However, proportional calculations were made to make the data suitable for analysis.

to total debt, the ratio of short-term debt to total debt, and the ratio of total debt to total assets. Additionally, total asset size, net sales, and the size of R&D expenditures were also included as control variables.

This study differs from other studies in the following aspects. Firstly, it focuses solely on the impact of the capital structure on the performance of manufacturing subsectors in Türkiye. Secondly, in terms of the data used, it includes not only publicly traded companies but also encompasses the entire manufacturing sector. Thirdly, it involves research and development (R&D) capacity into the set of control variables. Finally, to measure the related relationship, panel data methodology has been applied. It is thought that this study will be beneficial for the managers of the manufacturing industry companies to decide on the right combination of equity and debt in order to maximize the value of the company while evaluating the financial options, and will contribute to the sectoral capital structure studies, too.

Following the introduction part of this study, the theoretical framework and literature research on capital structure decisions are included. In the following stage, information about the methodology of the study was given and the research findings were explained. In the last part of the research study, a general summary and evaluations of the study are presented.

2. SCOPE of CAPITAL STRUCTURE and LITERATURE REVIEW

Firms' financing decisions involve financial risk. Financial risk occurs when debt is used as a financial resource. Debt repayments are payments that include principal and interest on the debt and are not dependent on the profitability or loss of the company. Furthermore, when the debt financing option costs less than the cost of equity, the increase in the level of borrowing of companies can positively affect their profitability due to the lower cost of resources. Thanks to tax advantages, increases in debt level can increase firm profits and hence, earnings of the firm's shareholders. However, increases in debt level may increase financial risk. In this case, it can be assumed that a firm without debt will not encounter financial risk. In this sense, financial risk is an avoidable risk. Yet, without debt financing, it may not be possible to increase the shareholder's return as equity financing does not have the tax advantage (Sana et al., 2017: 167). For companies operating in the related market, the financial resource is essential for the fixed assets and working capital they need. Companies obtain the necessary financing from three main sources: excess cash resulting from operating activities, new capital, borrowing from banks, and non-bank sources (Coyle, 2006).

Company strategic planning is one of the important tools to achieve the goal of maximising shareholder value. The strategic plan includes all the financing and investment decisions, as well as the company's sales forecasts For businesses, financial planning is a plan regarding which financial instruments and with what maturity the business assets should be financed, and is also an issue providing the right working capital. Under normal circumstances, the capital structure of any company is basically a combination of three kinds of sources or the result of the changes in the usage weights of these three sources. These are debt, equity created internally as a result of company activities, and the supply of new equity. Debt financing imposes interest and principal obligations on companies. Failure to pay or possible delays may cause creditors to take legal action. If the company's activities are carried out with the equity financing method, there will be expectations such as cash dividends and an increase in the value of the stock shares (Fabozzi and Drake, 2009).

The capital structure, in essence, expresses the distribution of alternative financing resources among all resources of the firm, but it can be said that this structure is also represented by equity and debt ratios. Both types of resources have their advantages and disadvantages. Although debt involves a higher risk, it is a significantly cheaper type of resource than equity. Any firm manager must make a capital structure decision that will maximize the firm value and minimize risk. For this, the optimum capital structure combination should be created (Sana et al., 2017: 32).

Having the appropriate capital structure can positively affect the profitability and share value of any firm. Firms can increase their borrowing opportunities until the weighted marginal cost of capital calculated for their investment equals the marginal return calculated for the last unit of capital. After this point, the marginal cost of the resource provided will exceed the marginal return, and therefore the return on investment will decrease, the company's revenues may be adversely affected, and in this case, the company's profitability and share value may be adversely affected. From this point of view, it would not be a mistake to state that maximizing firm value is directly related to the firm's cost of capital (Eun and Resnick, 2018: 432).

There is no single optimum capital structure ratio that applies to every company. Different combinations of assets require different combinations of resources. As capital structure decisions are closely related to company value. It is one of the most critical challenges for a company's finance manager. The appropriate capital structure contributes to the company in producing the optimal output with the most suitable resource

at the lowest cost, thus maximising its profitability. Furthermore, an increase (or decrease) in profit before interest and tax leads to an increase (or decrease) in the market value of the company's shares

The transformation of efficient use of resources into more output indicates efficiency. In other words, the efficient use of provided resources reflects on the amount of output produced and profitability. These sources include equity or debt financing alternatives. The main purpose of an effective capital structure is to maximize the value of the company with the resources obtained and to reduce the cost of capital.

One of the most basic theories for determining the relationship between capital structure, cost of capital, and company value is the traditional approach, and the other is the modern approach. According to theorists who adopt the traditional approach, companies can increase the value of the company up to an optimum level of debt, and borrowing up to this optimum level of debt affects the company positively. However, exceeding the optimum level negatively impacts the company value and starts to negatively affect the company value. Thus, borrowing up to a certain debt level may be a demandable situation for companies, but after this level, it has negative consequences. Modern approaches, on the other hand, consist of three sub-sections. These approaches are "Net Income Approach, Net Operating Income Approach, and Modigliani-Miller Approach". According to the net income approach, companies can increase their value by borrowing. According to this approach proposed by Durand (1952), companies should borrow more and take advantage of debt financing to increase their value. However, there are some problems with the assumptions of the net income approach. Namely, this approach assumes that there is no corporate tax and that borrowing costs are lower than equity financing. Additionally, it is argued that the use of debt will not change the perception of risk in the market regarding the company. The validity of these approaches in real life is questionable. The approach, which is defined as the net operating income approach, argues that, unlike the previous approach, the company value is independent of the capital structure and the company value will not be affected by this decision. It is possible to state that the traditional approach adopts a combination of the net income approach and the net operating income approach (Paramasivan and Subramanian, 2009: 51-55).

Modigliani and Miller (1958) put forward an approach claiming that companies' capital structure decisions are unrelated to company value. The researchers argue that capital structure decisions have nothing to do with company value, ignoring any tax expenses and the costs of financial distress due to the increased probability of bankruptcy. However, if taxes are included in the analysis for capital structure decisions, it is highly likely that these decisions will become associated with company value. Because the tax deduction of the interest paid turns the interest into a tax shield and encourages the use of debt. In addition to taxes, the costs associated with financial distress can reduce the benefits of debt in changes in capital structure. Therefore, the value of the company can be affected by financial distress costs. As a result, the way we finance the company's assets can impact on the company's value and therefore its equity (Fabozzi and Drake, 2009: 405).

Also, some modern approaches have been developed in this research field. According to the information asymmetry theory developed by Myers and Majluf (1984), one of these approaches is if the investors who are not currently in the management of the company buy shares as partners instead of lending to the company, they discount the shares they will receive with a higher earnings ratio, and the company managers create new solutions to avoid the financing hierarchy. They claim to delay their joint purchases as much as possible. The theory, which is another modern approach, is a theory that should be evaluated within the scope of information asymmetry theory. According to the finance hierarchy theory of Myers (1984), companies should exercise options in their use of financing options, starting with retained earnings, and finally issuing new shares or hiring new partners. For this reason, financing opportunities should first be provided with internal resources and then with external resources, and the option of acquiring new partners should be considered as the last alternative/option. According to the market timing theory, another modern approach developed by Baker and Wurgler (2002), there is a tendency for company management to sell company shares when they are overvalued relative to their book values and past market prices, and to buy their own shares from the market when they become worthless. It reveals that the capital structures of companies are affected by the prices of stocks on the market. Another modern approach is the Barter theory, developed by Frank and Goyal (2008: 135), where choice of capital structure can have both beneficial and detrimental aspects to companies. The point where the cost of the last debt unit is equal to the benefit of the last unit may be the most appropriate level (Sayılgan, 2017: 342-344).

Today and in recent years, it has been possible to come across many studies on the effect of capital structure decisions on profitability. It should not be overlooked that different results were obtained in these studies. These differences may be due to the fact that different sectors or different periods were investigated in these studies, or there may be other reasons. In other words, there is different empirical evidence rather than a definitive finding that high debt ratios will lead to high profitability.

There exist many studies that have found a positive relationship between high borrowing rates and profitability. One of these studies is that of González and González (2012). In this study, taxes and bankruptcy costs (or financial distress costs) are shown as justification to detect a positive relationship.

Azhagaiah and Gavoury (2011) examined companies operating in the information technology sector in India. Their research states that the increase in debt ratios of these companies had significant effects on their profitability. Despite researchers concludes that these effects are negative, Gill et al. (2011) determines a positive relationship between borrowing and return on equity (for both sectors) as a result of their study on the service and manufacturing sectors in the USA.

On the other hand, there are many studies that reveal negative relationships between debt ratios and profitability in the literature. The studies by Yat Hung et al. (2002), Shubita and Alsawalhah (2012), and Çöllü (2021) can be given as examples. Yat Hung et al. (2002) examined Hong Kong construction and development companies and concluded the negative association between profitability and capital structure due to increased bankruptcy risk. Likewise, Shubita and Alsawalhah analysed Jordanian manufacturing industry firms for a period of 2004-2009 and found negatively association between debt and profitability. He explains this result with increasing credit default risk and corporate illiquidity.The paper by Çöllü results in negative relationship between debt ratios and profit, after analyzing data from 17 sectors for the years 2010-2019 in Türkiye. The study by Revathy and Santhi (2016) reveals that the increase in the debt equity ratio of the manufacturing sector in India adversely affects the profits of this sector. In the study of Herciu and Ogrean (2017), a very strong and positive relationship was found between ROE and debt-equity in the technology, health and telecommunications sectors, while it was concluded that the relationship was positive but not very strong in the energy and motor vehicles and spare parts sectors. Studies on the Turkish manufacturing industry have also been carefully examined.

In the study conducted by Avcı (2016) on the effect of capital structures of manufacturing companies traded on Borsa Istanbul in the 2003-2015 period, it was determined that both short-term debt and long-term debt have a negative and statistically significant effect on return on assets and return on equity. On the other hand, İskenderoğlu et al. (2012) found that increases in deposit(debt)/equity ratio in the Turkish banking sector have a negative effect on return on assets and return on equity. Similarly, Eriotis et al. (2002) concluded that the debt/equity ratio has a negative effect on the profitability of the firms, thus, the firms that prefer to finance their investments with equity capital are more profitable than those that finance their investments by borrowing.

Rouf (2015) revealed that the debt ratio and debt/equity ratio of non-financial companies traded on the Dhaka Stock Exchange (DSE) for the period 2008-2011 are negatively related to the return on assets (ROA). It is possible to find different results in the study by Abor (2005). In this study, a positive relationship was found between return on equity and the ratio of short-term debts to total assets, while negative correlations were found with the ratio of long-term debts to total assets. Other remark of the aforementioned study is the positive relationship between total debt ratios and return on equity. Similar to this study, De Mesquita and Lara (2003) found that return on equity (ROE) was positively correlated with short-term debt ratios, in addition, they concluded that long-term debt ratios and return on equity were negatively related.

This research provides evidence about the capital structure alternatives by using data from the Turkish manufacturing industry. Different ways in which the capital structure is managed can have a significant impact on the profitability of firms. The academic literature includes a number of studies that attempt to identify and quantify the effects of capital structure decisions on profitability. The results obtained in these researches conducted on a national and international scale are remarkable. However, in this study, a broad perspective research was carried out by taking into account all sub-sectors of the manufacturing industry sector, which was not encountered in other studies. In addition, in this study, which includes a wide period of 15 years, the dependent variable was also differentiated and an analysis was carried out not only on the return on assets but also on the return on equity. In this sense, efforts have been made to be as inclusive as possible.

3. METHODOLOGY

As this research aims to contribute to one of the significant research fields, that is, the relationship between capital structure and performance with reference to the Turkish manufacturing sector, applied econometric analysis is discussed, as well as data used. This section also includes the dependent and independent variables used in the panel data regression analysis to capture the relationship between capital structure and performance in the Turkish manufacturing sector.

3.1. Data

As the objective of the article is to evaluate the relationship between capital structure and performance in the Turkish manufacturing sector, the Panel Data (yearly) was collected from the Entrepreneur Information

System (EIS, 2023), a databank that releases consolidated balance sheets of all entrepreneurs in Türkiye, for the period from 2006 to 2020 (15 years). Using 22 manufacturing sub-sector consolidated balance sheet data, 330 observation numbers are provided in total. All analyses were carried out using Stata 14.2.

Within the scope of this research, the Turkish manufacturing industry sub-sectors have been examined. The content of Turkish manufacturing industry sub-sectors is shown in Table 1 in detail. The average number of companies operating in these sub-sectors during the research period is given in Table A1 in Appendix 1.

Table 1. The subsectors of the manufacturing industry in Türkiye

No	*Subsector Name (Manufacture of…)*
1	Food Products
2	Beverages
3	Textiles
4	Wearing Apparel
5	Leather and Related Products
6	Wood and of Products of Wood and Cork, Except Furniture; Articles of Straw and Plaiting Materials
7	Paper and Paper Products
8	Printing and Reproduction of Recorded Media
9	Chemicals and Chemical Products
10	Basic Pharmaceutical Products and Pharmaceutical Preparations
11	Rubber and Plastic Products
12	Other Non-Metallic Mineral Products
13	Basic Metals
14	Fabricated Metal Products, Except Machinery and Equipment
15	Computer, Electronic and Optical Products
16	Electrical Equipment
17	Machinery and Equipment N.E.C.
18	Motor Vehicles, Trailers and Semi-Trailers
19	Other Transport Equipment
20	Furniture
21	Other Manufacturing
22	Repair and İnstallation of Machinery and Equipment

Source: www.gbs.sanayi.gov.tr

In compliance with the related literature Vătavu (2015), Nassar (2016), Chinaemerem and Anthony (2012), Salim and Yadav (2012), El-Sayed Ebaid (2009), ROA, Return on assets (net income to total assets), and ROE Return on equity (the ratio of net income to shareholders' equity) were selected as performance indicators and dependent variables. The reason for choosing these variables as performance indicators is that they are widely used variables reflecting the performance of companies in the related literature. To research a relationship between capital structure and performance, it is used short-term debt to total assets (STTA), long-term debt to total assets (LTTA), and total debt to total assets (TDTA) as independent variables. Thus, the Natural Logarithm of the firm's Assets (LNTA), Natural Logarithm of the firm's R&D expenditures (LNRD), Natural Logarithm of the firm's net sales (LNNS) were determined as control variables in our models.

Some sub-sectors, such as the manufacture of tobacco products, were excluded from the analysis due to the unavailability of some data. The data in the EIS (2023) is given as the sum of the data of the companies in that sector as of that year. For instance, the asset size data of a sector included in the research for a certain year is the sum of the asset sizes of all companies in that sector as of that year. As the related data is given in the format of the total amount, the average values of the assets, R&D, and net sales have been calculated by dividing them by the number of firms. The average value of these variables has been used in the models as control variables in order to obtain consistent models.

Table 2. Variables and abbreviations used in the research

Abbreviation	*Variable Definition*	*References*	*Data Sources*
Dependent Variables			
ROA	Net Income/ Assets	Avcı (2016), Azhagaiah and Gavoury (2011), Chinaemerem and Anthony (2012), Çöllü (2021), El-Sayed (2009), González and González (2012), Herciu and Ogrean (2017), İskenderoğlu et. al. (2012), Nassar, S., 2016, Rouf (2015), Salim and Yadav (2012), Vătavua (2015)	EIS(2023)
ROE	Net Income/ Equity	Abor (2005), Avcı (2016), Chinaemerem and Anthony (2012), Çöllü (2021), De Mesquita and Lara (2003), El-Sayed (2009), Gill et al. (2011), Herciu and Ogrean (2017), İskenderoğlu et. al. (2012), Nassar, S., 2016, Salim and Yadav (2012), Shubita and Alsawalhah (2012), Vătavua (2015)	EIS(2023)
Independent Variables			
STTA	Short-term debt/total assets.	Avcı (2016), Çöllü (2021), El-Sayed (2009), Gill et al. (2011), Salim and Yadav (2012), Shubita and Alsawalhah (2012), Vătavua (2015)	EIS(2023)
LTTA	The long-term debt/total assets.	Avcı (2016), Çöllü (2021), El-Sayed (2009), Gill et al. (2011), Salim and Yadav (2012), Shubita and Alsawalhah (2012), Vătavua (2015)	EIS(2023)
TDTA	Total debt/total assets	Azhagaiah ve Gavoury (2011), Chinaemerem and Anthony (2012), Çöllü (2021), El-Sayed (2009), Gill et al. (2011), İskenderoğlu et. al. (2012), Nassar (2016), Revathy and Santhi (2016), Rouf (2015), Salim and Yadav (2012), Shubita and Alsawalhah (2012), Vătavua (2015)	EIS(2023)
Control Variables			
LNTA	Natural Logarithm of firm's Assets	Avcı (2016), Chinaemerem and Anthony (2012), Çöllü (2021), El-Sayed (2009), Herciu and Ogrean (2017), İskenderoğlu et. al. (2012), Rouf (2015), Salim and Yadav (2012)	EIS(2023)
LNRD	Natural Logarithm of firm's R&D expenditures	Rafiq, S. et al. (2016).	EIS(2023)
LNNS	Natural Logarithm of the firm's net sales	Abor (2005), Avcı (2016), Rouf (2015), Shubita and Alsawalhah (2012)	EIS(2023)

3.2. Method and Findings

The purpose of this analysis is to determine whether there is a relationship between the capital structure of Turkish manufacturing companies and their profitability as well as to capture the direction and severity of this relationship. To this aim, based on the findings in related literature six hypotheses are put forward:

H1: There is no relationship between the Short-Term Debt Ratio and ROA.

H2: There is no relationship between the Long-Term Debt Ratio and ROA.

H3: There is no relationship between the Total Debt Ratio and ROA

H4: There is no relationship between the Short-Term Debt Ratio and ROE.

H5: There is no relationship between the Long-Term Debt Ratio and ROE.

H6: There is no relationship between the Total Debt Ratio and ROE.

The relationship between variables was estimated by applying linear model as in Equation 1.

$$Y_{i,t} = \beta_{0it} + \beta Debt_{i.t} + \delta Control_{i,t} + \varepsilon_{i,t} \quad (1)$$

In the model, Y represents return on assets (ROA) or return on equity (ROE) for each company (i) and year (t), while Debt stands for Short-Term (STTA), Long-Term (LTTA), Total Debt Ratio (TDTA) and Control

represent LNTA, LNRD and LNNS. Where $\boldsymbol{\beta_i}$ (i=1,2,3…22) constant term for every sector, t (*t*=1,2,3…16) illustrates the year $\boldsymbol{\beta's}$ are coefficients for each independent variable $\boldsymbol{\varepsilon_{i,t}}$ is the error term. In each model was one leverage ratio included to see the impact of every single debt ratio on output, and in doing so we avoided the autocorrelation.

The econometric relationship between variables was estimated using the standard error estimator proposed by Driscoll and Kraay (1998). Driscoll and Kraay (1998) claim a panel estimation model, providing autocorrelation and heteroscedasticity consistent standard errors in the case of n>t. This estimator also ensures standard errors that are robust to conventional forms of cross-sectional and temporal dependence (Hoechle, 2007).

We can see the summary statistics of the dependent and independent variables used in the models in Table 3. As one can infer from Table 3, the average ratio of ROA is about 4 %, that is, the Turkish manufacturing sector uses its assets efficiently. Considering the value of ROE, another indicator gives us information on how efficiently equity is used in firm activities, it is in alignment with ROA. The Standard deviation for ROA and ROE are calculated as 0.032 and 0.073 respectively. The higher standard deviation of ROE displays different responses among subsectors in terms of ROE. As ROA has a fewer standard deviation, similar behaviour is shown between subsectors regarding ROA. The variable TDTA is the leverage ratio that refers to what extent firms' assets are financed by debt. Considering the ratio of 62%, it can be stated that manufacturing firms in Türkiye prefer liabilities in general. In detail, with an average mean of 45 % the share of short-term debts in total resources is higher. The mean of long-term debt is just 16 %. The standard deviation of TDTA is 0.078, indicating capital structure decisions are changing among subsectors. It may be that some subsectors have limitations in accessing debt finance. The other control variables used in the models are in logarithmic form and range from 8% to 15%. All control variables have high figures for standard deviation, since subsectors of the Turkish manufacturing industry have different features in terms of total asset, R&D capacity, and net sales volume.

Table 3. Descriptive statistics

Variables	*N*	*Mean*	*Std.Dev.*	*Min*	*Max*
STTA	330	0.450	0.077	0.207	0.601
LTTA	330	0.164	0.058	0	0.358
TDTA	330	0.615	0.078	0.359	0.791
ROA	330	0.038	0.032	-0.123	0.160
ROE	330	0.098	0.073	-0.183	0.331
LNTA	330	15.69	1.089	13.37	18.18
LNRD	330	7.812	4.368	0	15.02
LNNS	330	15.61	1.031	13.44	18.10
Number of groups	22	22	22	22	22

Table 4 represents the correlation coefficient between variables, used in the models. As expected, the correlation is high (0.84) between performance indicators, ROE, and ROA respectively. However, we use only one performance indicator as a dependent variable in the regression models, this problem does not affect the robustness of the models. On the other hand, negative correlations can be observed between debt ratios and ROA, while positive correlations occur between ROE and debt ratios, except for short-term debt.

Table 4. Correlation matrix

Variables	*ROA*	*ROE*	*STTA*	*LTTA*	*TDTA*	*LNTA*	*LNRD*	*LNNS*
ROA	1							
ROE	0.840	1						
STTA	-0.165	-0.047	1					
LTTA	-0.007	0.192	-0.372	1				
TDTA	-0.170	0.096	0.718	0.377	1			
LNTA	0.322	0.430	-0.537	0.667	-0.035	1		
LNRD	0.245	0.389	-0.094	0.361	0.176	0.466	1	
LNNS	0.370	0.465	-0.480	0.539	-0.075	0.957	0.496	1

Control variables indicate positive correlations with ROA and ROE, therefore it is expected that asset size, net sales, and R&D expenditures have a positive impact on performance in the Turkish manufacturing sector. The figures in Table 4 show that the size, net sales, and R&D expenditures are positively correlated with the performance indicators. This means that those figures move in the same direction. To avoid the multicollinearity problem, it was checked by VIF (Variance İnflation Factor). As panel data is used in our analysis, it is important to consider whether cross-section dependency exists between panel units. Cross-section dependency (CD) is the fact that cross-section units are affected by each other in case of a shock

to which the series is exposed. Additionally, following the related literature, it determines the unit root test which is applied to the series. In the case of CD, it is recommended to apply second-generation unit root tests. Thereby, we started our empirical approach by researching the existence of CD and employed the CD test, recommended by Pesaran (2004) to test CD. Pesaran (2004) proposed an alternative version of the Breausch-Pagan LM test in the case of $t < n$. It uses the formula in Equation 2.

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{j=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \quad (2)$$

Table 5 illustrates the results of the CD test for variables. We reject the null hypothesis for all variables, stating that there is no CD, that is, it provides strong evidence of the existence of CD. As a result, we accept the existence of CD. In other words, a shock that occurred in one of the sub-sectors seems to affect other sub-sectors.

Table 5. Cross-section dependency test

Variables	*CD-Test*	*Probability*
ROA	13.70***	0.000
ROE	26.52 ***	0.000
STTA	15.16***	0.000
LTTA	28.95***	0.000
TDTA	37.86 ***	0.000
LNTA	56.97 ***	0.000
LNRD	25.03 ***	0.000
LNNS	56.20***	0.000

As we have the CD in our models, we continued with the second-generation unit root test, taking into account the cross-section dependency developed by Pesaran (2007). According to the results illustrated in Table 6, we reject the null hypothesis for all variables except for TDTA, LNTA, and LNNS. However, considering the results of the Harris-Tzavalis (HT) and Levin, Lin, and Chu (LLC) tests which can also be used under CD by adjusting first-generation unit root tests, it is supposed that all variables have stability in I(0).

Table 6. Unit root tests

Variables	*CADF test ist*	*Probability*	*HT Test*	*Probability*	*LLC*	*Probability*
ROA	-2.945***	0.000	0.093***	0.000	-8,37***	0.000
ROE	-2.866***	0.000	0.174***	0.000	-8.99***	0.000
STTA	-2.041***	0.000	0.621***	0.000	-5.37***	0.000
LTTA	-2.615***	0.000	0.499***	0.000	-4.59***	0.000
TDTA	-2.020*	0.100	0.684***	0.000	-3.51***	0.000
LNTA	-1.847	0.294	0.673***	0.000	-1.458*	0.073
LNRD	-3.332***	0.000	0.166***	0.000	-23.3***	0.000
LNNS	-1.770	0.415	0.747**	0.050	-2.61***	0.004

***, p<0.01; **, p<0.05; *, p<0.1

Note: HT and LLC tests are implemented to the series created by taking the difference from the cross-sectional averages. In this way, the effect of CD is decreased (Tatoğlu, 2017).

To determine whether an individual effect occurs in the models, the F test (all u_i=0) (given Table 8 and Table 9) was employed and since the prob value is less than 1%, the null hypothesis has been rejected, stating that all models have a cross-section effect. Subsequently, the Hausman test (Table 7) was used to decide between fixed and random effect methods. As the prob. value is less than 1% significance level for all models, we apply one-way fixed effect model estimation in our analysis.

Table 7. Hausman Test

Model	*Chi-Square Statistics*	*Probability*
1	20.27	0.0004
2	24.41	0.0001
3	49.81	0.0000
4	61.85	0.0000
5	63.97	0.0000
6	77.29	0.0000

Tables 8 and Table 9 reveal the results of regressions aiming to investigate the relationship between performance and capital structure, as well as control variables, size, sales, and R&D expenditure. In both tables, the prob value of the F test statistic is less than 1% and significant. These results show the validity of the models. The value of the R-square illustrates the percent of the variation explained by independent

variables. The figures for R-square are 0.12, 0.19, and 0.21 respectively for the first three models. The following models have the value of 0.34, 0.35, and 0.40 respectively. As one can see from the tables, model 6 has the biggest magnitude for R-squared among all models, proving that 0.40 variation in ROE is explained by independent variables.

The results of Table 8 illustrate the models when the return on asset is the dependent variable. In Model 1, it has been found that short-term debt has a negative relationship with ROA, but the coefficient of STTA is insignificant. This is the only coefficient that we have found insignificant at 10% significance level. As for long-term debt (model 2), it is significantly and negatively correlated with the dependent variable at the 1% significance level, indicating that an increase of 1 unit in long-term debt led to a decrease of 0.31 units in the performance proxy. Similarly, the total debt ratio (TDTA) is also significantly and negatively correlated with ROA, but the coefficient value is slightly different from that of Model 2.

Table 8. Regression Results with DK Standard Errors (Dependent Variable: ROA)

Variable	*Model 1*	*Model 2*	*Model 3*
STTA	-0.124		
	(0.078)		
LNTA	-0.057***	-0.024*	-0.051***
	(0.014)	(0.012)	(0.014)
LNRD	-0.001	0.000	0.000
	(0.000)	(0.001)	(0.001)
LNNS	0.083***	0.055***	0.089***
	(0.015)	(0.012)	(0.016)
LTTA		-0.314***	
		(0.057)	
TDTA			-0.262***
			(0.030)
Constant	-0.293***	-0.387***	-0.394***
	(0.065)	(0.082)	(0.053)
Prob > F	0.0000	0.000	0.000
R-squared	0.1280	0.1929	0.2118
Observations	330	330	330
Number of groups	22	22	22
F-ind(all u_i=0)	3.38***	3.47***	4.76***
Cd Test (Pesaran, 2004)	33.77(0.000)	21.31(0.000)	28.57(0.000)
Autocorrelation			
Modified Bhargava et al. DW	1,736	1,782	1,798
Baltagi-Wu LBI	1,850	1,908	1,904
Heteroskedasticity			
chi2 (22)	1911,88***	1601,4***	3470,86***
Multicollinearity			
VIF	7,17	10,09	6,93

Robust standard errors in parentheses.
***, p<0.01; **, p<0.05; * p<0.1

Similar to Table 8, Table 9 illustrates the figures for other models, however, they have ROE as the independent variable. There is a negative relationship between all capital structure ratios and ROE. The coefficients of the variables are significant at 5% and 1% significance levels. This can be justified by the fact that debt financing is more expensive than equity financing.

As a result of this, an increase in both short and long-term debt leads to a decrease in profitability. Different from Model 1, the coefficient of STTA is significant at 5% level and negatively correlated with ROE in that case. In other words, it can be stated that an increase of 1 unit in short-term debt results in a 0.4 decrease in profit. Likewise, other leverage ratios have the value of 0.50 and 0.56 respectively. Those figures are negatively and significantly correlated with ROE.

As we used control variables consistent with the literature in order to reflect sub-sector characteristics and to capture more reliable results in the regression models, we can measure the effect of those control variables net sales, total assets, and R&D on the performance variables.

In all models, it can be observed that as a proxy of size, net sales, have a positive and significant correlation with the dependent variables used. Depending on the net sales of sub-sectors, an increase in net sales leads to an increase in performance proxies. However, both ROA and ROE decline with increasing Total assets. This result indicates that total assets affect performance in the Turkish manufacturing sector

negatively. Therefore, we could not find any significant effect of R&D on performance, which may be due to a lack of data.

Table 9. Regression results with Driscoll-Kraay standard errors (Dependent Variable: ROE)

Variable	*Model 4*	*Model 5*	*Model 6*
STTA	-0.397**		
	(0.155)		
LNTA	-0.137***	-0.066*	-0.111***
	(0.034)	(0.033)	(0.026)
LNRD	0.000	0.001	0.001
	(0.001)	(0.001)	(0.001)
LNNS	0.229***	0.160***	0.227***
	(0.036)	(0.030)	(0.028)
LTTA		-0.505***	
		(0.147)	
TDTA			-0.558***
			(0.074)
Constant	-1.158***	-1.291***	-1.362***
	(0.172)	(0.236)	(0.148)
Prob > F	0.000	0.000	0.000
R-squared	0.346	0.355	0.401
Observations	330	330	330
Number of groups	22	22	22
F-ind(all u_i=0)	5.59***	6.44***	7.96***
Cd Test (Pesaran, 2004)	46.31(0.000)	41.58(0.000)	39.96(0.000)
Autocorrelation			
Modified Bhargava et al. DW	1,705	1,677	1,687
Baltagi-Wu LBI	1,887	1,910	1,892
Heteroskedasticity			
chi2 (22)	864,77***	1273,17***	1206,12***
Multicollinearity			
VIF	7,17	10,09	6,93

Robust Standard errors in parentheses
***, p<0.01; **, p<0.05; *, p<0.1

Lastly, we checked the robustness of the models. To test autocorrelation, we used Durbin-Watson and Baltagı-Wu. İt is stated that if Durbin-Watson factors are close to 2 we can assume that there is no autocorrelation problem. Therefore, the Modified Wald test was applied to Models, and due to the fact, that for all models we have the prob. value below 1% we do not reject H0 and accept that models suffer from heteroskedasticity. Another diagnostic test that one needs to consider to avoid biases in regression model estimations is the Multicollinearity problem which occurs if the independent variables in the model are correlated. As seen in Table-8 and Tablo-9, the values of VIF (Variance Inflation Factor) are less than 10, assuming that the models do not have severe multicollinearity (Midi et al.,2010; O'brien, 2007).

4. CONCLUSION

The correct selection and efficient use of financial resources of any company may have a positive impact on its profit, by ensuring financial efficiency. Some assets belonging to the company can be financed by the short-term, while others can be financed by long-term financing sources. Similarly, some assets may be financed by long-term external sources of financing, while some assets may be financed by long-term internal sources of financing. All the financial decisions mentioned here have the potential to directly affect profitability, which is one of the most important indicators of company efficiency. In this context, the reflection of financial decisions on efficiency can be measured over profit. In a different way, "financial efficiency and effectiveness" can be monitored through the impact of alternative financing sources on profit.

The capital structure decisions of the companies are one of the decisions that are emphasized in financial management, and their reflection on the operating results should be followed in terms of resource efficiency. It is a matter of deciding on a combination of debt and equity, taking into account capital structure, maturity, and cost. It may be possible to increase profitability by making effective financial structure decisions. For financial efficiency, finance managers need to decide on the optimum mix of resources because the optimum capital structure (or mix of resources) can positively affect the company's financial efficiency and increase its profitability.

In this paper, a panel data set covering the years 2006-2020 has been analyzed to investigate the nexus between capital structure decisions and the performance of manufacturing industry companies operating in Türkiye, by applying the Driscoll-Kraay panel data model. The results show that the debt level, and the maturity of the debt (long-short term) affect the profitability level of the companies significantly. All debt ratios (short, long, and total debt) included in models negatively affect a company's ROA and ROE. Except for H1, the results provided from this panel data analysis reject the other (h2, h3, h4, h5, h6) hypothesis, that is, we accept the alternative hypothesis stating that there is a negative and significant relationship between debt ratios and profitability for both performance proxies, ROA, and ROE. As we were unable to find any significant relationship between the short-term debt ratio and ROA, H1 cannot be rejected. Regarding the control variables, we concluded that net sales have a positive and significant correlation with profitability, whereas total assets were negatively significantly affected by the increase in leverage ratios. R&D variable has no significant effect on performance. The results are consistent with the studies of Shubita and Alsawalhah (2012), Çöllü (2021), and Yat Hung et al. (2002); but inconsistent with the paper of Gill et al. (2011). Also, Eriotis et al. (2002), who found that companies operating with more debt will be less profitable. Revathy and Santhi (2016), who concluded that a high debt-equity ratio will have a negative effect on profitability, produced results parallel to their studies.

On the one hand, debt financing provides companies with tax advantages as the interest on debt can be tax deductible, on the other hand, using excessive debt leads to the possibility of default risk for financial institutions. In case of default risk, using debt can be more expensive for companies. So, it is in favor of companies to use debt until they reach the optimal financial structure. In the Turkish manufacturing sector, inefficient use of funds or more expensive loan conditions may explain the negative relationship between capital structure and profitability. Based on this research paper's results, it is recommended that Turkish firms in the manufacturing sector should use more equity rather than debt to increase profitability and financial efficiency. Additionally, the companies should focus on increasing net sales to contribute to profitability. Overall, we can infer from this study that both the maturity of debt, and the capital structure have a significant impact on profitability. In that sense, the correct management of capital structure will also increase financial efficiency.

This study is limited in that it considers just Turkish manufacturing companies. The findings of the study cannot be generalized for other developing countries, or sectors. This study can be extended using different samples, sectors, or countries as well as different control variables. It is thought that the research findings will provide useful information to the owners and finance managers of financial institutions and manufacturing industry companies.

Author Contributions
Batuhan Özdemir: Methodology, Modeling, Analysis, Article Writing-original draft, Modelling *Özgür Özel*: Literature Review, Conceptualization, Data Curation, Article Writing-review and editing.

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It was declared by the authors that the tools and methods used in the study do not require the permission of the Ethics Committee.

Ethical Statement
It was declared by the author(s) that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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APPENDIX

Table A1: Türkiye Manufacturing industry sub-sectors and the average number of companies they include

No	*Subsectors of the Manufacturing Industry*	*Average number of companies in the sector (2006-2020)*
1	Food Products	17.810
2	Beverages	595
3	Textiles	11.576
4	Wearing Apparel	16.744
5	Leather and Related Products	3.925
6	Wood and of Products of Wood and Cork, Except Furniture; Articles of Straw and Plaiting Materials	4.888
7	Paper and Paper Products	2.442
8	Printing and Reproduction of Recorded Media	6.531
9	Chemicals and Chemical Products	4.902
10	Basic Pharmaceutical Products and Pharmaceutical Preparations	444
11	Rubber and Plastic Products	9.731
12	Other Non-Metallic Mineral Products	8.283
13	Basic Metals	4.027
14	Fabricated Metal Products, Except Machinery and Equipment	19.782
15	Computer, Electronic and Optical Products	1.170
16	Electrical Equipment	4.855
17	Machinery and Equipment N.E.C.	11.298
18	Motor Vehicles, Trailers and Semi-Trailers	3.347
19	Other Transport Equipment	917
20	Furniture	10.183
21	Other Manufacturing	7.401
22	Repair and İnstallation of Machinery and Equipment	8.181

Source: www.gbs.sanayi.gov.tr (Entrepreneur Information System)

The Relations between Digitalization, Service Innovation and Service Value Creation Capability: A Model Adaption in the Service Industry

Mune Moğol Sever[1]

ABSTRACT

***Purpose*:** The purpose of this paper is to determine the effect of service innovation and service value creation capability on the digitalization process on a firm scale.

***Methodology*:** The 1-7-point Likert-type measurement scale was administered to tourism enterprise managers and operational staff. Partial Least Square-Structural Equation Modelling (PLS-SEM) modeling was used to analyze the relationships among the following constructs: service innovation capability, service value creation capability, and effect on digitalization. Three types of service facilities were considered: Hospitality, Food & Beverage (F&B), and health care. Descriptive analysis and model structure were analyzed on SPSS 24 and Smart PLS 3.0 respectively.

Findings: The relationship between service value creation capability and digitalization service innovation capability and service value creation capability, and service value creation capability and digitalization is supported, as all other constructed hypotheses respectively.

Originality: This study is one of a limited number of studies that have empirically addressed service innovation capability and value creation capability relations with digitalization in firms' operational processes. Additional attempt is required to integrate all functions of the enterprise with in organizational perspective. The main contributions of this paper lie in proposing empirical research that supports service innovation capability, service value creation capability, and digitalization in the case of tourism enterprises.

Keywords: Digitalization, Service Value Creation Capability, Service Innovation Capability, Tourism.

JEL Codes: Z3, L8, L83, M15.

Dijitalleşme, Hizmet İnovasyonu Kabiliyeti ve Hizmet Değeri Yaratma Kabiliyeti Arasındaki İlişki: Hizmet Endüstrisi İçin Bir Model Uyarlaması

ÖZET

Amaç: Bu çalışmanın amacı, hizmet inovasyonu ve hizmet değeri yaratma kabiliyetinin dijitalleşme sürecine etkisini firma ölçeğinde belirlemektir***.***

***Yöntem*:** 7'li Likert ölçeğiyle geliştirilmiş ölçüm aracı, turizm işletmesi yöneticilerine ve işletme çalışanlarına uygulanmıştır. PLS SEM modellemesi, şu yapılar arasındaki ilişkileri analiz etmek için kullanılmıştır: hizmet inovasyon kabiliyeti, hizmet değeri yaratma kabiliyetinin ve dijitalleşme üzerindeki etkisi. Çalışmada üç tür hizmet tesisi göz önünde bulundurulmuştur: Konaklama, yiyecek-içecek ve sağlık hizmetleri. Betimleyici istatistikler ve model yapısı SPSS 24 ve Smart PLS 3.0'da analiz edilmiştir.

Bulgular: Hizmet değeri yaratma yeteneği ve dijitalleşme, hizmet yeniliği yeteneği ve hizmet değeri yaratma yeteneği, hizmet değeri katlama yeteneği ve dijitalleşme arasındaki ilişkiler ve kurulan tüm diğer hipotezler sırasıyla doğrulanmıştır.

Özgünlük: Bu çalışma, işletmelerin operasyonel süreçlerinde dijitalleşme ve hizmet inovasyon kabiliyeti ve değer yaratma kabiliyeti arasındaki ilişkiyi ampirik olarak ele alan sınırlı sayıdaki çalışmadan biridir. Bu çalışmanın, turizm işletmelerinde hizmet inovasyon kabiliyeti, hizmet değeri yaratma kabiliyeti ve dijitalleşme arasındaki ilişkiyi destekleyen ampirik bir araştırma olması açısından önemli olduğu düşünülmektedir.

Anahtar Kelimeler: Dijitalleşme, Hizmet Değeri Yaratma Kabiliyeti, Hizmet İnovasyon Kabiliyeti, Turizm.

JEL Kodları: Z3, L8, L83, M15.

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1. INTRODUCTION

Digitalization and digital transformation have been a buzzword recently. Although it became popular after the last pandemic, the phenomenon is still so much to say about it. It is more than a fashion; it has a function to create a new value for enterprises to change their business models. After the structure of advanced economies shifted from manufacturing towards service industries the importance of innovation, R&D, and investing in digital technologies became a more important issue in case of increasing productivity (Hall, 2011). Moreover, the service value creation and innovation capability of enterprises is still an issue to put on the agenda.

The structure of the service industry especially the tourism industry and most of its sectors are labor intensive. Any abnormal changes in participating in the work affect the productivity negatively. In order to minimize this negative effect investing in digital assets has become crucial subject than ever. Moreover, the upcoming digital economy and digitalization on a firm scale have a positive effect on productivity in a firm scale. Besides, the capability of value generation in this digitalization process is an issue to be considered on the digitalization process. Accepting all, enterprises should know their ability or capability on digitalization of utilizing service value creation capability and innovation capability to invest in digitalization. Investing in digital technologies has resulted in an increase in productivity efficiency and modularity in business operations in an enterprise (Tuunanen and Cassab, 2011; Voss and Hsuan, 2009; Cenamor et al., 2017; Opresnik and Taisch, 2015).

Service innovation capability of a firm means the ability to come up with new ideas, and knowledge to leverage the firm within the competitive environment (Parashar and Singh, 2005). Service innovation creates new services, products, and combinations of both for value-adding to a firm's scale (Parida et al., 2015; De Brentani and Ragot, 1996). An increase in service innovation in products and processes has resulted in increased performance of enterprises (Martinez-Roman et al., 2015; Örmeci and Öcal, 2023). The increase in overall performance directly results in a productivity improvement (Grünberg, 2004).

Utilizing new technologies results in value creation in organizations' processes or the generation of new business models (Corsaro and Anzivino, 2021). Service value creation capability and digitalization relations were handled by scholars under these subjects; implementation of IT Technologies (Dominguez-Pe´ry et al., 2013), digital technology adaption (Cenamor et al., 2017), strategy (Möller et al., 2008), value creation in B2B digital context (Corsarao and Anzivino, 2021), value offering, performance and customer satisfaction (O'Cass and Ngo, 2011), tangible technologies (Maglio and Spohrer, 2008; Häikiö and Koivumäki 2016), service value creation capability for an enterprise from an operational perspective (Nada and Ali, 2015). In operational meaning, the service value creation capability is dealt with under service process management, service performance management, and IT infrastructure (Nada and Ali, 2015). This study was discussed based on the operational processes of the service business.

After a detailed literature review, it was seen that there was a gap between service value creation and service innovation capability effect on digitalization and that there were rare studies in this area. This study tries to unpack the digitalization, service innovation, and service value creation concepts in the case of tourism enterprises. The main aim of this study is to reveal and measure the effect of service value creation capability and innovation capability of a firm on digitalization. The study also investigates the relationship between Information Technology (IT), Performance, process management of a firm, and service value creation capability. This study is novel for considering the ability of a firm to take a digital journey in case innovation capability and service value creation capability from an operational perspective. The study is original because of handling the subject in the tourism industry, one of the sectors most prone to the use of digital technology. The paper is organized as follows. In section 1 the digitalization, relations with service innovations and service value creation capability, the importance and the role of digitalization as a triggering force in I4.0, service innovation and service innovation capability, service value creation capability and implementation in service and especially tourism industry is discussed broadly. In sections 2 and 3 an empirical model is explained and tested statically to show the acceptance/ rejection of constructed hypothesis. Lastly, two parts of the study consist of the interpretation of the results and the discussion of the evidence for future recommendations.

2. THEORETICAL BACKGROUND and LITERATURE REVIEW

Digitalization is the main devastating force triggered by Industry 4.0 (I 4.), which has changed the way of doing business and forced businesses to think about new business models (Parida, 2018: 23). B2B mainstream has an effect in increasing e-services and digitalization. Digital services and channels soared after the implementation of B2B models (Oliveira and Roth, 2012). The idea behind directly reaching the client without any mediator has resulted in thinking more broadly on the digitalization phenomenon.

Accepting digitalization and the level of digital transformation are not the same in each industry and sector. Digitization speed and acceptance level are higher in human-intensive sectors like service industries than the capital incentive sectors because of the technological infusion and its effect on humans (Andrews et al., 2018). Including human capital, digitalization, and reaching maturity in digitalization requires the investment in infrastructure in IT like servers, software, analytic tools, etc. (Parida et al., 2015). Thus, digital technology adoption resulted in increased enterprise value, maximized profitability, decreased operational costs and reduced middleman, and increased operational efficiency and productivity (BarNir et al., 2003; Benjamin and Wigand,1995; Gallaugher, 1997; Gago and Rubalcaba, 2006). Tangible Technologies and technology-oriented approaches are accepted as an integral part of service value creation and innovation (Maglio and Spohrer, 2008; Häikiö and Koivumäki, 2016). This technology-driven approach is now termed digitalization.

Digitalization capability is directly related to the ability to use advanced smart and connected physical products to facilitate service innovation. Besides, innovation orientation directly affects digitalization in processes, products, and services and entirely in organizations (BarNir et al., 2003). Service-dominant logic, servitization, and digitalization are accepted as megatrends and important tools in the generation value-generation process (Häikiö and Koivumäki, 2016). In other words, an increase in service innovation capability results an increase in value creation (Parida et al., 2015).

Furthermore, digitalization and value creation have positively related to and implementation of digital technologies to reach the demand of mass customization and resulted in an increase in productivity efficiency and modularity in business operations in an enterprise (Tuunanen and Cassab, 2011; Voss and Hsuan, 2009; Cenamor et al., 2017; Opresnik and Taisch, 2015).

2.1. Service Innovation Capability

Innovation is the idea of creating a new process, product, or service as a powerful tool to meet customer needs, and increase service quality (Rogers, 2004; Fitzsimmons and Fitzsimmons, 1999: 106). It is accepted as a major force propelling economic dynamics (Carlsson, 2007) and bundling relevant and different resources, and knowledge to create a new powerful, and useful resource and knowledge (Lusch and Nambisan, 2015; Parashar and Singh, 2005).

Innovation was described as a multidimensional phenomenon. Thus, deploying the typology of innovation helps to understand and explain the subject broadly. According to OECD and Eurostat, innovation can be subdivided into two groups: technological innovation and non-technological innovation. Technological innovation is improvement comprised of product and process innovations while nontechnological innovations deal with organizational and marketing innovation (Opazo-Basaez et al., 2021). Digitalization can be handled in both cases but it is rather closer subject to product & process innovation or operational innovation which is accepted as an issue of this study. Additionally, it is stated that knowledge is fed by innovation capability, because the and innovation capability provides instant and accurate access to information (Gulyaz and Erturk, 2020). Real-time data and instant access to the data is the core function of every digital system. Thus, it can be concluded that the company's innovation ability has a direct impact on digitalization.

Innovation in service industries or service innovation is accepted as the most powerful tool to fight commoditization. Because of the structural characteristics of service industries, there is no physical product in most of the cases. The innovation in service is easier, more comfortable, and less time-consuming than the physical product comparable, because of the patents, commercial rights, shorter product life cycle, and less capital investment (Lyons et al., 2007).

Service innovation offers the potential to create new services, products, or combinations of value-adding to a firm’s scale (Parida et al., 2015; De Brentani and Ragot, 1996). Service innovation capability is accepted as the ability to come up with new ideas, and knowledge to leverage the firm within the competitive environment (Parashar and Singh, 2005). Service innovation capability is important for hotels whether to meet customer requirements or exceed them. However, its importance, and enhancing service innovation is still a gap in the tourism area. Studies related to service innovation in tourism emphasize the importance and mediating effect of social capital, and knowledge, in the whole process (Tang et al., 2015). Also, tourism and innovation studies are limited in the success of the innovation process, factors influencing the process, and performance results after new service innovation (Ottenbacher and Gnoth, 2005). In another study scholars have developed a three phase to simplify the process of service innovation capability such as: sensing, seizing & transforming (Pöppelbuß et al., 2011). In the sensing phase, the idea, itself should be scanned, evaluated, and detailing. In other words, it is the step of understanding the issue. In the seizing phase, it is focused on the solution more than identification. In the transforming phase, the idea has already been understood, hashas acted for a solution and now it consists also unfreezing, changing, and freezing steps.

Service and tourism studies are mostly related to service innovation. However, in order to overcome the innovation process in firm operations, innovation capability should be defined and assessed. Innovation capability directs the firm to new products, process, and techniques (Yousaf et al., 2022). Innovation from in operational perspective resulted in; improving high speed to deliverables, improving computational capabilities, reducing deployment cost, supporting identity management functionalities, improving data security reliability of digital processing capability, productivity, improving real-time response to customer feedback, quality improvement, customization of operational processes, services and products (Edu et al, 2020). Innovation capability and technological innovation directly affect the performance of the firm. An increase in innovation in products and processes is resulted in increased performance of enterprises (Martinez-Roman et al., 2015; Örmeci and Öcal, 2023). Thus, the hypothesis is;

H1: digitalization and service innovation capability positively related to digitalization

H3: service innovation capability and service value creation capability are positively related

2.2. Service Value Creation Capability

Value creation is a redesigning of the process, product, and strategy of an enterprise to meet customers' experimentation (O'cass and Ngo, 2011; Martin et al., 2019). Customers' needs and demands are accepted as de facto in the value creation process (Grönroos, 2011; Vargo and Lusch, 2008). This value-creation process cannot be successful regarding the digital instrument, of which has a direct effect on digitalization (Schroeder and Kotlarsky, 2015). The increased use of new technologies and digital instrument facilitate adaptation to the Industry 4.0 revolution (Karaata, 2021). Besides, ongoing trends on servitization and blending servitization into an operational process to create new generating revenue-generating areas is linked with digitalization and digital instruments (Vendrell-Herrero et al., 2014; Vandermerwe and Rada, 1988).

Service value creation and innovation capability are directly related elements and innovation capability is accepted as a crucial and critical factor in the service value creation process (Hogan et al., 2011; Saunila, 2016; Pöppelbuß et al., 2011; Häikiö and Koivumäki, 2016). Using innovative technologies results in value creation in organizations' processes or the generation of new business models (Corsaro and Anzivino, 2021).

Implementing any Information Technologies (IT) to upgrade the service and processes in the service area which is called IT-driven service innovation using digital technologies mostly results as value creation on a firm scale (Dominguez-Pe´ryet al., 2013; Fitzgerald et al., 2014). It is realized by means of the service value creation ability of enterprises.

Service value creation capability and digitalization concepts are fall between IT-driven service innovation and implementation of IT Technologies (Dominguez-Pe´ryet al., 2013; Mahmoud et al., 2017), digital technology adaption (Cenamor et al., 2017), strategy (Möller et al., 2008), value creation in B2B digital context (Corsarao and Anzivino, 2021), value offering, performance and customer satisfaction (O'Cass and Ngo, 2011). Service value creation capability for an enterprise from an operational perspective can be classified as service process management, service performance management, and IT infrastructure (Nada and Ali, 2015). In this study, the service value creation capability is examined in the case of enterprise operational capability. Therefore, the hypothesis is;

H2: digitalization and service value creation capability positively related

H4: service value creation capability and IT infrastructure are positively related

H5: service value creation capability and service performance management are positively related

H6: service value creation capability and service process management are positively related.

Under the comprehensive search on service value creation capability, innovation capability, and effect on digitalization, the study tries to fill the gaps on service value creation capability and innovation capability effect on digitalization for tourism industries. The study is also focused on the relationship between process management, performance, and IT and service value creation capability.

3. METHOD

Study grounded to service value creation capability and innovation capability models. It is a section cross-section of tourism enterprises in three sectors: hospitality, food& beverage, and healthcare facilities. In the model exogenous variable is digitalization which is affected by two endogenous variables; service value creation capability and service innovation capability.

3.1. Sampling

Stratified random sampling is used in this study. If the population is heterogeneous the stratified sampling methods should be implemented. In stratified sampling whole population is divided into a homogenous subgroup, known as strata, and the units of each subgroup is chosen randomly (Singh and Masuku, 2013). It is the method of increasing efficiency by means of increasing sample size (Arnab, 2017: 107). In stratified sampling, you dealtdeal with the bigger heterogeneous subgroups (but homogenous inside the group), rather than one homogenous small sample size. Besides, the random selection inside each stratum provides the researcher with statistical inference and generality to a population. Subgroups might be based on selected factors depending on the research such as company size, sector, occupation, etc. (Taherdoost, 2016). Eventually, in stratified sampling, the sample size is smaller, it is less costly and samples within the strats are more homogenous than the other random sampling methods (Neuman et al., 2011).

The tourism industry consists so many sectors and branches. The study is dealt on three of the most revenue-generating heterogeneousheterogeneous tourism sectors: hospitality, food & beverages, and health. Therefore, there are three strats. The criteria for deciding stratums are their business type, products, and services. The number of samples in each stratum will be chosen proportionally considering the weight of each stratum in the population. Random selection principle will be considered to assign to each subgroup. The number of samples for exploratory studies depends on the number of variables. Depending on the complexity of the study and structural design it is common to have at least *20 observations for each variable. Besides, if the construct is fewer than 7 the minimum number of the sample size is suggested to be 150 (Hair et al., 2010: 662). In order to decide the proportion, the number of facilities in a city (Eskişehir) should be considered. Each strats is summarized on Table 1.

Table 1. The # of facilities and proportion for each strats

*Strats**	*The #of units in each strats*	*The proportion of each strats (%)**	*Sample size of each strats*
Hospitality	19	34	68
Food & Beverage	27	48	96
Health care facilities	10	18	36
Total	56	100	200

*: according to the proportion sampling methods, the proportion is each strats is calculated as: (34/56) *100 for hospitality and rest is calculated respectively.

The number of hospitality facilities is 19, and the number of food and beverage facilities is 27 calculated as an enterprise that has a certificate of the Ministry of Culture and Tourism (The Ministry of Culture and Tourism, 2023). the number of tourist arrivals, especially from the Middle East, to the city is increasing catastrophically for medical (health and wellness) purposes. In the selection of healthcare facilities, the main consideration is determining if the facility has involved any process or department providing a service for medical tourists or not. The private & public hospitals, beauty & wellness centers and physical treatment/therapy facilities are subjected to this study as care facilities. As accepted sample size for these 6 variable studies is 120 (6*20-Hair et al., 2010). Respecting scientific notions but to increase the generality, the number of 438 participants is subjected to in this study. The stratified sampling principle is only used to allocate the enterprises into a homogenous subgroup. The stratified samples will be considered as one sample in further analysis and explaining the results.

3.2. Measurement Scale

The measurement scale consists of six sections. Sections 1 and 2 consist of demographic information, Section 3 items adapted from Oliviera and Roth, 2012; Section 4 items from Rabetino et al. (2017); Section 5 items from Martinez-Roman et al., (2015) (items 1-6); from Grawe et al., (2009) (items 7-10); from Panayides, (2006); from Vicente et al., (2015) (articles 11-12); Section 6 from Häikiö and Koivumäki (2016); Mahmud et al, (2016). All questions were translated into Turkish.

To approve scope and face validity a face-to-face interview was executed to have an expert opinion between 15.02.2023 and 20.02.2023 a group of 5 experienced academicians and sector representatives. Besides, reliability and validity tested by conducting a pilot study between 23.02.2023 and 28.02.2023 after necessary corrections the measurement scale will be implemented.

3.3. Data Gathering

The pilot study was conducted between 23.02.2023 and 28.02.2023 and after a few changes data was collected between 15.04.2023-15.05.2023 from a senior & executive manager in facilities. Besides, the study is mainly focused on operational structure and service processes in the facility, so, data also will be collected from the operation personnel who are the main owners of the processes and who are the people doing the job at the operational level.

4. RESULTS

The PLS-SEM model is best to meet Maximum Likelihood Estimation requirements and is an appropriate tool to test if the construct consists of reflective and formative structures together and if normality conditions fail (Fornell, 1981). This study failed in normality tests. Thus, the PLS-SEM model will be used and tested with Smart PLS software. Smart PLS is reliable software in which reflective and formative structures can created and tested in the same model while the data is not normally distributed. SPSS 24 and Smart PLS 3.0 is used in this study for analyzing descriptives and model structure.

Demographic results for participants are summarized in Table 2. As indicated 51.5 % of the participants are female, 37.1 % of participants are between age 36-45, 34.1 % of them are between age 20-35 and 28.8 % of participants fall between age 46-60 which are supposed to be executives and senior managers.

Table 2. Demographic variables

		Frequency	*%*
Age	20-35	149	34.1
	36-45	162	37.1
	46-60	126	28.8
Gender	Male	212	48.5
	Female	225	51.5
Education	Primary school	54	12.4
	Secondary school	70	16.0
	High school	226	51.7
	Bachelor	83	19.0
	Postgraduate	4	0.9
HR Profile	Operational staff	264	60.4
	Senior manager	124	28.4
	Executives	49	11.2
Capacity of Enterprise	1--50	60	13.7
	51-100	366	83.8
	101-500	11	2.5
The # of Personnel	1-10	88	20.1
	11-30	250	57.2
	31-100	74	16.9
	101-500	25	5.7

Most of the participants graduated from high school (51.7 %) and worked as operational staff (60.4 %). the highest record for the capacity of enterprises is 83.8 % which has the capacity of visitors between 51-100. The number of personnel working in enterprises fall between 11-30 with a 57.2 % percentage in all sample. The study consists of six variables. The relationship between the variables and model structure is shown in Figure 1.

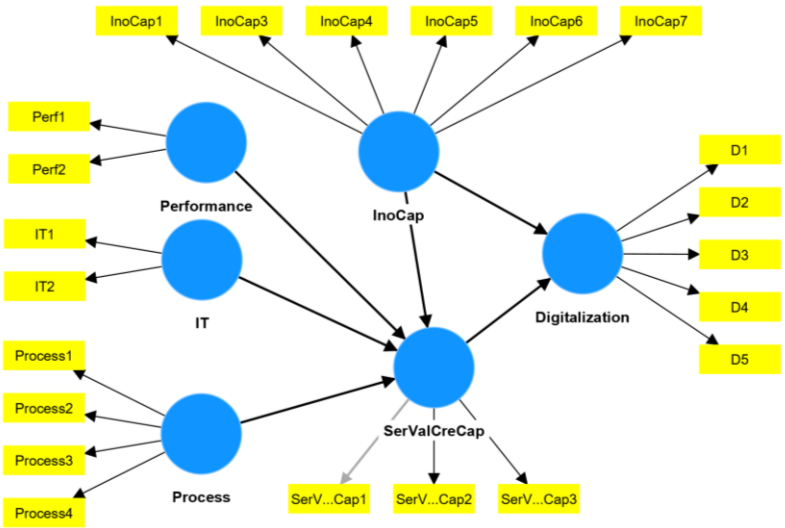

Figure 1. The model structure

As shown in Figure 1 the model tests the relation between digitalization &service value creation capability, digitalization and innovation capability, and service value creation capability with IT, Performance &

Process respectively as indicated in the given hypothesis in the previous sections. Before going further in analyzing the construct validity and reliability statistics are interpreted in Table 3.

Table 3. The measurement scale

Structures	*Loadings*	*α*	*AVE*	*CR*
Service Value Creation Capability		*0.72*	*0.61*	*0.84*
SerValCreCap1	0.71			
SerValCreCap2	0.65			
SerValCreCap3	0.88			
Process		*0.64*	*0.58*	*0.78*
Process1	0.69			
Process2	0.77			
Process3	0.67			
Process4	0.71			
IT		*0.72*	*0.65*	*0.83*
IT1	0.68			
IT2	0.98			
Performance		*0.60*	*0.53*	*0.73*
Perf1	0.87			
Perf2	0.46			
Innovation Capability		*0.76*	*0.62*	*0.87*
InoCap1	0.59			
InoCap2	0.61			
InoCap3	0.72			
InoCap4	0.75			
InoCap5	0.60			
InoCap6	0.77			
InoCap7	0.53			
Digitalization		*0.78*	*0.71*	*0.89*
D1	0.98			
D2	0.64			
D3	0.51			
D4	0.62			
D5	0.65			

As indicated in Table 3 AVE>0.50) and CR (>0.70) values are acceptable for convergent validity and discriminant validity confirmation. Besides, exploratory factor analysis indicates that the number of factors in this construct is six. Besides AVE and CR values, HTMT values are also significant (>0.85). The goodness of fitness value of SRMR is lower than 0.10 (0.09). Another important parameter for the goodness of fitness NFI value is <1 (0.858, $p<0.05$). The Squared Euclidean distance-d_ULS and The Geodesic Distance d-G values are more significant (at $p>0.05$) than the model is acceptable. Looking at R^2 values on Table 4; Service value creation capability is explained 38 % by IT (R^2= 0.38), 30 % by process (R^2= 0.30), and 24 % by performance (R^2= 0.24). Innovation capability is explained by the 21 % of service value creation capability (R^2= 0.21) and respectively Innovation capability and Service value creation capability are explained by the digitalization with 42 % and 39 % (R^2= 0.42 and R^2= 0.39 $p<0.05$). Besides, the effect size should also be considered. Table 4 interprets the results of effect sizes.

Table 4. Hypothesis

Hypothesis	*ß*	*R^2*	*t-values*	*f^2*	*Decision*
H1: Dig&InnoCap	0.548	0.42	7.891	0.48 (large)	Supported
H2: Dig&SerValCreCap	0.456	0.39	6.782	0.369 (large)	Supported
H3: InnoCap&SerValCreCap	0.298	0.21	3.283	0.013 (small)	Supported
H4: SerValCreCap&IT	0.476	0.38	5.267	0.391 (large)	Supported
H5: SerValCreCap&Performance	0.314	0.24	3.675	0.016 (small)	Supported
H6: SerValCreCap&Process	0.345	0.30	4.218	0.089 (medium)	Supported

* $p<0.05$

As stated the effect size index are f ² for small, medium, and large effects are f^2 = 0.02, 0.15, and 0.35 respectively (Cohen, 1998). According to f^2 values, there is a large effect between digitalization & and innovation capability and digitalization & and service value creation capability, Service value creation capability & IT, a medium effect between service value creation capability & and process management, small effect between innovation capability & and service value creation capability and performance & service value creation capability respectively. Besides, comparing ß and t-values of path analysis shows

that outcomes are reliable and significant in our case. Going further, the mediator effect of service value creation capability in this study is also examined. Table 5 shows the results of the analysis.

Table 5. Mediator effect of service value creation capability

Variables	*Coefficient*	*S.E.*	*t*	*p*	*LLCI*	*ULCI*
constant	4.3383	0.3017	14.3771	0.0000	3.7452	4.9313
Process1	0.0060	0.0503	0.1189	0.9054	-0.0929	0.1049
SerValCr	-0.0613	0.0511	-1.2001	***0.2308***	-0.1617	0.0391

Since p values in Table 5 (0.2308>0.05 accept) are not significant hypothesis that indicates the mediation effect of service value creation capability has failed. This means that there is no mediation effect of service value creation capability on digitalization. Otherwise, this variable cannot be accepted as a mediator in this model. Hence all the hypothesis is supported in this study.

5. CONCLUSION and DISCUSSION

The study is based on constructing a model to test the relations between six variables which are explained in the previous sections: digitalization (as a dependent variable), service value creation capability, innovation capability, IT, process, and performance. The outcomes approved the positive relations between dependent and independent variables exist, hence hypothesis is supported.

However, scholars insist on the importance of service value creation capability and digitalization concept, digital technology adaption (Cenamor et al., 2017), strategy development (Möller et al., 2008), value creation in B2B digital context (Corsarao and Anzivino, 2021), value offering, performance and customer satisfaction (O'Cass & Ngo, 2011) there is still a gap in service value creation capability and digitalization especially on service industries. Accepting all the studies with their novelty, there is a need to explore this relation for most of the revenue-generating tourism sectors. Looking in service value creation capability context, service value creation capability is explained digitalization with 42 % (R^2=0.42). This result supports previous studies explaining the relationship between service value creation capability and digitalization (Schroeder and Kotlarsky, 2015; Corsarao and Anzivino, 2021; Häikiö and Koivumäki, 2016; Parida et al., 2015; Edu et al, 2020; Vendrell- Herrero et al., 2014; Vandermerwe and Rada, 1988).

Tangible technologies like IT-driven ones have a direct effect on service value creation capability and hence digitalization (Parida et al., 2015; BarNir et al., 2003; Benjamin and Wigand,1995; Gallaugher, 1997; Gago and Rubalcaba, 2006; Maglio and Spohrer, 2008; Häikiö and Koivumäki 2016). The result of this study supports the main findings of recent studies; service value creation capability is explained 38 % by IT (R^2= 0.38) and there is a strong relationship between service value creation capability and digitalization as stated before (R^2= 0.42). Performance is accepted as the main component of the service value creation process from an operational perspective (Nada and Ali, 2015). One of the findings of this study supports also the previous studies, to show the relationship between service value creation capability and performance relation (R^2 = 0.24). There is a weak relation between innovation capability and service value creation capability, which is not supposed to be at the beginning of the research. Although scholars emphasized using digital technologies for service innovation mostly resulted in a value creation on the firm scale (Péry et al., 2013; Fitzgerald et al., 2014) supporting the literature but relationship between those two variables is lower than expected. As considering the dynamics and structural situation of the tourism industry as human human-intensive sector and in which innovative technologies are rarely used in operational processes, the results can be acceptable. Thus, respondents failed to answer these questions positively. However, the relations (R^2 = 0.21) were weak the hypothesis was still supported.

Although there is a weak relationship between innovation capability and service value creation capability, there is a strong relationship between innovation capability and digitalization, which is supported by our beginning hypothesis.

The study is the first to consider the effect of service value creation and innovation capability on digitization in three sectors of tourism. In this case, it is contributed to the literature in:

- Adding value in the creation of the relations digitalization and service value creation and innovation capability in the tourism industry with three main revenue generating sector
- Giving a framework to tourism stakeholder in digitalization, innovation capability, and service value creation capability in their information technology, process, and performance management.

The structural characteristics of service industries facilitate the realization of innovation easily and are accepted as the most powerful tool for fighting commoditization with characteristics of easy, comfortable, and less consuming time-consuming than the physical product because of the commercial rights, and short Product Life Cycle (PLM). The short PLM is also an important point for innovation in the service industry. The mass customization and personalization concepts shorten the lifecycle of a tourism product. In the

case of being agile and adapting the process and services to a rapid change, the tourism industry decision-makers should be more aware of the innovation and innovative technologies concepts.

6. LIMITATIONS and FUTURE WORKS

Almost all the technology developments are launched as fancy toys or magic wands. It is given meaning as expected to solve the ongoing and possible problems in a utopian way. Besides, the power of technology in the current human resources is another issue that should also be considered for adapting the technology to the enterprises. Digitalization and digital transformation are also long-term changes and need strategic plans for human resource planning. The study can be rehandled by considering the HR capital adaption capability in a digitalization process.

The technological investment among competitors becomes a fashion somehow. But in reality, it is more than a trendy concept. While investing the technology, enterprises may fall into “The Modern Productivity Paradox”. As Van Ark (2016) quoted the Modern Productivity Paradox tells the firm in order to see the super effect of technology in the processes, the investment costs should be acceptable. Otherwise, the management or decision makers see the investment in the related technology as unnecessary. The digitization concept can be reconsidered by taking a return on investment values into account.

The main belief of the service industry is that it is human-intensive. This phenomenon is thought of as a constant parameter that cannot be changed by any means. Because of this cultural barrier and lack of vision some parts of the tourism industry fall behind in accepting the digitalization. To change the situation, well-educated young managers with a technological background should be hired in this sector. Being still under the impression of the last pandemic wave, the tourism industry may recover by adapting digital technologies to its operational processes. Because of the human-intensive structure investment in digitalization is more important than any other sector considering such a new pandemic wave or any other loss of man-hours.

According to “Neo-Schumpeterian meso dynamics: theory” the innovation process is subdivided into two sections: objects and subjects of the innovation process. Subjects of the process are accepted as entrepreneurship, firms, networks, and suppliers, object of the process is explained as knowledge and competencies (Carlsson, 2007). Study based on a firm perspective without touching intellectual capital, knowledge, and some other subjects. The study can be extended with customer involvement in the processes.

Conflict of Interest
No potential conflict of interest was declared by the author.

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Compliance with Ethical Standards
For this study, the approval of the Anadolu University Social Sciences and Humanities Research and Publication Ethics Committee was obtained with the decision dated 11 May 2023 and numbered 525325.

Ethical Statement
It was declared by the author that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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VERİMLİLİK DERGİSİ
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Government Support and Employment of Manufacturing SMEs*

Ali Recai Direkçi[1], Abdullah Tirgil[1]

ABSTRACT

Purpose: This study aims to examine how government incentives affect SME employment in Türkiye's manufacturing sector.

***Methodology*:** The dataset used in this study was derived from a survey conducted by a privately owned London-based company with the assistance of Türkiye's Ministry of Industry and Technology. Ordinary least squares and two-stage least squares regression techniques were used to analyze the relationship between government incentives and employment.

Findings: In the analysis, we found that between 2013 and 2016, jobs were created by Turkish manufacturing SMEs with the use of state assistance. Firm-level characteristics, including firms' age, capacity utilization rate, and innovative activities, were also found to have a substantial impact on SME employment.

Originality: Our study is the first to examine the impact of incentives on employment in manufacturing SMEs in Türkiye using a micro dataset administered to 10.063 manufacturing firms by the Ministry of Industry and Technology.

Keywords*:* Government Incentives, Employment, Manufacturing Industry, SMEs.

JEL Codes: H32, H81, J18, J21, O25.

Devlet Desteği ve İmalat Sanayii KOBİ'lerinin İstihdamı

ÖZET

Amaç: Bu çalışma, devlet teşviklerinin Türkiye imalat sektöründe KOBİ istihdamını nasıl etkilediğini incelemeyi amaçlamaktadır.

***Yöntem*:** Çalışmaya konu veri seti Türkiye Sanayi ve Teknoloji Bakanlığı'nın yardımıyla Londra merkezli özel bir şirket tarafından gerçekleştirilen bir anket araştırmasından edinilmiştir. Devlet teşvikleri ile istihdam arasındaki ilişkiyi analiz etmek için sıradan en küçük kareler ve iki aşamalı en küçük kareler regresyon teknikleri kullanılmıştır.

Bulgular: Çalışmada, 2013 ile 2016 yılları arasında Türk imalat KOBİ'leri tarafından devlet yardımı kullanılarak istihdam yaratıldığını bulunmuştur. Firmaların yaşı, kapasite kullanım oranı ve yenilikçi faaliyetleri gibi firma düzeyindeki özelliklerin de KOBİ istihdamı üzerinde önemli bir etkiye sahip olduğu bulunmuştur.

Özgünlük: Çalışmamız, T.C. Sanayi ve Teknoloji Bakanlığı tarafından 10.063 imalatçı firmaya uygulanan bir mikro veri setini kullanarak Türkiye'deki imalatçı KOBİ'lerde teşviklerin istihdam üzerindeki etkisini inceleyen ilk çalışmadır.

Anahtar Kelimeler*:* Devlet Destekleri, İstihdam, İmalat Sanayi, KOBİ'ler.

JEL Kodları: H32 H81 J18 J21 O25.

* This study is derived from the master dissertation titled " Government Incentives and Employment in SMEs, an Econometric Analysis on Turkey's Manufacturing Industry" which is conducted by Ali Recai Direkçi at Ankara Yıldırım Beyazıt University Graduate School of Social Sciences under the supervision of Prof. Dr. Abdullah Tirgil.

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1. INTRODUCTION

Analyzing the effect of incentives on employment is a topic that has attracted many researchers. The virtue of planning is to put resources into a cycle that helps individuals become involved and evolve. In this respect, successful planners have been praised by many great minds, as they might deserve more applause than philosophers (Cicero, 1999: 3). Today, to appraise planners' success in job creation, the main requirement is repetitive analyses of past policies.

The strong connection between creating jobs and being productive is crucial to society's progress (van Ark et al., 2004). Jobs are where people's abilities turn into economic value, boosting overall output and supporting growth. When the workforce is productive, it starts a cycle of continuous improvement, leading to long-lasting advantages. This interdependence is vital for economic health, emphasizing that jobs create wealth and encourage ongoing skill development and progress. In the complex process of societal development, the combination of jobs and productivity weaves a fabric that encompasses individual dreams and the prosperity of the whole nation.

In 2012, Türkiye's development objectives focused more on government funds' power to incentivize more employment. The Turkish government has designed various programs to incentivize Small and Medium Enterprises (SMEs) in the manufacturing industry. These programs include the Investment Incentive Program and Technology Development Zones Program (Kahraman et al., 2019). The Investment Incentive Program offers exemptions and tax reductions, social security premiums, and land allocation fees for SMEs that invest in specific regions and sectors. Meanwhile, the Technology Development Zones Program provides infrastructure, R&D support, and tax reductions for SMEs in designated technology zones. The government provides financial support through different programs, such as the credit guarantee fund and SME support and development programs. However, micro-enterprises find it challenging to benefit from these funds in Türkiye, whereas medium-sized enterprises can monitor legislation and credit incentive channels because of their advanced institutional structures (Erdin and Ozkaya, 2020).

Additionally, medium-sized enterprises employing 50-250 workers benefit from these loans in Türkiye, especially if they have an R&D infrastructure to design original products. Medium-sized enterprises in Türkiye can also provide counter guarantees for investment banks, which distribute funds to SMEs through low-interest, long-term investment loans. Moreover, the European Union's umbrella programs include support, grants, and loans for SMEs in Türkiye, which can further assist the manufacturing industry.

The Turkish government plays a significant role in promoting the growth and development of SMEs in the manufacturing industry. It offers various incentive mechanisms such as providing information and technology sources, establishing science parks, and directing financial support to innovative enterprises (Eceral and Köroğlu, 2015). However, the effectiveness of these incentives in promoting the growth and development of SMEs in the manufacturing industry has not been discussed explicitly in the literature. Incentives related to overall market conditions, government policies, and competition structure are essential in allocating resources and efforts to develop new knowledge. The industry in Türkiye is heavily regulated and protected, with public instruments used to support national interests and domestic firms. In the literature, the effectiveness of these incentives is explored in the case of the defense and aviation industry, where various institutions offer incentive mechanisms that firms exploit, leading to their growth and development. The defense and aviation industry invests heavily in research and development, which is essential for innovation and growth. The relationship between incentive exploitation levels and firm characteristics such as size, age, labor quality, innovative capacity, and performance needs to be evaluated to determine the effectiveness of incentive mechanisms in promoting the growth and development of SMEs in the manufacturing industry in Türkiye. Incentive and support mechanisms are crucial in ensuring the development and sustainability of the industry's growth and performance.

The Turkish manufacturing industry comprises 382,974 SMEs, which account for almost 60% of the industry's total Employment (TurkStat, 2021). However, these SMEs generally produce low-value-added products, and the SME legend does not provide a sufficient economic contribution to Türkiye. In contrast, large-scale enterprises that produce high-value-added products are required for the development of regions and cities. Large enterprises (4,335) account for only 0.1% of the total enterprises but contribute 40% of Employment (TurkStat, 2021) and 73.1% to the value-added. The added value per person is $10,300 in medium-sized enterprises and $4,700 in large enterprises, while the added value per facility is $1,860,000 in medium-sized enterprises and $41,200 in large enterprises (Erdin and Özkaya, 2020). To ensure SMEs' survival in the long run, it is critical to understand the mediating effects of government incentives on their survival.

In this study, we contribute to the literature by assessing the perception of SMEs in the Turkish manufacturing industry. Previous research on the relationship between incentives and regional development has focused on developed countries. Studies on developing countries have generally

examined the impact of public support on overall employment in the economy. This study fills a gap in the literature by conducting a micro-level analysis of Turkish manufacturing SMEs. The study found that Turkish manufacturing SMEs are struggling but can still create jobs with the help of state support. Balancing inequalities among firms also seems to be far from being achieved. We conducted empirical analyses in the study to obtain a more detailed picture of the relationship between firms' employment and government incentives. The dataset used in the analyses was obtained from a survey of Turkish manufacturing SMEs. The study's sampling was made on 10,063 respondent firms based on their sectors and regions.

In addition to the variables derived from the survey study, we obtained variables from the database published by TurkStat to control for the effects of regional differences. We applied the Ordinary Least Squares (OLS) and Instrumental Variable (IV) approaches to analyze the relationship between variables. The OLS results showed a significantly positive relationship between general incentives and firms' employment. The IV approach found higher coefficients between these variables. The study's findings based on heterogenous effects revealed that SMEs with 1 to 19 employees employ more people when they benefit from incentives than those without incentives. Additional factors that were found to be significantly influential on SME employment are firm-level characteristics: the capacity utilization rate and innovation. The study's findings suggest that government incentives can positively impact SME employment, but other factors, such as firm-level characteristics, also play a role. The study's findings also suggest that the objective of balancing inequalities among firms is still a challenge.

The following is how the remaining portion of the article is organized: the second section explores the pertinent literature. The third chapter discusses the methodological approach taken for this investigation and presents the findings in the fourth part. In the final section, the conclusion and final thoughts are offered.

2. LITERATURE REVIEW

The literature on the effects of incentives on employment is vast. Whether in policy briefs or empirical analyses of industries, the academic consensus is that the effectiveness of incentives is uncertain (Patrick, 2014). However, it is important to note that certain structural factors found in studies of manufacturing SMEs contribute more to the national employment level (Voulgaris et al., 2005). In this section, empirical literature and recent discussions on the relationship between state support and firms' employment growth and level will be elaborated on.

Empirical studies on government incentives and employment changes differ in their theoretical frameworks and empirical strategies. Most studies assume that incentives have a lagged effect on employment, with a minimum of three years between the time of enrolment in an incentive program and the level of or change of Employment (Bartik, 2018: 18). As a result, government incentives variables in econometric models are either constructed periodically before the employment level variable (see for example Westhead and Birley 1995; Hoyt et al. 2008; Courseuil and Moura 2010; Jensen 2017) or the establishment-expansion decision of firms in the study sample is used to determine the time point of the variables (Faulk 2002; Gabe and Kraybill 2002; Fukanuma et al. 2006; Gamberoni et al. 2016).

Bartik (2018, p. 5) argues that economic development incentives are effective for at least 3 years, but no more than 20 years. He reasons that if a firm receives public funds to locate or relocate, it will eventually become clear that the decision was not in the firm's best interest if the incentive is not renewed. Therefore, one-time incentives are not a reliable way to reduce regional inequality.

Government incentives are often designed to create jobs, but they can also destroy jobs. The effectiveness of an incentive program depends on how it is structured and how it is implemented. Even unrealistic promises in political campaigns can reduce unemployment. Alt (1985) found that political interventions by newly elected and existing governments can positively affect the unemployment rate in the short term. However, he also found that this effect is only sustained if the government has a majority in parliament.

The success of government policies depends on how locals perceive them. Politicians and institutions need to gain the trust of the majority of society, not just a selected few. A study by Walker and Greenstreet (1991) found that favoring new manufacturing firms in sub-regions of Appalachia leads to intra-regional and intra-sectoral competition. This competition wastes resources that could be used to create jobs. Furthermore, regional imbalances deepen with the transfer of capital from one region to another. Therefore, governments should seek the trust of the majority of society when designing policies that are intended to create jobs.

In today's world, governments need to attract foreign investment to create jobs. A study by McAleese and McDonald (1978) found that there is no significant difference between the responsiveness of newly established domestic firms and foreign firms to government policies. They also found that government support for foreign manufacturing firms in Ireland has a significant positive impact on employment. McAleese and McDonald recommend that governments should carefully target their support to the right enterprises in order to maximize the benefits of foreign investment.

Some studies have examined the effectiveness of government policies and programs in targeting the best possible entities. Box et al. (1994) studied manufacturing entrepreneurs and found that firms owned by people with a strong desire for success and a keen awareness of their environment have more employment growth than those who lack these characteristics. They also found that government incentives have a significant positive impact on employment growth, but that these policies are not always targeted at the firms that are most likely to benefit from them. This is because government incentive programs are often designed to capture in-need firms, sectors, and regions. As a result, finding entrepreneurs with a strong desire for success in-need positions could be difficult, except for the early years of their startup.

Westhead and Birley (1995) studied the performance of firms in their starting years. They found that it is difficult to pick winners among new ventures, and that the relationship between employment growth and owner-manager characteristics is not profound. However, they did find that manufacturing firms that have been granted public funds tend to have more employment growth than services firms that raised finance through credits and loans from non-governmental institutions. They also found that startup size and the firm's sub-sector are significantly affecting firms' employment growth.

Gabe and Kraybill (2002) studied firms in their median age. They found that firms that expect to employ more people with government support for expansion tend to overestimate their future employment growth. Gabe and Kraybill state that firms do this to be eligible for incentives. The authors conclude that while incentives positively affect firms' announced employment growth, the actual growth is negatively correlated with government support.

Voulgaris et al. (2005) studied the factors that affect manufacturing firms' employment growth in Greece between 1995 and 1999. They found that firms with 1-19 employees create more jobs than firms with 20 and more employees, and that the age of the firm is negatively correlated with employment growth. These findings are similar to those of other studies which analyze alike countries' markets.

Hoyt et al. (2008) found that regional differences affect the development of firms. They also found that incentives have a positive relationship with employment, but the effect varies from county to county. Border counties of Kentucky saw the most employment growth from incentives, while neighboring states saw an increase in employment from businesses attracted to Kentucky's public funds.

Incentives can also be used to alleviate disparities between people in the workforce with different conditions. For example, Lalive et al. (2009) found that Austria's policies to encourage firms to employ disabled workers led to an increase in the employment of disabled workers, but also a decrease in total employment. This is because the incentives displaced non-disabled workers.

Most studies of government support for firms only consider firms that receive support or those that do not. Courseil and Moura (2010) broke this mold by studying firms that were eligible for support but did not receive it. They found that firms that received support had more employment growth, while firms that were eligible but did not receive support had a negative trend in employment.

Patrick (2014) found that increasing public funds to help private entities negatively affects rural employment in the medium term. However, she also found that public support has a positive impact on urban county employment in the short term. Patrick suggests that public authorities should increase the restrictions on eligibility for government support. Other studies (Rolnick and Burstein, 1995: 8 Thomas, 2010: 161) support this recommendation.

Few studies have examined the effectiveness of employment incentives. Gamberoni et al. (2016) found that firms eligible for employment subsidies in Spain had 2% more employment growth in 2013. However, robustness tests and difference-in-discontinuities regressions failed to confirm a significant relationship between employment incentives and employment growth of SMEs. The authors are not skeptical about the long-term effects of the reform as more post-reform data become available.

Jensen (2017) argues that studies on the relationship between incentives and job creation are flawed if they do not control for other factors. He proposes using matching methods to compare firms that receive incentives with similar firms that do not. Jensen found that firms that received incentives were more likely to recommend the program to other firms, but he could not confirm that the program caused the employment growth. He concludes that firms that would have expanded their businesses anyway are more likely to apply for incentives, and he warns policymakers about the financial burden of these programs.

Partridge et al. (2020) conducted a more current analysis that takes into account a number of remedies to the issues mentioned by Jensen (2017). To examine the longer-term effects of incentives, they use Patrick's (2014) IEI as a variable in their research. They isolate the county fixed effects, employ Lewbel's (2012) instrumental variable approach, and develop a variable to simulate local demand shocks, also known as the Bartik instrument in the literature, to address potential endogeneity issues. Authors use the number of

new startups in a county as a measure of job growth. Their findings demonstrate that a decrease in the number of new companies is related to a shift in incentives. There is a clear inverse correlation between new startups and incentives, particularly in the manufacturing and export industries. They urge that the focus of future studies should be on the varied impacts of incentives. Furthermore, they argue that given that larger enterprises already predominate in the incentive market, researchers should concentrate on the long-term effects of incentives on SMEs when conveying their findings to policymakers.

A number of studies have found a positive correlation between government incentives and increased employment in Turkish manufacturing enterprises (Yavuz, 2010; Uğurlu, 2020). Tax incentives, grants, and subsidies have encouraged these businesses to expand and hire more workers. Despite the positive effects of public support, there are also challenges that need to be addressed. These include bureaucratic red tape, limited access to financing, and political instability. These challenges can hinder the full potential of public support programs. There is a paucity of studies that have explored the long-term sustainability of firms' employment resulting from public support (Yanıkkaya and Karaboğa, 2017). Understanding the durability of these initiatives is essential for policymakers. Regardless of the industry and sector, firms in Türkiye cite unfair competition from informal firms, high labor costs, and inadequately skilled workers as major challenges to doing business and creating jobs (Erdoğan and Carpio, 2019).

This study signifies a noteworthy exploration of the relationship between government support and employment in Türkiye's manufacturing sector. It diverges from existing research by centering on 2013-2016, providing a distinctive perspective on the immediate impact of the newly implemented incentive reform in 2012. Importantly, this research utilizes survey data for empirical analysis, distinguishing it from prior studies. Furthermore, we contribute to the academic conversation by extending and refining control variables. Mindful of the study's limitations, these methodological and contextual enhancements aim to deepen our understanding of the relationship between government interventions and employment outcomes in Türkiye.

3. DATA and METHODOLOGY

This study's data originates from a survey that was conducted in 2016. The survey involves 10 063 businesses. A commercial company working with the Turkish Ministry of Industry and Technology surveyed manufacturing businesses. The survey's questions are made to capture the general state of businesses' productivity levels and the variables influencing them. The sample was representative of regional, firm scale, and sectoral levels, with 24 subsectors in manufacturing (NACE Rev.2 Level 2), 26 regions by NUTS2 level, and two-scale groups (1-19 employees and 20+ employees). We consider firm sizes of 1-19 and 20+ in our study because the 10th Development Plan of Türkiye (2014-2018) used this classification for all projections to evaluate the efficiency of public policies. In addition, the survey we used aimed to conduct analyses at the regional, scale (1-19 employees and 20+ employees), and sector levels. Therefore, the representativeness of the sample at these levels was ensured. The population was divided into 1,248 strata using 24 manufacturing sectors (NACE Rev.2 Level 2), 26 regions according to the NUTS2 level classification, and two-scale groups of 1-19 and 20+ employees. Sampling was conducted at the level of these strata. The sample size was calculated at a 95% confidence level and a ±7.5% confidence interval. The number of firms surveyed and the population represented by these firms are given in Appendix A.

An overview of the traits of the companies in the study is provided in Table 1. Most of the companies in our dataset are SMEs. Additionally, 67.2 percent of the dataset's companies are younger. Almost one-third of the companies in our sample are based in the Marmara region, which includes Istanbul, the most populous city in Türkiye, as one might anticipate. The manufacturing of food goods dominates the industry in which businesses are engaged.

Furthermore, it is observed from the sample that each region of Türkiye has a particular sector to which the government gives financial support attentively. For instance, 55 percent of SMEs operating in the textile manufacturing industry in Tekirdağ, Edirne, and Kırklareli have stated that they received incentives between 2013 and 2016. Finally, our data reveal that the Turkish government appears to be achieving its goal of assisting in pre-planned areas and industries. However, almost all 26 regions have a much lower percentage of the runner-up sector receiving public support than the leading industry. For instance, in the TRA1 region (Erzurum, Erzincan, and Bayburt), 50 percent of the enterprises producing clothing have received incentives, but just 23 out of 100 firms producing food goods have received incentives. This scenario might be seen as a targeted yet unfair distribution of public resources.

Table 1. Characteristics of firms in the survey

Characteristics	*Number*	*Percentage*
Size (Number of employees as of 2016)		
1-19 employees	6,724	66.8
20+ employees	3,339	33.2
Age (Number of years passed from the date of establishment)		
≤20 years	6,765	67.2
>20 years	3,298	32.8
Region (Regional location of the firm)		
Marmara Region	3,084	30.6
Central Anatolia Region	1,687	16.8
Aegean Region	1,343	13.3
Black Sea Region	1,213	12.1
Mediterranean Region	1,088	10.8
South-eastern Region	831	8.3
Eastern Region	817	8.1
Sector (Firm's sector in which has operations)		
Manufacture of food products	1,513	15.0
Manufacture of fabricated metal products	755	7.5
Manufacture of other non-metallic mineral products	675	6.7
Manufacture of textiles	610	6.1
Repair and installation of machinery and equipment	600	6.0
Manufacture of wearing apparel	590	5.9
Other sectors (18 sectors)	5,320	53.0

According to the theoretical and empirical literature (Gabe and Kraybill, 2002), our choice of variables is consistent. One distinction is that we increase the number of variables as much as our dataset permits rather than exactly copying the models of previous studies. We had to treat several survey questions that got no responses as being absent. We list our variables and their summary statistics in the table below.

Table 2. Definitions and summary statistics of variables

Variables	*Explanation*	*Obs.*	*Mean*	*SD*
Employment growth	Employment growth between 2013 and 2016	9,429	0.11	0.48
Employment level	Average employment between 2014, 2015, and 2016	9,429	44.73	146.26
Employment level in 2013	Employment level in 2013	9,429	42.76	142.32
Incentive	Dummy variable for receiving any government support between 2013 and 2016 (1 = at least once, 0 = never)	9,429	0.25	0.43
Firm age	Age of the firm	9,429	18.17	12
Capacity utilization rate	Categorical variable for capacity utilization rate for operations in 2015 (1 = %0-25, 2 = %26-50, 3 = %51-75, 4 =%76-100)	9,429	3	1.06
Export	Dummy variable for having export activities (1 = yes, 0 = no)	9,429	0.3	0.46
Innovation	Dummy variable for R&D and innovation activities (1 = yes there are, 0 = if there are no activities)	9,429	0.24	0.43
Technological sophistication level of machinery equipment	Categorical variable for level of sufficiency in machinery and equipment (1 = inadequate, 2 = neither inadequate nor adequate, 3 = adequate)	9,429	1.39	0.68
Utilization of Information technology	Categorical variable for utilization level of information technologies (1 = inadequate, 2 = neither inadequate nor adequate, 3 = adequate)	9,429	1.44	0.69
Firm size	Dummy variable for firm size (1 = 20 and more employees, 0 = 1 to 19 employees)	9,429	0.34	0.47
GDP per capita	The logarithm of the average gross domestic product per capita for years between 2013-2016 at a province level	9,429	9.38	0.4
Inflation	Average inflation rate between the years 2013-2016 on the province level	9,429	0.08	0.003

Our dependent variables are employment growth and employment level. For our analysis, we calculate employment growth between 2013 and 2016. For employment level, we average employment levels for 2014, 2015, and 2016 and take the natural logarithm of that value to use in our regression analysis. Over the study period, employment growth at businesses in our sample increased on average by 11%. While the average employment level is about 45 employees, the employment level in 2013 for firms was 43. The difference between the average employment growth rate and the increase in the number of people employed (approximately two employees) may imply that smaller firms may have had more growth rates proportionate to their size. Incentive, our key variable of interest, indicates that 25% of the firms in our sample received at least one government incentive between 2013 and 2016. The average age of firms in our sample is 18. Firms, on average, use between 51 and 75 percent of their total capacity, defined as the ratio of the total amount of production realized by the enterprise in a given period to the maximum amount of production that it can physically produce. Innovative activity is present in 24 out of 100 businesses. Generally speaking, the surveyed organizations do not believe their firms are well-established in using information technologies or machines. The initial employment level of companies, expressed as a natural logarithm, is added to the model along with other control variables where we regress $Incentive$ on employment level. We also include some macroeconomic variables at the province level to account for regional variations, which include the natural logarithm of average Gross Domestic Product (GDP) per capita between 2013 and 2016 and the average inflation rate between 2013 and 2016.

The ordinary least squares (OLS) approach is the first step in our empirical strategy for obtaining indicative estimates. At this phase, the goal is to determine whether government incentives are statistically significantly correlated to employment growth and the employment level of firms. As a result, we estimate the following model (Equation 1).

$$y_i = \gamma_0 + \delta Incentive_i + \theta X_i + \Omega Region_r + \beta Sector_s + \epsilon_i \quad (1)$$

where for the ith manufacturing SME in our dataset, y_i denotes two separate outcome variables, such as job growth from 2013 to 2016 and the average employment level between 2014 and 2016. $Incentive_i$ is an indicator variable taking the value of 1 if a firm received any government support at least once between 2013 and 2016 and zero otherwise. The key coefficients to be estimated are denoted by the symbol δ. γ_0 is a constant term. X_i include control variables such as firms' age, capacity utilization level, export and innovation activity levels, machinery and equipment level, information technology usage rate, size of SMEs, and the firm's employment level in 2013 (in the model where we use $Employment\ level_i$ as a dependent variable). Additionally, we include some macroeconomic variables such as province-level average GDP per capita and average inflation rate. $Region_r$ controls for regional fixed effects and $Sector_s$ controls for the sectoral fixed effects.

OLS estimates could result in biased estimations of our key independent variable, $Incentive_i$. The assumption that the independent variable is exogenous may not be met, which could lead to biased estimates (Koop, 2005: 215). To put it another way, the endogeneity problem with $Incentive_i$ may arise due to the fact that $Incentive_i$ is likely to be correlated with some unobservable factors in error term which might also have impact on employment growth or employment level (i.e., omitted variable bias). Another potential problem is the possibility that enterprises with more considerable employment growth or employment level would be the ones to gain from government incentives could cause reverse causality. Hence, the OLS estimator would be biased.

To account for the endogeneity problem, we use the instrumental variable (IV) method, where we identify a variable that is not directly connected with the dependent variable but is correlated with the variable that is thought to be endogenous, $Incentive_i$. When employing an instrumental variable, the primary concern is determining if any pathways other than those directly relevant via which the instrumental variable can influence the outcome variable (Angrist and Pischke, 2010). Simply put, we must ensure that no exogenous variables in the error term relate to our instruments and affect the degree of SME employment.

As our instrumental variable, we take advantage of the regional and sectoral average of the indicator variable, $Incentive_i$. The concept of "contextual effect" states that exogenous characteristics of the involved group shape individual acts justifies using our instrument (Manski, 1993). Equation 2 shows the first step of the 2SLS regression approach, from which we shall acquire fitted values. In order to obtain estimates using the IV regression approach, we will go back to our original linear regression (Equation 1) with these fitted values.

$$Incentive_i = \beta_0 + \beta_1 Incentive_{rs} + \beta_2 X_i + \ + \gamma_1 Sector_s + \vartheta Region_r + \epsilon_i \quad (2)$$

where $Incentive_{rs}$ is the average of the incentives at the regional and sector levels, and Equation 1 defines the other variables.

Our instrumental variable's rationale is heavily influenced by the concepts of contextual effect (Manski, 1993) and Currie and Gruber's (1996) "simulated eligibility" method. According to the contextual effect, any company in a given industry and location behaves similarly to its competitors in related clusters. The difference between the two ideas is that the peer effect assumes that businesses in the same league are inherently competing with one another, and as a result, their actions influence the movement space of other businesses. Regarding the idea of simulated eligibility, it is expected that firms in the same cluster, which we formed based on the geography and industry of the firm, will all have an equal chance of being eligible for incentives while holding firm-level attributes constant. Therefore, to simulate whether enterprises are eligible for government incentives, we must ensure that the control variables in the equation are adequate to account for firm-level peculiarities.

Our firm- and area-level metrics are sufficiently specific to rule out any relationship between the error term and government incentives. Additionally, area-based variations are employed as instruments for endogenous explanatory variables dependent on related regional variables being controlled and occurring in individual-level equations (Wooldridge, 2002).

4. FINDINGS

The present study was designed to assess the effect of government incentives on two outcome variables, including employment growth and average employment levels for manufacturing SMEs. We briefly report the findings from the first stage of the IV estimation before explaining our main findings. Our F-statistics are far higher than the suggested values, and our first-stage results are strong across different specifications.

Table 3 presents the results obtained from the preliminary analysis of receiving any government incentive for employment growth. The first column reports OLS coefficients, and the second column reports IV coefficients. This table is quite revealing in several ways. First, OLS results indicate a statistically significant positive correlation between incentives and employment growth. Second, IV coefficients are statistically significant and three times larger than OLS coefficients in magnitude. In other words, our OLS results are underestimated.

Further analysis shows that years spent in business have a detrimental effect on employment growth, which could be explained due to cost-cutting opportunities as a result of SMEs' experiences, which is known as passive firm learning (Jovanovic, 1982; Dunne et al., 1989; Gabe and Kraybill, 2003). If we now turn to the capacity utilization rate of firms, our findings show that enterprises operating at capacity levels over 75% see employment growth that was 4.2 percentage points higher than firms operating at capacity levels between 0 and 25%. What is surprising is that employment growth appears to be unaffected by the technological sophistication level of machinery equipment of firms. There seems to be a negative correlation between a sufficient level of information technology in a firm and employment growth; however, the precision is lower. Additionally, innovative SMEs experience employment growth of 5.1 percentage points higher than non-innovative SMEs.

Strong evidence of the correlation was found in the firm size, such that firms with 20 or more employees had 4.7 percentage points more employment growth than SMEs with 1-19 employees. A possible explanation for this might be that smaller firms may have limited resources, be more risk-averse, or have limited growth opportunities. However, it is also important to note that smaller firms are more likely to be innovative and entrepreneurial, and they are more likely to be located in new and growing industries. Because of this, smaller firms can create a disproportionate share of new jobs in the economy.

Overall, these results indicate that from 2013 to 2016, the job growth of SMEs was statistically significantly boosted by all forms of government encouragement. Additionally, SMEs' characteristics and the expansion of their employment are closely associated.

With the first set of findings, we examined how incentives affect the job-creation process. Unfortunately, using employment growth as a dependent variable necessitates including certain temporary employees in businesses. In other words, due to factors like the potential rehiring of former employees, we cannot be sure how many jobs are produced by simply looking at swings in the employment growth of organizations. People previously employed with public assistance before 2013 might have been rehired between 2013 and 2016. We must, in essence, consider the likelihood that public support may be misused.

The next section of the survey was concerned with the effect of government incentives on SMEs' average employment. Table 4 provides the OLS and IV results of receiving any incentive on firms' average employment in the first and second columns, respectively. OLS estimates indicate 4.4 percent more employment in firms that receive incentives than in organizations not offered incentives. Of interest here is the increase in the IV coefficient is more than doubled and takes on the value of 9.5 percent. This outcome could be explained by the fact that, between 2014 and 2016, Turkish manufacturing SMEs' employment levels were reliant on government subsidies.

Table 3. Regression results for the relationship between employment growth and receiving any government incentive

Variables	*(1) OLS*	*(2) IV*
Incentive	0.050***	0.134**
	(0.013)	(0.067)
Firm age	-0.003***	-0.003***
	(0.000)	(0.000)
Capacity utilization rate		
%0-25	Ref.	Ref.
%26-%50	-0.015	-0.016
	(0.019)	(0.019)
%51-%75	0.017	0.013
	(0.018)	(0.019)
>%75	0.043**	0.042**
	(0.018)	(0.017)
Technological sophistication level of machinery equipment		
Insufficient	Ref.	Ref.
Neither sufficient nor insufficient	-0.013	-0.016
	(0.021)	(0.021)
Sufficient	-0.018	-0.020
	(0.023)	(0.023)
Utilization of Information technology (computer, software, internet)		
Insufficient	Ref.	Ref.
Neither sufficient nor insufficient	-0.034	-0.036
	(0.023)	(0.023)
Sufficient	-0.041	-0.048*
	(0.025)	(0.025)
Export	-0.017	-0.030*
	(0.012)	(0.017)
Innovation	0.066***	0.051***
	(0.014)	(0.019)
Firm size	0.058***	0.047***
	(0.012)	(0.015)
Regional variables		
GDP per capita	0.068	0.072
	(0.044)	(0.045)
Inflation	-23.920**	-25.178**
	(10.483)	(10.628)
Sector fixed effects	Yes	Yes
Region fixed effects	Yes	Yes
First-stage regression results		0.800***
		(0.040)
First-stage F statistics		397.21
R-squared	0.032	0.027
N	9429	9429

Notes: The first row in Column 1 reports coefficients (robust standard errors in parenthesis) on incentive from estimating equation (1) by OLS, and the first row in Column 2 reports coefficients (robust standard errors in parenthesis) on incentive from estimating equation (1) by IV using average incentives at the region and sector levels as an instrument. Our dependent variable is the employment growth between 2013 and 2016, calculated as [(employment in 2016 - employment in 2013)/ employment in 2013]. All regressions control for sector fixed effects and region fixed effects as well as firm characteristics such as age, capacity utilization rates, technological sophistication level of machinery equipment, utilization of information technology, whether the firm exports or not, whether the firm carries out innovation activities, size, regional variables such as GDP per capita, and inflation rate. * p < .1, ** p < 0.05, *** p < 0.01.

Turning now to the firm characteristics on employment, there was a significant positive correlation between capacity utilization rate and employment. Businesses that operated at a capacity utilization level of above 75% had 5.5 percent more employees than those whose capacity utilization level was between 0 and 25%. A positive correlation was found between innovation and export operations and firms' employment. Further analysis showed that inflation has a significant unfavorable effect on employment. We controlled for the initial employment level of firms by including it as a covariate in the regression model, which was done to

remove the influence of the firm's employment level before 2013. The relationship between changes in employment and firm size has been the subject of much research (Wagner, 1992; Gabe and Kraybill, 2002). Larger firms are expected to have more significant employment change than smaller firms (Faulk, 2002). As one might expect, we found a positive relationship between a firm's initial and future employment levels with a highly significant coefficient.

In addition, we found a statistically significant positive relationship between GDP per capita and average employment level. Provinces with a high GDP per capita tend to have a high level of employment. To elaborate, GDP per capita is a measure of the average income of a province's residents, while employment is a measure of the number of people who are working in a city. A province with a high GDP per capita is likely to have a high level of employment because businesses are more likely to be located in cities with a high concentration of potential customers and workers. Incentives can also play a role in attracting businesses and jobs to cities. For example, a city that offers businesses tax breaks or other financial incentives is more likely to attract new businesses and create new jobs. The relationship between GDP per capita, employment, and incentives is complex. However, these factors all play a role in determining the development of SMEs.

In the final part of the analysis, we examined the heterogenous impact of incentives on employment growth for firms with 1-19 employees. Table 5 reports the OLS and IV estimates. We found that incentives had a significant impact on employment growth for small firms, which is expected, as smaller firms are more likely to expand and develop to compete with larger firms.[1]

Regarding firms' characteristics, we found that firms' capacity level (>%75) and innovativeness (less precisely estimated) positively correlated with employment growth. We also found that the age of the firms and the inflation rate at the city level were negatively correlated with employment growth for smaller firms, which means that when inflation is high, smaller firms are less likely to afford to hire new employees.

Inflation has been found to be a consistently negative factor in the employment growth and employment level of manufacturing SMEs in Türkiye, which is valid for SMEs of all sizes but is particularly pronounced for those with 1-19 employees. As the prices of goods and services rise, the number of people employed in manufacturing SMEs decreases. There could be three main reasons for this negative relationship between inflation and employment: Inflation can lead to higher unemployment. As businesses raise wages to attract and retain workers, their production costs increase, making it difficult for businesses to compete, and they may be forced to lay off workers to reduce costs. Employment can lead to higher inflation. When more people work, more money is circulating in the economy, leading to higher demand for goods and services, which can put upward pressure on prices. However, if businesses can increase production to meet the increased demand, inflation may not rise as much. Government policies can also affect inflation and employment. Governments can use monetary policy (such as interest rates) and fiscal policy (such as spending and taxes) to influence inflation and employment. For example, if the government raises interest rates, it can help slow the economy, leading to lower inflation and employment. The employment status of manufacturing SMEs in Türkiye may have been negatively affected by the government's disinflationary monetary and fiscal policies.

What emerges from the results reported here is that general government incentives seem to have considerably more of an impact on the employment status of enterprises. Regardless of the particular incentive offered, we emphasized that incentives significantly affect the employment levels of Türkiye's manufacturing SMEs.

[1] Results for firms with 20+ employees show no significant relationship and are available upon request.

Table 4. Regression results for the relationship between average employment and receiving any government incentive

Variables	*(1) OLS*	*(2) IV*
Incentive	0.044***	0.095***
	(0.006)	(0.034)
Employment level in 2013	0.944***	0.941***
	(0.003)	(0.004)
Firm age	0.001***	0.001***
	(0.000)	(0.000)
Capacity utilization rate		
%0-25	Ref.	Ref.
%26-%50	0.006	0.005
	(0.010)	(0.010)
%51-%75	0.040***	0.038***
	(0.010)	(0.010)
>%75	0.055***	0.055***
	(0.009)	(0.009)
Technological sophistication level of machinery equipment		
Insufficient	Ref.	Ref.
Neither sufficient nor insufficient	0.008	0.006
	(0.011)	(0.011)
Sufficient	0.005	0.005
	(0.011)	(0.011)
Utilization of Information technology (computer, software, internet)		
Insufficient	Ref.	Ref.
Neither sufficient nor insufficient	0.002	0.001
	(0.011)	(0.011)
Sufficient	0.014	0.011
	(0.011)	(0.011)
Export	0.021***	0.015**
	(0.006)	(0.007)
Innovation	0.049***	0.041***
	(0.007)	(0.009)
Firm size	0.118***	0.117***
	(0.007)	(0.008)
Regional variables		
GDP per capita	0.041*	0.044**
	(0.021)	(0.022)
Inflation	-14.531**	-15.362**
	(6.090)	(6.111)
Sector fixed effects	Yes	Yes
Region fixed effects	Yes	Yes
First-stage regression results		0.772***
		(0.040)
First-stage F statistics		375.20
R-squared	0.969	0.969
N	9429	9429

Notes: The first row in Column 1 reports coefficients (robust standard errors in parenthesis) on incentive from estimating equation (1) by OLS, and the first row in Column 2 reports coefficients (robust standard errors in parenthesis) on incentive from estimating equation (1) by IV using average incentives at the region and sector levels as an instrument. Our dependent variable is the natural logarithm of the average employment calculated by averaging the firm's 2014, 2015, and 2016 employment levels. All regressions control for sector fixed effects and region fixed effects as well as firm characteristics such as age, capacity utilization rates, technological sophistication level of machinery equipment, utilization of information technology, whether the firm exports or not, whether the firm carries out innovation activities, size, firms employment level in 2013, regional variables such as GDP per capita, and inflation rate. * p < .1, ** p < .05, *** p < .01.

Table 5. Regression results for the relationship between employment growth and receiving any government incentive by firm size (1-19 employees)

Variables	*(1) OLS*	*(2) IV*
Incentive	0.069***	0.176**
	(0.020)	(0.090)
Firm age	-0.002***	-0.002***
	(0.001)	(0.001)
Capacity utilization rate		
%0-25	Ref.	Ref.
%26-%50	-0.005	-0.006
	(0.023)	(0.023)
%51-%75	0.029	0.028
	(0.022)	(0.022)
>%75	0.046**	0.046**
	(0.021)	(0.021)
Technological sophistication level of machinery equipment		
Insufficient	Ref.	Ref.
Neither sufficient nor insufficient	0.004	0.000
	(0.024)	(0.024)
Sufficient	-0.024	-0.029
	(0.025)	(0.025)
Utilization of Information technology (computer, software, internet)		
Insufficient	Ref.	Ref.
Neither sufficient nor insufficient	-0.036	-0.037*
	(0.022)	(0.022)
Sufficient	-0.029	-0.035
	(0.023)	(0.024)
Export	-0.014	-0.030
	(0.016)	(0.020)
Innovation	0.069***	0.049*
	(0.020)	(0.026)
Regional variables		
GDP per capita	0.069	0.069
	(0.049)	(0.049)
Inflation	-23.313**	-23.486**
	(11.106)	(11.233)
Sector fixed effects	Yes	Yes
Region fixed effects	Yes	Yes
First-stage regression results		0.740***
		(0.046)
First-stage F statistics		260.18
R-squared	0.034	0.027
N	6253	6253

Notes: The first row in Column 1 reports coefficients (robust standard errors in parenthesis) on incentive from estimating equation (1) by OLS, and the first row in Column 2 reports coefficients (robust standard errors in parenthesis) on incentive from estimating equation (1) by IV using average incentives at the region and sector levels as an instrument. Our dependent variable is the employment growth between 2013 and 2016, calculated as [(employment in 2016 - employment in 2013)/ employment in 2013]. All regressions control for sector fixed effects and region fixed effects as well as firm characteristics such as age, capacity utilization rates, technological sophistication level of machinery equipment, utilization of information technology, whether the firm exports or not, whether the firm carries out innovation activities, regional variables such as GDP per capita, and inflation rate. * p < .1, ** p < .05, *** p < .01.

5. CONCLUSION

This study sets out to establish whether government incentives have an impact on employment growth and the employment level of firms. As monetary policy instruments are restricted for direct state interventions, government support for businesses as a fiscal policy weapon is becoming increasingly crucial. In this regard, we looked at the success of incentives provided to Turkish manufacturing SMEs. Our data

demonstrate how strongly SMEs rely on incentives to grow and compete. Therefore, general incentives do aid in the expansion of SMEs.

The effectiveness of incentives is also significantly influenced by the firm's size in our sample. While businesses with 1 to 19 employees are keener to grow with public funds, businesses with 20 or more employees have less success with incentives. This result reflects those of Voulgaris et al. (2005), Faulk (2002), Gamberoni et al. (2016) who also found that smaller firms are more likely to participate in an incentive program hence create more jobs by the support than larger firms. Other factors strongly and positively connected with enterprises' employment level include firm-level characteristics like capacity level, exporting, innovation, and advancements in technology and machinery. Outcome for export is contrary to that of Partridge et al. (2020) who found negative relation. This fact compels us to advise Turkish officials to develop and carry out policies that support small businesses if they possess potential qualities.

Furthermore, regional disparities persist, with less-incentivized regions receiving higher incentives than those supposed to get most public funding. If research examines corporations' employment based on their factories instead of their headquarters, we predict that wealth dispersion between these locations could be shown to be more severe, which would be a fruitful area for further work.

The effects of public funds on firms' employment are complex and depend on a variety of factors, including the type of public funds, the size of the public funds, the way the public funds are used, and the economic environment. Some theories suggest that public funds can have a negative impact on employment, while others suggest that they can have a positive impact. Our study found a positive relationship between public funds and employment. This finding broadly supports the work of other studies in this area linking incentives with employment (Faulk, 2002; Voulgaris et al., 2005; Courseuil and Moura, 2010). These results provide further support for the hypothesis that public funds can positively impact employment, but the specific mechanisms through which this occurs are unclear. An implication of this finding is the possibility that public funds increased employment by subsidizing firms' costs, which can make it more profitable for firms to hire more workers. Alternatively, it is also possible that the multiplier effect played a role whereby public funds created jobs indirectly by stimulating economic activity. However, Yanıkkaya and Karaboğa (2017) suspected that the displacement effect could occur within the Turkish manufacturing sector, which might hamper job creation as the explanation for why they could not find any relationship between incentives and employment, which differs from the findings presented here.

Based on our findings, policymakers should adopt a targeted approach to government support for the Turkish manufacturing sector. Given the pronounced impact of incentives on small and medium-sized enterprises (SMEs), there is a pressing need to tailor policies to the specific needs of businesses with 1-19 employees. The observed variation in incentive effectiveness based on firm size underscores the importance of designing nuanced policies that cater to the unique characteristics of different segments within the manufacturing landscape. Policymakers are urged to bolster support for smaller firms as they demonstrate a greater propensity to generate employment through incentive programs. Furthermore, the study highlights the complex nature of the relationship between public funds and employment, warranting further research to elucidate the specific mechanisms through which these funds positively influence employment outcomes. Despite study limitations, our findings emphasize the need for policymakers to refine and optimize government incentives, ensuring they are both accessible and effective for the diverse array of manufacturing enterprises in Türkiye.

The issue of employment incentives is intriguing and could be usefully explored in further research. Furthermore, we do not have panel data to examine the effects of incentives over a more extended period. Notwithstanding these limitations, the study suggests continued efforts are needed to make government incentives more accessible to firms with 1-19 employees.

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Author Contributions
Ali Recai Direkçi: Literature Review, Data Curation, Analysis, Writing-original draft *Abdullah Tirgil*: Conceptualization, Methodology, Data Curation, Analysis, Modelling, Writing-review and editing

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Compliance with Ethical Standards
It was declared by the authors that the tools and methods used in the study do not require the permission of the Ethics Committee.

Ethical Statement
It was declared by the authors that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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APPENDIX

Table A1. Number of firms in the sample and population by firm size, subsector, and region

	Number of Firms Participated in the Survey	*%*	*Total Number of Firms Represented by the Sample*	*%*
By Size				
1-19 Employees	6 724	66,82	189 222	87,29
20+ Employees	3 339	33,18	27 552	12,71
Total	10 063	100	216 774	100
By Subsector				
10 - Manufacture of food products	1 513	15,04	34 857	16,08
11 - Manufacture of beverages	175	1,74	455	0,21
12 - Manufacture of tobacco products	2	0,02	11	0,01
13 - Manufacture of textiles	610	6,06	14 589	6,73
14 - Manufacture of wearing apparel	590	5,86	26 381	12,17
15 - Manufacture of leather and related products	446	4,43	5 441	2,51
16 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	447	4,44	8 823	4,07
17 - Manufacture of paper and paper products	230	2,29	1 778	0,82
18 - Printing and reproduction of recorded media	358	3,56	7 262	3,35
19 - Manufacture of coke and refined petroleum products	100	0,99	212	0,10
20 - Manufacture of chemicals and chemical products	281	2,79	3 447	1,59
21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations	108	1,07	217	0,10
22 - Manufacture of rubber and plastic products	580	5,76	10 470	4,83
23 - Manufacture of other non-metallic mineral products	675	6,71	11 359	5,24
24 - Manufacture of basic metals	391	3,89	6 135	2,83
25 - Manufacture of fabricated metal products, except machinery and equipment	755	7,50	29 460	13,59
26 - Manufacture of computer, electronic and optical products	213	2,12	1 279	0,59
27 - Manufacture of electrical equipment	283	2,81	4 205	1,94
28 - Manufacture of machinery and equipment (not elsewhere classified)	421	4,18	7 435	3,43
29 - Manufacture of motor vehicles, trailers and semi-trailers	279	2,77	2 905	1,34
30 - Manufacture of other transport equipment	189	1,88	694	0,32
31 - Manufacture of furniture	539	5.,6	16 497	7,61
32 - Manufacture of furniture	278	2,76	4 986	2,30
33 - Repair and installation of machinery and equipment	600	5,96	17 906	8,26
Total	10 063	100	216 802	100
By Region				
TR10-İstanbul	1 476	14,67	77 909	35,94
TR21-Tekirdağ, Edirne, Kırklareli	364	3,62	4 422	2,04
TR22-Balıkesir, Çanakkale	305	3,03	4 032	1,86
TR31-İzmir	611	6,07	15 001	6,92
TR32-Aydın, Denizli, Muğla	362	3,60	8 888	4,10
TR33-Manisa, Afyonkarahisar, Kütahya, Uşak	370	3,68	7 154	3,30
TR41-Bursa, Eskişehir, Bilecik	612	6,08	15 759	7,27
TR42-Kocaeli, Sakarya, Düzce, Bolu, Yalova	520	5,17	10 752	4,96
TR51-Ankara	531	5,28	14 459	6,67
TR52-Konya, Karaman	363	3,61	6 547	3,02
TR61-Antalya, Isparta, Burdur	335	3,33	5 918	2,73
TR62-Adana, Mersin	417	4,14	7 479	3,45

Table A1. (*Continued*)

	Number of Firms Participated in the Survey	*%*	*Total Number of Firms Represented by the Sample*	*%*
By Region				
TR63-Hatay, Kahramanmaraş, Osmaniye	336	3,34	4 596	2,12
TR71-Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir	281	2,79	2 298	1,06
TR72-Kayseri, Sivas, Yozgat	363	3,61	5 029	2,32
TR81-Zonguldak, Karabük, Bartın	252	2,50	1 929	0,89
TR82-Kastamonu, Çankırı, Sinop	240	2,38	1 279	0,59
TR83-Samsun, Tokat, Çorum, Amasya	333	3,31	4 726	2,18
TR90-Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane	333	3,31	4 661	2,15
TRA1-Erzurum, Erzincan, Bayburt	222	2,21	1 127	0,52
TRA2-Ağrı, Kars, Iğdır, Ardahan	147	1,46	477	0,22
TRB1-Malatya, Elazığ, Bingöl, Tunceli	264	2,62	2 276	1,05
TRB2-Van, Muş, Bitlis, Hakkâri	195	1,94	759	0,35
TRC1-Gaziantep, Adıyaman, Kilis	378	3,76	6 698	3,09
TRC2-Şanlıurfa, Diyarbakır	239	2,38	1 929	0,89
TRC3-Mardin, Batman, Şırnak, Siirt	214	2,13	694	0,32
Total	10 063	100	216 796	100

The Ministry of Industry and Technology, Directorate General of Productivity, prepared and implemented the Productivity Strategy and Action Plan for 2015-2018 (Çoban et al., 2018). The document aimed to develop specific policies and instruments to improve productivity at the regional, scale, and sectoral levels (which is also included in the 10th Development Plan) (Republic of Türkiye Ministry of Development, 2014). However, the lack of data and findings on the causes of productivity problems at these levels hindered the achievement of this goal. The first action under the document was to create a Türkiye Regional and Sectoral Productivity Development Map, which would provide data and findings on the levels of differentiation and concentration of productivity problems in industrial sectors and regions.

VERİMLİLİK DERGİSİ
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Analysis of the Operational Performance of International Aviation Institutions with the EIFTOPSIS Method

Mustafa Özdemir[1]

ABSTRACT

Purpose: The main goal of this study is to rank the operational performance variables used in aviation according to their importance levels and to measure the operational performance of international aviation institutions.

***Methodology*:** An extended intuitionistic fuzzy TOPSIS method with maximum deviation is used in criterion weighting and performance measurement, which is relatively new and has no use case in aviation.

Findings: According to the results obtained in the study, it is understood that the total airport movements controlled among the variables used in the operational performance evaluation are the criterion with the highest importance. DSNA (France), ENAIRE (Spain), and DHMI (Türkiye) are in the top three in the best operational performance rankings.

Originality: The operational performance variables offered by EUROCONTROL have been tested for the first time with the extended intuitionistic fuzzy TOPSIS method.

Keywords*:* Aviation, Operational Performance, Intuitionistic Fuzzy Logic, EIFTOPSIS, MCDM.

JEL Codes: D81, L25, L93.

Uluslararası Havacılık Kurumlarının Operasyonel Performansının GSBTOPSIS Yöntemi ile Analizi

ÖZET

Amaç: Çalışmanın temel amacı havacılık alanında kullanılan operasyonel performans değişkenlerinin önem düzeylerine göre derecelendirilmesi ve uluslararası havacılık işletmelerinin operasyonel performanslarının ölçülmesidir.

***Yöntem*:** Kriter ağırlıklandırmada ve performans ölçümünde nispeten yeni ve havacılık alanında kullanım örneği bulunmayan maksimum sapma ile genişletilmiş sezgisel bulanık TOPSIS yöntemi kullanılmıştır.

Bulgular: Araştırma sonuçlarına göre operasyonel performans değerlendirmesinde kullanılan değişkenler içerisinde kontrol edilen toplam havaalanı hareketliliği en yüksek önem ağırlığına sahip kriter olduğu anlaşılmaktadır. En iyi operasyonel performans sıralamasında DSNA (Fransa), ENAIRE (İspanya) ve DHMİ (Türkiye) ilk üç sırada yer almaktadır.

Özgünlük: EUROCONTROL tarafından sunulan operasyonel performans değişkenleri ilk kez genişletilmiş sezgisel bulanık TOPSIS yöntemi ile test edilmiştir.

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1. INTRODUCTION

The aviation sector, which is a segment of the travel and transportation industry, has recently developed quite rapidly. The annual growth of the global aviation industry is 5-6%. The development of the aviation industry is due to the increase in international trade and the tendency of people to travel (Yu et al., 2008). The aviation industry plays an integral role in the creation of the macro-economy due to its effects on its own activities and other related industries (Belobaba, 2015:116). The aviation industry is part of general transport networks. In addition to having common features with other transportation systems, it also has its characteristics. With the use of specialized equipment due to technological development, the aviation industry is becoming more and more capital-intensive. Due to the fierce competitive pressure and high fixed costs in the industry, the survival and sustainability of aviation companies have become more difficult, especially during periods of low demand. The fierce competition in the aviation industry has become more evident today. Competitive conditions force organizations to reduce costs while increasing quality (Lu, 2012). To overcome these key challenges, to be successful and survive in the global airline market, performance measurement in aviation companies can be an important key (Wu and Liao, 2014).

The current conditions of the global economy and the size of airports in passenger and cargo traffic make performance evaluations an indispensable task (Shojaei et al., 2018). Barros and Dieke (2008) discuss the importance of performance evaluation of aviation enterprises for three main reasons:

- Efficient aviation services are essential for the sustainability of airline operations.
- Performance measurement studies are helpful in evaluating the effectiveness of governments' investments.
- Provides managers and decision-makers in aviation businesses with a source of information about benchmarks with other businesses.

For these reasons, performance evaluation with appropriate different approach tools is very important for the effective management of aviation services.

Due to the multitude of indices in performance evaluation methods, measuring values can be difficult and complex, and the presence of multiple variables also involves high uncertainty and blurriness (Anbanandam et al., 2011). Various models have been presented by researchers to examine performance in uncertain environments. To cope with the uncertainty in the aviation industry, the extended intuitionistic fuzzy TOPSIS (EIFTOPSIS) method, which is an Multi-Criteria Decision-Making (MCDM) approach and proposed as a new model by Shen et al, (2018), was used in this study. This new model, which eliminates the drawbacks of the existing intuitive fuzzy set distance measure, is used for the first time in performance measurement in the aviation industry. This newly developed method was preferred because it does not have any application in the aviation industry, it can help decision-makers in combating uncertainty, and it models a stronger distance measure by eliminating the weaknesses of existing distance measures.

This study, which focuses on the operational performance of international aviation service providers, basically consists of 4 sections. In the first section, the literature review and the conceptual framework of operational performance are explained. The methodology and algorithms used are presented in the next section. Then, analysis and findings are given. In the last section, research results and recommendations are mentioned.

2. OPERATIONAL PERFORMANCE

The global air transport industry is becoming more and more competitive. Airline companies have to make quick decisions in an intensely competitive environment to survive in the sector. While low input prices were important in the past to provide a competitive advantage, the strength of operational performance is more evident today (Wu and Liao, 2014). Operational performance is important for companies as it demonstrates the improvement in quality in terms of flexibility of service delivery (Zhang and Xia, 2013). Operational performance, which supports competitive advantage (Narasimhan and Das, 2001; Schroeder et al., 2011), continues to attract the attention of managers and industry observers from past to present.

In recent years, the issue of performance evaluation has created interest in every sector. In the performance evaluation literature, some studies evaluate the performance of organizations through both subjective and objective data (Ouellette et al., 2010; Lu et al., 2012, Gramani, 2012; Lee et al., 2013).

When the relevant literature is examined, performance measurement studies related to the aviation sector are encountered. In the studies conducted, Schefczyk (1993) compared the operational performance of 15 international airline companies in 1990 with the data envelopment analysis (DEA) method. Färe et al. (2007) analyzed the performance of an airline company with the Malmquist Efficiency Index, taking into account the time factor. Barbot et al., (2008) examined the effectiveness and efficiency of 49 international airline companies in a single period using DEA and total factor productivity approaches. He also investigated the

differences in productivity of factors. Barros and Peypoch (2009) analyzed the performance of the members of the European Airlines Association between 2000 and 2005 using the DEA method by combining operational and financial variables. Assaf and Josiassen (2011) focused on UK airlines and measured their efficiency. They tried to explain the sources of efficiency differences using an innovative DEA model and a 5-year data set of 15 airline companies. Lu et al., (2012) examined the relationship between operational performance and corporate governance of 30 airline companies operating in the USA with the help of the two-stage DEA method. Zou and Hansen (2012) empirically investigated the operational performance of US airlines during the period 1995-2007 and its impact on cost structure using the aggregate statistical cost estimation approach. Wanke et al. (2015) evaluated the performance of Asian airlines in the 2006-2012 period with the MCDM method. Wanke and Barros (2016) investigated the operational performance of Latin American airlines in the 2010-2014 period using the virtual frontier dynamic DEA method. Yu et al. (2017) examined the dynamic production efficiency, service efficiency, and overall operational efficiency of 30 global airline companies from 2009 to 2012 with the two-stage dynamic network DEA method. Seufert et al. (2017) evaluated the operational performance of the world's largest airlines between 2007 and 2013. In the study, a production indicator is proposed for undesirable outputs in airline performance analysis. Mhlanga et al. (2018) examined the factors affecting the operational efficiency of airlines in South Africa and their impact on airline performance. Pineda et al. (2018) ranked airlines in the US based on their financial and operational performance. They proposed an integrated model combining data mining and MCDM by identifying critical factors for improving airline performance. Bakir et al. (2020) evaluated the operational performance of 11 airlines operating in emerging markets with a new proposed MCDM method. Kiraci and Yasar (2020) examined the operational data of 52 airlines, which control more than 90% of the global airline transportation industry, between 1990 and 2017 with panel data analysis. They report the factors determining the operational performance of airlines. Pinchemel et al. (2022) investigated the relationship between management and operational efficiency of the four largest private airlines in Brazil. The relationship between performance indicators was tried to be revealed by regression analysis using panel data from 2009 to 2017. Looking at the scientific literature, there is a consensus that operational performance is based on service delivery, quality practices, efficiency, and environmental and legal responsibility (Sharma and Modgil, 2020; Heizer et al., 2020:34). Performance measurements for all studies should be accessible, reliable, and accurate (Wyman, 2012).

The operation and management of airports are carried out by air transport service provider companies. The management of the airport is similar to other sectors in terms of corporate ethics and operational efficiency (Dožić, 2019). Researchers generally make use of operational or financial criteria when evaluating the overall performance of aviation enterprises (Gramani, 2012). In recent performance measurement studies, a transition from simple financial indicators to a multidimensional measurement perspective is observed. Therefore, researchers focus on multidimensional indicators (Lu et al., 2012). The operational efficiency of the airport operation can be examined in four dimensions these; airline companies, aviation management services, passengers, and airports. Airline companies cover the number of routes and the number of take-offs and landings. The aviation control service includes the number of aviation controllers. Passenger ratings include the total number of passengers served. The airport is evaluated in terms of workforce, terminal facilities, aviation facilities, traffic volume, and revenue. The overall operational performance is evaluated by examining the productivity of employees, aviation, passenger and airline service levels (Wang et al., 2004).

Managers, decision-makers, and people in organizations are faced with a wide variety of decisions in their daily lives that require evaluation related to multiple features, criteria, and factors (Bai et al., 2014). Improving operational performance in aviation businesses requires a decision-making process that includes a systematic approach due to its complex nature. Such decision-making processes require consideration of sometimes contradictory and sometimes interrelated criteria (Gomes et al., 2014). All these factors make performance evaluation in aviation companies a MCDM problem (Bae et al., 2021).

A review of the literature reveals that operational performance studies in the aviation sector are conducted on airline companies. However, the aviation industry is multidimensional. Airport operations and management play a key role in the aviation industry. It is noticed that airport businesses are ignored in operational performance measurement and there is a gap in the aviation sector literature. This research will contribute to the literature in this context with its originality.

3. METHOD

The fuzzy set (FS) theory proposed by Zadeh (1965) has been successfully applied in many fields to overcome uncertainty problems. The basis of the FS theory is based on the membership degrees of the set elements. Researchers have developed different applications for the traditional FS theory recently. Intuitive fuzzy set (IFS), developed by Atanassov (1986) and an extension of classical FS, is explained by membership degree, non-membership degree and hesitation degree. Many researchers state that the IFS

approach offers meaningful results in dealing with blurriness and is very useful in applications (Shen et al., 2016).

MCDM methods help decision-makers organize and synthesize information in a way that gives them confidence in decision-making (Belton and Stewart, 2002:264). MCDM methods provide a systematic quantitative approach to decision problems involving multiple criteria and actions. MCDM can assist decision makers in rationally evaluating all the important objective and subjective criteria for a problem (Hatami-Marbini and Tavana, 2011). TOPSIS method, which is one of the MCDM approaches, offers managers the opportunity to make decisions based on solid foundations. TOPSIS was developed to minimize the distance of an object value from the positive ideal solution and maximize its distance from the negative ideal solution (Hwang and Yoon, 1981). TOPSIS method can be categorized as an objective, deterministic, discrete alternative, compensatory MCDM approach. TOPSIS method, which is one of the MCDM approaches that is used successfully in many fields and gives effective results, draws attention in research (Junior et al., 2014; Boutkhoum et al., 2018; Prascevic and Prascevic, 2017; Roy and Dutta, 2019; Samanlioglu et al., 2018; Venkatesh et al., 2019; Bai and Sarkis, 2013; Chen and Tzeng, 2004; Krohling and Campanharo, 2011; Wang and Chang, 2007).

In traditional TOPSIS methods, criteria have definite values in the evaluation of alternatives. Recently, the combination of the TOPSIS method and IFSs has received widespread attention from many researchers (Shen et al., 2018). In the literature, some studies use the Fuzzy TOPSIS approach to measure performance in the aviation industry (Wang, 2008; Garg, 2016; Barros and Wanke, 2015). However, the proposed TOPSIS methods in the heuristic fuzzy environment have some disadvantages, such as not being able to take an alternative order of preference and negative effects in the real decision-making process (Ye, 2010; Joshi and Kumar, 2014; Wang et al., 2016). In this study, the heuristic fuzzy distance measure, which was proposed by Shen et al. (2018) as a new approach, and which overcomes the drawbacks of the existing IFS distance measure, was used. The basic algorithm of the IFS approach is shown in Equations 1-3.

For any $x \in X$ where $A = \{(x, \mu A(x), \nu A(x)) / x \in X\}$ for the intuitionistic fuzzy set A in the set X;

$$\mu A : X \to [0,1], x \in X \to = \mu A(x) \in [0,1] \quad (1)$$

the degree of membership of $x \in X$ to A

$$\nu A : X \to [0,1], x \in X \to = \nu A(x) \in [0,1] \quad (2)$$

the degree of non-membership of $x \in X$ to A, and

$$\mu A(x) + \nu A(x) \leq 1 \quad (3)$$

is expressed.

The degree of hesitation or uncertainty of X in A is calculated by the function $\pi A(x) = 1 - \mu A(x) - \nu A(x)$ (Atanassov, 1986). Especially if $\pi A(x) = 0$, A is reduced to a fuzzy set.

In MCDM problems, decision-makers need to weigh more than one criterion according to the level of importance and choose the most appropriate one among various alternatives. Among the MCDM methods, the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method attracts a lot of attention. The extended intuitionistic fuzzy TOPSIS (EIFTOPSIS) approach based on the new distance measure is preferred to be used in this article because of its effective results and advantages. The application procedure and mathematical notations of the EIFTOPSIS method, which is integrated with the extended intuitionistic fuzzy approach, are presented below (Shen et al., 2018).

Step 1: A decision matrix containing row-based competitive alternatives (i) and column-based criteria (j) is created as shown in Equation 4.

$$D = (a_{ij})_{mxn} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_j \end{array} \\ \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1j} \\ a_{21} & a_{22} & \cdots & a_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} \end{pmatrix} \end{array} \quad (4)$$

Step 2: Each value in the decision matrix is normalized with the help of Equation 5 (Jahanshahloo et al., 2006).

$$n_{ij} = x_{ij} / \sqrt{\sum_{j=1}^{m} x_{ij}^2} \qquad i = 1\ldots, m.\ j = 1, \ldots, n \quad (5)$$

Step 3: The exact data in the normalized decision matrix are transformed into intuitionistic fuzzy values by using the Equations 6-8 respectively (Atanassov, 1986; Singh et al., 2019).

$$v_i' = 1 - \mu_i \tag{6}$$

$$\pi_i = \frac{v_i'}{\sum_{i=1}^{n} v_i'} \tag{7}$$

$$v_i = 1 - \mu_i - \pi_i \tag{8}$$

Step 4: IFSs-based positive ideal solution values for each criterion are calculated using $\tilde{a}^+ = \tilde{a}_1^+, \tilde{a}_2^+, \dots, \tilde{a}_3^+$, and negative ideal solution values $\tilde{a}^- = \tilde{a}_1^-, \tilde{a}_2^-, \dots, \tilde{a}_3^-$ using Equations 9 and 10, respectively. C^+refers to the benefit cluster criteria and C^- refers to the cost cluster criteria in the equations.

$$\tilde{a}_j^+ = \begin{cases} \left(max_{1\le i\le m}\{\mu_{ij}\}, min_{1\le i\le m}\{v_{ij}\}\right) = \left(\mu_j^+, v_j^+\right), \ if\ C_j \in C^+ \\ \left(min_{1\le i\le m}\{\mu_{ij}\}, mak_{1\le i\le m}\{v_{ij}\}\right) = \left(\mu_j^+, v_j^+\right), \ if\ C_j \in C^- \end{cases} \tag{9}$$

$$\tilde{a}_j^- = \begin{cases} \left(min_{1\le i\le m}\{\mu_{ij}\}, mak_{1\le i\le m}\{v_{ij}\}\right) = \left(\mu_j^+, v_j^+\right), \ if\ C_j \in C^+ \\ \left(mak_{1\le i\le m}\{\mu_{ij}\}, min_{1\le i\le m}\{v_{ij}\}\right) = \left(\mu_j^+, v_j^+\right), \ if\ C_j \in C^- \end{cases} \tag{10}$$

Step 5: With the new distance measure shown in Equations 11-12, the intuitionistic fuzzy distances between $\tilde{a}_{ij}$, $\tilde{a}_j^-$ and $\tilde{a}_{ij}$, $\tilde{a}_j^+$ are calculated separately. Then, intuitionistic fuzzy distance matrices in Equations 13 and 14 are generated.

$$\tilde{\mu}_{ij} = \mu_{ij}\left(1 + \frac{2}{3}\pi_{ij}\left(1 + \pi_{ij}\right)\right) \tag{11}$$

$$\tilde{v}_{ij} = v_{ij}\left(1 + \frac{2}{3}\pi_{ij}\left(1 + \pi_{ij}\right)\right) \tag{12}$$

$$D^+ = \left(d\left(\tilde{a}_{ij}, \tilde{a}_j^+\right)\right)_{mxn} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_j \end{array} \\ \begin{pmatrix} d(\tilde{a}_{11}, \tilde{a}_1^+) & d(\tilde{a}_{12}, \tilde{a}_2^+) & \cdots & d\left(\tilde{a}_{1j}, \tilde{a}_j^+\right) \\ d(\tilde{a}_{21}, \tilde{a}_1^+) & d(\tilde{a}_{22}, \tilde{a}_2^+) & \cdots & d\left(\tilde{a}_{2j}, \tilde{a}_j^+\right) \\ \vdots & \vdots & \ddots & \vdots \\ d(\tilde{a}_{i1}, \tilde{a}_1^+) & d(\tilde{a}_{i2}, \tilde{a}_2^+) & \cdots & d\left(\tilde{a}_{ij}, \tilde{a}_j^+\right) \end{pmatrix} \end{array} \tag{13}$$

$$D^- = \left(d\left(\tilde{a}_{ij}, \tilde{a}_j^-\right)\right)_{mxn} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_j \end{array} \\ \begin{pmatrix} d(\tilde{a}_{11}, \tilde{a}_1^-) & d(\tilde{a}_{12}, \tilde{a}_2^-) & \cdots & d\left(\tilde{a}_{1j}, \tilde{a}_j^-\right) \\ d(\tilde{a}_{21}, \tilde{a}_1^-) & d(\tilde{a}_{22}, \tilde{a}_2^-) & \cdots & d\left(\tilde{a}_{2j}, \tilde{a}_j^-\right) \\ \vdots & \vdots & \ddots & \vdots \\ d(\tilde{a}_{i1}, \tilde{a}_1^-) & d(\tilde{a}_{i2}, \tilde{a}_2^-) & \cdots & d\left(\tilde{a}_{ij}, \tilde{a}_j^-\right) \end{pmatrix} \end{array} \tag{14}$$

Step 6: The Composite intuitionistic fuzzy distance matrix expressed by Equation 15 is created. In the best performance data, $d\left(\tilde{a}_{ij}, \tilde{a}_j^-\right)$ values should be large and $d\left(\tilde{a}_{ij}, \tilde{a}_j^+\right)$ values should be small. In other words, the data with the best performance should be far from the cost criteria and close to the benefit criteria. The larger the Z_{ij}^* value, the better the $\tilde{a}_{ij}$ performance data indicates.

$$D^* = \left(Z_{ij}^*\right)_{mxn} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_j \end{array} \\ \begin{pmatrix} d(\tilde{a}_{11}, \tilde{a}_1^-) - d(\tilde{a}_{11}, \tilde{a}_1^+) & d(\tilde{a}_{12}, \tilde{a}_2^-) - d(\tilde{a}_{12}, \tilde{a}_2^+) & \cdots & d\left(\tilde{a}_{1j}, \tilde{a}_j^-\right) - d\left(\tilde{a}_{1j}, \tilde{a}_j^+\right) \\ d(\tilde{a}_{21}, \tilde{a}_1^-) - d(\tilde{a}_{21}, \tilde{a}_1^+) & d(\tilde{a}_{22}, \tilde{a}_2^-) - d(\tilde{a}_{22}, \tilde{a}_2^+) & \cdots & d\left(\tilde{a}_{2j}, \tilde{a}_j^-\right) - d\left(\tilde{a}_{2j}, \tilde{a}_j^+\right) \\ \vdots & \vdots & \ddots & \vdots \\ d(\tilde{a}_{i1}, \tilde{a}_1^-) - d(\tilde{a}_{i1}, \tilde{a}_1^+) & d(\tilde{a}_{i2}, \tilde{a}_2^-) - d(\tilde{a}_{i2}, \tilde{a}_2^+) & \cdots & d\left(\tilde{a}_{ij}, \tilde{a}_j^-\right) - d\left(\tilde{a}_{ij}, \tilde{a}_j^+\right) \end{pmatrix} \end{array}$$

$$= \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ Z_{11}^* \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_j \end{array} \\ \begin{pmatrix} Z_{11}^* & Z_{12}^* & \cdots & Z_{1j}^* \\ Z_{21}^* & Z_{22}^* & \cdots & Z_{2j}^* \\ \vdots & \vdots & \ddots & \vdots \\ a_{i1} & Z_{i2}^* & \cdots & Z_{ij}^* \end{pmatrix} \end{array} \tag{15}$$

Step 7: $w_{ij}^{*}(j = 1,2,\dots,n)$ importance weights are calculated for each criterion. The maximum deviation method shown in Equation 16 can be used to determine the weight of each of the criteria. In this method, decision makers derive the weights of the criteria from the variability of the data. w_j^{*} shows the optimal weight for each criterion.

$$w_j^{*} = \frac{\sum_{i=1}^{m}\sum_{k=1}^{m}\left|Z_{ij} - Z_{kj}\right|}{\sum_{i=1}^{n}\sum_{i=1}^{m}\sum_{k=1}^{m}\left|Z_{ij} - Z_{kj}\right|} \tag{16}$$

Step 8: The weighted intuitionistic fuzzy distance measures of each alternative are calculated with the help of Equation 17. At the last stage in the application procedure of the method, the alternatives are ranked according to the D_i score. The higher the D_i value, the better the alternative's performance.

$$D_i = \sum_{j=1}^{n} w_j^{*} Z_{ij}^{*},\ i = 1,2,\dots,m. \tag{17}$$

In TOPSIS, the positive ideal solution is a solution that maximizes the benefit criterion, which improves as the value increases, and minimizes the cost criterion, which improves as the value decreases. The negative ideal solution maximizes the cost criterion while minimizing the benefit criterion. In other words, while the positive ideal solution includes all the best values that the criteria can achieve, the negative low solution includes all the worst values that the criteria can achieve (Bai and Sarkis, 2013).

4. FINDINGS

In this MCDM-based study, which examines the operational performance of international aviation enterprises, primarily evaluation criteria have been determined. The determination of the most appropriate variables to be used in the evaluation is extremely important for the validity and reliability of the research results. In this study, operational performance variables presented by the EUROCONTROL Performance Review Unit (PRU), which has an active role in the aviation industry, were used. The variables that were weighted and used in the performance evaluation are presented in Table 1. The variables in the table are positive benefit criteria.

Table 1. Evaluation criteria

Code	*Criteria*	*Data source*
C1	Size of controlled airspace in km^2	EUROCONTROL NM
C2	Number of airports with TWR operational unit	ANSP
C3	Total IFR flights controlled by the ANSP	EUROCONTROL NM
C4	% Overflights	EUROCONTROL NM
C5	% Domestic flights	EUROCONTROL NM
C6	% Arr/Dep international flights	EUROCONTROL NM
C7	Total distance (km) controlled by the ANSP	EUROCONTROL NM
C8	Total IFR flight-hours controlled by the ANSP	EUROCONTROL NM/ PRU
C9	Total IFR airport movements controlled by the ANSP	EUROCONTROL NM
C10	Sum of IFR ACC movements	EUROCONTROL NM
C11	Sum of IFR Km controlled by the ACCs	EUROCONTROL NM
C12	Sum of flight-hours controlled by the ACCs	EUROCONTROL NM /PRU

Source: EUROCONTROL (2021)

Within the scope of the research, there are 38 international aviation enterprises as the decision-making unit (DMU), shown in Table 2. The 2021 data of 38 service provider decision-making units (DMU) presented by EUROCONTROL PRU were analyzed using the maximum deviation and EIFTOPSIS method procedure. By applying the equations (4-17) in order, firstly the importance weight scores of the evaluation criteria and then the performance values of the aviation enterprises were calculated.

Table 2. Evaluated decision units

Code	*ANSP Name*	*Country Name*	*Code*	*ANSP Name*	*Country Name*
DMU1	Albcontrol	Albania	DMU20	LFV	Sweden
DMU2	ANS CR	Czech Republic	DMU21	LGS	Latvia
DMU3	ARMATS	Armenia	DMU22	LPS	Slovakia
DMU4	Austro Control	Austria	DMU23	LVNL	Netherlands
DMU5	AVINOR (Continental)	Norway	DMU24	MATS	Malta
DMU6	BHANSA	Bosnia and Herzegovina	DMU25	M-NAV	North Macedonia
DMU7	BULATSA	Bulgaria	DMU26	MOLDATSA	Republic of Moldova
DMU8	Croatia Control	Croatia	DMU27	NATS (Continental)	United Kingdom
DMU9	DCAC Cyprus	Cyprus	DMU28	NAV Portugal (Continental)	Portugal
DMU10	DFS	Germany	DMU29	NAVIAIR	Denmark
DMU11	DHMI	Republic of Turkiye	DMU30	Oro Navigacija	Lithuania
DMU12	DSNA	France	DMU31	PANSA	Poland
DMU13	EANS	Estonia	DMU32	ROMATSA	Romania
DMU14	ENAIRE	Spain	DMU33	SAKAERONAVIGATSIA	Georgia
DMU15	ENAV	Italy	DMU34	skeyes	Belgium
DMU16	Fintraffic ANS	Finland	DMU35	Skyguide	Switzerland
DMU17	HASP	Greece	DMU36	Slovenia Control	Slovenia
DMU18	HungaroControl	Hungary	DMU37	SMATSA	Serbia & Montenegro
DMU19	IAA	Ireland	DMU38	UkSATSE	Ukraine

As can be seen in Figure 1, the total controlled airport movements (0,093) were found to be the most important criterion in the operational performance evaluation. This variable is an indicator for the output of terminal air traffic control covering the first and last stages of the flight (Bilotkach et al., 2015). In addition, total airport movements controlled reflect the relative monetary importance of on-route and terminal area services on average for all European navigation service providers (ENSP) on a total cost basis (Arnaldo et al., 2014). The increase in controlled airport movements leads to a proportionally lower increase in the total cost (Buyle et al., 2018). The percentage of top flights (0,056) was determined as the criterion with the lowest importance. If a flight's departure and arrival airports are located outside the country, that flight is considered an overflight.

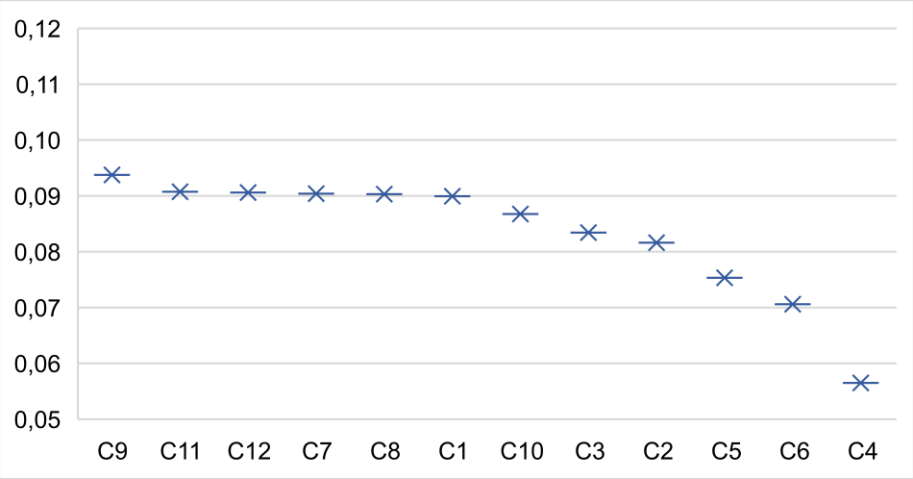

Figure 1. Criterion significance weights

When Figure 2 is examined, the DSNA -France (0,350) aviation enterprise has the highest value in operational performance. ENAIRE – Spain (0,129) and DHMI – Republic of Türkiye (0,129) rank second in the indicator of the highest performance in aviation operations. ARMATS – Armenia (- 0,477), M-NAV – Macedonia (-0,477), and MOLDATSA – Moldova (-0,480) are in the last places by showing the lowest score in operational performance.

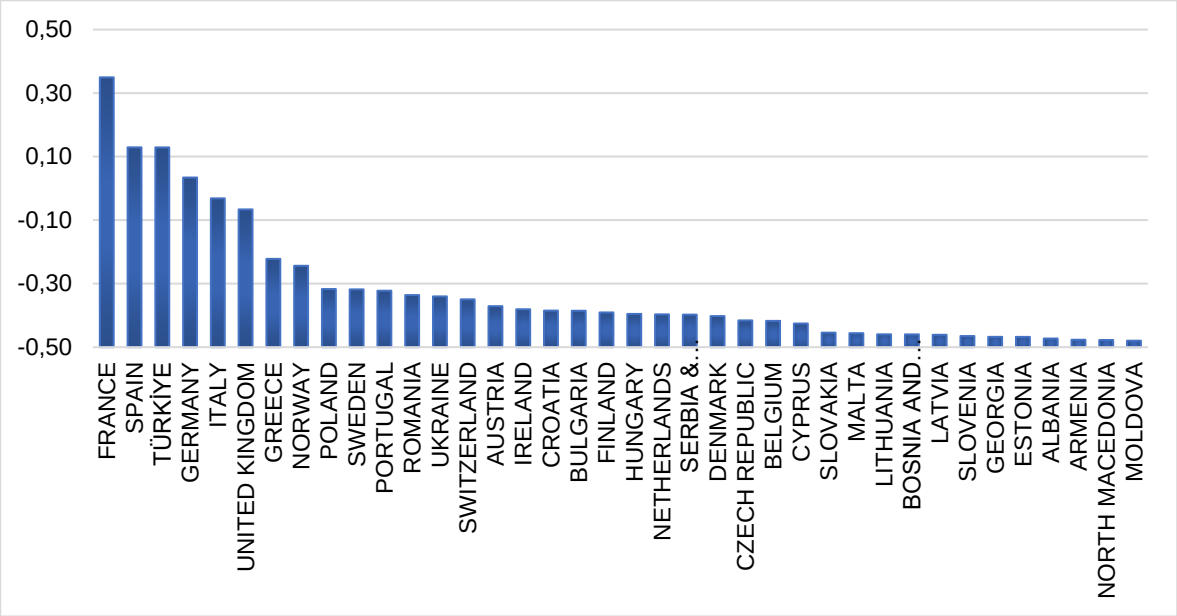

Figure 2. Operational performance ranking

5. CONCLUSION

It is especially important for a free market economy, as problems in the aviation industry can affect both global economic development and international politics. Airline service providers, who view both airlines and passengers as consumers, need to make well-founded decisions on how to improve their competitive position in the market and their operational performance.

In this study, using panel data from EUROCONTROL PRU annual comparison reports, variable importance weights were calculated and the operational performances of international aviation enterprises were measured. The article differs from previous research in that it takes into account the multifaceted nature of the aviation industry and uses a relatively new method, an extended heuristic fuzzy approach. Intuitive fuzzy approaches can minimize the error of uncertainty in multiple decision-making and evaluation situations.

The variable of total airport movements controlled in the results of the research was calculated as the most important variable in the operational performance evaluation. This variable is also important in cost controls. Decision-makers can determine more effective strategies to improve their operational performance over this variable. European countries are taking steps to modernize their aviation infrastructures. This improves cost-effectiveness, spectrum utilization, and the provision of new and more services. According to the results of the study, DSNA, which has the highest operational performance, has taken important steps such as radar vectoring, and reduced separation minimums, especially for the rationalization of aviation infrastructure, while providing a better service to airspace users. In addition, DSNA aims to go further in multinational coordination to achieve an efficient infrastructure. All of the work done by DSNA can be taken as an example by other countries' aviation businesses in improving operational performance. These research results highlight some quantitative issues that need to be considered in depth in the strategy and policy setting of service providers in the aviation industry. It also presents guiding findings that will shed light on decision-makers in improving operational performance.

Indication of limitations in research is important in revealing the importance of the study and providing information to researchers. The most important limitation of this study is that the data used in this research covers only one year and a periodic comparison cannot be made. In future studies, the results of this cross-sectional study can be compared by adding data from the next period to the results of this cross-sectional study and comparing the analyses made with different methods.

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It was declared by the author that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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VERİMLİLİK DERGİSİ
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Technology Adoption, Innovation and the South Korean Miracle

M. Aykut Attar[1]

ABSTRACT

Purpose: The main purpose is to understand the microeconomic foundations of the South Korean miracle through careful analysis and a realistic equilibrium model.

Methodology: The paper constructs a simple equilibrium model where productivity growth is endogenous to (i) human capital, (ii) the country's distance to the global technology frontier, and (iii) the level of urban agglomeration. The paper identifies and calculates unobserved productivity terms using various observed variables from South Korean national accounts for the post-1960 period. The paper then presents the structural estimates of the model parameters and the results of the decomposition analysis.

Findings: While the South Korean economy was initially using a backward technology, it became an innovation economy in the early 1980s. Structural estimates show that urban agglomeration is not statistically significant in the South Korean case. Finally, a decomposition analysis shows that, in the early 1960s, human capital and distance to the frontier made similar contributions to productivity growth.

Originality: The model economy has two sectors. Technology in the modern sector exhibits Constant Returns to Scale, but traditional technology is constrained by Decreasing Returns to Scale. In addition, both the technology adoption regime and the innovation regime can be represented by the same mathematical function, and the article is therefore theoretically original.

Keywords: Endogenous Technology, Equilibrium Model, Structural Estimation, Catching Up.

***JEL Codes*:** O12, O33, O41.

Teknoloji Benimseme, İnovasyon ve Güney Kore Mucizesi

ÖZET

Amaç: Ana amaç, özenli bir analiz ve gerçekçi bir denge modeli ile Güney Kore mucizesinin mikroekonomik temellerini anlamaktır.

Yöntem: Makale, verimlilik büyümesinin, (i) beşerî sermayeye, (ii) ülkenin küresel teknoloji uç sınırına olan uzaklığına ve (iii) kentsel yığılma düzeyine içsel olduğu basit bir denge modeli inşa etmektedir. Makale, 1960 sonrası dönem için Güney Kore ulusal hesaplarından çeşitli gözlemlenen değişkenleri kullanarak, gözlemlenmemiş verimlilik terimlerini belirlemekte ve hesaplamaktadır. Makale, daha sonra, model parametrelerinin yapısal tahminlerini ve ayrıştırma analizinin sonuçlarını sunmaktadır.

Bulgular: Güney Kore ekonomisi başlangıçta geri bir teknoloji kullanırken, 1980'lerin başında yenilikçi bir ekonomi haline gelmektedir. Yapısal tahminler, kentsel yığılmanın Güney Kore örneğinde istatistiksel olarak anlamlı olmadığını göstermektedir. Son olarak, bir ayrıştırma analizi, 1960'ların başında beşerî sermayenin ve teknoloji uç sınırına olan uzaklığın verimlilik büyümesine benzer katkılar yaptığını göstermektedir.

Özgünlük: Model ekonominin iki sektörü vardır. Modern sektördeki teknoloji, Ölçeğe Göre Sabit Getiri sergilemektedir, ancak geleneksel teknoloji, Ölçeğe Göre Azalan Getirilerle kısıtlanmıştır. Ek olarak hem teknoloji benimseme rejimi hem de yenilik rejimi aynı matematiksel fonksiyonla temsil edilebilmektedir ve bu nedenle makale teorik olarak orijinaldir.

Anahtar Kelimeler: İçsel Teknoloji, Denge Modeli, Yapısal Tahmin, Yakalama.

JEL Kodları: O12, O33, O41.

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1. INTRODUCTION

The South Korean economy has exhibited rapid economic growth in per capita terms in the second half of the 20th century. The updated Maddison Project database indicates that, measured in 2011 international dollars, real GDP per capita has been around 38,000 United States' dollar (USD) in 2018 (Bolt and van Zanden, 2020). This is about 28 times larger than 1,373 USD recorded in 1954, i.e., in the immediate aftermath of the Korean War. From 1954 to 2018, the average growth rate of real GDP per capita has been around 5.4% per annum, and the miraculous growth rate has been around 7.4% per annum for the period starting in 1961 and ending with the Asian Financial Crisis in 1997.

The main purpose of this paper is to present new evidence on the microeconomic foundations of the South Korean miracle. The microeconomic foundations are simply the deep determinants of sectoral and aggregate productivity growth rates in the economy. The paper closely follows Lucas (2009) and constructs a two-sector catching up model to understand the drivers of endogenous productivity growth in South Korea. As in Lucas (2009), the sector that uses the modern (i.e., constant returns to scale) technology adopts foreign technologies from the world frontier, and the sector that uses the traditional (i.e., decreasing returns to scale) technology benefits from a spillover from the modern sector. But differently from Lucas (2009), the present framework introduces (i) physical capital in the modern technology as an essential input and (ii) human capital as a determinant of endogenous productivity growth. In these respects, the model studied in this paper is much more realistic. Furthermore, neglecting the sectoral differences and structural transformation in understanding miraculous economic growth may lead to wrong lessons about the true sources of growth and change, as previously demonstrated by Nelson and Pack (1999).

Since productivity levels are not directly observed by the econometrician, estimating structural parameters that determine productivity growth rates are typically infeasible. Whereas one can estimate production functions and, hence, residual productivity levels, it is not entirely straightforward to obtain the structural estimates of parameterized versions of nonlinear endogenous technology models. Besides, in multi-sector models that feature productivity spillovers, identification is all the more formidable. On the other hand, imposed theoretical structures may still allow us to identify some or all of the structural parameters if some model inputs are set arbitrarily at the outset. The present analysis benefits from such a possibility; the structural model has six structural parameters, and the empirical strategy identifies five of these six structural parameters using observed data after fixing one of them.[2] More specifically, this paper estimates two parameters of the traditional technology and three parameters that determine productivity growth rate of the modern technology by assigning a value to the labor share of the traditional technology. The observed data needed for this estimation to work covers real GDP per capita, physical capital stock, human capital stock, and the share of rural population.

Results indicate that the South Korean miracle has two distinct episodes or regimes. The former, from 1960 to the early 1980s, is an era of very rapid productivity growth. Decadal averages of productivity growth rates typically exceed 7% per annum in this first period. The major driver of productivity growth in the first regime is the distance to the frontier. That is, the South Korean economy is not a technology leader in this regime, but it keeps closing its distance with the world frontier by successfully adopting foreign technologies. Eventually, in the early 1980s, productivity in South Korea forges ahead the frontier productivity. In the second regime, South Korea becomes an innovator economy. In this regime, productivity growth rates are much lower, and the advantage of relative backwardness of the first regime now acts as an obstacle for higher productivity growth, as the economy already achieved high levels of productivity. Hence, the second regime after the early 1980s is similar to the experiences of other innovative high-income economies that are themselves technology leaders. Results also show that, in both regimes, human capital works as a crucial determinant of productivity growth in South Korea.

The remainder of the paper is organized as follows: Section 2 presents a discussion of the related literature and the contributions of the present paper. Section 3 introduces the model economy. Section 4 explains the methodological approach and describes the dataset. Section 5 presents the main results of the paper. Section 6 demonstrates that the main results are not much sensitive to the arbitrary parameter values. Section 7 concludes the paper with some remarks. Detailed mathematical derivations are presented in the appendices.

2. RELATED WORKS and CONTRIBUTIONS

By identifying unobserved productivity terms for South Korea using a two-sector catching-up model and by providing structural econometric estimates of the relevant microeconomic foundations, this paper makes several empirical contributions to the related literature.

[2] The qualitative nature of results is not sensitive to this arbitrary parameter value; see Section 6.

The earliest thoughts on catching up and technology adoption can be found in Veblen (1915: 1) where he discusses how technology diffuses from early-industrialized countries such as Britain to a late-industrialized country such as Germany. The advantage of relative backwardness hypothesis of Gerschenkron (1962: 1) builds upon the experience of other follower countries such as Japan and Russia. The earliest formulations of how education (or human capital) affects technology adoption can be found in Nelson and Phelps (1966) and Gomulka (1971). In the present paper, human capital is shown to play a major role in positively affecting technology adoption during the miraculous transformation of the South Korean economy.

Early empirical assessments of whether initially poorer economies grow faster has been presented by Kormendi and Meguire (1985), Baumol (1986), DeLong (1988), and Barro (1991). These works have initiated the so-called Convergence Controversy, and various methodologies have been exploited to study the world income distribution and convergence clubs.[3] The results presented here demonstrate that the South Korean economy completed its convergence to the world frontier in the early 1980s.

The seminal works of Abramovitz (1986) and Cohen and Levinthal (1989, 1990) focus on how successfully a laggard country adopts foreign technologies and what are the determinants of a country's absorptive capacity in technological catching up. Empirical results generally support the notion that human capital and education have a significant role in positively affecting the absorptive capacity in technology adoption (Rogers, 2004; Benhabib and Spiegel, 2005; Kneller and Stevens, 2006). Some of the theoretical works on catching up and falling behind, i.e., Acemoglu et al. (2006) and Stokey (2015), clarify how extended endogenous technology models may lead to no-growth or low-growth equilibria. Here, the empirical results substantiate the view that, exactly as in Acemoglu et al. (2006), the transition of South Korea from a technology adopter to an innovator is an optimal response to the changing fundamentals of relative productivity. Once the relative gain from technology adoption becomes sufficiently small, the economy spends more of its scarce resources to innovation.

Attar's (2018) is the most directly related work, and similarities and differences with that paper deserve some attention here. Also following Lucas (2009) very closely, Attar (2018) aims at understanding the comparative development differences between Türkiye and South Korea. Türkiye in the early 1960s has better development prospects, but South Korea forges ahead, leaving only missed opportunities to her fellow. Attar (2018) studies two extensions of the baseline economy in Lucas (2009) to understand this divergence. Contrary to the structural estimation work presented here, he focuses on quantitative experiments that build upon a rigorous calibration of structural parameters.

The present paper contributes to the related literature from another, theoretical perspective. Structural models of catching up and technology diffusion typically focuses on a laggard economy's distance to the frontier by assuming that the laggard country does not forge ahead the world frontier. In reality, a follower country may exhibit miraculous productivity growth and eventually become an innovative country that contributes to the world frontier. In such a case, the country would experience a reversal of fortune in productivity growth because the advantage of relative backwardness disappears once the distance to the frontier closes down. Then, faster productivity growth that moves the economy further up on the technology ladder creates its own mean-reverting force that limits productivity growth rates. In models of endogenous technology, such an effect is typically called the fishing-out effect or the low-hanging-fruit effect. In the present paper, there is a single mathematical formulation of the technology that creates productivity growth. When the economy is behind the frontier (i.e., when it is absolutely less productive), the distance to the frontier contributes positively to productivity growth. When the economy is at the frontier (once the economy forges ahead the frontier productivity level), the very same term's contribution becomes negative.

3. MODEL

The purpose here is to develop the simplest model economy that is most informative about the fundamental determinants of productivity growth in South Korea. For simplification, we assume away the household's decisions, the role of government, and international trade flows as in Lucas (2009). We also presume that physical capital and human capital grow exogenously. All of these restrictions allow us to isolate the technological microeconomic foundations within a multi-sector endogenous technology model, and the only decision problem to be solved is the sectoral allocation of resources. As in Lucas (2009), the present formulation leaves this choice to the market, and resource allocation achieves the maximization of total output in real terms.

3.1. Overview

Time in the model is discrete with an infinite horizon: $t \in \{0, 1, \dots\}$. The length of a period is a calendar year. There is a single, all-purpose good, and there are two sectors/technologies that produce this good. The

[3] See Durlauf and Quah (1999) and Islam (2003) for two extensive reviews.

modern technology exhibits Constant Returns to Scale (CRS), but the traditional technology is subject to Decreasing Returns to Scale (DRS) because of a fixed input such as land. Productivity change is endogenous in both sectors. In the modern sector, there is either technology adoption from the frontier economy in the world or domestic innovation, depending on whether the economy's aggregate modern sector productivity is at the frontier. In the traditional sector, productivity changes as a result of spillovers from the modern sector. Only the modern sector uses physical capital. Table 1 summarizes the model parameters.

Table 1. Structural parameters of the model economy

Parameter	*Support*	*Source, identification, or estimation*
Capital share in the modern sector λ	$(0,1)$	Arbitrarily preset at $\lambda = 0.4$, see Lucas (2009)
Labor share in the traditional sector α	$(0,1)$	Identification via $\alpha = 1 - \lambda$
Productivity spillover parameter ξ	$(0,1)$	Structural estimation, joint estimates for (ξ, μ)
Traditional sector fixed productivity μ	$(0, +\infty)$	Structural estimation, joint estimates for (ξ, μ)
Productivity growth, fixed component ϕ	$(0, +\infty)$	Structural estimation, joint estimates for (ϕ, ζ, θ)
Urban agglomeration parameter ζ	$(0, +\infty)$	Structural estimation, joint estimates for (ϕ, ζ, θ)
Relative productivity, elasticity θ	$(0,1)$	Structural estimation, joint estimates for (ϕ, ζ, θ)
Frontier economy growth rate γ	$(0, +\infty)$	Estimated for the United States, see Lucas (2009)

3.2. Production Technologies

In Equations 1 and 2, let $Y_t(M)$ and $Y_t(T)$ denote output flows in the modern sector and in the traditional sector, respectively.

$$Y_t(M) = K_t^{\lambda}[A_t h_t L_t(M)]^{1-\lambda} \tag{1}$$

$$Y_t(T) = \mu A_t^{\xi}[h_t L_t(T)]^{\alpha} \tag{2}$$

where $K_t > 0$ is the stock of physical capital, $A_t > 0$ is an unobserved productivity term, $h_t > 0$ is average human capital, $L_t(M)$ and $L_t(T)$ are levels of raw labor employed, $\mu > 0$ is a fixed and exogenous productivity term (a shift parameter), $\xi \in (0,1)$ is the modern-to-traditional productivity spillover parameter, $\lambda \in (0,1)$ is the elasticity of the modern sector output with respect to physical capital, and $\alpha \in (0,1)$ is the elasticity of traditional sector output with respect to labor. For simplicity (and without loss of too much significance), we assume that h_t and K_t are exogenously given for all t.

3.3. GDP and the Static Equilibrium

Real GDP in year t, denoted by Y_t, is defined simply as in $Y_t = Y_t(M) + Y_t(T)$. As in Lucas (2009), define the static equilibrium as a resource allocation problem that maximizes Y_t by choosing $L_t(M)$ and $L_t(T)$ under the resource constraint as in Equation 3.

$$L_t(T) + L_t(M) = L_t \tag{3}$$

where L_t is also exogenous and given for all t. Formally, Equation 4 represents the optimization problem:

$$\max_{L_t(M)} \quad \mu A_t^{\xi} h_t^{\alpha}[L_t - L_t(M)]^{\alpha} + K_t^{\lambda}[A_t h_t L_t(M)]^{1-\lambda} \tag{4}$$

In general, there does not exist a closed-form solution to this problem. However, a unique, closed-form solution exists if $\alpha = 1 - \lambda$. As demonstrated in Appendix A, this unique solution implies Equation 5

$$\frac{L_t(T)}{L_t} = \frac{\tilde{A}_t}{K_t + \tilde{A}_t} = \ell_t \tag{5}$$

where $\tilde{A}_t$ is some unobserved productivity term defined in Equation 6 below

$$\tilde{A}_t = \left(\mu A_t^{\xi+\lambda-1}\right)^{\frac{1}{\lambda}} \tag{6}$$

This solution tells us that the share of labor employed in the traditional sector depends on a composite term $K_t/\tilde{A}_t$ of relative productivity. If $K_t/\tilde{A}_t$ goes to positive infinity because the spillover effect is not sufficiently strong (low enough ξ *ceteris paribus*), then the modern sector becomes increasingly more productive and labor is allocated more intensively in the modern sector; the traditional sector disappears ($\ell_t \to 0$). Conversely, if $K_t/\tilde{A}_t$ goes to zero with a sufficiently strong spillover effect (high enough ξ *ceteris paribus*), then the share of labor employed in the traditional sector goes to unity; the modern sector disappears ($\ell_t \to 1$).

3.4. Dynamics and the Growth of Productivity

Since we take the sequences $\{K_t, h_t, L_t\}_t$ as given model inputs for the entire history, the dynamics of the economy are determined by how A_t evolves in time.

Let $G_t = 1 + g_t = A_{t+1}/A_t$ denote the gross growth rate of the productivity term A_t. Equation 7 shows this growth rate that is endogenously determined:

$$G_t = \frac{\phi h_t (1-\ell_t)^{\zeta}}{a_t^{\theta}} \tag{7}$$

Here, parameters satisfy ϕ, $\zeta > 0$ and $\theta \in (0,1)$, where a_t denotes the modern sector productivity relative to the frontier economy, defined formally in Equation 8:

$$a_t = \frac{A_t}{\bar{A}_t} \tag{8}$$

Here, then, three distinct mechanisms described below govern the dynamics of productivity growth.

- *Distance to the frontier*: With relative productivity a_t defined above, the economy's distance to the frontier economy is inversely related with a_t. Whether it is additive ($d = 1 - a$) or multiplicative ($d = 1/a$), assume that productivity growth rate G_t is larger if a_t is lower, *ceteris paribus*. This is the typical catching up effect associated with relative backwardness of the follower economy (Gerschenkron, 1962; Abramowitz, 1986). In the present setup, the elasticity with respect to a_t, denoted by θ, is between 0 and 1 as in Lucas (2009).
- *Human capital*: Productivity growth rate increases with average human capital in the economy to reflect the notion that human capital of an economy's workforce is a crucial determinant of the economy's absorptive capacity for technology adoption. This is the mechanism proposed by Nelson and Phelps (1966) and Gomulka (1971).
- *Urban agglomeration*: Productivity growth rate also increases with the relative size $(1 - \ell_t)$ of the modern sector. As in Lucas (1988, 2009), cities where the modern technology firms operate are the locations where more productive and more creative people generate positive externalities for each other.

3.5. Productivity Growth in the Frontier Economy

To complete the formal characterization of the model economy, we need to specify how $\bar{A}_t$ changes in time. Equation 9 below shows the law of motion for $\bar{A}_t$:

$$\bar{A}_{t+1} = (1 + \gamma)\bar{A}_t \tag{9}$$

$\gamma > 0$ and $\bar{A}_0 > 0$ are exogenously given. Hence, the frontier economy in the world has perpetual productivity growth taking place at a fixed rate.

4. METHODOLOGY and DATA

Our fundamental task is to understand the evolution of productivity in South Korea using the above model. By this is meant (i) how the South Korean productivity relative to the frontier economy evolved in time, (ii) how the human capital, urban agglomeration, and the distance to the frontier affected the growth rate of South Korean productivity, and (iii) how much of the observed growth can be attributed to these potential sources.

For the first dimension, we need to identify and compute both the frontier productivity $\bar{A}_t$ and the South Korean productivity term A_t, as the relative productivity a_t is defined as the ratio $A_t/\bar{A}_t$. For the second dimension, we use the equilibrium definitions to formulate regression models and obtain structural estimates of several parameters. Finally, after estimating the structural parameters, we simply decompose productivity growth into its structural sources.

4.1. Identifying the Unobserved Relative Productivity a_t

Identifying the unobserved relative productivity is of central interest since it is this variable that allows us to make an inference about the date at which the South Korean economy closes its gap with the frontier. Recall from Equation 8 that this productivity term, denoted by a_t, is defined simply as the ratio $A_t/\bar{A}_t$. Therefore, one needs to identify both the numerator and denominator to identify a_t.

4.1.1 Identifying the Unobserved Productivity Terms $\tilde{A}_t$ and A_t

In general, we do not observe the share ℓ_t of labor allocated to use traditional technologies. The closest observables for this variable are the shares of rural employment and rural population. Exactly as in Lucas (2009), we take ℓ_t as the share of rural population. But if both ℓ_t and K_t are observed, Equation 5 uniquely identifies $\tilde{A}_t$ as shown in Equation 10:

$$\tilde{A}_t = \frac{\ell_t K_t}{1-\ell_t} \tag{10}$$

After identifying $\tilde{A}_t$ using the above equation, we need another observable to identify A_t. This observable is real GDP per capita, denoted by y_t. As demonstrated in Appendix B, real GDP per capita can be written as in Equation 11:

$$y_t = A_t^{1-\lambda} h_t^{1-\lambda} \left(\frac{\tilde{A}_t}{L_t} + \frac{K_t}{L_t}\right)^{\lambda} \tag{11}$$

Hence, we only need a value of λ to identify A_t since the rest of the terms are readily available, either observed or identified. Specifically, the resulting identifying formula is shown in Equation 12:

$$A_t = \left[\frac{y_t}{h_t^{1-\lambda}\left(\frac{\tilde{A}_t}{L_t} + \frac{K_t}{L_t}\right)^{\lambda}}\right]^{\frac{1}{1-\lambda}} \tag{12}$$

The baseline results presented in the next section build upon a value of $\lambda = 0.4$ that implies $\alpha = 0.6$ as in Lucas (2009), but we also present a sensitivity analysis.

4.1.2 Identifying the Unobserved World Frontier $\bar{A}_t$

To identify the frontier productivity that is assumed to grow perpetually at a fixed rate as in Equation 9, both the initial value $\bar{A}_0$ and the growth rate γ must be specified. For both of these inputs, the US is taken as the frontier economy as in Lucas (2009).

For the initial value $\bar{A}_0$ of the US economy, a meaningful estimate is available through the relative TFP data of Isaksson (2007). In their baseline sample, the South Korean economy's TFP relative to the US is equal to $a_0 = 0.317$ in 1960. Since we have $\bar{A}_0 = A_0/a_0$ by definition and $A_0 = 179.16$ from the baseline identification, we obtain $\bar{A}_0 = 565.18$. For the growth rate γ, the value of 2.1% per annum, representing the long-term growth rate in the US, is used as a benchmark as in Lucas (2009) and Attar (2018).

4.2. Estimating the Structural Parameters

The complete model economy has five structural parameters other than $\alpha = 1 - \lambda$, i.e., $(\mu, \xi, \phi, \zeta, \theta)$. The first two of these are $\mu > 0$ and $\xi \in (0,1)$ that, along with α, characterize the traditional technology of production. The other three parameters $\phi > 0$, $\zeta > 0$, and $\theta \in (0,1)$, on the other hand, describe how productivity grows from t to $t+1$; they characterize the technology of innovation and technology adoption. It turns out that, given λ, identified sequences of $\tilde{A}_t$ and A_t uniquely identify $\mu > 0$ and $\xi \in (0,1)$ through Equation 6. To see how, rewrite Equation 6 as a loglinear regression Equation 13 with an additive error term u_t that satisfies typical regulatory assumptions:

$$\ln\left(\tilde{A}_t\right) = \ln\left(\mu^{1/\lambda}\right) + \left[\frac{\xi-(1-\lambda)}{\lambda}\right]\ln(A_t) + u_t \tag{13}$$

Clearly, with uniquely identified sequences of $\tilde{A}_t$ and A_t, the ordinary least squares estimate of the intercept and the slope parameters in Equation 13 yield unique estimates of $\mu > 0$ and $\xi \in (0,1)$; see Appendix C.

For the remaining three parameters, one can easily derive an estimating equation from Equation 7 by introducing another additive error term v_t. This regression is shown in Equation 14:

$$G_t = \frac{\phi h_t (1-\ell_t)^{\zeta}}{a_t^{\theta}} + v_t \tag{14}$$

This can be estimated via nonlinear least squares, and it would return unique estimates of (ϕ, ζ, θ).

4.3. Decomposing Productivity Growth into Its Sources

Recall the interpretation of Equation 7 that specifies how productivity grows in time. If $a_t < 1$, the economy has a scope for technology adoption. In this case, productivity growth has three components associated with h_t, a_t, and $(1-\ell_t)$, respectively. Since $a_t < 1$, all of these three components have positive contributions to productivity growth.

If the economy is sufficiently advanced to have $a_t \geq 1$, technology adoption stops. From this point on, productivity growth is driven by innovation and a_t now acts as a drag that reflects the loss due to the fishing-out mechanism. Thus, a_t's contribution to growth is negative and the total contribution of h_t and $(1-\ell_t)$ is thus larger than 100%.

Since the task is to decompose the observed productivity growth into various components, we need to have an additive structure. Such a structure can be derived by taking the natural logarithm of G_t/ϕ by using Equation 7. The result is shown in Equation 15:

$$\ln\left(\frac{G_t}{\phi}\right) = \ln(h_t) + \zeta \ln(1-\ell_t) - \theta \ln(a_t) \tag{15}$$

Dividing both sides of this equation to $\ln(G_t/\phi)$ then implies the formula in Equation 16 that we can use for the decomposition:

$$\frac{\ln(h_t)}{\ln(G_t/\phi)} + \frac{\zeta \ln(1-\ell_t)}{\ln(G_t/\phi)} + \frac{-\theta \ln(a_t)}{\ln(G_t/\phi)} = 100\% \tag{16}$$

5. RESULTS

5.1. Identified Productivity Terms

Figure 1 pictures the identified sequences of absolute productivity levels A_t and $\bar{A}_t$. The first thing to note from this figure is the date at which absolute productivity A_t of the modern sector surpasses the world frontier $\bar{A}_t$. This event happens in the year 1983.[4] Within the narrative of the present framework, this means that the South Korean miracle of productivity growth made the follower South Korea an innovator economy sometime in the early 1980s. The second implication of these results is that the growth rate of absolute productivity A_t is not fixed across decades. In fact, it exhibits an early acceleration and a late slowdown, and both the acceleration and the slowdown are sizable. The average growth of rate of A_t is equal to 7.6%, 7.2%, and 8.4% per annum for the 1960-1969, 1970-1979, and 1980-1989 periods, respectively.[5] However, productivity growth rates are much lower than these impressive rates for the 1990-1999, 2000-2009, and 2010-2019 decades, being equal to 3.8%, 3.1%, and 1.1% per annum, respectively. The acceleration-slowdown pattern of productivity growth is clearly in line with the logic of convergence and catching up. After 1983, once technology adoption stops, relative productivity enters a regime at which it fluctuates around a fixed value. This is the third noteworthy implication of Figure 1.

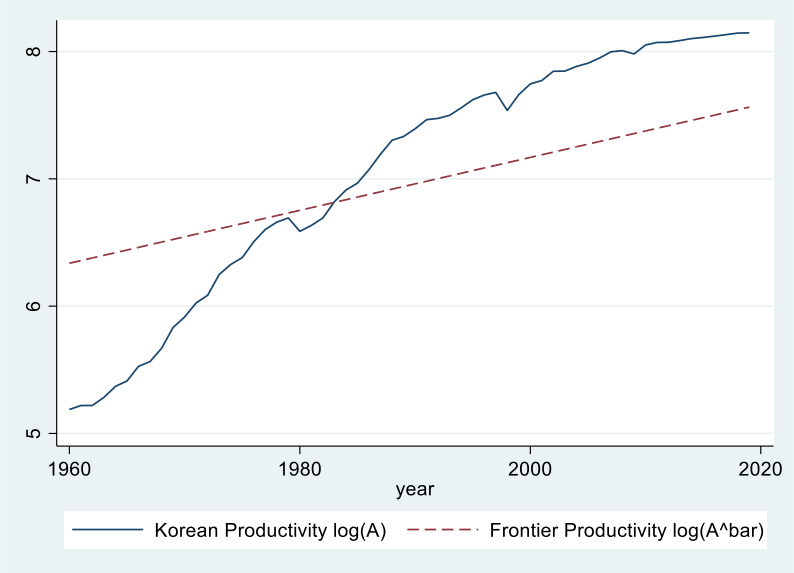

Figure 1. Identified productivity terms, South Korea versus the world frontier

[4] It is not feasible to calculate confidence intervals for this estimate since it follows from a deterministic identification.
[5] While these figures seem exceptionally high at first glance, the reader should recall that these aggregative figures originate from a two-sector model, and the aggregate production technology is not of Cobb-Douglas type.

5.2. Structural parameters

The empirical strategy estimates five structural parameters of the model. Recall that the shift parameter μ and the spillover parameter ξ of the traditional technology are estimated via the regression Equation 13. Table 2 presents the estimation results for the reduced-form parameters $(cons, b)$ and the structural parameters (μ, ξ). All of these estimates satisfy the sign expectations, and the Newey-West (robust) standard errors indicate that all of them are statistically significant at 1% level. Regarding the magnitudes, it is difficult to interpret the shift parameter μ that has an unbounded support. The magnitude of ξ, on the other hand, lies within the (0,1) interval as expected, and it is larger than the value of 0.75 that is used by Lucas (2009). Put differently, the South Korean economy has a stronger modern-to-traditional productivity spillover that characterizes the baseline economy in Lucas (2009).[6]

Note that the null hypothesis of joint residual normality can be rejected with a *p value* less than 1% while its skewness still fits a Gaussian distribution well. Results of various unit root tests (not reported here for space considerations) indicate that the residual term has a unit root. These together imply that the residual term carries a stochastic trend that the theoretical model does not capture well. A more detailed structural model would be useful in achieving efficient estimates of the structural parameters, but this is left for future research.

Table 2. Structural estimates of $\mu > 0$ and $\xi \in (0, 1)$

Reduced-form estimates of (13)		*Structural estimates*	
Intercept $(cons)$	9.1794***	Mu (μ)	39.3218***
	(0.7455)		(11.7261)
Slope (b)	0.6183***	Xi (ξ)	0.8473***
	(0.1049)		(0.0420)
		Residual Normality	
# Observations	60	Skewness *p value*	0.3902
R-squared	0.823	Kurtosis *p value*	0.0003
F stat. *p value*	0.000	Joint *p value*	0.0037

Notes: This table collects the reduced-form estimates of (13) and structural estimates of $\mu > 0$ and $\xi \in (0,1)$. These structural estimates are exactly identified. The Newey-West standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3 collects the second set of structural parameter estimates and model diagnostics. Here, the estimating equation is Equation 14, and the estimated parameters are (ϕ, ζ, θ). The table reports estimation results for restricted models $\zeta = 0$ and $\theta = 0$, and the general model. For each of these three models, a specification with a dummy variable that controls for large contractions in productivity is estimated as well.[7] It should also be noted that all of these specifications are still restricted in the sense that the exponent of human capital h_t is equal to unity; specifications that allowing for this exponent to be different than unity do not fit the South Korean data.

Among the three specifications, the one that returns the minimum values for Akaike and Bayesian Information Criteria is the model that excludes the urban agglomeration mechanism. That is, results suggest that productivity growth is driven by human capital and relative productivity. When the agglomeration mechanism of Lucas (2009) is included through $(1 - \ell_t)^{\zeta}$, the parameter ζ is not statistically significant at 5%.

Table 4 summarizes the marginal effects of human capital and relative productivity on productivity growth rate using the preferred specification of the estimated model. As expected, both human capital and relative productivity create statistically significant marginal effects. An increase in human capital creates a very large marginal effect on the gross growth rate. Human capital h_t is equal to 1.59 and 3.77 in 1960 and 2019, respectively, and a unit increase has a marginal effect of around 1.00 on G_t whose sample average is equal to 1.053 and sample standard deviation is equal to 0.056. The marginal effect −0.43 of relative productivity a_t on gross growth rate G_t of productivity is also sizable; the sample range of relative productivity is nearly one half.

[6] Attar (2018) uses a minimum distance algorithm to calibrate ξ for South Korea within a similar setup and obtains $\xi = 0.8281$.

[7] Parameter estimates are similar in sign, in magnitude, and in statistical significance when the model excludes this dummy variable.

Table 3. Structural estimates of $\phi > 0$, $\zeta > 0$, and $\theta \in (0,1)$

Dependent Variable: Gt = At+1/At Nonlinear Least Squares Estimates			
	(1)	*(2)*	*(3)*
Phi (ϕ)	0.2716***	0.4127***	0.5007***
	(0.0057)	(0.0042)	(0.0525)
Zeta (ζ)	−0.7528***		0.3496*
	(0.0311)		(0.1948)
Theta (θ)		0.4347***	0.6335***
		(0.0154)	(0.1097)
DV(G < 0.95)	Yes	Yes	Yes
# Observations	59	59	59
Adj. R-squared	0.9930	0.9945	0.9946
RMSE	0.0881	0.0781	0.0776
log(Likelihood)	61.1238	68.2458	69.1773
Akaike IC	−116.2476	−130.4916	−130.3547
Bayesian IC	−110.0150	−124.2590	−122.0445
Residual Normality			
Skewness *p value*	0.2487	0.1560	0.2568
Kurtosis *p value*	0.0344	0.3495	0.6076
Joint *p value*	0.0622	0.2199	0.4462

Notes: This table collects structural estimates of $\phi > 0$, $\zeta > 0$, and $\theta \in (0,1)$. These structural estimates are exactly identified. DV stands for a dummy variable that takes the value of unity for years in which there is a large contraction in productivity. Robust standard errors are reported in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4. Marginal effects of h and a on G

Specification (2)	Human capital	$\partial G/\partial h$	1.00403***
			(0.00073)
	Relative productivity	$\partial G/\partial a$	−0.43645***
			(0.01536)

Notes: This table collects estimates of marginal effects in the second specification of productivity growth estimates. Standard errors calculated via the delta method are reported in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.3 Sources of Productivity Growth in South Korea

Figure 2 pictures the baseline decomposition results and 95% confidence intervals. Productivity growth is simply decomposed into its time-varying components using Equation 16 at the baseline parameter estimates reported in Table 3. The second specification with $\zeta = 0$ is adopted as the preferred model. The shares shown in the vertical axes are in percentage terms. The shaded areas show the 95% confidence intervals. The top panel shows the contribution of the fishing-out effect, the middle panel shows the contribution of relative productivity, and the bottom panel shows the contribution of human capital.

From 1960 to 1983, relative productivity satisfies $a_t < 1$, and productivity growth is mainly due to technology adoption. In the beginning of this episode, human capital and the distance to the frontier have almost equal shares, nearly 50%. In time, the contribution of the distance to the frontier decreases since the distance itself decreases as the economy converges to the frontier. The share of human capital thus increases from 1960 to 1983. In the year 1982, the share of human capital is almost 100% and the corresponding share of the distance to the frontier is almost nil.

From 1983 to the end of the sample, relative productivity satisfies $a_t > 1$, and productivity growth is mainly due to innovation. By definition, the contribution of the fishing-out effect is always negative since a larger value of a_t exceeding unity implies a lower likelihood in introducing new products and new processes. The negative contribution of the fishing-out effect to productivity growth levels out around −30%.

Results presented above are within the limits of theoretical expectations, and the overall message originating from the analysis is consistent with the established view of the catching up/falling behind literature. Human capital and the distance to the frontier jointly explain the acceleration-slowdown pattern of productivity growth. Technology adoption stops at finite time, and the initially laggard South Korean economy becomes an innovator.

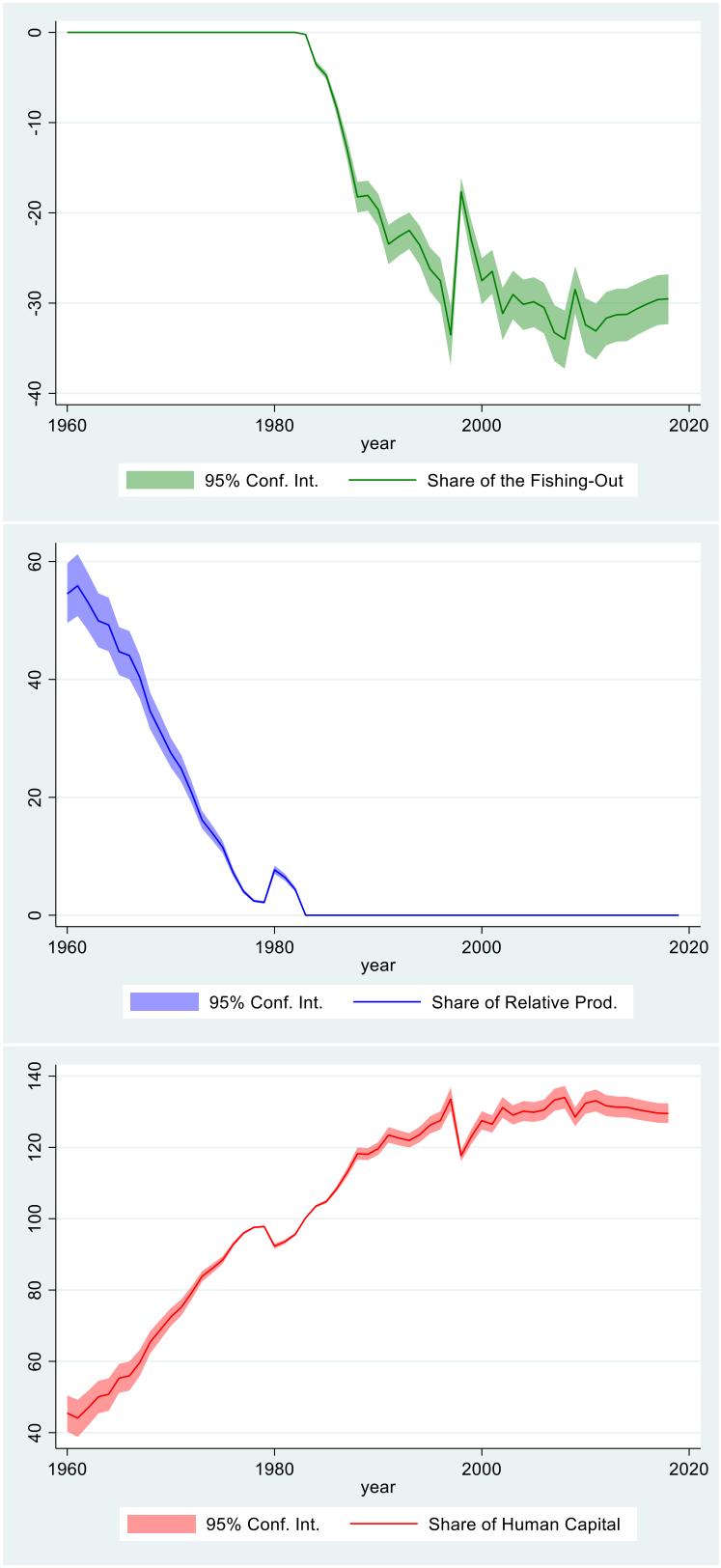

Figure 2. Decomposing productivity growth into its sources

6. ROBUSTNESS

This short section presents the results of two robustness checks.[8] It studies the effects of changes in two arbitrary model inputs. These are;

• the percentage growth rate γ of frontier productivity $\bar{A}_t$, and
• the capital share λ of the modern technology.

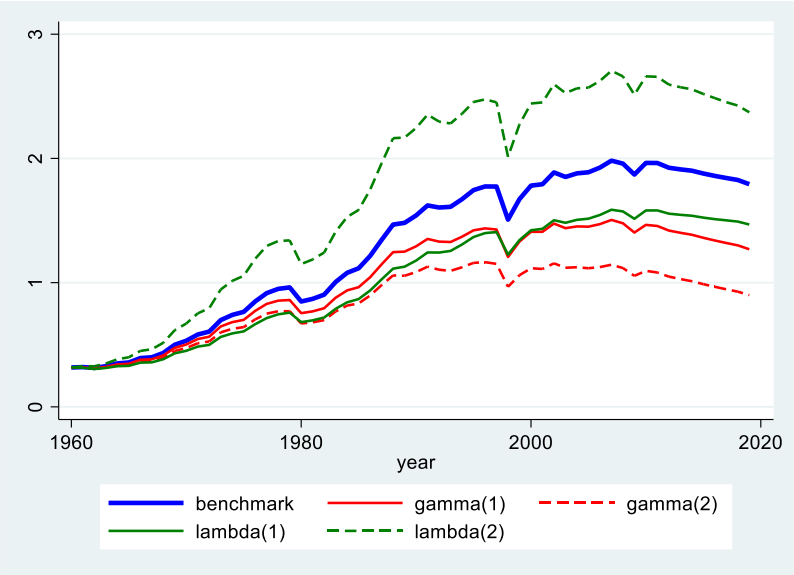

Figure 3. Alternative identifications of relative productivity in South Korea

For frontier growth rate γ, it is difficult to motivate a value other than the US long-run growth rate. But there exists a particular value for this parameter as suggested by Stokke (2004); $\gamma(1) = 0.027$. This is 0.6 percentage points larger than the benchmark value of 2.1% per annum, and the second experimented value is set to $\gamma(2) = 0.021 + 2 \times 0.6 = 0.033$. For λ, the capital share of the modern technology, the experimented values are $\lambda(1) = 0.3$ and $\lambda(2) = 0.5$.

The full set of results are pictured in Figure 3 that shows all of the experimented sequences of relative productivity as well as the benchmark sequence obtained in the baseline analysis. The main message originating from Figure 3 is that, from a qualitative perspective and except for the cases of $\lambda = \lambda(2) = 0.5$, the evolution of relative productivity is not sensitive to arbitrary model inputs. That is, it still is characterized by an initial acceleration and a later slowdown, and it still exceeds unity in the early 1980s. For the case of $\lambda = \lambda(2)$ that implies a rather large capital share in the modern sector (and a corresponding low labor share in the traditional sector), the economy passes the threshold of unity at an unrealistically early date.

The question of robustness then becomes whether the case of $\lambda = \lambda(2)$ is realistic. It should be noted that a modern sector capital share of 1/2 is perhaps too large since the aggregate labor share reported in the Penn World Tables of Feenstra et al. (2015) averages to 0.57 for the 1960-2019 period.

7. CONCLUSION

One of the most remarkable economic transformations of the postwar period was observed in South Korea. In only a few decades, the South Korean economy converged to the developed world as a result of rapid economic growth, integrated with the global value chains as a result of product diversification, and became a locus of innovation that defines the world technology frontiers in various industries.

This paper constructs a model of endogenous technology to shed new light on the South Korean miracle. The model is a two-sector catching up model where the sector that uses the modern technology adopts frontier technologies, and the sector that uses the traditional technology benefits from productivity spillovers. In time, the technology gap with the frontier closes, and the economy becomes an innovator that starts characterizing the world frontier.

[8] For space considerations, the results documented here focus only on the evolution of relative productivity. The full set of sensitivity results is available upon request.

The analysis presented in this paper devises an empirical strategy that identifies and estimates the structural parameters, and the evolution of productivity relative to the frontier. Then, the strategy allows the econometric estimations of identified structural parameters that characterize the traditional technology of production and the adoption/innovation technology of productivity growth.

Results substantiate the conventional notion that an economy that achieves fast productivity growth eventually stops technology adoption and becomes an innovation economy. Findings also reveal that, in the case of the South Korean miracle, human capital (per person) and the distance to the frontier (measured by the inverse of relative productivity) are significant drivers of productivity growth. In fact, since the South Korean economy exhibited not-so-slow productivity growth even as an innovator economy after the early 1980s, we learn that human capital accumulation was a crucial factor that trivialized the adverse fishing-out effect.

The logic of the model economy studied in this paper implies that, as an innovator economy, South Korea will remain one of the top-performing countries shaping the world technology frontiers. The observed innovation record of South Korea in the last two decades indeed shows that, among her closer peers, South Korea ranks at the top categories, especially with respect to the innovation outputs.

But does this mean that the research policy problem for South Korea has been effectively solved and should no longer be a primary policy concern? The correct answer is possibly negative. The findings presented above show that sustaining sufficiently larger relative productivity levels among the world's frontier economies requires sufficiently high human capital stocks per person. This means that a top-performing innovating economy should keep diversifying the skill content of her human capital stocks since the quantity of human capital would eventually converges to its maximum. That is, the critical task is to enlarge the innovative capacity of high-skilled researchers especially in the frontier technologies and associated, technologically-complex products. According to Harvard University's *Atlas of Economic Complexity*, South Korea has already achieved a relatively high economic complexity for its export products, and growth opportunities lie in developing and exporting new high-complexity products and processes. It is in this respect crucial for South Korea to focus on the quality of human capital and the productivity of R&D technologies. The county's projected 2.8% real GDP growth rate per annum for the next decade requires policymakers to respond to such challenges in terms of innovation inputs.

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Compliance with Ethical Standards
It was declared by the author that the tools and methods used in the study do not require the permission of the Ethics Committee.

Ethical Statement
It was declared by the author that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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APPENDIX

Derivation of Equation 5:

The allocation problem is to maximize

$$\mu A_t^{\xi} h_t^{1-\lambda}[L_t - L_t(M)]^{1-\lambda} + K_t^{\lambda}[A_t h_t L_t(M)]^{1-\lambda} \quad \text{(A1)}$$

by choosing $L_t(M)$. The first-order necessary condition (FONC) for an interior optimum is

$$-(1-\lambda)\mu A_t^{\xi} h_t^{1-\lambda}[L_t - L_t(M)]^{-\lambda} + (1-\lambda)K_t^{\lambda}(A_t h_t)^{1-\lambda}[L_t(M)]^{-\lambda} = 0 \quad \text{(A2)}$$

After some arrangements, this FONC implies

$$K_t^{\lambda} A_t^{1-\lambda} = \mu A_t^{\xi}\left[\frac{L_t - L_t(M)}{L_t(M)}\right]^{-\lambda} \quad \text{(A3)}$$

After further arrangements, we have

$$1 = \left(\frac{\mu A_t^{\xi+\lambda-1}}{K_t^{\lambda}}\right)\left[\frac{L_t(M)}{L_t - L_t(M)}\right]^{\lambda} = \left(\frac{\tilde{A}_t}{K_t}\right)\left[\frac{L_t(M)}{L_t - L_t(M)}\right] \quad \text{(A4)}$$

Defining $\ell_t(M) = L_t(M)/L_t$ and $\ell_t(T) = L_t(T)/L_t$ and recalling the definition of $\tilde{A}_t$, this equation implies

$$1 - \ell_t(T) = \left(\frac{\tilde{A}_t}{K_t}\right)\ell_t(M) \quad \text{(A5)}$$

Since we also have $\ell_t(M) + \ell_t(T) = 1$, we obtain

$$\ell_t(T) = \left(\frac{\tilde{A}_t}{K_t}\right)[1 - \ell_t(T)] \quad \text{(A6)}$$

directly implying

$$\ell_t(T) = \frac{\tilde{A}_t}{K_t + \tilde{A}_t} = \ell_t \quad \text{(A7)}$$

Derivation of Equation 11:

Notice that real GDP can be written as in

$$Y_t = \mu A_t^{\xi} h_t^{1-\lambda}(\ell_t L_t)^{1-\lambda} + K_t^{\lambda}[A_t h_t(1-\ell_t)L_t]^{1-\lambda} \quad \text{(B1)}$$

$$\frac{Y_t}{L_t} = \mu A_t^{\xi} h_t^{1-\lambda}\ell_t^{1-\lambda}L_t^{-\lambda} + K_t^{\lambda}[A_t h_t(1-\ell_t)]^{1-\lambda}L_t^{-\lambda} \quad \text{(B2)}$$

Define real GDP per capita as $y = Y/L$. Then, we have

$$y_t = h_t^{1-\lambda}\left\{\mu A_t^{\xi}\ell_t^{1-\lambda}L_t^{-\lambda} + K_t^{\lambda}[A_t(1-\ell_t)]^{1-\lambda}L_t^{-\lambda}\right\} \quad \text{(B3)}$$

Substituting ℓ_t and $1-\ell_t$, we obtain

$$y_t = h_t^{1-\lambda}\left\{\mu A_t^{\xi}\left(\frac{\tilde{A}_t}{K_t+\tilde{A}_t}\right)^{1-\lambda}L_t^{-\lambda} + K_t^{\lambda}\left[A_t\left(\frac{K_t}{K_t+\tilde{A}_t}\right)\right]^{1-\lambda}L_t^{-\lambda}\right\} \quad \text{(B4)}$$

$$y_t = h_t^{1-\lambda}\left\{\mu A_t^{\xi}\left(\frac{\tilde{A}_t}{K_t+\tilde{A}_t}\right)^{1-\lambda}L_t^{-\lambda} + A_t^{1-\lambda}K_t^{\lambda}\left(\frac{K_t}{K_t+\tilde{A}_t}\right)^{1-\lambda}L_t^{-\lambda}\right\} \quad \text{(B5)}$$

$$y_t = h_t^{1-\lambda}\left\{\mu A_t^{\xi}\left(\frac{\tilde{A}_t}{K_t+\tilde{A}_t}\right)^{1-\lambda}L_t^{-\lambda} + A_t^{1-\lambda}\left(\frac{1}{K_t+\tilde{A}_t}\right)^{1-\lambda}K_t L_t^{-\lambda}\right\} \quad \text{(B6)}$$

$$y_t = \left(\frac{h_t}{K_t+\tilde{A}_t}\right)^{1-\lambda}L_t^{-\lambda}\left\{\mu A_t^{\xi}\left(\tilde{A}_t\right)^{1-\lambda} + A_t^{1-\lambda}K_t\right\} \quad \text{(B7)}$$

After some arrangements with $\left(\tilde{A}_t\right)^{1-\lambda} = \left(\mu A_t^{\xi+\lambda-1}\right)^{\frac{1-\lambda}{\lambda}}$, we get

$$y_t = \left(\frac{h_t}{K_t+\tilde{A}_t}\right)^{1-\lambda}L_t^{-\lambda}\left\{\mu^{\frac{1}{\lambda}}A_t^{\frac{\xi}{\lambda}}A_t^{\frac{-(1-\lambda)^2}{\lambda}} + A_t^{1-\lambda}K_t\right\} \quad \text{(B8)}$$

Factoring out $A_t^{1-\lambda}$ returns

$$y_t = \left(\frac{h_t}{K_t+\tilde{A}_t}\right)^{1-\lambda} L_t^{-\lambda} \left\{ \frac{\mu^{\frac{1}{\lambda}} A_t^{\frac{\xi}{\lambda}} A_t^{\frac{-(1-\lambda)(1-\lambda)}{\lambda}}}{A_t^{1-\lambda}} + K_t \right\} A_t^{1-\lambda} \tag{B9}$$

and, given the explicit expression of $\tilde{A}_t = \mu^{\frac{1}{\lambda}} A_t^{\frac{\xi}{\lambda}} A_t^{-\frac{(1-\lambda)}{\lambda}}$, further arrangements allow us to write

$$y_t = \left(\frac{h_t}{K_t+\tilde{A}_t}\right)^{1-\lambda} L_t^{-\lambda} \left(\tilde{A}_t + K_t\right) A_t^{1-\lambda} \tag{B10}$$

$$y_t = A_t^{1-\lambda} h_t^{1-\lambda} \left(\frac{\tilde{A}_t}{L_t} + \frac{K_t}{L_t}\right)^{\lambda} \tag{B11}$$

Exact identification of μ and ξ:

Let $cons$ and b represent the intercept and slope coefficients of the ordinary least squares regression

$$\ln\left(\tilde{A}_t\right) = \ln\left(\mu^{1/\lambda}\right) + \left[\frac{\xi-(1-\lambda)}{\lambda}\right] \ln(A_t) + u_t \tag{C1}$$

Then, we have

$$\ln\left(\mu^{\frac{1}{\lambda}}\right) = cons \quad \Rightarrow \quad \mu^{\frac{1}{\lambda}} = \exp(cons) \quad \Rightarrow \quad \mu = [\exp(cons)]^{\lambda} \tag{C2}$$

and

$$\frac{\xi-(1-\lambda)}{\lambda} = b \quad \Rightarrow \quad \xi - (1-\lambda) = \lambda b \quad \Rightarrow \quad \xi = \lambda b + (1-\lambda) \tag{C3}$$

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Kaynak Temelli Yaklaşım Bileşenleri, Özümseme Kapasitesi ve Tedarik Zinciri Çevikliği Arasındaki Bağlantının Ortaya Çıkarılması*

Hülya Meral[1], Erdinç Koç[2]

ÖZET

Amaç: Bu çalışmada kaynak temelli yaklaşım bileşenleri ve tedarik zinciri çevikliği arasındaki ilişki araştırılmaktadır. Öğrenme yönelimi, teknoloji yönelimi, özümseme kapasitesi ve tedarik zinciri çevikliği birer boyut olarak ele alınarak bu çalışma kapsamında aralarındaki ilişkiler incelenmiştir.

***Yöntem*:** Anket yöntemi kullanılarak Türkiye'de imalat sektöründe faaliyet gösteren 289 işletmenin üst ve orta düzey yöneticilerinden veriler elde edilmiştir. Elde edilen veriler öncelikle güvenirlik ve geçerlilik testlerine tabi tutulmuş ve sonuçları paylaşılmıştır. Daha sonrasında ise araştırma hipotezleri test edilmiş ve ulaşılan sonuçlar sunulmuştur.

Bulgular: Öğrenme yönelimi, teknoloji yönelimi, özümseme kapasitesi ve tedarik zinciri çevikliği arasındaki doğrusal ilişkileri test eden hipotezler ile birlikte özümseme kapasitesinin aracılık etkisinin incelendiği hipotezler, yapılan analizler neticesinde kabul edilmiştir.

Özgünlük: Literatürde, çalışmada kullanılan kaynak temelli yaklaşım bileşenleri ile tedarik zinciri çevikliği arasındaki ilişkide özümseme kapasitesinin aracı rolünü inceleyen bir çalışmaya rastlanılmamıştır. Bu çalışmanın ulaştığı sonuçlar ile literatüre katkı sağlayacağı düşünülmektedir.

Anahtar Kelimeler*:* Kaynak Temelli Yaklaşım, Öğrenme Yönelimi, Teknoloji Yönelimi, Özümseme Kapasitesi, Tedarik Zinciri Çevikliği.

JEL Kodları: M10, M11, M15.

Unveiling the Nexus among Resource-Based Approach Components, Absorptive Capacity and Supply Chain Agility

ABSTRACT

Purpose: This study investigates the relationship between resource-based approach components and supply chain agility. Learning orientation, technology orientation, absorptive capacity and supply chain agility are considered as dimensions and their relationships are examined in this study.

***Methodology*:** Using the survey method, data were obtained from the top and middle level managers of 289 enterprises operating in the manufacturing sector in Türkiye. The data obtained were first subjected to reliability and validity tests and the results were shared. Afterwards, the research hypotheses were tested and the results were presented.

Findings: The hypotheses testing the linear relationships between learning orientation, technology orientation, absorptive capacity and supply chain agility and the hypotheses examining the mediating effect of absorptive capacity were accepted as a result of the analyses.

Originality: There is no study in the literature that examines the mediating role of absorptive capacity in the relationship between the resource-based approach components used in the study and supply chain agility. It is thought that this study will contribute to the literature with its results.

Keywords*:* Resource Based Approach, Learning Orientation, Technology Orientation, Absorptive Capacity, Supply Chain Agility.

JEL Codes: M10, M11, M15.

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EXTENDED ABSTRACT

The natural and man-made disasters of the last decade have once again highlighted the importance of supply chains. These disasters worry consumers in terms of access to vital products and company managers in order to survive in these challenging conditions. However, not only disasters, but also the change in consumer demands in the last few decades, the shortening of product life cycles, and increasing competition in almost every sector force companies and their supply chains to be agile. How supply chains can be agile and the factors affecting agility have been the subject of studies in recent years. In this study, unlike the studies in the related field, the mediating role of absorptive capacity in the relationship between learning and technology orientation and supply chain agility was investigated.

In addition, the factors that are thought to affect supply chain agility are examined from a resource-based approach perspective. The resource-based approach emphasizes that the main factor that will give firms a competitive advantage is their intangible capabilities. In this context, some of the orientations and capabilities of firms are shown and accepted among their intangible assets.

Learning orientation, which is one of these orientations, enables firms to acquire new knowledge and use this new knowledge to change their existing routines and procedures. Thanks to learning orientation, firms can change the way their employees think and restructure in tough competitive conditions (Lonial and Carter, 2015).

One of the intangible assets that firms possess is their technology orientation. Firms can see R&D and new product development as part of their routine activities thanks to the technology-oriented firm vision they will achieve with the intensity of their technology orientation. In this way, firms can acquire a hard-to-imitate capability that the resource-based approach recommends to firms. With this capability, firms can create new market opportunities, meet new needs of customers and achieve higher profits (Zhu and Gao, 2021). Through learning orientation and technology orientation, the knowledge and capabilities that firms will acquire through learning orientation and technology orientation are absorbed and transformed into new knowledge that the firm can use through absorptive capacity (Kharabsheh et al., 2017). It is seen in different studies that learning orientation and technology orientation affect firms' product innovation. Product innovation is also associated with supply chain agility as it is considered to be the result of rapid response to the market (Zhu and Gao, 2021). Seven hypotheses were formed between the stated learning orientation, technology orientation, absorptive capacity and supply chain agility.

The data obtained from 289 firms in the manufacturing sector operating in Türkiye were first subjected to reliability and validity analyses. All of the scales used in the study were found to be highly reliable. In the context of validity analysis, divergence validity, merger validity, explanatory factor and confirmatory factor analyses were conducted. With the results obtained, it was seen that the data had divergence and convergence validity.

Then, seven hypotheses between learning orientation, technology orientation, absorptive capacity and supply chain agility were tested and confirmed. As a result of the findings, it can be stated that learning orientation and technology orientation have a direct impact on supply chain agility. In addition, absorptive capacity has a partial mediating effect both between learning orientation and supply chain agility and between technology orientation and supply chain agility.

1. GİRİŞ

Günümüzde sürekli belirsizliklerin yaşandığı global dünyada hızla büyüyen, değişen ve gelişen işletmeler sürekli rekabet içerisindedirler. İşletmelerin varlıklarını sürdürebilmeleri ve rakiplerine karşı rekabet avantajı sağlayabilmeleri için uygun stratejiler benimsemeleri ve bunu başarılı bir şekilde uygulamaları gerekmektedir. Firmaların bu stratejileri uygulamaları ve sürdürülebilir rekabet üstünlüğü elde edebilmeleri için kaynak temelli yaklaşım teorisi önerilmektedir (Özer ve Özer, 2014). Özellikle 1980'li yıllardan sonra gelişmeye başlayan kaynak temelli yaklaşım teorisi, endüstride bulunan firmaların varlıklarını sürdürebilmeleri ve rakiplerine karşı rekabet üstünlüğü elde etmelerinin kendilerine ait olan kaynak ve yeteneklerle elde edilebileceğini savunmaktadır.

Firmaların içsel özellikleri ile ilgilenen kaynak temelli yaklaşım teorisi (Barney, 1991); firmaların rekabet üstünlüğü oluşturmasının temel etmenlerini firmalara ait olan maddi olmayan kaynaklara dayandırmaktadır (Karacaoğlu, 2006). İlk olarak Wernerfelt (1984) tarafından kullanılan kaynak temelli yaklaşım kavramının, geçmişte nadir olarak bulunan ve henüz harekete geçirilmeyen değerli varlıkların nasıl kar ve kazanç sağladığını anlatan Ricardo kuramına dayandığı görülmektedir. Daha sonra birçok yazar tarafından araştırılan bu kavram Barney tarafından geliştirilmiştir. Barney (1991) bir firmanın, rakiplerine karşı rekabet üstünlüğü elde etmesi ve varlığını sürdürebilmesi için kaynak ve yeteneklerinin; değerli, nadir, taklit edilemeyen ve ikame edilemeyen özelliklere sahip olması gerektiğini savunmaktadır. Ayrıca Barney, bu özelliklerin firmayı müşterilerinin gözünde rakiplerinden ayırdığını ve firmanın rakiplerine karşı rekabet avantajı sağladığını dile getirmektedir.

Rekabetçi bir endüstride, firmaların normatif kar düzeyinin üzerine çıkabilmeleri için sahip oldukları kaynakların rakiplerinden üstün olması ve bu kaynakların endüstri içinde kopyalanmasını önlemek amacıyla gerekli koruma mekanizmalarına sahip olmaları gerekmektedir. Bu bağlamda kaynak temelli yaklaşım teorisi, potansiyelleri birbirinden farklı olan kaynak ve yeteneklerin aynı öneme sahip olması ve rekabet avantajı sağlayabilecek kapasiteye sahip olması gerektiğini savunmaktadır. İşletmelerin sahip oldukları maddi (finansal, fiziksel, teknolojik) kaynaklar kolayca taklit ve ikame edileceğinden rekabet üstünlüğü yaratmayacağı gibi işletmelerin maddi olmayan (insan, itibar) kaynakları ise kolayca taklit ve ikame edilemediği için rekabet üstünlüğü sağlamaktadır. Kaynak temelli yaklaşım teorisi firmaların; yoğun rekabet ortamında büyümek, geleceğini ikame etmek, karını yükseltmek ve rekabet üstünlüğü elde etmek için rakiplerine karşı benzersiz mal veya hizmet üretmeleri gerektiğini savunan görüştür. Bu bağlamda firmaların kaynak ve yeteneklerini etkin bir biçimde yöneten esnek ve çevik yapıya sahip olmaları rekabet avantajı elde etmeleri için doğru stratejilerle birlikte tedarik zincirini yönetebilmeleri gerekmektedir.

Tedarik zinciri, hammadde alımından başlayıp mamulün veya hizmetin son tüketiciye kadar ulaştırılmasına kadar olan süreçteki faaliyetler bütünü olarak ifade edilmektedir (Acar ve Ateş, 2011). Her geçen gün daha karmaşık bir hal alan ve hızlı bir biçimde değişiklik gösteren iş ortamında rekabet arttıkça tedarik zinciri çevikliği, önem kazanmakta ve rekabet avantajı olarak karşımıza çıkmaktadır. Tedarik zinciri çevikliği; müşteri taleplerinde ve tedarikte yaşanan ani değişliklere hızlı bir biçimde cevap verme yeteneğidir (Çankaya, 2020). Başka bir deyişle firma içerisinde üretilen ürün veya hizmetin müşteriye hızlı ve güvenli bir biçimde ulaştırılması tedarik zinciri çevikliği ile ifade edilmektedir. Tedarik zinciri çevikliği, farklı ağlar arasındaki koordinasyon ile ilgili olduğundan kolayca taklit ve ikame edilememektedir. Bu nedenle tedarik zinciri çevikliği, firma performansının iyileştirilmesi için önemli olan nadir, değerli, taklit ve ikame edilmeyen yetenekler bütünü olarak görülmektedir.

Tedarik zinciri çevikliği, bir firmanın pazardaki değişikliklere hızlı bir biçimde uyum sağlamak veya bunlara yanıt vermek için tedarik ağında bulunan ortaklarıyla birlikte operasyonel faaliyetler gerçekleştirme becerisini ifade eder. Bir tedarik zinciri normalde, tedarik üyeleri arasında ürün veya hizmetlerin tasarımı, üretimi ve teslimatı dâhil olmak üzere bir dizi bağlantılı faaliyetleri içermektedir. Firmanın, bağlantılı faaliyetlerini verimli bir biçimde gerçekleştirebilmesi ve pazardaki değişiklikleri yönetebilmesi için ortaklarıyla iş birliği yapması gerekmektedir. Tedarik zinciri çevikliği kavramı, kolayca uygulanabilen veya taklit edilebilen kurallar ve prosedürlerle ilgili değil, tedarik ağı boyunca farklı ağlar arasındaki koordinasyon veya entegrasyonla ilgili olan karmaşık bir olguyu yansıtmaktadır (Liu ve diğerleri, 2013). Çağdaş stratejik yönetim yaklaşımlarından olan, çevikliğin tedarik zinciri teorisine ve pratiğine uyarlanması ile elde edilen kavram; bir firmanın başarısının yalnızca sahip olduğu statik kaynaklar ile gerçekleşemeyeceğini, tedarik zinciri faaliyetlerini de etkin bir şekilde yöneterek, optimize ederek ve öngörülemeyen pazar değişikliklerine adapte ederek gerçekleşebileceğini savunmaktadır. Kaynak temelli yaklaşımın genişletilmiş hali olarak kabul edilen dinamik yetenekler yaklaşımı (Teece ve diğerleri, 1997), tedarik zinciri çevikliğini firmalara rekabet üstünlüğü sağlayacak başarı unsurlarından birisi olarak görmektedir. Bu doğrultuda kaynak temelli yaklaşım bileşenleri ile tedarik zinciri çevikliği arasındaki ilişkinin değerlendirilmesi ve tedarik zinciri çevikliğine etki eden faktörlerin bu kapsamda incelenmesi ile yapılan çalışmanın literatüre katkı sağlayacağı öngörülmektedir.

Çalışmanın ikinci bölümünde kaynak temelli yaklaşım kavramı ve tedarik zinciri çevikliği teorik çerçeve başlığı altında sunulmuştur. Üçüncü bölümde ise öğrenme yönelimi, özümseme kapasitesi, teknoloji yönelimi ve tedarik zinciri çevikliği arasındaki ilişkiler açıklanmış ve hipotezler oluşturulmuştur. Çalışmanın yöntemi, kullanılan ölçekler dördüncü bölümde, çalışma bulguları ise beşinci bölümde paylaşılmıştır. Daha sonra ise sonuç bölümünde bulgular değerlendirilmiş, çalışmanın kısıtları ifade edilmiş ve gelecek çalışmalara öneriler getirilmiştir.

2. TEORİK ÇERÇEVE ve LİTERATÜR TARAMASI

2.1. Kaynak Temelli Yaklaşım

Rekabet üstünlüğü oluşturmanın temel etmenlerini firmalara ait stratejik kaynaklara ya da firmaların maddi olmayan varlıklarına dayandıran; Dinamik Bazlı Firma Yaklaşımı, Bilgi Temelli Yaklaşım, Temel Yetenek Tabanlı Strateji ve Yetenekler Teorisi olarak da adlandırılan Kaynak Temelli Yaklaşım teorisidir (Karacaoğlu, 2006). Stratejik yönetim literatürüne uyarlanan ve firmalar arasındaki performans farklılıklarının işletmelerin varlık ve kabiliyetlerine göre belirlendiğini savunan bu kuram ilk olarak Wernerfelt (1984) tarafından ortaya atılmıştır. Ancak kaynak temelli yaklaşım teorisinin, geçmişte nadir olarak bulunan ve henüz harekete geçirilmeyen değerli varlıkların nasıl kar ve kazanç sağladığını anlatan Ricardo (1817) kuramına dayandığı da ifade edilmektedir (Kamaşak ve Yozgat, 2013).

Kaynak temelli yaklaşım teorisinin oluşumuna bakıldığında; firmaya ait olan kaynakların rekabet avantajı üzerindeki etkilerinden ilk olarak 1930'lu yıllarda Chamberlin (1933: 21) ve daha sonra Robinson (1933: 16) tarafından bahsedildiği görülmektedir. Wernerfelt (1984) ise, Penrose (1959) ve Rubin'in (1973) yapmış oldukları çalışmalara dayanarak kaynak temelli yaklaşım için araştırma gündemi oluşturmuştur (Akt., Breznik, 2012).

Kaynak temelli yaklaşım teorisi, firmaların sahip olduğu kaynak ve kabiliyetlerin firmaların başarılarında ve varlıklarını sürdürebilmesinde etkili rol oynadığını savunmaktadır. Aynı zamanda firmaların, kendine özgü kaynak ve deneyimleriyle birbirinden farklı özellikler sergilediğini savunan bu görüş, firmaların kendi ölçek ekonomilerini artırmaları için kullanmadıkları kaynaklarını kullanmaya başlamaları gerektiğini vurgulamaktadır (Trevino ve Grosse, 2002). Michalisin ve diğerleri (2000), kaynak temelli yaklaşımı; firmaların sahip oldukları kaynakların aynı nitelik ve öneme sahip olmaları veya rekabet avantajı elde edebilecek potansiyelde olmaları gerektiğini açıklayarak kaynakların potansiyellerinin birbirinden farklı olduklarını vurgulamışlardır. Araştırmacılar bu teoriye göre, firmaların piyasanın üstünde gelir elde etmeleri için ellerinde bulunan varlıkların, rakip işletmelerin ellerinde bulunan varlıklardan daha değerli olmaları ve farklı endüstrilerde kopyalanmamaları için firmaların gerekli önlemleri almış olmaları gerektiğini belirtmektedirler.

Kaynak temelli yaklaşıma önemli bir katkısı olan diğer bir çalışma ise Barney (1991)'in, "Firma Kaynakları ve Sürdürülebilir Rekabet Avantajı" isimli çalışmasıdır. Barney bu çalışmasında bir firmanın sürdürülebilir rekabet avantajı sağlaması için dört özelliğe sahip olması ve bunları anlaması gerektiğini vurgulayarak bu dört özelliğin firmanın sürdürülebilir rekabet avantajı sağlamasında etkili olacağı düşüncesindedir. Bu dört özellik; kaynakların değerli, nadir, taklit edilemeyen ve ikame edilemeyen özelliklere sahip olması olarak sıralanabilir. Bir firmanın sürdürülebilir rekabet avantajı elde etmesi için elinde bulunan kaynaklar ile rakipleri tarafından elde edilemeyecek veya çoğaltılamayacak olan stratejiyi bulması ve uygulaması gerektiğini söylemektedir (Barney, 1991).

Firmalar günümüzde giderek daha dinamik ve belirsiz ortamlarda faaliyet göstermekte ve değişen piyasa koşullarına uyum sağlama ve yanıt verme gereği hissetmektedir. Bu nedenle firmalar sahip oldukları maddi kaynaklarının yanı sıra maddi olmayan kaynaklar ve yetenekler de geliştirmelidir. Firmaların yalnızca kendi içsel kaynaklarının yanı sıra bir tedarik zinciri içerisinde faaliyetlerine devam ettikleri ve rekabetin firmalar düzeyinden tedarik zincirleri boyutuna taşındığı bilinmektedir. Dolayısıyla firmalar tedarik zinciri boyutunda yaratıcı yeteneklere sahip olmalı ve bu yeteneklerini sürdürebilmelidir. Bu yeteneklerin biri dinamik yeteneklerden biri olarak kabul edilen tedarik zinciri çevikliğidir. Tedarik zinciri çevikliği sayesinde firmalar, firma ya da tedarik zinciri seviyesinde kaynakları yeniden yapılandırabilme yeteneğine sahip olabilirler (Dubey ve diğerleri, 2018).

2.2. Tedarik Zinciri Çevikliği

1990'lı yılların başında üretim sektöründe yaşanan değişime firmaların, hızlı bir biçimde uyum sağlamaları çeviklik kavramının ortaya çıkmasına neden olmuş (Avelar-Sosa ve diğerleri, 2019) ve bu kavramın gelişimine paralel olarak 1990'ların sonunda tedarik zinciri çevikliği ortaya çıkmıştır (Özgüner ve Cantaşdemir, 2021). Tedarik zinciri çevikliği, tedarik ağının değişen pazar ortamına zamanında ve hızlı bir biçimde cevap verme kabiliyeti olarak tanımlanmaktadır. Ayrıca, bir işletmenin herhangi bir faaliyetin sonuç

ölçütlerine ne kadar etkili bir biçimde ulaşıldığıyla değil firmanın sonuç ölçütlerine ne kadar hızlı yanıt veya tepki verme yeteneği olduğu ile ilgilenmektedir (Braunscheidel ve Suresh, 2009).

Tedarik zinciri çevikliği, işletmelerin tüm tedarik ağında değişim ve gelişime uyum sağlamasını ve bunlara hızlı yanıt vermeyi amaçlayan dinamik bir kabiliyet olarak tanımlanabilir. Bu nedenle tedarik zinciri çevikliği, tek bir işletmenin ötesine geçerek tedarikçiler ve müşteriler ile uyum sağlamayı içermektedir (Martinez-Sanchez ve Lahoz-Leo, 2018). Christopher (2000) ise tedarik zinciri çevikliğini; kişiselleştirilmiş müşteri istek ve ihtiyaçlarını öngörebilmek ve buna yanıt vermek, kısaca; pazara duyarlılık göstermek olarak tanımlamıştır.

Tedarik zinciri çevikliği; firmanın pazarda yaşanan değişikliklere hızlı bir biçimde uyum sağlaması ya da yaşanan değişime cevap vermesi için tedarik ortaklarıyla beraber operasyonel faaliyetleri gerçekleştirme kabiliyeti olarak tanımlanmaktadır. Bir tedarik zinciri, genelde kanal üyeleri arasında ürün veya hizmetin tasarımı, üretimini ve dağıtımı dâhil olmak üzere koordinasyon faaliyetlerini içermekte ve kaynak üyeleri arasında bilgi paylaşımında ve kaynak oluşumunda ne kadar iyi iş birliği yaptığını göstermektedir. Bu nedenle tedarik zinciri çevikliği; firma performansını iyileştirebilmek için kritik öneme sahip nadir, değerli ve mükemmel bir biçimde taklit edilemeyen bir yetenek olarak karşımıza çıkmaktadır (Liu ve diğerleri, 2013). Tedarik zinciri çevikliğine sahip olan firmalar, öngörülmeyen olaylara karşı daha iyi cevap verebildikleri ve arz ile talep dengesini koruyabildikleri için pazar odaklı olarak kabul edilmektedir. Ayrıca, firmalar tedarik zinciri çevikliği yetenekleri sayesinde müşterilerine özel olarak üretilmiş ürünleri seri üretim maliyetinde ya da buna yakın bir maliyetle teslim edebilme kabiliyetine sahip olabilmektedir (Swafford ve diğerleri, 2008).

Son birkaç on yıl içerisinde tedarik zinciri çevikliğine etki ettiği düşünülen faktörler üzerine çok sayıda çalışma gerçekleştirilmiştir. Swafford ve diğerleri (2008) bilgi teknolojileri entegrasyonunun ve tedarik zinciri esnekliğinin; Tse ve diğerleri (2016) tedarik zinciri entegrasyonu ve dışsal öğrenmenin; Gligor ve diğerleri (2016) tedarik zinciri oryantasyonu ve pazar oryantasyonunun; Brusset (2016) dışsal yeteneklerin, görünürlük yeteneklerinin ve içsel süreç yeteneklerinin; Kim ve Chai (2017) tedarikçi yenilikçiliğinin, bilgi paylaşımının ve stratejik kaynak kullanımının; Irfan ve diğerleri (2020) tedarik esnekliği ve süreç entegrasyonunun; Zhu ve Gao (2021) ise öğrenme ve teknoloji yöneliminin tedarik zinciri çevikliğine olan etkilerini araştırmışlardır. Bu çalışmada ise Zhu ve Gao (2021)'nun tedarik zinciri çevikliğine çalışmasında kullanmış olduğu bağımsız değişkenlere (öğrenme yönelimi ve teknoloji yönelimi) özümseme kapasitesi aracı değişkeni eklenmiştir. Böylece bağımsız değişkenlerle aracı değişken arasındaki ilişki ve bağımsız değişkenlerin aracı değişken üzerinden bağımlı değişken olan tedarik zinciri çevikliği üzerinde etkileri açıklanmaya çalışılmıştır. Literatürde çalışmada kullanılan değişkenler arasındaki ilişkileri inceleyen bir çalışma ile karşılaşılmamıştır. Bu nedenle çalışmanın tedarik zinciri yönetimi literatürüne katkı sağlayabileceği düşünülmektedir.

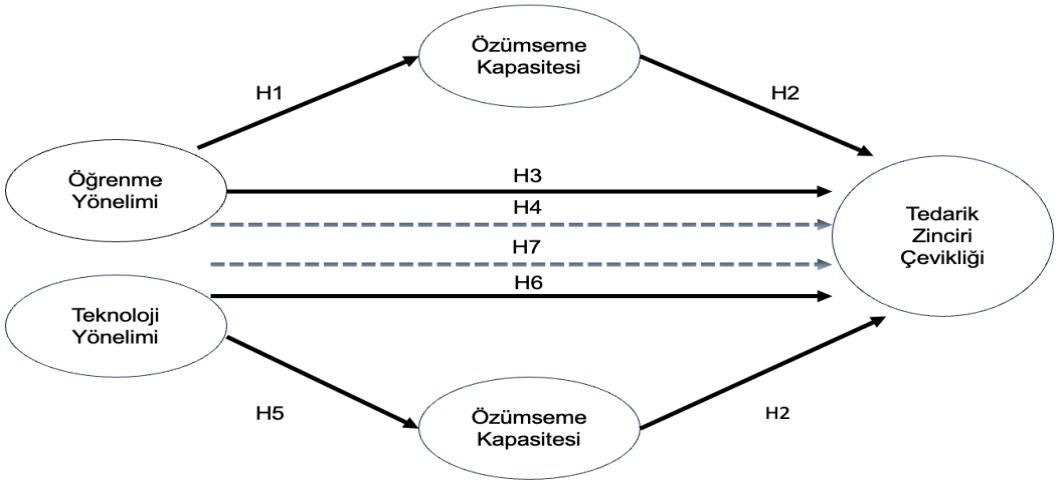
3. ARAŞTIRMA HİPOTEZLERİNİN KURULMASI

Firmaların sahip oldukları bazı yönelimler maddi olmayan varlıklar arasında kabul edilmekte olup firmaların rutinlerine gömülü olduklarından rakipler tarafından kopyalanması da mümkün görünmemektedir. Bu yönelimlerden olan öğrenme yönelimi sayesinde firmalar yeni bilgiler edinebilir ve bu yeni bilgileri kullanarak mevcut rutin ve prosedürlerini değiştirebilir. Öğrenme yönelimi sayesinde firmalar çalışanlarının düşünme biçimlerini değiştirebilir ve zorlu rekabet şartlarında yeniden yapılanabilirler (Lonial ve Carter, 2015). Firmaların sahip olduğu maddi olmayan varlıklardan biri de teknoloji yönelimleridir. Firmalar teknoloji yönelimlerinin yoğunlukları ile elde edecekleri teknoloji odaklı firma vizyonu sayesinde Ar-Ge'yi ve yeni ürün geliştirmeyi rutin faaliyetleri içerisinde görebilir. Bu sayede kaynak temelli yaklaşımın firmalara salık verdiği taklit edilmesi zor bir yetenek kazanabilir. Firmalar elde ettikleri bu yetenek ile yeni pazar fırsatları yaratabilir, müşterilerin yeni ihtiyaçlarını karşılayabilir ve daha yüksek kara ulaşabilirler (Zhu ve Gao, 2021). Öğrenme yönelimi ve teknoloji yönelimi sayesinde firmaların elde edecekleri bilgiler ve yeteneklerin özümsenmesi ve firmanın kullanabileceği yeni bilgilere dönüştürülmesi özümseme kapasitesi ile gerçekleşmektedir (Kharabsheh ve diğerleri, 2017). Öğrenme yönelimi ve teknoloji yöneliminin firmaların ürün inovasyonuna etki ettiği farklı çalışmalarda görülmektedir. Ürün inovasyonu ayrıca pazara hızlı yanıt vermenin sonucu olarak kabul edildiğinden tedarik zinciri çevikliği ile de ilgili yönelimler ilişkilendirilmektedir (Zhu ve Gao, 2021). Öğrenme yönelimi ve teknoloji yöneliminin tedarik zinciri çevikliğine doğrudan ve özümseme kapasitesi üzerinden dolaylı etkilerine dair oluşturulan araştırma modeli Şekil 1'de gösterilmektedir. Çalışmada yedi hipotez oluşturularak aşağıda sırasıyla açıklanmaktadır.

Firmanın somut değerler yaratabilen maddi olmayan varlıklarından biri olarak ifade edilen öğrenme yönelimi, firmanın öğrenmeye yönelik sahip olduğu değerler bütünü olarak dile getirilmektedir (Tse ve diğerleri, 2016). Bu değer; bir firmanın öğrenme kültürünü teşvik edip etmeyeceğini etkilemektedir (Sinkula ve diğerleri, 1997). İşletmenin belirli bir alanda öğrenme faaliyetleri o alandaki bilgi tabanını geliştirmekte ve bu da özümseme kapasitesini artırmakta ve o alanda öğrenmeyi kolaylaştırmaktadır. Özümseme kapasitesi, bir örgütün önceki ilgili bilgisine, etkili öğrenme becerisine ve iletişimine dayalı pazar bilgisi

hakkında katkı sağlamaktadır. Aynı zamanda örgütün rekabet avantajı kazanmasına ve bunu sürdürmesine yardımcı olabilecek rekabette bilgi yaratma ve kullanma yeteneği olarak tanımlanmaktadır. Firmanın öğrenmeye dayalı varlıklarını etkin bir biçimde yeniden tanımlayarak, özümseme kapasitesine sahip olması, değişime ve yeniliğe açık olarak performansını yükseltebileceği anlamına gelmektedir (Liu ve diğerleri, 2013). Bundan dolayı öğrenme yönelimi ve özümseme kapasitesi arasında sürekli yenilenen bir ilişki olduğu sonucuna varılmaktadır (Lane ve diğerleri, 2006). Bu bilgilerden yola çıkılarak öğrenme yönelimi ve özümseme kapasitesi arasında aşağıda ifade edilen hipotez oluşturulmuştur.

H1: Öğrenme yönelimi özümseme kapasitesini olumlu yönde etkilemektedir.



Şekil 1. Araştırma modeli

Özümseme kapasitesine sahip firmalar; müşterileri, tedarikçileri ve rakipleri ve diğer tedarik ortaklarından elde ettikleri yeni bilgileri pazardaki iş fırsatlarını belirleyerek ilgili alanlara uygulamaktadır. Bilginin farklı fonksiyonel departmanlar arasında kapsamlı bir biçimde aktarılması firma içerisindeki ağların kurulmasını kolaylaştırmaktadır. Ayrıca, firmanın ulaşabileceği bilgi erişimi ve karlılık derecesinin çeviklik tarafından belirlendiği savunulmaktadır. Bundan dolayı firma, süreçlerini yeniden yapılandırmak, ürün ve hizmetlerini iyileştirmek için yeni bilgiyi nasıl uygulayacağını etkili bir biçimde öğrenebilmektedir. Bu da firmanın rekabet avantajı temelinin, çeviklik gibi benzersiz bir operasyonel yetenek geliştirmek için özümseme kapasitesinden faydalanmak olduğunu göstermektedir. Firmanın geliştirmiş olduğu bu yetenek zenginleştirilmiş bir bilgi tabanı kullanılarak kanal ortaklarıyla iyi ilişkilerin kurulmasına ve tedarik zinciri görünürlüğünün artırılmasına yardımcı olmaktadır. Yenilenen bilgi tabanı, firmanın pazarı ve ortakların görüş ve değerlerini daha iyi anlamasına yardımcı olarak tedarik zinciri çevikliğini sağlayacak ve tedarik zinciri genelinden paylaşılan değerleri artıracaktır (Liu ve diğerleri, 2013). Bu bilgiler doğrultusunda özümseme kapasitesi ve tedarik zinciri çevikliği arasında aşağıda ifade edilen hipotez oluşturulmuştur.

H2: Özümseme kapasitesi tedarik zinciri çevikliğini olumlu yönde etkilemektedir.

Öğrenme yönelimli firmalar; sürekli değişen pazar durumu hakkında hızlı bir şekilde bilgi edinmek ve pazardaki beklenmedik değişimi algılamak için müşteriler, rakipler ve tedarikçilerle sürekli ileşitim halinde olmak ve onlara göre hareket etmek zorundadırlar (Sinkula ve diğerleri, 1997). Öğrenme yönelimi, tedarik zinciri bağlamında iki bileşenden oluşmaktadır: Müşterilerden ve tedarikçilerden öğrenme. Müşterilerden öğrenme; firma müşterilerinden gelen geri bildirimi öğrenerek ürün tasarımı ve hizmetini geliştirerek firmanın yenilik hızını tahmin etmektir. Tedarikçilerden öğrenme ise; yeni ürün ya da süreç tasarımına ve ürün kalitesinin iyileştirilmesine tedarikçilerle uzun vadeli bir ilişkinin meydana gelmesi sonucu oluşmaktadır (Tse ve diğerleri, 2016). Bir örgütün sürekli olarak öğrenmesi ve sürekli değişen pazar ortamında ortaya çıkabilecek yeniliklere hazırlıklı olması gerekmektedir. Ayrıca öğrenme yönelimi; "-öğrenmeye verilen değeri ifade eden öğrenmeye bağlılık, -firma üyeleri arasında öğrenmenin yönü ve odağı konusunda fikir birliği ile ilgili paylaşılan görüşler, -tedarik zinciri çevikliğini değerlendirme ve yeni fikirleri kabul etme" maddelerinden oluşmaktadır. Tedarik zinciri çevikliği, firmanın beklenmeyen pazar değişikliklerine anında yanıt verebilmesi için değişiklikleri öğrenmesi anlamına gelmektedir (Ngai ve diğerleri, 2011). İlgili alanda yapılan çalışmalar doğrultusunda öğrenme yönelimi ve tedarik zinciri çevikliği arasında aşağıda ifade edilen hipotez oluşturulmuştur.

H3: Öğrenme yönelimi tedarik zinciri çevikliğini olumlu yönde etkilemektedir.

Firmanın, sürekli gelişen ve değişen pazar ortamında geleceğini devam ettirebilmesi için yeniliğe ayak uydurması ve sürekli öğrenme eğiliminde olması gerekmektedir. Firma, tedarikçilerinden elde edilen yeni

bilgileri endüstrisinde bulunan ürün ve hizmete uyarlaması ve pazar istek ve ihtiyaçlarına göre müşteriye ulaştırılması konusunda çevik davranmak zorundadır. Firmanın, pazardaki değişikliklere hızlı bir biçimde uyum sağlaması veya bunlara yanıt vermesi ve rekabet avantajı elde etmesi için tedarik ağında bulunan ortaklarıyla operasyonel faaliyetler gerçekleştirmesi gerekmektedir. Bu doğrultuda özümse kapasitesinin; öğrenme yönelimi ve tedarik zinciri çevikliği arasındaki ilişkide aracılık rolü üstlendiğine dair hipotez oluşturulmuştur.

H4: Özümseme kapasitesi; öğrenme yönelimi ve tedarik zinciri arasındaki ilişkide aracılık rolü üstlenmektedir.

Teknoloji yönelimi; firmaların, araştırma geliştirme kabiliyetine sahip olduğu ürün geliştirmede son teknolojinin elde edilmesi ve kullanılması olarak adlandırılmaktadır (Masa'deh ve diğerleri, 2018). Teknolojik yenilikleri iyi yönlendirilmiş ve verimli bir biçimde kullanılmasını sağlamak için yenilik yönetimine sahip firmaların, özellikle tekonolojik araştırmalar konusunda çevreden üretilen bilgiyi uygulamaları gerekmektedir. Firmaların çevreden gelen teknolojik yenilikleri tanımlayarak ilgili alanlara uyarlama ve kullanma yeteneği özümseme kapasitesi olarak ifade edilmektedir. Teknolojik fırsatlar, temel olarak diğer bilgi kaynakları (özellikle müşteriler gibi) tarafından üretilenlerden daha yüksek düzeyde özümseme kapasitesine ihtiyaç duyarlar (Becker ve Peters, 2006). Özümseme kapasitesinin, bir firmanın üretimine dogrudan katılım yoluyla belirli bir ürün pazarıyla ilgili yeni bilgileri daha iyi tanımlayarak ilgili alanlara kullanabildiği belirtilmiştir (Cohen ve Levinthal, 1990). Daha fazla teknoloji, daha fazla bilgi ve fırsat anlamına gelmekte bu da firmaların rekabet güçlerini korumak için mali bütçelerinin, bir kısmını özümseme kapasitelerinin sürdürülmesine ve geliştirilmesine yatırım yapmak zorunluluğunu arttırmaktadır (Cohen ve Levinthal, 1990). İlgili alandaki literatür doğrultusunda test edilmek üzere teknoloji yönelimi ve özümseme kapasitesi arasında aşağıda ifade edilen hipotez oluşturulmuştur.

H5: Teknoloji yönelimi özümseme kapasitesini olumlu yönde etkilemektedir.

Teknoloji yönelimi, firmanın aktif bir biçimde pazarla sürekli etkileşim halinde olarak yeni teknolojileri araştırıp geliştirmesi ve bunu ürünlere uyarlaması anlanıma gelmektedir (Rezazadeh ve diğerleri, 2016). Ürün ve hizmetlerin kısalan yaşam döngüleri nedeniyle işletmeler, rekabet ortamında varlıklarını devam ettirebilmek için teknoloji alanında gelişmek zorunda kalmışlardır (Masa'deh ve diğerleri, 2018). Firmanın teknoloji yönünden gelişmesi alıcı ve tedarikçi arasındaki ilişkinin gelişmesini de beraberinde getirmektedir. Tedarikçileri ve müşterileri arasında önemli bir etkileşim sağlayabilmek için aracı rolü oynayan firmaların, gelişen teknolojiyi hızlı bir biçimde alıp ürünlere uyarlaması gerekmektedir. Firmaların; pazar ihtiyaçlarına cevap verebilecek netilikteki ürünlerin müşterilere hızlı bir biçimde ulaştırılması için son zamanlarda popüler bir kavram haline gelen tedarik zinciri çevikliğini iyi koordine etmeleri gerektiği savunulmaktadır. (Bargshady ve diğerleri, 2016). İlgili alanda yapılan çalışmalar ışığında teknoloji yönelimi ve tedarik zinciri çevikliği arasında aşağıda ifade edilen hipotez oluşturulmuştur.

H6: Teknoloji yönelimi tedarik zinciri çevikliğini olumlu yönde etkilemektedir.

Firmaların, çevreden gelen teknolojik yenilikleri ürün ve hizmetlerine tanımlama, uyarlama ve uygulama yeteneklerini ifade eden özümseme kapasitesi; yeni ve iyileştirilmiş ürünleri geliştirmek için teknolojik yönelimleri ile firma kabiliyetleri arasındaki bağlantıyı temsil etmektedir (Cohen ve Levinthal, 1990). Firmadan firmaya değişiklik gösteren özümseme kapasitesi, teknolojik gelişmeleri özellikle bilgisayar, uçak, uzay bilimleri ve ilaç sanayi gibi araştırma geliştirme bakımından yoğun endüstrilerdeki yüksek teknoloji firmaları için önem arz etmektedir (Becker ve Peters, 2006). Firmalar, değişen pazar ortamına ayak uydurmak ve müşteri istek ve ihtiyaçları doğrultusunda ürünler üretebilmek ve onları tükeceticilere ulaştırmak konusunda çevik davranmak zorundadırlar (Masa'deh ve diğerleri, 2018). Firmaların, yeniliğe ayak uydurabilmek ve geleceğini ikame edebilmek için tedarik zinciri ağıyla tedarikçilerinden edindiği teknolojik gelişmeleri ürünlere uyarlamaları ve hızlı bir biçimde tüketiciye ulaştırmak için tedarik zinciri çevikliği kavramından yararlanmaktadırlar. Bu bilgilerden yararlanılarak özümseme kapasitesinin; teknoloji yönelimi ve tedarik zinciri çevikliği arasındaki ilişkide aracılık hipotezi oluşturulmuştur.

H7: Özümseme kapasitesi; teknoloji yönelimi ve tedarik zinciri arasındaki ilişkide aracılık rolü üstlenmektedir.

4. YÖNTEM

Bu çalışmada nicel araştırma yöntemlerinden olan anket tekniği kullanılmıştır. Araştırmanın anakütlesini, Türkiye'de imalat sektöründe faaliyet gösteren küçük, orta ve büyük ölçekteki 73857 işletme oluşturmaktadır (Kosgeb, 2023). Toplamda 950 kişiye gönderilmiş olan ankete toplam 289 kişi katılım sağlamıştır. %90 güven seviyesi ve %5 hata payı ile örneklemin 272 birim olması aşağıda belirtilen örneklem hesaplama yöntemi ile bulunmuştur. %90 güven seviyesi ve %5 hata payı ile ulaşılan 289 kişilik örneklem büyüklüğü yeterli bulunmuştur (Eşitlik 1).

$$n = \frac{z^2 * p(1-p)}{\varepsilon^2} = \frac{1{,}65^2 * 0{,}5(1-0{,}5)}{0{,}05^2} \cong 272 \quad (1)$$

Eşitlikte 1'de n, örneklem sayısını; p, popülasyon oranını ve ε, hata payını ifade etmektedir.

Yapılan ankette katılımcılara demografik bilgilerin yanı sıra öğrenme yönelimi, teknoloji yönelimi, özümseme kapasitesi ve tedarik zinciri çevikliği üzerine sorular yöneltilmiş ve katılımcıların cevapları alınmıştır. Anket formu, LinkedIn üzerinden ilgili firma üst düzey yöneticileri ile iletişime geçilerek online doldurulacak şekilde kendilerine iletilmiştir. Anket cevaplayıcılarına olasılıklı olmayan örnekleme yöntemlerinden olan kolayda örnekleme yöntemi ile ulaşılmıştır. Sosyal bilim araştırmalarında sıklıkla kullanılan kolayda örnekleme yönteminin diğer örneklem tekniklerine göre daha kolay, ucuz ve hızlı olması avantajları arasında gösterilmektedir (Gürbüz ve Şahin, 2017).

Araştırmanın amacına yönelik kullanılacak olan anket madde ölçekleri detaylı bir litaratür taraması yapıldıktan sonra oluşturulmuştur. Araştırmada, Zhu ve Gao (2021)'nun güvenirliğini ve geçerliğini test ettiği öğrenme yönelimi, teknoloji yönelimi ve tedarik zinciri çevikliği ölçekleri ile Riquelme-Medina ve diğerleri (2022)'in güvenirliğini ve geçerliğini test ettiği özümseme kapasitesi ölçeği kullanılmıştır.

Tablo 1. Araştırma ölçekleri ve maddeleri

Ölçek	*Maddeler*
Öğrenme Yönelimi	- İşletme olarak çalışanların öğrenmesinin tedarik zincirinde bir masraf değil, bir yatırım olduğu anlayışını benimsemekteyiz. - İşletme olarak tedarik zinciri sürecinin temel değerlerinden olan öğrenmeyi, iyileştirmenin anahtarı olarak benimsemekteyiz. - İşletme olarak tedarik zincirinde öğrenmeyi bıraktığımızda geleceğimizi tehlikeye attığımızı biliriz. - İşletme olarak tedarik zinciri sürecinde öğrenme yeteneğini gelişmenin anahtarı olarak görmekteyiz.
Özümseme Kapasitesi	- İşletme olarak ilişki içerisinde olduğumuz diğer kuruluşlardan edinilen yeni bilgileri tanımlayıp, değerlendirip işletme içine aktarabiliriz. - İşletme olarak ilişki içerisinde olduğumuz diğer kuruluşlardan gelen harici bilgileri analiz etmek rutinlerimiz arasındadır. - İşletme olarak ilişki içerisinde olduğumuz diğer kuruluşlardan edinilen yeni bilgileri mevcut bilgilerle entegre hale getirebiliriz. - İşletme olarak yeni entegre edilmiş bilgiyi somut uygulamalarla başarılı bir şekilde kullanabiliriz.
Teknoloji Yönelimi	- Yeni ürün geliştirme projelerimizde gelişmiş teknolojiler kullanmaktayız. - Yeni ürünlerimizde her zaman en son teknolojiyi kullanmaktayız. - Araştırma sonuçlarına dayalı olarak geliştirilen teknolojik yenilikleri kolaylıkla kabul etmekteyiz. - Teknolojik yenilikler program/proje yönetimimizde kolaylıkla kabul edilir.
Tedarik Zinciri Çevikliği	- İşletme olarak çevremizdeki değişiklikleri hızlı bir şekilde tespit edebiliriz. - İşletme olarak iş ortamındaki fırsatları anında tespit edebiliriz. - İşletme olarak, çevremizdeki tehditleri hızla algılayabiliriz. - İşletme olarak, çevremizdeki değişikliklerle başa çıkmak için kesin kararlar alabiliriz. - İşletme olarak çevremizdeki tehditlere yanıt vermek için kesin kararlar alabiliriz. - İşletme olarak iş ortamındaki değişikliklere hızla yanıt verebiliriz. - İşletme olarak çevremizdeki fırsatları hızla ele alabiliriz. - İşletme olarak çevremizdeki tehditlerle hızla başa çıkabiliriz. - İşletme olarak gerektiğinde, kararlarımızı uygulamak için tedarik zinciri operasyonlarımızı ayarlayabiliriz.

Çalışmada kullanılan anket formu, firmayı tanımlayabilecek sorular ve araştırmanın amacına yönelik ölçek maddelerinden oluşmaktadır. Araştırmada kullanılan ölçek ifadeleri; "(1) Kesinlikle katılmıyorum, (2) Katılmıyorum, (3) Kararsızım, (4) Katılıyorum, (5) Kesinlikle katılıyorum" kullanılan 5'li likert ölçeği biçiminde derecelendirilmiştir. Ayrıca anket formu, 5 tane katılımcı ve firmaya ait tanımlayıcı soru içerirken 21 tane de 1 ve 5 arasında değer verilerek cevap verilmesi istenen maddelerden oluşmaktadır. Bu bölümde yer alan Formell-Larcker kriteri, HTMT (Heterotrait-Monotrait Ratio) Oranı, DFA model uyum indeks tabloları ve DFA sonuçları SmartPLS programında gerçekleştirilmiştir. Aracılık analizleri sonuçları ise SPSS Hayes Macro eklentisi kullanılarak elde edilmiştir.

5. BULGULAR

5.1. Tanımlayıcı İstatistikler

Katılımcıların cevaplamaları için anket içerisinde 5 tane demografik soru yöneltilmiştir. Elde edilen sonuçlar doğrultusunda ankete katılım sağlayan katılımcıların çalıştıkları işletmelerin; 150'si (%51,9) Marmara bölgesinde, 39'u (%13,5) Ege bölgesinde, 14'ü (%4,8) Karadeniz bölgesinde, 23'ü (%8,0) Akdeniz bölgesinde faaliyet göstermektedir. 37'si (%12,8) ise İç Anadolu bölgesinde, 9'u (%3,1) Doğu Anadolu bölgesinde, 17'si (%5,9) Güneydoğu Anadolu bölgesinde faaliyet göstermektedir. Katılımcıların; 101'i (%34,9) üretim müdürü, 2'si (%0,7) yeni ürün geliştirme müdürü, 21'i (%7,3) tedarik zinciri müdürü, 47'si (%16,3) genel müdür pozisyonuna sahiptir. 10'u (%3,5) ise ar-ge müdürü, 18'i (%6,2) üretimden sorumlu genel müdür yardımcısı, 15'i (%5,2) üretim planlama müdürü, 75'i (%26,0) ise diğer üst düzey yönetici pozisyonuna sahiptir. Tablo 2'de diğer demografik sorulara ilişkin yüzde oranları ve frekanslar hakkında bilgi verilmektedir.

Tablo 2. Betimsel analiz sonuçları

	Frekans	*Oran*	*Geçerli Oran*	*Kümülatif Oran*
İşletme İçerisindeki Pozisyonunuz				
Üretim Müdürü	101	34,9	34,9	34,9
Yeni Ürün Geliştirme Müdürü	2	0,6	0,6	35,5
Tedarik Zinciri Müdürü	21	7,3	7,3	42,8
Genel Müdür	47	16,3	16,3	59,1
Ar-ge Müdürü	10	3,5	3,5	62,6
Üretimden Sorumlu Genel Müd, Yrd.	18	6,2	6,2	68,8
Üretim Planlama Müdürü	15	5,2	5,2	74,0
Diğer	75	26,0	26,0	100,0
İşletmenin Faaliyet Gösterdiği Sektör				
Gıda Ürünleri İmalatı	32	11,1	11,1	11,1
İçecek İmalatı	1	0,3	0,3	11,4
Tekstil Ürünleri İmalatı	94	32,5	32,5	43,9
Giyim Eşyaları İmalatı	13	4,5	4,5	48,4
Kâğıt ve Kâğıt Ürünleri İmalatı	5	1,7	1,7	50,2
Kimyasal Ürünler İmalatı	10	3,5	3,5	53,6
Eczacılık ve Ecz. İliş. Malz. Üretimi	1	0,3	0,3	54,0
Kauçuk ve Plastik Ürünler İmalatı	6	2,1	2,1	56,1
Metalik Olmayan Ürünler İmalatı	4	1,4	1,4	57,4
Ana Metal Sanayi	15	5,2	5,2	62,6
Fabrikasyona Metal Ürünler İmalatı	6	2,1	2,1	64,7
Bilgisayar, Elektronik ve Optik İmalatı	2	0,7	0,7	65,4
Elektrikli Teçhizat İmalatı	8	2,8	2,8	68,2
Makine ve Ekipman İmalatı	24	8,3	8,3	76,5
Diğer Ulaşım Araçları İmalatı	1	0,3	,3	76,8
Mobilya İmalatı	9	3,1	3,1	79,9
Diğer İmalatlar	58	20,1	20,1	100,0
İşletmenizin Faaliyet Yılı				
1-10	75	26,0	26,0	26,0
11-20	44	15,2	15,2	41,2
21-30	58	20,0	20,0	61,2
31 ve üzeri	112	38,8	38,8	100,0
Çalışan Sayınız				
10-49	65	22,5	22,5	25,3
50-249	89	30,8	30,8	53,3
250 ve üzeri	135	46,7	46,7	100,0
İşletmenizin Bulunduğu Bölge				
Marmara	150	51,9	51,9	51,9
Ege	39	13,5	13,5	65,4
Karadeniz	14	4,8	4,8	70,2
Akdeniz	23	8,0	8,0	78,2
İç Anadolu	37	12,8	12,8	91,0
Doğu Anadolu	9	3,1	3,1	94,1
Güneydoğu Anadolu	17	5,9	5,9	100,0

5.2. Güvenirlik Analizi

Çalışmada ölçeğin güvenirliğinin test edilmesinde iç tutarlılık katsayısı olan Cronbach's alpha katsayısından faydalanılmıştır. Taber (2018)'e göre Cronbach's alpha katsayısı 0,70 ve üzeri değere sahipse ölçeğin güvenilir olduğu değerlendirilir. Öğrenme yönelimi ölçeğine ait dört maddenin Cronbach's alpha iç tutarlılık katsayısı 0,903, özümseme kapasitesi ölçeğine ait dört maddenin katsayısı 0,831, teknoloji yönelimi ölçeğine ait dört maddenin katsayısı 0,860, tedarik zinciri çevikliği ölçeğine ait dokuz maddenin katsayısı 0,942 olarak bulunmuş olup, bu değerler ölçeklerin yüksek derecede güvenilir olduğunu ifade etmektedir. 21 maddenin hepsinin dahil edildiği test ile tüm ölçeklerin Cronbach's alpha iç tutarlılık katsayısı ise 0,932 olarak bulunmuş olup, dolayısıyla bu değer de ölçeğin yüksek derecede güvenilir olduğunu anlamına gelmektedir. Tablo 3'te çalışmada kullanılan ölçeklerin güvenirlik istatistikleri verilmiştir.

Tablo 3. Ölçeklere ait güvenirlik istatistikleri

Ölçek	*Cronbach's Alpha*	*Madde Sayısı*
Öğrenme Yönelimi	0,904	4
Özümseme Kapasitesi	0,836	4
Teknoloji Yönelimi	0,862	4
Tedarik Zinciri Çevikliği	0,942	9
Tüm Değişkenler	0,932	21

5.3. Geçerlik Analizi

Geçerlilik analizi bağlamında ayrışma geçerliliği, birleşme geçerliliği, açıklayıcı faktör ve doğrulayıcı faktör analizleri yapılmıştır. Geçerlilik analizi öncesinde normallik analizi yapılarak verilerin normal dağılıp dağılmadığını göstermek için çarpıklık ve basıklık değerleri incelenmiştir. Byrne (2010) verilerin normallik varsayımına sahip olduğunu kanıtlamak için çarpıklık değerinin 3'ten basıklık değerinin ise 7'den düşük olması gerektiğini savunmaktadır. Test sonucu ile verilerin çarpıklık değerinin -1,508 ile -,506 aralığında ve basıklık değerinin ise 0,005 ve 4,422 aralığında olduğu gözlemlenmektedir. Bu doğrultuda elde edilen verilerin normallik varsayımını karşıladığı ifade edilebilir. Ayrışma geçerliliği sonucuna göre; Formell-Larcker kriteri ölçüm modelinin ayrışma geçerliliğinin sağlanması için AVE değerlerinin karekökleri 0,50'ten büyük olmalı ve aynı zamanda araştırmada kullanılan diğer değişkenler arasındaki korelasyonlardan daha büyük olması gerekmektedir (Cesur ve Memiş, 2021). Test sonucu, kareköklerin değişkenler arası korelasyon katsayıları 0,50'ten yüksek olduğu için Formell-Larcker kriterini sağlamaktadır. HTMT (Heterotrait-Monotrait Ratio) değerinde ise birbirine yakın olan kavramlarda 0,90'nın, birbirine uzak olan kavramlarda ise 0,85'in altında olması gerektiği savunulmaktadır (Nart ve diğerleri, 2020). Test sonucuna göre HTMT değerlerinin üst sınırı olan 0,85'in altında olduğu için bu kriterin sağlandığı görülmüştür. Açıklayıcı faktör analizine göre; KMO değerinin ölçülebilmesi için değerlerin 0,5'ten büyük olması gerekmektedir. Elde edilen veriler sonucunda KMO değerinin 0,914 bulunduğundan ve ortalamanın çok üzerinde (KMO>0,500) olduğundan örneklem sayısının faktör analizi için uygun olduğu sonucuna varılmıştır.

Tablo 4'te doğrulayıcı faktör analizine ilişkin standart değerler verilmiştir. Doğrulayıcı faktör analizine göre standart değerlerin 0,5'ten büyük olması gerekmektedir (Koç, 2021). Tabloya bakıldığında, öğrenme yönelimi ölçeğine ait değerlerin 0,80'den, özümseme kapasitesine ait değerlerin 0,60'tan, teknoloji yönelimi ölçeğine ait değerlerin 0,80'den, tedarik zinciri çevikliği ölçeğine ait değerlerin 0,70'ten büyük ve $p<0,05$ düzeyinde anlamlı olduğu anlaşılmaktadır. Çalışmada birleşme geçerliliğinin sağlanıp sağlanmadığının tespiti için birleşik güvenirlik (CR) ve açıklanan ortalama varyans (AVE) değerleri incelenmiştir. Fornell and Larcker (1981) birleşme geçerliliğinin sağlanması için AVE değerinin 0,50'den ve CR değerinin ise 0,70'dan büyük olması gerektiğini ifade etmiştir. Tablo 4.'te görüldüğü üzere öğrenme yönelimi boyutuna ait AVE değeri 0,776, CR değeri 0,905'tir. Özümseme kapasitesi boyutuna ait AVE değeri 0,671, CR değeri 0,862'dir. Teknoloji yönelimi boyutuna ait AVE değeri 0,708, CR değeri 0,871'dir. Tedarik zinciri çevikliği boyutuna ait AVE değeri 0683, CR değeri 0,944'tür. Bu değerlerle ölçeğin birleşme geçerliliğine sahip olduğu ifade edilebilir.

Ayrıca Tablo 4'te doğrulayıcı faktör analizine ilişkin t değerleri verilmiştir. Tablodaki veriler dikkate alınarak t değerlerinin % 95 güvenilirlik düzeyinde 1,96'dan büyük olduğu ve böylece gözlenen ve gizil değişken arasındaki ilişkinin anlamlı olduğu görülmektedir (Koç, 2021).

Tablo 4. Doğrulayıcı faktör analizi değerleri

Faktörler ve Maddeler	*Standart Değerler*	*Cronbach's Alpha*	*AVE*	*CR*	*T Değeri*
Öğrenme Yönelimi					
ÖY1	0,872				37,804
ÖY2	0,905	0,904	0,776	0,905	49,925
ÖY3	0,862				26,768
ÖY4	0,886				45,000
Özümseme Kapasitesi					
ÖK5	0,690				8,383
ÖK6	0,849	0,836	0,671	0,862	31,405
ÖK7	0,884				24,684
ÖK8	0,840				27,247
Teknoloji Yönelimi					
TY9	0,811				25,350
TY10	0,807	0,862	0,708	0,871	25,014
TY11	0,849				32,816
TY12	0,894				63,244
Tedarik Zinciri Çevikliği					
TZÇ13	0,805				28,645
TZÇ14	0,821				30,640
TZÇ15	0,798				20,436
TZÇ16	0,843				34,310
TZC17	0,827	0,942	0,683	0,944	30,609
TZÇ18	0,846				35,471
TZÇ19	0,858				36,427
TZÇ20	0,871				43,501
TZÇ21	0,766				17,620

5.4. Araştırma Modelinin ve Hipotezlerinin Test Edilmesi

Baron ve Kenny (1986) aracılık analizinin yapılabilmesi için aşağıdaki şartların yerine getirilmesi gerektiğini savunmuşlardır: (a) Bağımsız değişkenin aracı değişken ile arasında anlamlı bir ilişkinin olması gerekmektedir. (b) Bağımsız değişkenin bağımlı değişken ile arasında anlamlı bir ilişkinin olması gerekmektedir. (c) Aracı değişkenin bağımlı değişken ile arasında anlamlı bir ilişkinin olması gerekmektedir. (d) Aracı değişkenin devreye girmesiyle, bağımsız değişkenin bağımlı değişken üzerindeki etkisinin azalması kısmi aracılığı, tamamen ortadan kalkması ise tam aracılığı meydana getirmektedir.

Öğrenme yöneliminin bağımsız değişken ve özümseme kapasitesinin bağımlı değişken olduğu regresyon modeli Tablo 5'te gösterilmektedir. Öğrenme yöneliminin özümseme kapasitesini 0,3180 katsayısı ile olumlu olarak etkilediği bu etkinin $p<0,001$ düzeyinde anlamlı olduğu sonucuna varılmıştır. Elde edilen sonuç Yang ve diğerleri (2022)'nin çalışmalarında ulaştıkları öğrenme yönelimi özümseme kapasitesini olumlu yönde etkiler bulgusu ile uyum içerisindedir. Stelmaszczyk (2020) de çalışmasında örgütsel öğrenme yönelimindeki bir değişikliğin özümseme kapasitesi üzerinde bir değişikliğe yol açtığı sonucuna ulaşmıştır. Ayrıca özümseme kapasitesinin temelde öğrenme yöneliminin iki ana boyutu olan öğrenmeye bağlılık ve açık fikirlilikten etkilendiği bulgusuna ulaşmıştır. Bu sonuç doğrultusunda H1: "Öğrenme yönelimi özümseme kapasitesini olumlu yönde etkilemektedir" hipotezi kabul edilmektedir.

Tablo 5. Öğrenme Yöneliminin Özümseme Kapasitesi üzerindeki etkisinin incelenmesi (H1)

Bağımlı Değişken	*Bağımsız Değişken*	*β*	*SE*	*T*	*P*	*LLCI*	*ULCI*
Özümseme Kapasitesi	Öğrenme Yönelimi	0,3180	0,540	5,8906	0,000	0,2117	0,4242

Özümseme kapasitesinin bağımsız değişken ve tedarik zinciri çevikliğinin bağımlı değişken olduğu regresyon modeli Tablo 6'da gösterilmektedir. Özümseme kapasitesinin tedarik zinciri çevikliğini 0,1645 katsayısı ile olumlu olarak etkilediği ve bu etkinin $p<0,01$ düzeyinde anlamlı olduğu sonucuna varılmıştır. Abourokbah vd. (2023) Suudi Arabistan'da imalat sektöründeki firmalardan alınan verilerle gerçekleştirdikleri nicel analiz ile özümseme kapasitesinin tedarik zinciri çevikliğini pozitif yönde etkilediğini tespit etmişlerdir. Isfianadewi ve Annindityo (2022), Yogyakarta'da faaliyet gösteren hizmet sektöründeki katılımcılardan elde ettikleri verilerle yaptıkları analizde, özümseme kapasitesinin tedarik zinciri çevikliği üzerinde anlamlı ve pozitif bir etkiye sahip olduğu sonucuna ulaşmışlardır. Çalışmanın bulgularının Abourokbah ve diğerleri (2023) ile Isfianadewi ve Annindityo'nun (2022) sonuçlarıyla uyumlu olduğu ifade edilebilir. Bu sonuç doğrultusunda H2: "Özümseme kapasitesi tedarik zinciri çevikliğini olumlu yönde etkilemektedir" hipotezi kabul edilmektedir.

Tablo 6. Özümseme Kapasitesinin Tedarik Zinciri Çevikliği üzerindeki etkisinin incelenmesi (H2)

Bağımlı Değişken	*Bağımsız Değişken*	*β*	*SE*	*T*	*P*	*LLCI*	*ULCI*
Tedarik Zinciri Çevikliği	Özümseme Kapasitesi	0,1645	0,048	3,4145	0,0007	0,0697	0,2594

Öğrenme yöneliminin bağımsız değişken ve tedarik zinciri çevikliğinin bağımlı değişken olduğu regresyon modeli Tablo 7'de gösterilmektedir. Öğrenme yöneliminin tedarik zinciri çevikliğini 0,4271 katsayısı ile olumlu olarak etkilediği bu etkinin p<0,01 düzeyinde anlamlı olduğu sonucuna varılmıştır. Elde edilen sonuç Zhu ve Gao (2021)'in çalışmalarında ulaştıkları öğrenme yöneliminin tedarik zinciri çevikliğini olumlu yönde etkilediği bulgusu ile uyum içerisindedir. Bu sonuç doğrultusunda H3: "Öğrenme yönelimi tedarik zinciri çevikliğini olumlu yönde etkilemektedir" hipotezi kabul edilmektedir.

Tablo 7. Öğrenme Yöneliminin Tedarik Zinciri Çevikliği üzerindeki etkisinin incelenmesi (H3)

Bağımlı Değişken	*Bağımsız Değişken*	*β*	*SE*	*T*	*P*	*LLCI*	*ULCI*
Tedarik Zinciri Çevikliği	Öğrenme Yönelimi	0,4271	0,0467	9,1543	0,0000	0,3353	0,5189

Tablo 5, Tablo 6 ve Tablo 7'den elde edilen sonuçlar doğrultusunda aracılık analizinin gerçekleştirilebilmesi için Baron ve Kenny (1986) tarafından öne sürülen tüm koşulların sağlandığı söylenebilir. Tablo 8'de öğrenme yöneliminin tedarik zinciri çevikliği üzerindeki etkisinin 0,4271'den 0,0523'e düştüğü görülmektedir. Sonuçlar incelendiğinde, özümseme kapasitesinin öğrenme yönelimi ve tedarik zinciri çevikliği arasındaki ilişkide kısmi aracılık rolü oynadığı sonucuna varılmıştır.

Tablo 8. Özümseme Kapasitesinin Öğrenme Yönelimi ve Tedarik Zinciri Çevikliği arasındaki ilişkide aracılık etkisinin incelenmesi (H4)

Bağımlı Değişken	*Bağımsız Değişken*	*β*	*BootSE*	*BootLLCI*	*BootULCI*
Tedarik Zinciri Çevikliği	Öğrenme Yönelimi	0,0523	0,0235	0,0113	0,1036
Tedarik Zinciri Çevikliği	Özümseme Kapasitesi				

Teknoloji yöneliminin bağımsız değişken ve özümseme kapasitesinin bağımlı değişken olduğu regresyon modeli Tablo 9'da gösterilmektedir. Teknoloji yöneliminin özümseme kapasitesini 0,2534 katsayısı ile olumlu olarak etkilediği bu etkinin p<0,01 düzeyinde anlamlı olduğu sonucuna varılmıştır. Sugiyanto ve diğerleri (2019) ana evrenini Bali'de otelcilik sektörü yöneticilerinin oluşturduğu çalışmada, teknoloji yöneliminin özümseme kapasitesi üzerinde anlamlı ve pozitif bir etkisi olduğu sonucuna varmışlardır. Bu sonuç doğrultusunda H5: "Teknoloji yönelimi özümseme kapasitesini olumlu yönde etkilemektedir" hipotezi kabul edilmektedir.

Tablo 9. Teknoloji Yöneliminin Özümseme Kapasitesi üzerindeki etkisinin incelenmesi (H5)

Bağımlı Değişken	*Bağımsız Değişken*	*β*	*SE*	*T*	*P*	*LLCI*	*ULCI*
Özümseme Kapasitesi	Teknoloji Yönelimi	0,2534	0,0501	5,0611	0,0000	0,1548	0,3519

Teknoloji yöneliminin bağımsız değişken ve tedarik zinciri çevikliğinin bağımlı değişken olduğu regresyon modeli Tablo 10'da gösterilmektedir. Teknoloji yöneliminin tedarik zinciri çevikliğini 0,4924 katsayısı ile olumlu olarak etkilediği bu etkinin p<0,01 düzeyinde anlamlı olduğu sonucuna varılmıştır. Abdallah ve Ayoub (2020) çalışmalarında kurumsal kaynak planlaması, radyo frekansı ile tanımlama, bulut bilişim ve Web 2.0 araçları gibi bilgi teknolojisi bileşenlerine yönelimin tedarik zinciri çevikliğini olumlu yönde etkilediği sonucuna varmışlardır. Bu çalışma ile elde edilen sonuç Zhu ve Gao (2021)'in çalışmalarında da ulaştıkları teknoloji yöneliminin tedarik zinciri çevikliğini olumlu yönde etkilediği bulgusu ile uyum içerisindedir. Bu sonuç doğrultusunda H6: "Teknoloji yönelimi tedarik zinciri çevikliğini olumlu yönde etkilemektedir" hipotezi kabul edilmektedir.

Tablo 10. Teknoloji Yöneliminin Tedarik Zinciri Çevikliği Üzerindeki Etkisinin İncelenmesi (H6)

Bağımlı Değişken	*Bağımsız Değişken*	*β*	*SE*	*T*	*P*	*LLCI*	*ULCI*
Tedarik Zinciri Çevikliği	Teknoloji Yönelimi	0,4924	0,0379	12,9837	0,0000	0,4178	0,5671

Tablo 6, Tablo 9 ve Tablo 10'dan elde edilen sonuçlar doğrultusunda aracılık analizinin gerçekleştirilebilmesi için tüm koşulların sağlandığı söylenebilir. Tablo 11'e bakıldığında teknoloji yöneliminin tedarik zinciri çevikliği üzerindeki etkisinin 0,4924'ten 0,0381'düştüğü anlaşılmaktadır. Sonuçlar incelendiğinde, özümseme kapasitesinin teknoloji yönelimi ve tedarik zinciri çevikliği arasındaki ilişkide kısmi aracılık rolü oynadığı sonucuna varılmıştır.

Tablo 11. Özümseme Kapasitesinin Teknoloji Yönelimi ve Tedarik Zinciri Çevikliği arasındaki ilişkide aracılık etkisinin incelenmesi (H7)

Bağımlı Değişken	*Bağımsız Değişken*	*β*	*BootSE*	*BootLLCI*	*BootULCI*
Tedarik Zinciri Çevikliği	Teknoloji Yönelimi	0,0381	0,0178	0,0095	0,0793
Tedarik Zinciri Çevikliği	Özümseme Kapasitesi				

Aracılık analizinin anlamlı olup olmadığının anlaşılması için yukarıdaki belirtilen şartların yanında Sobel Testi de yapılmaktadır. Aracılık etkisinin incelenmesinde sobel test sonucu Z katsayısı 2,951 değeri p<0,05 düzeyinde hesaplanmış olup özümseme kapasitesinin öğrenme yönelimi ve tedarik zinciri çevikliği arasındaki ilişkide aracılık rolü istatiksel olarak anlamlı olduğu sonucuna varılmıştır. Bu sonuç doğrultusunda H4: "Özümseme kapasitesi öğrenme yönelimi ve tedarik zinciri çevikliği arasındaki ilişkide aracılık rolü üstlenmektedir" hipotezi kabul edilmektedir. Elde edilen aracılık analizi ve Sobel test sonuçlarına göre özümseme kapasitesinin öğrenme yönelimi ve tedarik zinciri çevikliği arasındaki ilişkide kısmi aracılık etkisine sahip olduğu görülmektedir.

Tablo 12. Sobel test sonucu (H4)

Bağımlı Değişken	*Bağımsız Değişken*	*Test İstatistiği*	*P*
Tedarik Zinciri Çevikliği	Öğrenme Yönelimi	2,951	0,003
Tedarik Zinciri Çevikliği	Özümseme Kapasitesi		

Aracılık etkisinin incelenmesinde sobel test sonucu Z katsayısı 2,878 değeri p<0,05 düzeyinde hesaplanmış olup özümseme kapasitesinin teknoloji yönelimi ve tedarik zinciri çevikliği arasındaki ilişkide aracılık rolü istatiksel olarak anlamlı olduğu sonucuna varılmıştır. Bu sonuç doğrultusunda H7: "Özümseme kapasitesi teknoloji yönelimi ve tedarik zinciri çevikliği arasındaki ilişkide aracılık rolü üstlenmektedir" hipotezi kabul edilmektedir. Aracılık analizi ve Sobel test sonuçları dikkate alındığında özümseme kapasitesinin teknoloji yönelimi ve tedarik zinciri çevikliği arasındaki ilişkide kısmi aracı role sahip olduğu anlaşılmaktadır.

Tablo 13. Sobel test sonucu (H7)

Bağımlı Değişken	*Bağımsız Değişken*	*Test İstatistiği*	*P*
Tedarik Zinciri Çevikliği	Teknoloji Yönelimi	2,878	0,003
Tedarik Zinciri Çevikliği	Özümseme Kapasitesi		

6. SONUÇ

Günümüzde gelişen teknolojiyle; sürekli belirsizliklerin yaşandığı, müşteri istek ve ihtiyaçlarının değiştiği, ürün yaşam döngülerinin kısaldığı ve işletmelerin sürekli rekabet içerisinde olduğu faaliyetler baş göstermektedir. Firmaların rekabet avantajı sağlaması ve geleceklerini ikame etmesindeki rolüne değinilen kaynak temelli yaklaşım kavramı, firmanın sürdürülebilir rekabet avantajı elde etmesi ve geleceğini ikame etmesi konusunda kaynak ve yeteneklerini kullanma kabiliyeti olarak görülmektedir. Barney (1991), firmanın sürdürülebilir rekabet avantajı elde etmek için dört belirgin özelliğe sahip olması gerektiğini vurgulayarak, bu özellikleri anlamanın firmanın sürdürülebilir rekabet avantajını sağlamada etkili olacağı düşüncesini ortaya koymaktadır. Bu dört özellik; kaynakların değerli, nadir, taklit edilemeyen ve ikame edilemeyen özelliklere sahip olması olarak sıralanabilir. Bir firmanın sürdürülebilir rekabet avantajı elde etmesi için elinde bulunan kaynakları etkili bir şekilde kullanması ve rakipleri tarafından elde edilemeyecek veya çoğaltılamayacak olan stratejiyi bulması ve uygulaması gerekmektedir. Kaynak temelli yaklaşımda öğrenme yönelimi, özümseme kapasitesi ve teknoloji yöneliminin incelendiği çalışmalar görülmektedir. Bununla beraber H1 ve H5 hipotezleri çalışma içerisinde test edilerek literatürdeki çalışmaları destekleyen sonuçlar elde edilmiştir. Sonuç olarak; işletmenin belirli bir alanda öğrenme faaliyetleri o alandaki bilgiyi firma kaynaklarına uyarlamasıyla, öğrenme yöneliminin özümseme kapasitesini olumlu yönde etkilemektedir sonucu H1'i destekler niteliktedir. Ulaşılan bu sonuç Khrabsheh ve diğerleri (2017)'nin çalışmaları ile elde ettiği bulgular ile örtüşmektedir. Firmaların çevreden gelen teknolojik yenilikleri tanımlayarak ilgili alanlara uyarlama ve kullanma yeteneğiyle teknoloji yöneliminin özümseme kapasitesini olumlu yönde etkilediği sonucu H5' i destekler niteliktedir. Lichtenthaler (2016) yapmış olduğu teorik çalışmada teknoloji yönelimi ile özümseme kapasitesi bileşenlerinden olan bilgiden yararlanma düzeyi arasında pozitif yönde bir ilişki bulunduğunu iddia etmektedir. Ulaşılan sonuç Lichtenthaler (2016)'in önerisini ampirik sonuçlarla doğrulamaktadır.

Bir ürünün hammadde aşamasından, malzeme, bilgi, üretim, montaj, depo, stok, ürünlerin dağıtım ve teslimatı gibi faaliyetleri içeren tedarik zinciri; mamulün teminatından başlayarak üretim ve son tüketiciye ulaşıncaya kadar gerçekleşen faaliyetler bütünüdür. Firmaların müşteri taleplerine hızlı ve esnek bir biçimde yanıt verme yetenekleri rakipleri arasında rekabet üstünlüğü elde etmeleri, pazarda başarılı olmanın ve rekabet avantajı elde etmenin temel etmenlerinden birisi de tedarik zinciri çevikliğidir. Tedarik zinciri

çevikliği, tedarik ağının değişen pazar ortamına zamanında ve hızlı bir biçimde cevap verme kabiliyeti olarak görülmektedir. Tedarik zinciri çevikliği, müşterilerini ve çalışanlarını memnun etme hedefleri doğrultusunda her organizasyonun kendi iş stratejisini, sürecini ve bilgi sistemini tasarlayabildiği bir yapıdır. İş ortamındaki belirsizliğe hızlı bir biçimde uyum sağlaması ya da yaşanan değişime cevap vererek stratejik rekabet avantajı elde etme kabiliyetini temsil etmektedir. Literatürde özümseme kapasitesi ile tedarik zinciri çevikliği, öğrenme yönelimi ile tedarik zinciri çevikliği ve teknoloji yönelimi ile tedarik zinciri çevikliği arasındaki doğrudan ilişkilerin incelendiği çalışmalar görülmektedir. Bu çalışmada ifade edilen doğrudan ilişkiler H2, H3 ve H6 şeklinde hipotezleştirilmiş ve test edilmiştir. Hipotez testleri neticesinde literatürdeki çalışmaları destekleyen sonuçlar elde edilmiştir. Sonuç olarak; firma, ürün ve hizmetlerini iyileştirmek için geliştirmiş ve zenginleştirmiş olduğu bilgiyi nasıl kullanacağını ve rekabet avantajını nasıl sağlayacağını tedarik zinciri çevikliğiyle öğrenebilmekte bu da özümseme kapasitesinin tedarik zinciri çevikliğini olumlu yönde etkiler olan H2'yi desteklemektedir. Ulaşılan bu sonuç Martinez-Sanchez ve Lahoz-Leo (2018) ile Riquelme-Medina ve diğerleri (2022)'nin çalışmaları ile uyum içerisindedir. Firmanın rekabet avantajı sağlaması, müşteri istek ve ihtiyaçlarına hızlı bir biçimde cevap verebilmesi ve beklenmeyen pazar değişikliklerine anında cevap verebilmek için değişiklikleri öğrenmesi, tedarik zinciri çevikliği sayesinde ancak gerçekleşebilir. Tse ve diğerleri (2016) firmaların dışsal öğrenme kaynaklarının tedarik zincirinin yukarı yönünde bulunan tedarikçiler ve aşağı yönünde bulunan müşteriler olduğunu belirtmektedir. Firmaların tedarik zincirlerinin yukarı ya da aşağı yönünde bulunan üyeleri ile gerçekleştirecekleri etkileşim neticesinde öğrenecekleri bilgiler tedarik zincirlerinin değişikliklere daha hızlı adapte olmasını sağlayacaktır. Öğrenme yönelimi ile tedarik zinciri çevikliği arasında oluşturulan H3 hipotezi de çalışma ile elde edilen sonuçlarla doğrulanmıştır. Zhu ve Gao (2021) de imalat sektöründeki işletmeler üzerine gerçekleştirdiği çalışmalarında benzer sonuçlar elde etmiş ve öğrenme yöneliminin tedarik zinciri çevikliğini olumlu yönde etkilediği bulgusuna ulaşmıştır. Firmanın teknoloji yönünden gelişmesi alıcı ve tedarikçi arasındaki ilişkinin gelişmesini de beraberinde getirmektedir. Tedarikçileri ve müşterileri arasında önemli bir etkileşim sağlayabilmek içir aracı rolü oynayan firmaların, gelişen tekonolojiyi hızlı bir biçimde alıp ürünlere uyarlaması gerekmektedir. Firmaların; pazar ihtiyaçlarına cevap verebilecek netilikteki ürünleri müşterilere hızlı bir biçimde ulaştırabilmesi için son zamanlarda popüler bir kavram haline gelen tedarik zinciri çevikliğini etkili bir şekilde koordine etmeleri gerektiği savunulmaktadır. Bu kapsamda oluşturulan teknoloji yöneliminin tedarik zinciri çevikliğini olumlu yönde etkilediğine dair H6 hipotezi test edilmiş ve kabul edilmiştir. Elde edilen sonuçlar ilgili ölçeğin alındığı Zhu ve Gao (2021)'nun çalışmaları ile de örtüşmektedir.

Tedarik zinciri çevikliğine etki eden faktörlerin kaynak temelli yaklaşım perspektifi ile incelenmesi bu çalışma ile amaçlanmıştır. Yapılan araştırmalar sonucunda anket ölçekleri öğrenme yönelimi, özümseme kapasitesi, teknoloji yönelimi ve tedarik zinciri çevikliği olarak dört alt ölçek biçiminde oluşturulmuştur. Anket sonuçları H4 ve H7'yi destekler nitelikte olup, özümseme kapasitesinin öğrenme yönelimi ve tedarik zinciri çevikliği arasında aracılık rolü üstlendiği ve özümseme kapasitesi teknoloji yönelimi ve tedarik zinciri çevikliği arasında aracılık rolü üstlendiği sonucuna varılarak hipotezler doğrulanmıştır. Aracılık analizlerinin gerçekleştirilmesi için geliştirilen hipotezlere yapılan literatür taramasında daha önceki çalışmalarda karşılaşılmamıştır. Bu çalışma ile özümseme kapasitenin kaynak temelli yaklaşım bileşenleri ile tedarik zinciri çevikliği arasındaki ilişkide kısmi aracılık rolü üstlendiği bilgisine ulaşılmıştır. Bu bilginin ilgili alanda çalışan teorisyenlere ve uygulama alanında çalışan pratisyenlere faydalı olacağı düşünülmektedir.

Sürekli gelişen teknolojiyle beraber tüketicilerin istek ve ihtiyaçları da çeşitlenmektedir. Firmalar değişen pazar ortamına, tüketici istek ve ihtiyaçlarına uyum sağlamak için tedarikçilerden elde ettikleri yeni bilgileri firma içerisinde bulunan kaynaklarına veya temin ettiği hammaddeye uyarlayıp ürün veya hizmet üretmek konusunda çevik davranmalıdır. Bu çalışma çeşitli sınırlılıklara sahiptir. Çalışmanın ana evrenini imalat sektöründeki işletmeler oluşturmaktadır. Hizmet sektöründe gerçekleştirilecek bir çalışma ile yapılan bu çalışmanın sonuçları karşılaştırılabilir ve sektörel farklar ortaya çıkartılabilir. Ayrıca bu çalışma zaman, maliyet ve insan kaynağı gibi kısıtlar dikkate alınarak yalnızca Türkiye içerisinde faaliyet gösteren firmalardan toplanan veriler ile gerçekleştirilmiştir. Gelecek çalışmalarda farklı ülkelerden firmalar çalışma içerisine alınarak tedarik zinciri çevikliğine etki ettiği düşünülen farklı değişkenler test edilebilir.

Yazar Katkıları /*Author Contributions*

Hülya Meral: Literatür Taraması, Kavramsallaştırma, Veri Derleme, Makale Yazımı-orijinal taslak *Erdinç Koç:* Metodoloji, Analiz, Modelleme, Makale Yazımı-inceleme ve düzenleme *Hülya Meral: Literature Review, Conceptualization, Data Curation, Writing-original draft Erdinç Koç: Methodology, Analysis, Modelling, Writing-review and editing*

Çatışma Beyanı /*Conflict of Interest*

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It was declared by the author(s) that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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VERİMLİLİK DERGİSİ
JOURNAL OF PRODUCTIVITY

Türkiye İtfaiye Teşkilatının Verimliliğini Artırmada Etkili Faktörlerin Belirlenmesi

Ayşe Ütük[1], Hayri Baraçlı[2]

ÖZET

Amaç: Bu çalışmanın amacı, Türkiye itfaiye teşkilatının verimliliğini artırmada etkili olan faktörlerin belirlenmesi ve analiz edilmesidir.

***Yöntem*:** Bu çalışmada 13 itfaiye daire başkanı ile yarı yapılandırılmış görüşme tekniğiyle nitel bir araştırma gerçekleştirilmiştir. İtfaiye daire başkanlarının cevaplayacağı sosyodemografik bilgiler ile sağlık bilgileri standart formatta hazırlanmış ardından 'İtfaiye teşkilatlarının verimliliklerini artırmak için görüş ve önerileriniz nelerdir' açık uçlu sorusu, yöneltilmiştir. Bunun sonucunda verimlilik artırma adına 26 farklı öneri ortaya çıkmış ve içerikleri bakımından değerlendirilerek 7 konu başlığı (ekipman, bütçe, mevzuat, insan kaynakları yönetimi, iş birliği, standadizasyon, organizasyon) altında toplanmış ve analiz edilmiştir.

Bulgular: Bu çalışmada, itfaiye daire başkanları tarafından; itfaiye teşkilatlarının verimliliğinin artırılmasına yönelik belirlenen 26 farklı öneri incelenmiştir. Bu faktörler arasında, itfaiye teşkilatlarında standardizasyonun sağlanması, itfaiye personeline yönelik mesleki düzenlemelerin yapılması, itfaiye personeli norm kadro sayılarının belirlenmesi ve bu kadrolarda doluluk zorunluluğunun uygulanması, nitelikli itfaiye personeli yetiştirilmesi için itfaiye akademilerinin açılması, afetlerde müdahale konusunda itfaiye teşkilatlarının öncülük rolünü üstlenmesi ve son olarak itfaiye kanununun oluşturulması en çok vurgulanan faktörlerdir. Bu faktörlerin iyileştirilmesiyle Türkiye'deki itfaiye teşkilatlarının verimliliğinin artacağı düşünülmektedir.

Özgünlük: Türkiye'deki itfaiye teşkilatları hakkında yapılan literatür çalışmaları, verimlilik üzerine odaklanırken, itfaiye daire başkanlarının görüşlerine dayanan bir çalışmaya rastlanmamıştır. Bu çalışmanın, itfaiye teşkilatlarının verimliliğini artırmak amacıyla politika yapıcıların düzenlemeler yapması ve stratejiler belirlemesi için bir kaynak olabileceği düşünülmektedir.

Anahtar Kelimeler*:* İtfaiye Teşkilatları, Verimlilik, İyileştirme, İş Sağlığı ve Güvenliği, Eğitim.

JEL Kodları: H83, J88, L98.

Identifying Influential Factors in Increasing the Efficiency of Turkish Fire Brigade Organization

ABSTRACT

Purpose: The aim of this study is to identify and analyze the factors that contribute to the efficiency of the Turkish fire brigade organization.

Methodology: In this study, a qualitative research was conducted using a semi-structured interview technique with 13 fire brigade chiefs. Socio-demographic and health information of the fire brigade chiefs were prepared in a standardized format, and then an open-ended question "What are your opinions and suggestions for increasing the efficiency of fire brigade organizations?" was asked. As a result, 26 different suggestions for increasing efficiency were gathered and evaluated based on their content, and categorized under 7 main topics (equipment, budget, legislation, human resources management, collaboration, standardization, organization), and analyzed.

Findings: In this study, 26 different suggestions identified by the fire brigade chiefs for increasing the efficiency of fire brigade organizations were examined. Among these factors, ensuring standardization in fire brigade organizations, making professional regulations for fire brigade personnel, determining the norm staff numbers and enforcing occupancy requirements for these positions, establishing fire academies to train qualified fire brigade personnel, taking a leading role in disaster response for fire brigade organizations, and finally, creating a fire brigade law were the most emphasized factors. It is believed that improving these factors will enhance the efficiency of fire brigade organizations in Türkiye.

Originality: While the literature studies on the fire department in Türkiye focus on efficiency, there is no study based on the opinions of the fire department heads. It is thought that this study can be a resource for policy makers to make regulations and determine strategies to increase the efficiency of fire departments.

Keywords*:* Firefighting Organizations, Efficiency, Improvement, Occupational Health and Safety, Training.

JEL Codes: H83, J88, L98.

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EXTENDED ABSTRACT

Our modern environment is surrounded by many highly flammable materials that ignite easily and burn violently under the right conditions (Irvine et al., 2000). This puts us at risk of fire whenever unsafe behavior and conditions occur in every environment we live in.

Fire department response plays a vital role in controlling the severity of fire incidents (He and Weng, 2020). Contemporary fire departments have a mission-critical role within their jurisdiction to ensure that 'first responders' are prepared to respond effectively, efficiently, and safely and mitigate various emergency events (Fleming and Zhu, 2009).

The services provided by fire departments are considered public service within the context of the institutional arrangement in which they are provided. The preparedness of countries for emergencies and disasters plays a role in helping people gain confidence in the administration and policymakers and positively affects the country's welfare level. Under these conditions, it has become necessary to carry out the necessary studies and practices to increase the efficiency of fire brigades, which are among the first teams to reach emergency and disaster scenes in Türkiye and intervene in the riskiest phase of the incident.

This study aims to identify and analyze the factors that are effective in increasing the efficiency of the Turkish fire department. While literature studies on fire departments in Türkiye focus on efficiency, studies based on the opinions of fire department heads have yet to be found.

The study examined the opinions of the fire department heads, who are seen as the leaders of the fire department, about the elements that they deem necessary and should be taken into consideration in order to increase the efficiency of the fire department in Türkiye.

The research problem of this study is to determine the factors that effectively increase the efficiency of the Turkish fire department. The research question is aimed at determining the most influential factors to increase the efficiency of the Turkish fire department.

There were 30 metropolitan fire department heads in the research. For this research, 29 fire department heads were informed about the purpose and method of the research, and 13 fire department heads who responded voluntarily were interviewed. The 13 chiefs determined as the sample size represent 43% of the population of Turkish fire department chiefs.

Before the interviews, the main questions to be asked to the fire brigade department heads participating in the research were prepared, and qualitative research was conducted with the fire brigade department heads using a semi-structured interview technique. Sociodemographic information and health information to be answered by the fire department heads were prepared in a standard format, and then the research problem was posed. As a result, 26 different suggestions emerged to increase productivity. They were evaluated in terms of content and collected and analyzed under 7 topics (equipment, budget, legislation, human resources management, cooperation, standardization, organization). Fire department heads have emphasized some of these 26 factors many times.

As a result of the study, In the analysis made on the question 'Which factors are effective to increase the efficiency of the Turkish fire brigade?', which was determined as the research problem, In order to increase the efficiency of the Turkish fire department, 26 factors were determined in line with the opinions of 13 fire department heads and analyzed under 7 topics. As a result of the data analysis, it was revealed that fire departments need to make improvements in human resources management, equipment, budget, legislation, cooperation, standardization, and organization.

In addition, among the suggestions examined based on the research question 'Which factors are most effective in increasing the efficiency of the Turkish fire department?' Ensuring standardization in fire brigades, making professional regulations for fire brigade personnel, determining the norm staff numbers of fire brigade personnel and implementing the occupancy requirement in these cadres, opening fire academies to train qualified fire brigade personnel, fire brigades taking a leading role in responding to disasters and finally establishing the fire brigade law are the most important ones. Were among the highlighted factors.

This study was critical because it was conducted with leading fire experts. In this way, by using the information obtained as a result of the in-depth analysis and experience of the fire department heads, Data that will be used to increase the efficiency of the fire brigade has been obtained.

These analyses made for fire departments will serve as a guide for legislators and decision-makers and will guide the studies to be carried out to improve fire departments. In this way, Turkish fire departments will be able to serve more effectively and reliably and contribute to the safety of society.

1. GİRİŞ

Ateşin keşfiyle birlikte oluşan istemsiz yanma olayları, geçmişte ve günümüzde büyük can ve mal kaybına sebep olan acil durumlardır. Yangınların meydana gelmesi için üç koşul gereklidir: yeterli yakıt veya yanıcı biokütle; bir ateşleme kaynağı ve hem yakıtı şartlandırmak hem de yangını sürdürmek için uygun hava (Herawati ve Santoso, 2011).

Modern çevremiz, doğru koşullar altında kolayca tutuşan ve şiddetle yanan çok çeşitli yüksek yanıcı malzemelerle çevrilidir (Irvine ve diğerleri, 2000). Bu da yaşadığımız her ortamda güvensiz davranış ve güvensiz durum şartlarının oluştuğu her koşulda bizi yangın tehlikesiyle karşı karşıya getirmektedir. Yangınla ilgili tehlikeler ve olaylar, insan toplumunu ağır bir şekilde etkileyen çok yaygın olgulardır. Bu nedenle pek çok kuruluş, uzun bir süre boyunca yangınları ve neden olduğu zararları azaltmak için çaba sarf etmiştir (Li ve diğerleri, 2018).

Günümüzde artan nüfus, teknolojik gelişmeler, endüstrinin gelişimi, çarpık kentleşme, kullanılan enerji miktarındaki artış gibi unsurlar yangınların oluşumunu artırmakta ve bu da geri dönüşü olmayan can, mal ve çevre kayıplarına sebep olmaktadır. Bu durumlar altında yangınla mücadeleye olan talep hızla artmaktadır.

İtfaiye teşkilatının başlıca işlevi; yangın önleme ve yangın söndürmedir. Yangın önleme, yangınların oluşmasını önlemek ve yangın çıkması durumunda can ve mal kaybını en aza indirmeye yardımcı olmak için gerçekleştirilen yangın öncesi faaliyetleri kapsar. Yangın söndürme ise minimum can ve mal kaybıyla meydana gelen yangınları söndürmek anlamına gelir (Wallace, 1977) .

Uluslararası Yangın ve Kurtarma Hizmetleri Birliği (The International Association of Fire & Rescue Services: CTIF), 2022 yılında yayınladığı raporda dünya genelinde 48 ülkede (3.3 milyar insanı kapsayan) meydana gelen yangın verilerini sunmuştur. Rapor, 2020 yılı verilerini içermektedir. Bu rapora göre;

- İtfaiye ekipleri yaklaşık 70 milyon göreve hizmet etmiştir,
- Yangınlarda 20.700'den fazla insan ölmüş ve 70.000'den fazla kişi yaralanmıştır,
- 1.000 kişi başına ortalama 20,8 olay vardır,
- 100.000 kişi başına 0,6 yangın ölümü ve 2,1 yaralanma kaydedilmiştir,
- Her 100 yangında 0,5 ölüm ve 1,8 yaralanma meydana gelmiştir (CTIF, 2022).

İtfaiyenin müdahalesi, yangın olaylarının ciddiyetinin kontrol edilmesinde önemli bir rol oynar (He ve Weng, 2020). Çağdaş itfaiye teşkilatları, 'ilk müdahale ekiplerinin' etkin, verimli ve güvenli bir şekilde müdahale etmeye ve çok çeşitli acil durum olaylarını hafifletmeye hazır olmasını sağlamak için hizmet ettiği yetki alanı içinde görev açısından kritik bir role sahiptir (Fleming ve Zhu, 2009).

İtfaiye teşkilatları üstlendiği bu görevler nedeniyle acil durumlara ve yangınlara karşı her zaman hazırlıklı ve etkin olmakla sorumlu tutulmuştur. Yangın gibi sonuçları çoklu can kayıplarına ve büyük ekonomik zararlara neden olabilecek acil durumlar karşısında itfaiye teşkilatlarının vermiş olduğu hizmetlerin verimliliği can kurtarıcı niteliktedir.

Gelişmiş ülkelerde itfaiye teşkilatları, güvenlik sisteminin temel unsurları olarak kabul edilmektedir. Yüksek risk ve hassasiyet, belirsiz ve karmaşık çalışma koşulları, stresli durumlar, her türlü kaza ve zararlı etmenlere doğrudan maruz kalınması, personelin günün her saatinde hazır bulunma ihtiyacı bu işi zor ve tehlikeli işlerden biri haline getirmiştir (Havasi, 2021).

Son yıllarda, itfaiye teşkilatlarının topluluklara sundukları hizmetlerin kapsamı önemli ölçüde artmıştır. Türkiye'de, 6 Şubat 2023 tarihinde yaşanan deprem felaketinin kriz yönetimi aşamasında, itfaiye teşkilatları arama kurtarma çalışmalarına öncülük etmiş, birçok vatandaşın depremin yıkıcı etkisinden minimum düzeyde bir hasarla kurtulmasında büyük bir rol oynamışdır.

Türkiye'de itfaiye teşkilatı, bir yerleşim yerinin nüfusu, fiziki ve coğrafi özellikleri, yangın ve diğer afetlere hassasiyeti ve gelişme potansiyeli gibi faktörler göz önünde bulundurularak birimler oluşturmaktadır. Belediye İtfaiye Yönetmeliği'nin 5. maddesi bu konuda açık bir şekilde belirlemeler yapmaktadır (T.C. Resmi Gazete, 2006). Bu belirlemelere göre, nüfusu 50.000'den fazla olan yerleşim yerlerinde kentsel arama ve kurtarma birimleri oluşturulur. Büyükşehir olan illerde bu birimler şube müdürlüğü şeklinde teşkilatlandırılırken, diğer il ve ilçelerde ise amirlikler şeklinde düzenlenir. Nüfusu 50.000-100.000 arasında olan yerleşim yerlerinde hafif, 100.000-300.000 arasında olan yerleşim yerlerinde orta ve 300.000'den fazla olan yerleşim yerlerinde ise ağır arama ve kurtarma ekipleri oluşturulur. Ayrıca, nüfusu 3.000.000'ü aşan yerleşim yerlerinde her 3.000.000 kişi için bir ağır arama kurtarma ekibi kurulması gerekmektedir. Kentsel arama ve kurtarma birimleri oluşturulurken Afet ve Acil Durum Yönetimi Başkanlığı'nın (AFAD) görüşü

alınmaktadır. Diğer afet ve acil durum hizmetleri için su üstü, su altı ve köpekli arama ve kurtarma ekipleri oluşturulabilir. Bu birimlerin oluşturulması ve standartları belirlenirken de AFAD'ın görüşü alınmaktadır.

İtfaiye teşkilatının görevleri ise Belediye İtfaiye Yönetmeliği'nin 6. Maddesinde belirtilmiştir (T.C. Resmi Gazete, 2006). İtfaiye teşkilatının görevleri, yangınlara müdahale etmek, kurtarma operasyonları gerçekleştirmek, su baskınlarına müdahale etmek, afet durumlarına katılmak, binaların yangından korunmasıyla ilgili görevleri yerine getirmek, belediye sınırları dışındaki olaylara müdahale etmek, kimyasal, biyolojik, radyolojik ve nükleer olaylara müdahale etmek, halkı bilgilendirmek ve eğitmek, baca temizliği yapmak ve denetlemek, talep edilmesi halinde orman yangınlarına müdahale etmek, parlayıcı, patlayıcı ve yanıcı madde depolama yerlerinin tespiti için ilgili birimlere görüş bildirmek, iş yerlerini yangına karşı önlemler yönünden denetlemek ve belediye başkanının verdiği diğer görevleri yapmaktan oluşmaktadır.

İtfaiye teşkilatlarının vermiş olduğu hizmetler, sunulduğu kurumsal düzenleme bağlamında bir kamu hizmeti olarak değerlendirilir. Ülkelerinin acil durum ve afetlere hazırlıklı olması, halkın yönetime ve politika yapıcılarına karşı güven kazanmasına ve ülkenin refah düzeyinin olumlu bir şekilde etkilenmesinde rol oynar. Bu koşullar altında Türkiye'de acil durum ve afet mahallerine ilk ulaşan ekipler arasında yer alan ve olayın en riskli aşamasında müdahalede bulunan itfaiye teşkilatlarının verimliliğinin artması için gerekli çalışmaların ve uygulamaların yapılması bir zorunluluk haline gelmiştir.

Verimlilik, tanımlanması kolay, hesaplanması zor bir 'başarı ölçüsü' olarak öteden beri bilinen ve tartışılan bir kavramdır (Özdemir ve Muradova 2008). Verimlilik, bir çalışanın kendisine verilen sorumluluklara uygun olarak görevlerini yerine getirirken elde ettiği işin nitelik ve nicelik olarak sonucu olup girdi, emek, hammaddeler, çalışma yöntemleri, çalışma araçları, işletme sermayesi ve bilgiden oluşur (Kadri ve diğerleri, 2021).

Verimlilik olmadan, örgütlerin varoluş mantığının hiçbir değeri yoktur. Verimlilik, kuruluşun yatırım getirisinin bir ölçüsüdür ve kuruluşun girdileri çıktılara ne kadar verimli dönüştürebildiğinin bir göstergesidir. Yönetim (emanet edilen kişi veya kişiler grubu) kullanılan kaynakların maksimum değerlerini vermeye çalışır ve bu kaynaklara değer katmada ne kadar başarılı olduklarına göre verimlilikleri değerlendirilir. Herhangi bir kuruluşta üretkenlik, işe alma, çalışma ilişkisi, eğitim ve gelişim, çalışan ilişkileri, öğrenme ve yenilik gibi daha iyi insan kaynakları uygulamalarından büyük ölçüde etkilenir ve yenilik, kuruluşta verimlilik üzerinde yüksek etkiye sahiptir (Ojha, 2014).

Bugün, kamu sektörü faaliyetlerinde verimliliğin artırılması konusunda açık bir endişe vardır. Bu, bir yandan daha fazla ve daha iyi kamu hizmeti talebinin, diğer yandan da kamu gelirlerinin ve borçlarının sınırlandırılmasının bir sonucudur. Bu nedenle kamu sektörü sınırlı kaynaklarla (girdilerle) kısıtlıyken daha fazla hizmet (çıktı) sunabilmek için etkinliğini artırmak zorundadır. Bu anlamda, son yıllarda kamu hizmetlerinin etkinliğine yönelik çalışmaların sayısında katlanarak bir artış görülmektedir (Benito ve diğerleri, 2019).

Bu çalışmanın amacı, Türkiye itfaiye teşkilatının verimliliğini artırmada etkili olan faktörleri belirleyerek analiz etmektir. Türkiye'deki itfaiye teşkilatları hakkında yapılan literatür çalışmaları, verimlilik üzerine odaklanırken, itfaiye daire başkanlarının görüşlerine dayanan bir çalışmaya rastlanmamıştır. Bu çalışmanın, itfaiye teşkilatlarının verimliliğini artırmak için politika yapıcıların düzenlemeler yapması ve stratejiler belirlemesi için bir kaynak olabileceği düşünülmektedir.

Bu çalışma ile itfaiye teşkilatının liderleri olarak görülen itfaiye daire başkanlarının, Türkiye'deki itfaiye teşkilatının, verimliliğini artırmak için gerekli gördüğü, göz önünde bulundurulması gereken unsurlar hakkındaki görüşleri incelenmiştir. Böylelikle yasa yapıcılara yönelik teşkilat içerisinden gereken değerlendirmeler sağlanarak, Türkiye itfaiye teşkilatlarının verimliliğini artıracak faktörler; belirlenen 7 konu başlığı altında toplanmış ve incelenmiştir.

Bu çalışmanın devam eden bölümlerinde, literatür taraması, yöntem, bulgular ve sonuç kısımları bulunmaktadır. Bulgular kısmında, itfaiye teşkilatlarının verimliliğini artırabilecek 7 konu başlığı incelenmiştir.

Bu konu başlıkları şunlardır: insan kaynakları yönetimi, ekipman, bütçe, mevzuat, iş birliği, standardizasyon ve organizasyon.

2. LİTERATÜR TARAMASI

Bu çalışma kapsamında incelenen literatür kaynakları, Türkiye itfaiye teşkilatının sorunları, itfaiye daire başkanlarının itfaiye teşkilatları açısından önemi ve görevleri ile itfaiye teşkilatlarının verimlilik kriterleri üzerine odaklanmaktadır.

Türkiye itfaiye teşkilatının sorunları; itfaiye teşkilatının etkin ve hızlı müdahale yeteneğini olumsuz yönde etkilemektedir. Birçok görevi yerine getirmekle görevli olan itfaiye teşkilatının sorunları ile ilgili literatür incelendiğinde aşağıdaki çalışmalara ulaşılmıştır.

Ay (2016: 47) yapmış olduğu yüksek lisans tezinde, Türkiye itfaiye teşkilatının sorunları arasında; yönetmeliklerin genel olmaması, merkezi otorite sisteminin olmaması, personel ve teçhizat eşitsizliğinin olması, trafik sorununun olması ve gönüllü itfaiyeciliğin yaygın olmamasını vurgulamıştır.

Tüzer (2022: 46) yapmış olduğu yüksek lisans tezinde, Türkiye itfaiye teşkilatının sorunları arasında; ülke bazında standart eğitimlerin olmaması, müdahale esnasında vefat edenlerin şehit sayılmaması, kurum içi eğitim olanaklarının kısıtlı olması, ülke geneli merkezi yönetim olmadığı için istatistik veri havuzunun olmaması, CBS (coğrafi bilgi sistemleri) eksikliklerinin yaşanması, lojman olanaklarının çok kısıtlı olması, maaş eşitsizliği, büyükşehir olmayan illerde personel, araç, malzeme ve sosyal olanakların yetersiz olması, emir üzerine itfai olmayan olaylara da müdahale etmeleri, olaylara müdahale ederken yetki ve sorumluluk eksiklikleri, yönetmeliklerin yetersiz olması ve mevzuatın yenilenmemesi gibi konuları vurgulamıştır.

Doğan (2023: 239) yapmış olduğu doktora tezinde, Türkiye itfaiye teşkilatının sorunları arasında; itfaiye eğitim merkezleri için, eğitim merkezlerinin sayısı ve nitelikleri ile eğitim materyalleri ve eğitici personelin yetersiz olmasından, itfaiye eri statüsündeki görevlerin farklı kadrolar (memur, işçi, sözleşmeli işçi) üzerinden yürütülmesinden ve standartların eksik olduğundan bahsetmiştir.

Yavuz ve Bozatay (2015) yapmış oldukları çalışmada, Türkiye'de itfaiye teşkilatının bir diğer köklü sorununun, itfaiyeciliğin 'bir meslek haline getirilememiş olması' olduğunu ifade etmiştir. Tataroğlu ve Altundağ (2022) yapmış oldukları çalışmada ise itfaiye teşkilatlarında koordinasyonu sağlayacak bir merkezi yönetim kuruluşunun eksikliğini vurgulamıştır.

İtfaiye daire başkanlarının, itfaiye teşkilatlarının verimliliği konusunda önemli bir role sahip olduğu da bu çalışmanın odağında yer almaktadır. İtfaiye daire başkanları, itfaiye teşkilatının yönetiminden sorumlu kişilerdir ve etkili bir liderlik sergilemekle görevlidirler. Çoğu zaman bilinmeyen ve dinamik ortamlarla karşı karşıya gelen itfaiye personellerinin vermiş olduğu hizmetin kalitesini ve verimliliğini artırma çalışmalarını yürütmek ve denetlemek Türkiye'de itfaiye daire başkanlarının sorumluluğu altındadır (Belediye İtfaiye Yönetmeliği, 2006). 'Ankara Büyükşehir Belediyesi İtfaiye Dairesi Başkanlığı İç Hizmet Yönergesinde' İtfaiye daire başkanlarının görevleri 4. Bölüm 9. Maddede ayrıntılı olarak belirtilmiştir (Ankara Büyükşehir Belediyesi İtfaiye Dairesi Başkanlığı İç Hizmet Yönergesi, 2023).

Türkiye'de İtfaiye daire başkanları; büyükşehirlerde bulunan itfaiye teşkilatında üst düzey yönetici olarak görev yapar ve itfaiyenin acil durumlara karşı haftanın her günü ve her saatinde etkili, verimli ve güvenli bir şekilde yanıt verebilmesi için yetkilendirilmiştir. İtfaiye daire başkanları, hem olay yeri içinde hem de olay yeri dışında, toplumun ihtiyaçlarına başarılı ve tam olarak yanıt verecek şekilde teşkilatı yönetmekten sorumludur (Fleming ve Zhu, 2009).

İtfaiye daire başkanları, hedef odaklı, uzun vadeli ve kapsamlı itfaiye hizmetleri sağlarken, bu hizmetlerin maliyetini minimum düzeyde tutarak aynı zamanda performansta herhangi bir kayıp olmamasını sağlayan ve sürekli olarak değişen koşullara uyum sağlayan bir yangın önleme ve kontrol sisteminin kurulmasıyla sonuçlanması gereken ana planlama sürecinde kilit bir rol oynar (Fleming ve Zhu, 2009). İtfaiye daire başkanları itfaiye teşkilatının başarısını belirlemede önemli bir paya sahiptir.

Fleming (2010) yapmış olduğu çalışmada, çağdaş bir itfaiye teşkilatının genişletilmiş misyonunu ve vizyonunu gerçekleştirme başarısının, büyük ölçüde itfaiye teşkilatının üst düzey yöneticilerinin yeteneği ve performansıyla bağlantılı olduğunu belirtmiştir.

Son olarak, itfaiye teşkilatlarının verimlilik kriterleri de bu çalışma bağlamında ele alınmaktadır.

İtfaiye teşkilatları, verimli bir yangın ve kurtarma teşkilatı bütçesini yöneterek kaynaklarını riskine göre ayarlamalıdır. Gelecekteki bütçeler, sağlam ve gerçekçi varsayımlara dayandırılmalıdır (HMICFRS, 2021a). Yangından korunma maliyetleri önemli ölçüde bir departmanın yangın önleme ve söndürme faaliyetlerinin sonuçlarına, bir departmanın yönetim uygulamalarının bazı temel yönlerine, iş gücü ve ekipmanının konfigürasyonuna, yasal yapısına ve dış çevresindeki faktörlere bağlı olduğunu göstermektedir (Donahue, 2004).

İtfaiye teşkilatlarının operasyonel verimliliğini artırmak için yapılan çalışmalar arasında, personelin sürekli eğitiminin önemi ve etkisi üzerinde durulmuştur. Eğitim, itfaiyecilerin amirlerinin emirlerine uyum sağlarken aynı zamanda bireysel yeteneklerini kullanarak kararlar almalarını sağlar. İyi eğitimli itfaiyeciler, kendilerini korumayı ve hayat kurtarmayı optimize etmek için beceri ve bilgi temelli davranışları benimserler. Eğitimin yanı sıra, alıştırmalar, olaylara müdahale, hikâye anlatımı, tartışmalar, dersler, kurslar, yeni teknolojilerin ve bilginin tanıtılması da itfaiyecilerin yeterliliklerinin gelişimine katkıda bulunur (Sommer ve Njå, 2011).

Dekker ve diğerleri (2008), etkili öğrenme için temel organizasyonel gerekliliklerin eksikliğinin verimliliğin iyileştirilmesini engellediğini vurgulamıştır. İtfaiyecilerin görevlerini etkili bir şekilde yerine getirebilmeleri için, organizasyonların eğitim programlarına yeterli önem ve kaynak ayırmasının gerekliliği ortaya çıkmaktadır. Eğitim, itfaiyecilerin bilgi ve becerilerini güncel tutmalarını, yeni durumlarla baş etme yeteneklerini artırmalarını ve mesleki performanslarını daha da iyileştirmelerini sağlamaktadır.

Guzzo ve diğerleri (1985) yapmış oldukları çalışmada, eğitim ve hedef belirlemenin verimlilik üzerinde önemli ve olumlu etkileri olduğunu belirtmiştir.

Coulter (1979) yapmış olduğu çalışmada, acil müdahalenin çok yönlülüğünün, personel sayısının, maksimum müdahale süresinin, itfaiyeciler için eğitim teşvikinin, sürekli personel alımının, itfaiye hizmeti planlamasının, sosyal sınıfın, karşılıklı yardım yanıtlarının itfaiye hizmetlerinin verimliliğinin göstergeleri olduğunu belirtmiştir. Maher ve diğerleri (2020) yapmış oldukları çalışmada, insan kaynaklarının düzenlenmesinin itfaiye ve kurtarma operasyonlarının verimliliği üzerinde önemli etkileri olduğunu vurgulamışlardır.

İtfaiye personelinin iş sağlığı ve güvenliği de (İSG) teşkilatın verimliliği üzerinde önemli bir etkiye sahiptir. İtfaiye personelinin güvende olması, görevleri daha iyi yerine getirmelerini sağlar ve dolayısıyla teşkilatın hedeflerine daha çabuk ulaşmasına yardımcı olur. Örneğin, itfaiye personelinin yaralanma ve hatta ölüm riskiyle karşı karşıya kalmamaları için uygun ekipmanların sağlanması ve güvenlik protokollerinin uygulanması gereklidir ayrıca itfaiyecilerin motivasyonunu artırmak (Horwitz ve McGahan, 2019) için departmanlar arasında bir işbirliği sistemi uygulanabilir. İtfaiye personelinin güvende hissetmeleri, işlerini daha iyi yapmalarına ve daha motive olmalarına yardımcı olur.

Verimlilik, performans ölçümünün bir alt kümesidir (Cavlak, 2021). Dolayısıyla performansın artması verimliliği artıran bir unsurdur. Lazear (2000) yapmış olduğu çalışmada parasal teşviklerin çalışanların çabalarını etkileyerek daha yüksek performansa sahip olacaklarını ve dolayısıyla verimliliği artıracağını belirtmiştir. Horwitz ve McGahan (2019) yapmış oldukları çalışmada ise itfaiye teşkilatlarının yapmış oldukları iş birlikleri sayesinde performanslarının artacağı vurgulanmaktadır.

Türkiye itfaiye teşkilatının verimliliği üzerine yapılmış çalışmalarda ise genellikle eğitim, koordinasyon, nitelikli personel ve insan kaynakları konuları üzerinde durulmuş olup; yapılan çalışmalardan bazıları aşağıda belirtilmiştir. Aydemir (2023: 89) yapmış olduğu yüksek lisans tezinde, personel eksikliğinin, asılsız ihbarların ve olay yerine giden itfaiye araçlarına yol vermeme gibi olayların itfaiyenin görevini verimli bir şekilde yapmasına engel olan unsurlar arasında olduğunu belirtmiştir. Demirci ve Özçelik (2021) yapmış oldukları çalışmada, Türkiye'deki itfaiye teşkilatının verimliliğini artırmada belirlenen engeller arasında; liyakatsiz personel alımı, iletişim, personel ve diğer kurumlarla olan koordinasyon eksikliği olduğunu belirtmiştir. Ay (2016: 67) yapmış olduğu yüksek lisans tezinde, Türkiye itfaiye teşkilatının verimliliğini artırma çalışmalarından bir tanesi olarak; teşkilat içerisindeki personelin arasındaki eğitim düzey farklılıklarının giderilmesi gerekliliğini vurgulamıştır.

Yapılan literatür taraması sonucunda; incelenen ulusal ve uluslararası araştırmalarda, itfaiye teşkilatlarının verimliliği üzerine çalışmaların olduğu gözlemlenmiştir. Ancak bu çalışmalarda Türkiye'deki itfaiye teşkilatının verimliliğini artırmak amacıyla görevlendirilen itfaiye daire başkanlarının görüş ve önerilerine yer veren bir çalışmaya rastlanmamıştır. Oluşan literatür boşluğunu tamamlamak amacıyla aşağıda yöntemi belirtilen çalışma gerçekleştirilmiştir.

3. YÖNTEM

Yangın gibi sonuçları toplumsal ve çevresel olumsuz etkilere sahip olan bir durumun yönetilmesi büyük önem arz etmektedir. Hayat kurtarmak gibi asli bir görev üstlenen itfaiye personelleri ve bağlı olduğu teşkilatlar için birçok sorun bulunmakla birlikte, yaptıkları görevler sebebi ile hiçbir hataya yer yoktur. İtfaiye teşkilatının verimliliğinin artırılması, bir kamu hizmeti olan itfaiye teşkilatının sürekliliğini sağlayacak ve verilen itfaiye hizmetlerinin kalitesinde artışlara sebep olacaktır.

Bu çalışmanın araştırma problemi 'Türkiye itfaiye teşkilatının verimliliğini artırmak için hangi faktörler etkilidir?' sorusu olarak belirlenmiştir.

Kamu kuruluşlarının en önemli işlevlerinden biri, vatandaşların beklentilerini karşılayan, verimli, etkin ve hakkaniyete uygun hizmetler sunmaktır (Andrews vd., 2011: 132). Verimliliği değerlendirmek için itfaiye teşkilatları kendi organizasyonlarına aşağıda soruları yöneltmelidir (HMICFRS, 2021b).

- Riski yönetmek için kaynakları ne kadar iyi kullanıyoruz?
- Şimdi ve gelecekte yangın riskini ve diğer riskleri yönetmenin uygun maliyetli bir yolunu sağlama konusunda ne kadar iyiyiz?

Bu çalışmanın araştırma sorusu olarak ise 'Türkiye itfaiye teşkilatının verimliliğini artırmak için en çok hangi faktörler etkilidir?' sorusu tasarlanmıştır. Türkiye İstatistik Kurumu'nun (TÜİK) 2022 yılı raporuna göre, Türkiye'nin nüfusu yaklaşık olarak 85 milyon kişidir (TÜİK, 2023). Ülkede toplam 81 şehir bulunmakta olup bunların 30'u büyükşehir statüsünde yer almaktadır. Büyükşehir sınırları içerisindeki nüfusun sayısı ise 66 milyondan fazladır ve toplam nüfusun yaklaşık %78'ini oluşturmaktadır (TÜİK, 2023).

Araştırmada 30 büyükşehir itfaiye daire başkanı bulunmaktadır ve bu araştırma için 29 itfaiye daire başkanı, araştırmanın amacı ve yöntemi hakkında bilgilendirilmiş ve gönüllülük esasına göre geri dönüş yapan 13 itfaiye daire başkanı ile görüşülmüştür. Örneklem büyüklüğü olarak belirlenen 13 başkan, Türkiye itfaiye daire başkanlarının popülasyonunun %43'ünü temsil etmektedir.

Görüşmeler öncesinde araştırmaya katılan itfaiye daire başkanlarına sorulacak olan ana sorular hazırlanmış ve itfaiye daire başkanları ile yarı yapılandırılmış görüşme tekniğiyle nitel bir araştırma gerçekleştirilmiştir. İtfaiye daire başkanlarının cevaplayacağı sosyodemografik bilgiler ile sağlık bilgileri standart formatta hazırlanmış ardından araştırma problemi yöneltilmiştir. Bunun sonucunda verimlilik artırma adına 26 farklı öneri ortaya çıkmış ve içerikleri bakımından değerlendirilerek 7 konu başlığı (ekipman, bütçe, mevzuat, insan kaynakları yönetimi, iş birliği, standadizasyon, organizasyon) altında toplanmış ve analiz edilmiştir. Bu 26 faktörden bazıları itfaiye daire başkanları tarafından birçok kez vurgulanmıştır.

Araştırma 13 farklı büyükşehir için gerçekleştirilmiş olup, çalışmanın kapsayıcılığı açısından kayda değerdir. Örnekleme yöntemi gereği 13 büyükşehir itfaiye daire başkanı ile görüşülmesi, diğer 17 başkanın görüşlerine yer verilmemesi ise araştırmanın sınırlılığıdır.

Bu çalışmanın önemi, önde gelen itfaiye uzmanları ile gerçekleştirilmiş olmasıdır. Bu sayede, itfaiye daire başkanlarının derinlemesine analizleri ve deneyimleri sonucunda edindiği bilgiler kullanılarak; itfaiye teşkilatının verimliliğini artırma çalışmalarında yararlanılacak veriler elde edilebilecektir.

4. BULGULAR

Çalışma kapsamında, 13 İtfaiye Daire Başkanı ile yapılan görüşmeler sonucunda Türkiye itfaiye teşkilatlarının verimliliğinin artırılması için gerekli görülen 26 faktör, 7 başlık altında toplanarak Tablo 1 oluşturulmuştur.

Tablo 1'deki mevcut veriler ışığında 7 konu başlığı altında analizler yapılarak; konuların altında itfaiye daire başkanlarının önerileri maddeler halinde belirtilmiştir. Bu 26 öneri çalışma probleminin cevabını oluştururken; artı işareti (+) ile belirtilen öneriler birden fazla itfaiye daire başkanı tarafından vurgulanmış ve araştırma sorusunun çözümüne ulaşılmıştır.

4.1. İnsan Kaynakları Yönetimi

4.1.1. Eğitim

İtfaiye teşkilatlarının verdiği hizmet düşünüldüğünde, personelin aldığı eğitim ve bu eğitimlerin sürekliliği müdahale ettiği acil olaylar için dinamik ortamlarda hızlı karar vermeleri adına büyük önem taşımaktadır.

İtfaiye teşkilatları genellikle bilgi edinimlerini yaşadığı deneyimlerden kazanmaktadır (Sommers ve diğerleri, 2011). Günümüzdeki acil olaylar; artan teknoloji, artan enerji kullanımı ve nüfus artışı ile birlikte daha kompleks hale gelmiştir ve artık bir acil duruma, deneyimlerin ötesinde güncel bilgi ve bu bilgiler ışığında kazanılan yeterlilikler sayesinde müdahale etme zorunluluğu doğmuştur.

Mesleki eğitim faktörleri, örgütsel işleyişin verimliliğini etkileyen önemli bir faktördür. Eğitim ve öğretimin etkinliğini artırmak için yangın politika yapıcılarının farkındalığı ve eğitim ve öğretime yatırım yaygınlaştırılmalı, merkezi ve yerel itfaiye okullarının yeniden gözden geçirilmelidir (Park, 2020).

Sopian ve Kusumayadi (2021) yapmış oldukları çalışmada, itfaiye teşkilatlarında, eğitimin iş verimliliği üzerinde önemli bir etkiye sahip olduğunu belirtmiştir. İtfaiyeciler, işe yarayacağını bildikleri yöntemleri kullanmayı ve kendilerini güvende hissettikleri şekilde görevlerini yürütmeyi faydalı görürler ve buna uygun olarak olaylara müdahalede bulunurlar (Sommer ve Njå, 2011). Bu nedenle itfaiye personelleri arasında eğitim kültürünün oluşturulması önemlidir.

Gelişmiş itfaiye teşkilatlarına sahip olan Amerika Birleşik Devletleri (ABD) ve Japonya itfaiyelerinde, itfaiye ve yangın akademilerinin yanı sıra konuyla ilgili lisans, lisansüstü programlar ile kolej ve enstitüler bulunmaktadır (IFSIC, 2018). Bu durum gelişmiş eğitim programları aracılığıyla; yangın güvenliği ve acil durumlar için yetkin itfaiye personelleri ve liderleri yetiştirmek adına önemli bir unsurdur.

Türkiye'de 6 Şubat 2023 tarihinde yaşanılan afet sonucunda binlerce vatandaş hayatını kaybetmiş ve milyonlarca kişi bu afetten etkilenmiştir. İtfaiye teşkilatları bilgi birikimi ve arama kurtarmaya yönelik olan saha tecrübeleri sayesinde binlerce kişinin enkaz altından çıkarılmasında görev almıştır.

İtfaiye daire başkanlarının önerileri dikkate alınarak, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için eğitim konusunda itfaiye teşkilatlarında yapılması gereken çalışmalar şunlardır:

- Türkiye'deki itfaiye teşkilatlarında yıllık eğitimler kapsamında "Afet ve Acil Durum" başlığı altında 8 saat 'Temel Afet ve Acil Durum Yönetimi' ve TAMP eğitimleri düzenlenmektedir. Ancak, bu eğitimlere afet türleri, önleyici ve sınırlayıcı önlemler, müdahale türleri gibi konuların yanı sıra afetlerde arama kurtarma eğitimleri de eklenmelidir.
- Türkiye'de itfaiye veya yangın akademilerinin kurulması ve nitelikli itfaiye personelleri yetiştirmek adına lisans ve lisansüstü eğitim programlarının açılması sağlanmalıdır.

Tablo 1. Türkiye itfaiye teşkilatlarının verimliliğini arttırmak için belirlenen unsurlar

İnsan Kaynakları Yönetimi	*Eğitim*		
	Hizmet içi eğitimlerde; arama kurtarma eğitimleri artırılmalı ve bu eğitimlere afetler konusu eklenmeli	İtfaiye akademisi kurulmalı **(+)**	Nitelikli personel için lisans ve lisansüstü eğitim programları açılmalı
	İnsan Kaynakları		
	Teşkilat içerisine Sivil Savunma ve İtfaiyecilik (SSI) programı mezunu nitelikli personel alımı yapılmalı	İtfaiye teşkilatlarının insan kaynakları planlanması nüfus, coğrafya ve yüz ölçümüne göre yapılmalı	Personel alımı için norm kadrolar oluşturulmalı ve bu norm kadrolara doluluk zorunluluğu getirilmeli **(+)**
	Özlük hakları		
	Mesleki kanun düzenlemesi yapılmalı, itfaiye personelinin hakları arttırılmalı **(+)**	Görevde yükselme sınavının her yıl ihtiyaca göre zorunlu açılması sağlanmalı	
	İş Sağlığı ve Güvenliği		
	Müdahale aşaması için dinamik risk yönetimi prosedürleri oluşturulmalı	Olay yeri yönetiminin herhangi bir kazayla sonuçlanmaması için güvenlik çalışmaları yapılmalı	
Ekipman	İtfaiye teşkilatlarında kullanılan ekipmanlar için teknolojik gelişmeler takip edilmeli ve nüfusa oranla teknolojik ekipmanlar temin edilmeli	Kesintisiz haberleşmenin sağlanması için ulusal itfaiye teşkilatı çapında telsiz sistemi kurulmalıdır	
Bütçe	İtfaiye teşkilatlarının bütçesi belediye bütçesi dışından desteklenmeli	İtfaiye teşkilatlarının belirlenen bütçelerine alt limit zorunluluğu getirilmeli ve itfaiye bütçelerinde harcama zorunluluğu getirilmeli	Teşkilatın yatırım yapması için bütçeler oluşturulmalı
Mevzuat	İtfaiye Kanunu çıkarılmalı **(+)**	Gönüllülük Kanunu çıkarılmalı	Afetlerde müdahale konusunda itfaiye teşkilatlarının öncülük rolünü üstlenmesi
İş Birliği	Müdahalelerin kolaylaştırılması amacıyla başta komşu iller ile bilgi paylaşımı gerçekleştirilmeli ve şehirler tanıtılmalı		
***Standardizasyon* (+)**	İtfaiye araç standardı çıkarılmalı Verilerin düzenli toplanması ve analizlerinin yapılması için ortak bir portal oluşturulmalı	Hizmet içi eğitim standardı oluşturulmalı Kıyafet, ekipman, kişisel koruyucu donanım (KKD) standardı oluşturulmalı	Merkezi itfaiye otomasyonu yazılımı yapılarak araç gereç ekipman ve personel envanteri tutulması sağlanmalı
Organizasyon	İtfaiye içi branşlaşma artmalı	İtfaiye teşkilatlanma yapısı gözden geçirilerek, İtfaiye teşkilatları merkezi bir yapılanma altında toplanmalı	

4.1.2. İnsan Kaynakları

Örgütlerin ve çalışma ortamlarının başarısı, davranış bilimlerine dayalı insan kaynağının verimli kullanımına bağlıdır. Cerna ve diğerleri (2020) yapmış oldukları çalışmada itfaiye teşkilatlarının verimliliğinde gelecekteki olası başarısızlıkları bilmenin ve insan kaynaklarının tahsisini optimize eden stratejiler geliştirmenin önemini vurgulamıştır.

İtfaiye birimleri için nitelikli personel sayısı, güvenli bir şekilde yangından korunmanın sağlanması açısından önemlidir. Gelişmiş itfaiye teşkilatları (ABD, Japonya, Fransa) düşünüldüğünde itfaiye personel sayıları, acil olaylara hızlı ve yeterli bir şekilde müdahale etmek için gerekli bir unsurdur. Türkiye'deki çalışan toplam itfaiye personeli sayısı istatistiki verilerin eksikliği nedeniyle tam olarak bilinmemektedir. Ancak norm kadro sayısı 2018 yılında 33.578 (Sakin, 2018) olarak belirlenmiştir. Bu kadroların dolulukları hakkında da yeterli bilgi mevcut değildir. Gelişmiş itfaiye teşkilatlarında ve İstanbul Büyükşehir İtfaiye Teşkilatı' nda, itfaiyeci başına düşen kişi sayıları Tablo 2'de karşılaştırılmıştır (CTİF, 2022).

Tablo 2. Şehirlerde bir itfaiye personeli başına düşen nüfus (kişi sayısı)

İstanbul (Türkiye)	2.826
New York (A.B.D)	774
Paris (Fransa)	772
Tokyo (Japonya)	339

Tablo 2'den de anlaşılacağı üzere Türkiye'de bulunan itfaiye personel sayısı (gönüllü + profesyonel) nüfusa oranla eksik kalmaktadır. İtfaiye daire başkanlarının önerileri dikkate alınarak, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için insan kaynakları konusunda yapılması gereken çalışmalar şunlardır:

- Nitelikli itfaiye personellerinin itfaiye teşkilatlarına kazandırılması adına norm kadro sayılarının; nüfus, coğrafya ve yüzölçümü kriterleri göz önünde bulundurularak yeniden revize edilmesi sağlanmalıdır.
- Belirlenen norm kadrolar için doluluk zorunluluğu getirilmelidir.
- Ayrıca Türkiye'de Sivil Savunma ve İtfaiyecilik programı kapsamında ön lisans programları (SSI) mevcuttur. Belediye İtfaiye Yönetmeliği, sınav ve atamaya ilişkin esasları içermekte olup, itfaiye eri atama kriterleri arasında, en az lise ya da dengi okul mezunu olma şartı yer almaktadır. Ancak, ne var ki, birçok itfaiye teşkilatı boş kadrolarına itfaiye eri alımı yaparken lise, dengi ya da herhangi bir ön lisans mezuniyet şartı talep etmekte, bu nedenle itfaiyecilik alanında ön lisans derecesi olan kişilerin hak kaybına uğramasına neden olmaktadır. Ayrıca bu teşkilatlar içerisinde, eğitim almayan personelin varlığı hizmetin etkinliğini de olumsuz yönde etkilemektedir.
- Belediye İtfaiye Yönetmeliği'nde sınav ve atamaya ilişkin esaslar kısmı düzenlenerek SSI ön lisans şartı konulmalıdır.

4.1.3. Özlük Hakları

İtfaiye hizmetlerinin verimliliğini artıran ve verilen hizmetin kalitesini belirleyen itfaiye personelleri, yaptıkları görevler itibarıyla fiziksel, kimyasal, biyolojik ve psikososyal risklerle sürekli olarak karşılaşma potansiyeline sahiptir. İtfaiye personelleri taşıdıkları ağır sorumlulukları, tehlikeli koşullar altında çalışmak zorunda kalmaları ve bir hata ile bir can kaybetmenin mümkün olacağının bilinci ile görevlerini devam ettirmeye çalışan saygın bir teşkilatın üyesidirler.

Birçok araştırma, örgütte çalışanların ihtiyaçlarının karşılanamamasından ve sorunların gün yüzüne çıkarılmamasından dolayı sonuçların düşük verimlilik ve gerçekleştirilemeyen hedefler şeklinde kendini gösterebileceğini göstermiştir (Havasi, 2021). Wallace (1977) yapmış olduğu çalışmada önlenen yangınların sayısının, müdahale sonucu kurtarılan mülk kaybının itfaiye teşkilatlarının kalite ölçütleri olarak belirlendiği ve bu ölçütlerin, optimum kaynak tahsisi ve itfaiye personeline sağlanan haklarla doğrusal bir orantı içerinde olduğunu belirmiştir.

Çalışanların iş verimliliğinin maksimum hedeflere ulaşmadaki başarısı, çalışanlarda çalışma şevkinin varlığını gerektirir. Çünkü çalışanlardan gelen yüksek moralin varlığı, çalışanların kendilerine verilen tüm iş ve sorumlulukları eksiksiz olarak yerine getirebilmeleri ile iş yerinde yüksek iş etkinliği yaratacaktır (Kadri ve diğerleri, 2021).

Lee ve Olshfski (2002) yapmış oldukları çalışmada, işe bağlılığın ve beraberindeki rol gerekliliklerinin itfaiye personeli için belirgin bir motivasyon kaynağı ve olağanüstü çabalarını belirleyen önemli bir faktör olduğunu belirlemiştir.

İtfaiye personelinin özlük haklarında iyileştirmeler yapılması, itfaiye teşkilatının verimliliği üzerinde olumlu bir etki yaratabilir. Bu iyileştirmelerin verimlilik üzerindeki olumlu etkileri;

- İtfaiye personelinin motivasyonunu artırır,

- İtfaiye personelinin teşkilata olan sadakatini artırır,
- İş memnuniyetini artırır ve personel, daha iyi çalışma koşullarına sahip olmanın verdiği memnuniyetle işlerini daha istekli ve keyifli bir şekilde yapar,
- Teşkilatın istihdam çekiciliğini artırır. Daha iyi maaş, sağlık hizmetleri ve diğer sosyal haklar sunan bir teşkilat, yetenekli ve nitelikli personelleri çekmekte daha başarılı olur.

İtfaiye personellerinin hak ettikleri çalışma standartlarına ulaşamaması itfaiye teşkilatlarının verimliliği üzerinde olumsuz etkiler yapmaktadır. Türkiye'deki itfaiye personelleri 657 Sayılı Devlet Memurları Kanunu'nda (DMK) 'Genel Hizmet Sınıfı'nda yer almaktadır (Devlet Memurları Kanunu, 1965). Sonuç olarak bu durum itfaiye personeli için meslek sınıflandırma sorunsalını ortaya çıkarmıştır. Ayrıca Belediye İtfaiye Yönetmeliği'nde bulunan 'Görevde Yükselme Esasları' kısmında (T.C. Resmi Gazete, 2006)) 'İdarenin insan kaynakları birimi tarafından; görevde yükselme suretiyle atama yapılacak boş kadroların unvanı, adedi, derecesi ve aranacak şartlar, her yılın 15 Ocak tarihine kadar duyurulur' ibaresi mevcuttur ancak görevde yükselme sınavının ne kadarlık bir zaman diliminde açılması gerektiği konusunda bilgi mevcut değildir.

İtfaiye daire başkanlarının önerileri dikkate alınarak, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için itfaiye personellerinin özlük hakları konusunda yapılması gereken çalışmalar şunlardır:

- DMK'de itfaiye personellerine özel bir sınıflandırma yapılması veya 'Teknik Hizmetler' sınıfına geçirilmesi ile itfaiye teşkilatları içinde farklı statülerin ortadan kaldırılması, maaş artışı, ek göstergelerinin artırılması, İSG konusunda daha fazla haklar kazanmaları, yıpranma tazminatlarının düzenlenmesi konularında haklar sağlanmalıdır.
- Görevde yükselme sınavlarının belirli aralıklarla açılması sağlanarak, itfaiye personelinin kendini ve yeteneklerini geliştirmesine katkı sağlanmalıdır.

4.1.4. İş Sağlığı ve Güvenliği

Son 25 yılda yangın dinamikleri önemli ölçüde değişmiştir. Sentetik malzemelerin yaygın olarak kullanılması ve farklı inşaat yöntemleri, daha tehlikeli yangınlarla karşılaşmamıza neden olmuştur. Bu nedenle, itfaiye teşkilatları, yangınların değişen koşullarına uyum sağlamak zorundadır (Hagen ve diğerleri, 2014).

İtfaiye personelleri, ellerindeki kaynakları en hızlı şekilde kullanarak olaya müdahale etmeye çalışırlar, fakat bu müdahaleler sırasında birçok akut tehlikeli durum ortaya çıkabilir, örneğin çökme tehlikesi, elektrik tehlikesi, zehirli gazlar ve yanma tehlikesi gibi. Ayrıca itfaiyeciler için akut olarak yaşayabildiği tehlikeli olaylar dışında, sağlıklarına yönelik tehditlerle de karşı karşıyadırlar, örneğin kanser, kardiyovasküler sağlık sorunları gibi. Bu nedenle, itfaiyecilerin kendilerini korumak için özel önlemler almaları gerekmektedir. Koruyucu giysiler giymek, güvenli çalışma uygulamalarını yerine getirmek ve fiziksel sağlıklarını korumak gibi önlemler almak önemlidir.

Ulusal Yangından Korunma Kurumu (National Fire Protection Association: NFPA) tarafından yangın ve itfaiye teşkilatlarına yönelik 300'den fazla standart mevcuttur ve NFPA 1500 ''İtfaiye İş Güvenliği, Sağlığı ve Zindelik Programı Standartı'', itfaiye birimleri veya kuruluşları için bir iş güvenliği ve sağlığı programı için minimum gereksinimleri belirtir.

Ancak Türkiye'de itfaiye hizmetleri çok tehlikeli işler sınıfına dahil edilmesine rağmen itfaiye teşkilatları için özel bir İSG mevzuatı veya standartı mevcut değildir. Bu durum itfaiye personelleri için güvenli bir çalışma ortamından yoksun olma ortaya çıkarmaktadır.

Yangınla mücadelede risk yönetimi, potansiyel tehlikelerin belirlenmesini ve bunları azaltmak için gerekli adımların atılmasını içerir (bkz. NFPA 1250). Türkiye'deki itfaiye teşkilatlarında acil olaylar için oluşturulmuş dinamik risk yönetim prosedürlerinin bulunmaması, itfaiye personellerinin güvenli çalışma ortamından yoksun kalmasına sebep olmuştur. Bu durum, dolaylı olarak sundukları hizmetin verimliliğini olumsuz etkileyen bir unsur olarak ortaya çıkmıştır.

Risk yönetimini öğretmek için iki temel yaklaşım vardır. İlk yaklaşım, itfaiyecilere çeşitli senaryolar arasında yol göstermek ve güvenli bir ortamda karar verme becerilerini geliştirmek için simülasyona dayalı eğitimi kullanmaktır. Piyasada bulunan birçok eğitim programı ve ürünü bu yaklaşımı kullanmaktadır. İkinci yaklaşım ise, riski artıran belirli eylemleri belirlemek ve itfaiyecileri bu eylemlerden kaçınmaları için eğitmektir (National Fallen Firefighters Foundation, 2014). Tehlikeli operasyonlar, hem iş gücü hem de kuruluşların sürdürülebilirliğini tehdit ettiği unutulmamalıdır (Sedlmeyer ve Dwyer, 2018).

İtfaiye daire başkanlarının önerileri dikkate alınarak, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için 'İSG' konusunda yapılması gereken çalışma: İtfaiye teşkilatlarında İSG standartları ve risk yönetim prosedürlerinin oluşturulmasıdır.

4.2. Ekipman

İtfaiye teşkilatlarının acil olaylara müdahale ederken kullanmış oldukları ekipman ve araçlar, müdahalenin hızlı ve etkili bir şekilde yürümesi adına önem arz etmektedir. Türkiye Belediye İtfaiye Yönetmeliğinin 11. maddesi olan 'Araç, Teçhizat ve Malzeme' kısmında nüfusa göre asgari araç sayıları belirtilmiştir (T.C. Resmi Gazete, 2006)). Kullanılacak ekipmanlarla ilgili belirli bir standart olmayıp bu ekipmanların temininde Türk Standartlarına (TS), Avrupa Standartlarına (EN) veya uluslararası standartlara uyulur ibaresi mevcuttur. Ancak itfaiye teşkilatları bütçeleri kapsamında bu ekipmanları temin ederler ve bu durum itfaiye teşkilatları arasında tek tipleştirilmiş araç ve ekipman birliğine engel teşkil etmektedir.

İtfaiye teşkilatlarının görev yaptıkları bölge ve nüfus ile toplumsal risk analizleri sonuçlarına göre gerekli teknolojik araç ve ekipman sayılarının belirlenmesi ve temin edilmesi itfaiye hizmetlerinin etkili bir müdahale sağlamasında önemli bir unsurdur.

Lan ve diğerleri (2011) yapmış oldukları çalışmada, itfaiyenin kamu güvenliğinden sorumlu olması nedeniyle, yangın kaynaklarının ölçeğinin kritik bir şekilde dikkate alınmasının önemli olduğunu ve teşkilatların kaynaklarının kısa bir süre içinde keskin bir şekilde azalması sonucunda kamu güvenliğinin etkileneceğini belirtmişlerdir.

Ayrıca itfaiyecilerin operasyonlarını daha iyi koordine etmesine ve güvenli, verimli müdahaleler sağlamasına olanak tanıyan gelişmiş iletişim ve izleme sistemleri de vardır. Yeni teknolojilerin yangınla mücadeleye dâhil edilmesi, yangınla mücadele çabalarının genel etkinliğini önemli ölçüde artırabilir. Ayrıca hızlı ve güvenli bir çalışma ortamı sağlar.

İtfaiye daire başkanlarının önerileri dikkate alınarak, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için ekipman konusunda yapılması gereken çalışmalar şunlardır:

- İtfaiye teşkilatlarında; gerekli olan teknolojik araç ve ekipmanın tespit edilmesi ve temin edilmesi sağlanmalıdır.
- Kesintisiz haberleşmenin sağlanması için ulusal itfaiye teşkilatı çapında telsiz sistemi kurulmalıdır.

4.3. Bütçe

İtfaiye teşkilatlarının hizmetleri kamu hizmeti olmakta olup halkın ülkenin her yerinde aynı hizmete ulaşması kamu hizmetlerinin sürdürülebilirliği açısından önemlidir. Gelişmiş ülkelerdeki çoğu itfaiye teşkilatı, belediyelere bağlı olarak hizmetlerini sunmak üzere merkezi bir birlik altında faaliyet gösterir. Bu birlik, itfaiye teşkilatlarının bütçelerinin belirlenmesi ve gerektiğinde asgari düzeyde temin edilmesi için çalışmalar yürütür.

Türkiye Belediye Kanunu'na göre, itfaiye hizmetlerinin finansmanı belediyelerin giderleri kapsamında yer almaktadır. Bu nedenle her itfaiye teşkilatının bütçesi ilgili belediye tarafından düzenlenmektedir. Ancak belediyelerin bütçeleri farklılık gösterdiği için, itfaiye teşkilatları arasında bütçe farklılıkları oluşmakta ve bu da hizmet için kullanılacak kaynaklarda farklılık yaratmaktadır.

Türkiye ile gelişmiş ülkelerin itfaiye teşkilatlarının bütçeleri kıyaslandığında; İstanbul'da kişi başına itfaiye bütçesi 36 TL iken, New York'ta 895 TL ve Tokyo'da 246 TL (Karahan, 2018) olduğu görülmektedir.

İtfaiye daire başkanlarının önerileri dikkate alınarak, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için bütçe konusunda yapılması gereken çalışmalar şunlardır:

- İtfaiye teşkilatlarının bütçesinin belediye dışından desteklenmesine olanak sağlayacak stratejiler oluşturulmalıdır.
- Bütçeler itfaiye hizmetinin verimliliğini optimize edecek şekilde azami olarak belirlenmelidir.
- Belirlenen bütçeyi harcama zorunluluğu getirilmelidir.

4.4. Mevzuat

İtfaiye teşkilatları için oluşturulmuş mevzuatlar, teşkilat içindeki standartların, performans ölçütlerinin ve sorumlulukların belirlenmesini sağlar ve yapılan işlemlerin açık bir şekilde ifade edilmesine olanak tanır. Ayrıca bu mevzuatlar sayesinde itfaiye teşkilatları, hukuki açıdan da korunmuş olur.

Gelişmiş ülkelerdeki yangınla mücadele mevzuatı genellikle kapsamlıdır ve yangından korunma, yangınla mücadele ekipmanı ve bina yönetmelikleri ile ilgili düzenlemeleri içerir. Örneğin, ABD'de hizmet veren NFPA, eyalet ve yerel yönetimler tarafından geniş çapta benimsenen yangın kuralları ve standartları geliştirir ve uygular (NFPA, 2023).

Türkiye'de yangınla mücadele mevzuatı düşünüldüğünde; Binaların Yangından Korunması Hakkında Yönetmelik Resmî Gazete Tarihi: 19.12.2007, Resmî Gazete Sayısı: 26735, Belediye İtfaiye Yönetmeliği Resmî Gazete Tarihi: 21.10.2006, Resmî Gazete Sayısı: 26326, Nükleer Tesislerde Yangın Güvenliği

Yönetmeliği Resmî Gazete Tarihi: 05.05.2023, Resmî Gazete Sayısı: 32181 mevcuttur. Ancak, Türkiye'de yürürlülükte olan yangınla mücadele mevzuatı düşünüldüğünde, itfaiye kanununun bütüncül olarak oluşturulmadığı, İSG mevzuatının eksik olduğu ve gönüllü itfaiyecilere yönelik bir kanunun olmamasının önemli bir eksiklik olduğu görülmektedir.

İtfaiye teşkilatlarında iş sağlığı ve güvenliğine dair mevzuat oluşturmak; personelin sağlığını ve güvenliğini korumaya, teşkilatın maliyetini azaltmaya, toplumda olumlu bir etkiye sahip olmaya, ayrıca teşkilatın yüksek performans göstermesine katkı sağlar. Ancak Türkiye'de itfaiye personeli için İş Sağlığı ve Güvenliği mevzuatı bulunmamaktadır. Bu durum, itfaiye personellerinin güvensiz bir çalışma ortamına maruz kalmasına ve ciddi riskler altında çalışmasına neden olmaktadır.

Gönüllü itfaiyecilik, çoğu ülkede profesyonel itfaiyecilerin çabalarını artırmada önemli bir rol oynamaktadır. Gönüllü itfaiyeciler, genellikle kendi bölgelerindeki acil durumlara müdahale eden topluluk üyeleridir. Ek destek sağlarlar ve genellikle yangınları kontrol altına almak, arama ve kurtarma operasyonları yürütmek, tıbbi yardım sağlamak ve diğer yardım biçimlerini sunmak için profesyonel itfaiyecilerle birlikte çalışırlar. Gönüllü yangınla mücadele, daha hızlı müdahale süreleri ve daha yüksek yangın söndürme kapasitesi sağlamaya yardımcı olur (Kim ve Lee, 2017). Türkiye'de itfaiye teşkilatlarının etkinliğini artıracak olan gönüllü itfaiyecilere yönelik bir mevzuat bulunmamaktadır. Bu durum, özellikle afet zamanlarında ve insan kaynaklarının yetersiz kaldığı durumlarda müdahalelere gönüllü itfaiyecilerin katılamamasına neden olmakta ve yapılacak müdahalenin etkinliğini sınırlamaktadır.

İtfaiye daire başkanlarının önerileri dikkate alınarak, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için mevzuat konusunda yapılması gereken çalışmalar şunlardır:

- Toplu halde yangın güvenliğine dair bir itfaiye kanunu çıkarılmalıdır.
- Bu kanun içerisinde itfaiye personeli için İSG standartları ve yönetmelikleri bulunmalıdır.
- Gönüllü itfaiyecilik kanunu oluşturulmalıdır.
- TAMP yeniden gözden geçirilerek; meydana gelen afetlerin müdahale kısmından itfaiye teşkilatlarının sorumlu olduğu belirtilmelidir.

Mevzuatın önemi, itfaiye teşkilatlarının başarısında büyük bir rol oynamaktadır. Teşkilatların mevzuatı doğru bir şekilde uygulaması, işleri daha kolay ve güvenli hale getirirken aynı zamanda topluma sunulan hizmetin kalitesini artırır.

4.5. İş Birliği

İtfaiye teşkilatlarının ortak bir görevi vardır; yangınlara ve acil durumlara müdahale ederek halkın can güvenliğini sağlamak. İtfaiyeciler müdahaleler sırasında her zaman ekipler halinde çalışırlar ve bu durum birbirleriyle etkileşime girmelerini ve birbirlerinden öğrenmelerini sağlar (Sommers ve diğerleri, 2011).

Türkiye Belediye İtfaiye Yönetmeliğinde, itfaiye teşkilatları; belediye sınırları dışındaki olaylara müdahale etmek, afetlerde arama kurtarma çalışmalarına katılmak, TAMP kapsamında verilen görevi yerine getirmek gibi bulunduğu il dışında da sorumlulukları vardır (T.C. Resmi Gazete, 2006)). İllerde meydana gelen acil durumlarda ve afetlerde müdahale konusunda yetersiz kalan itfaiye teşkilatına (personel, ekipman, araç), önce o ilin en yakın itfaiye teşkilatlarından yardım gelmektedir.

İtfaiye teşkilatları arasındaki iş birliği, verimliliği artırarak daha etkili bir hizmet sunma imkânı sağlar. İş birliği yoluyla birlikte hareket etmek, kaynakların daha iyi kullanılmasını ve zaman tasarrufunu sağlar. Ayrıca, birbirlerine destek olma ve bilgi paylaşımı gibi avantajlar da sunar. İş birliği sayesinde, itfaiye teşkilatları aşağıdaki şekillerde verimliliklerini artırabilirler:

- Kaynakların etkin kullanımı: İş birliği, farklı itfaiye teşkilatları arasında kaynakların paylaşılmasını sağlar. Yangın söndürme ekipmanları, yangınla mücadele araçları veya uzman personel gibi kaynaklar, acil durumlarda hızla hareket edebilmek için paylaşılabilir. Bu sayede her bir teşkilat kendi sınırlı kaynaklarını daha etkili bir şekilde kullanırken, diğer teşkilatlar da güçlerini birleştirerek daha büyük ve karmaşık olaylara müdahale edebilir.
- Eğitim ve bilgi paylaşımı: İş birliği, farklı teşkilatlar arasında eğitim programları ve deneyimlerin paylaşılmasını da mümkün kılar. İyi planlanmış ortak eğitimler, teşkilatların becerilerini ve bilgi düzeylerini artırır. İtfaiye teşkilatları arasındaki bilgi paylaşımı ise en iyi uygulamaların ve güncel tekniklerin yaygınlaşmasını sağlar ve sonuç olarak teşkilatlara daha iyi bir yangınla mücadele yetkinliği kazandırır.
- Acil durumlarda koordinasyon: İş birliği, büyük çaplı olaylarda teşkilatlar arasında koordinasyonu sağlayarak daha hızlı ve etkili müdahale edilmesini mümkün kılar. İtfaiye teşkilatları arasında oluşturulan bir koordinasyon mekanizması, operasyonların daha iyi planlanmasını ve daha iyi bir iş bölümünün yapılmasını sağlar (bkz. 06.02.2023 Kahramanmaraş depremi).

- Maliyet avantajları: İş birliği yoluyla, itfaiye teşkilatları maliyet avantajı elde edebilir. Örneğin, ortak satın alma faaliyetleriyle, yangınla mücadele ekipmanlarının ve araçların alımında daha düşük maliyetler elde edilebilir. Ayrıca, yanıt süresini iyileştirerek hasarın ve zararın azaltılmasına yardımcı olarak maliyetteki artışı önleyebilir.

Sonuç olarak, itfaiye teşkilatları arasında iş birliği, kaynakların etkin kullanılmasını, bilgi paylaşımını ve koordinasyonu artırarak verimliliği artırır. İtfaiye daire başkanlarının önerileri dikkate alınarak, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için iş birliği konusunda yapılması gereken çalışmalar şunlardır:

- İtfaiye teşkilatları komşu illerdeki itfaiye ekiplerinden yardım almak için ortak tatbikatlar düzenlemeli.
- İtfaiye teşkilatları sorumlu olduğu bölgelerin coğrafyaları ve barındırdıkları riskler hakkında birbirlerini bilgilendirmeli.
- Ayrıca, itfaiye teşkilatları, çalışabilirliği kolaylaştıran protokoller aracılığıyla oluşturulan prosedürlerle birlikte çalışabilirliği kolaylaştırmalıdırlar.

4.6. Standardizasyon

İtfaiye hizmetleri istatistikleri, mevcut durum analizleri aracılığıyla; gelecekteki önleme çalışmaları, eksikliklerin belirlenip giderilmesi ve kırılgan nüfusların belirlenmesi için önemli bilgi verileri sunar. Bu verilerin analizi, proaktif önleme ve sınırlama stratejilerinin oluşturulmasına yardımcı olur. Türkiye'deki itfaiye teşkilatlarında standart verileri giriş için bir portal teknolojisi yoktur. Büyükşehir belediyeleri bütçeleri sayesinde bu portalları oluşturabilse de, küçük belediyeler bütçe kısıtlamaları nedeniyle itfaiye hizmetlerinin raporlarını manuel olarak el ile tutmak zorunda kalmaktadır (T.C. Resmi Gazete, 2006)). Bu durum veri toplama ve analiz yapmanın önünde bir engeldir ve performans hakkında bilgi edinmeyi zorlaştırır.

Murpy ve Greenhalgh (2013) yapmış oldukları çalışmada, yangın ve kurtarma hizmetlerinin verimliliğinin artırılmasında teknikler, standartlar ve kıyaslamaların gözden geçirilmesi ve güncellenmesinin faydalı olacağını belirtmiştir.

A.B.D, 1976 yılında Yangın İdaresi Ulusal Yangın Veri Merkezi tarafından NFIRS sistemiyle yangın verilerinin toplanması için çalışmalar başlatmıştır. Bu sistem, her yangının nedeni, hasar boyutları, yapı türü, yangın önleme sistemi müdahaleleri ve itfaiye müdahalelerinin ayrıntılarını içeren verilerin toplanmasını amaçlamaktadır. NFIRS, itfaiye raporlarında yangına kimin, ne zaman, nerede ve nasıl müdahale edildiğine dair bilgileri sunmakta ve ayrıca kullanılan koruyucu ekipman ile meydana gelen hasarların ayrıntılarını da içeren özel bir raporlama formuna sahiptir. Toplanan veriler A.B.D Yangın İdaresi tarafından derlenir ve analiz edilerek yangınla ilgili bilgilerin diğer ülkelerle karşılaştırılması ve ABD'nin kendi yangın önleme stratejilerinin geliştirilmesi amacıyla kullanılır (Luis ve Moncayo, 2022).

Standartlaştırılmış uygulamalar, verimliliği artırmaya, riskleri azaltmaya ve personel ile halk için güvenliği artırmaya yardımcı olur. İtfaiye teşkilatları içinde standardizasyon çok önemlidir. Tüm itfaiyecilerin aynı prosedürler altında çalışmaları, aynı eğitimleri almaları, aynı statüler altında çalışmaları ve aynı araç ve ekipmanı kullanmaları gerekmektedir. Teşkilat içinde ölümleri ve yaralanmaları azaltmak için, tüm itfaiyeciler asgari düzeyde yeterlilik sağlamalı ve oluşturulan yangın standartlarını benimsemelidirler (National Fallen Firefighters Foundation, 2014).

İtfaiye teşkilatlarında kullanılan ekipmanların farklı olması hatta aynı ekipmanın farklı isimlerle bilinmesi afet gibi toplumun bütününü etkileyen ve ortak müdahale gerektiren olaylarda teşkilatlar arasında farklılaşmaya ve çatışmaya sebebiyet verebilir. Ülke çapında standartlaşmış araç ve ekipman kullanımı, acil olaylarda ve afetlerde teşkilatın verimliliği üzerinde önemli bir etkiye sahiptir. İtfaiye daire başkanlarının önerileri dikkate alınarak, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için 'standardizasyon' konusunda yapılması gereken çalışmalar şunlardır:

- İtfaiye teşkilatlarında, ekipman, kıyafet, KKD, hizmet içi eğitim gibi konularda standartlar oluşturulmalıdır.
- İtfaiye teşkilatlarının envanter kayıtlarının düzenli olarak tutulması amacıyla yazılım otomasyonu oluşturulmalıdır.

4.7. Organizasyon

Park (2020) yaptığı araştırmada, itfaiye teşkilatlarının verimliliğini artırmada en etkili faktörün itfaiye teşkilatının yapısı ve işlevi olduğunu belirtmiştir. Bir organizasyonun yapısı, denetim, koordinasyon ve görev dağılımı gibi faaliyetlerin organizasyonel hedeflere nasıl yönlendirildiğini tanımlar (Hessels, 2020: 7). Lettice ve diğerleri (2006) tarafından yapılan bir çalışmada, organizasyon büyüklüğü ve yapısının performans ölçümünün geliştirilmesini ve kullanımını etkileyen temel unsurlar olduğu belirtilmiştir.

İtfaiye teşkilatları, halk tarafından en çok güvenilen ve sevilen teşkilatlardır. Amacı, kamu güvenliğini ve düzenini sağlamak ve refahını artırmak için halkın canını, bedenini ve malını korumaktır (Park ve diğerleri, 2009). Bu kuruluş, idari hizmetlerin kalitesini artırarak, yeteneklerin geliştirilmesi yoluyla verimliliğini artırabilir.

Türkiye'deki itfaiye teşkilatları, belediyelerin bünyesinde hizmet vermektedirler (Belediye Kanunu, 2005). Bu durum, itfaiyeler arasında denetim, bütçe, eğitim, ekipman, İSG gibi konularda farklılaşmaya sebep olmaktadır. Gelişmiş ülkelerdeki gibi merkezi bir kurumun itfaiye teşkilatlarının tümünü bünyesinde barındırarak hizmetlerini yürütmesi önemlidir. Böylece denetim ve eğitim gibi kriterlerin sağlanması kolaylaşır. Örneğin, A.B.D Yangın İdaresi (USFA) federal düzeyde ulusal yangın politikası ve işlevlerini koordine ederken, yangın önleme ve kontrol planlarına rehberlik eder ve kapsamlı yangın verilerini yönetir ve analiz eder (Park ve diğerleri, 2009).

Ayrıca itfaiye personellerinin yetenekleri ve istekleri doğrultusunda branşlaşmanın artırılması, itfaiyenin verimliliğini artıracak bir unsur olabilir. Bu sayede, görevler daha verimli bir şekilde yerine getirilebilir ve halkın güvenliği daha iyi sağlanabilir.

İtfaiye daire başkanlarının önerileri dikkate alınarak, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için ‘organizasyon’ konusunda yapılması gereken çalışmalar şunlardır:

- Türkiye belediye itfaiye teşkilatlarının merkezi bir kurumun altında hizmetlerini yerine getirmesi sağlanmalı.
- İtfaiye teşkilatları içerisinde görevlerin daha verimli bir şekilde yerine getirilmesi için personelin yetenekleri ve istekleri doğrultusunda branşlaşmanın teşvik edilmesi sağlanmalıdır.

5. SONUÇ

İtfaiye teşkilatlarının verimliliğini artırmak, yangın ve acil durum müdahalelerinin daha etkin ve etkili bir şekilde gerçekleştirilmesini sağlayacaktır ve insanların can güvenliğini sağlama, mal kaybını minimuma indirme ve toplumda güvenlik hissi oluşturma gibi önemli sonuçları beraberinde getirecektir. Ayrıca, itfaiye teşkilatının verimliliğini artıran faktörlerin belirlenmesiyle, bu alanlarda eğitim programları, personel politikaları ve kaynak dağıtımı gibi stratejilerin geliştirilmesi de mümkün olacaktır.

Yapılan çalışma sonucunda; Araştırma problemi olarak belirlenen ‘Türkiye itfaiye teşkilatının verimliliğini artırmak için hangi faktörler etkilidir?’ sorusuna yönelik yapılan incelemede; Türkiye itfaiye teşkilatının verimliliğini artırmak için 13 itfaiye daire başkanının görüşleri doğrultusunda 26 faktör belirlenmiş ve 7 konu başlığı altında analiz edilmiştir. Elde edilen verilerin analizleri sonucunda, itfaiye teşkilatlarının insan kaynakları yönetimi, ekipman, bütçe, mevzuat, iş birliği, standardizasyon ve organizasyon alanlarında iyileştirmeler yapması gerekliliği ortaya çıkmıştır.

Ayrıca araştırma sorusu olarak ‘Türkiye itfaiye teşkilatının verimliliğini artırmak için en çok hangi faktörler etkilidir?’ sorusuna istinaden incelenen öneriler arasında; itfaiye teşkilatlarında standardizasyonun sağlanması, itfaiye personeline yönelik mesleki düzenlemelerin yapılması, itfaiye personeli norm kadro sayılarının belirlenmesi ve bu kadrolarda doluluk zorunluluğunun uygulanması, nitelikli itfaiye personeli yetiştirilmesi için itfaiye akademilerinin açılması, afetlerde müdahale konusunda itfaiye teşkilatlarının öncülük rolünü üstlenmesi ve son olarak itfaiye kanununun oluşturulması en çok vurgulanan faktörler arasında yer almıştır.

Bu çalışmanın sınırlılıkları bulunmakla birlikte, Türkiye'deki itfaiye teşkilatlarının verimliliğini artırmak için önemli ipuçları sunmaktadır. İtfaiye teşkilatları için yapılan bu analizlerin, yasa yapıcılar ve karar vericiler için bir rehberlik niteliği taşıyarak, itfaiye teşkilatlarının iyileştirilmesi için yapılacak çalışmalara yol gösterici olması hedeflenmektedir. Bu şekilde, Türkiye itfaiye teşkilatları daha etkin ve güvenilir bir şekilde hizmet verebilecek ve toplumun güvenliğine katkı sağlayabilecektir.

Bu çalışmanın sonucunda, Türkiye'deki tüm itfaiye daire başkanları ve teşkilat içindeki uzman personeller, konulara göre sınıflandırılarak bir araya getirilerek, beyin fırtınası yöntemiyle teşkilatın sorunları ve çözüm konuları hakkında bir çalışma gerçekleştirilebilir. Bu çalışma, itfaiye teşkilatının verimliliğini artırmak için önemli bir adım olarak değerlendirilebilir.

Yazar Katkıları /*Author Contributions*
Ayşe Ütük: Literatür Taraması, Kavramsallaştırma, Metodoloji, Veri Derleme, Analiz, Makale Yazımı *Hayri Baraçlı:* Modelleme, Makale Yazımı-inceleme ve düzenleme.
Ayşe Ütük: Literature Review, Conceptualization, Methodology, Data Curation, Analysis, Writing Hayri Baraçlı: Modelling, Writing-review and editing.

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T.C. SANAYİ VE
TEKNOLOJİ BAKANLIĞI

#MİLLİ TEKNOLOJİ HAMLESİ

STRATEJİK ARAŞTIRMALAR VE VERİMLİLİK GENEL MÜDÜRLÜĞÜ