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The Role of Absorptive Capacity in R&D Firms' Location Choice[1]

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Ar-Ge Firmalarının Yerleşim Seçiminde Özümseme Kapasitesinin Rolü[2]

Abstract

This study investigates the location choice behaviour of firms engaged in R&D activities in Türkiye. The primary objective is to analyse the effect of firm absorptive capacity on location choice. The empirical analysis is based on a firm-oriented approach, considering location as a source of knowledge-based competitive advantage. The TurkStat Research and Development Activities Survey (2019) Micro Data Set is the primary data source. The cross-sectional data set, created for 2019, includes data on 5,871 firms in the Micro Data Set. The geographical scope of the sample is NUTS Level 1 regions, where the headquarters of the R&D firm is located. The estimation method is the Nested Logit model. Results indicate that R&D firms in Türkiye tend to be located in regions with intense knowledge spillovers and favourable demand conditions. This results in an uneven distribution of R&D firms across regions. It is clear from the study's evidence that policymakers should consider the unique competencies and objectives of firms and regions in designing regional development and industrial policies.

Keywords : Location Choice, Firm Location, Absorptive Capacity, R&D, Regional Development.

JEL Classification Codes : R30, O30, O32, R11.

Öz

Bu çalışma, Türkiye'de Ar-Ge faaliyeti yürüten firmaların yerleşim seçim davranışını araştırmaktadır. Birincil amaç, firma özümseme kapasitesinin yerleşim seçimi üzerindeki etkisini analiz etmektir. Çalışmanın ampirik analizi, firma-odaklı bir yaklaşıma dayanmakta ve yerleşimin bilgiye dayalı rekabetçi güç kaynağı olmasını göz önüne almaktadır. Temel veri kaynağı, TÜİK Mali ve Mali Olmayan Şirketler Araştırma-Geliştirme Faaliyetleri Araştırması (2019) Mikro Veri Setidir. 2019 yılı için oluşturulan yatay kesit veri seti İBBS Düzey 1 bölgelerinde Ar-Ge faaliyetinde bulunan

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[2] *Bu çalışma, Büşra Akın'ın Akdeniz Üniversitesi'nde Doç.Dr. Ümit Seyfettinoğlu danışmanlığında yürütülen ve 2023 yılında tamamlanan "Türkiye'de Faaliyet Gösteren Araştırma ve Geliştirme Firmalarının Yerleşim Kararlarını Belirleyen Faktörler: Yuvalanmış Logit Model Uygulaması" başlıklı doktora tezinden üretilmiştir. Mikro veriye erişimde yardımcı olan Türkiye İstatistik Kurumu Antalya Bölge Müdürlüğü'ne ve müdürlüğe bağlı Veri Araştırma Merkezi sorumlusu Bilgi İşlem ve İletişim Takımı personeline teşekkür ederiz.*

5 bin 871 firmayı içermektedir. Tahmin yöntemi, Nested Logit modeldir. Sonuçlara göre Türkiye'deki Ar-Ge firmaları, bilgi ortamı ve talep koşulları bakımından elverişli yerleri seçme eğilimindedir. Bu eğilim, Ar-Ge firmalarının bölgeler arasında eşitsiz dağılmasıyla sonuçlanmaktadır. Dolayısıyla, politika yapıcıların bölgesel kalkınma ve sanayi politikaları tasarlarken firmaların ve bölgelerin yetenekleri ve hedeflerini dikkate alması elzemdir.

Anahtar Sözcükler : Yerleşim Seçimi, Firma Yerleşimi, Özümseme Kapasitesi, Ar-Ge, Bölgesel Kalkınma.

1. Introduction

The location or relocation of a firm is a crucial decision that determines the spatial distribution of its factors of production and technology. Therefore, the location decision may result in several advantages and disadvantages that affect not only the firm but also other elements of the economic order. This is why researchers from different disciplines have sought to answer the question, "Where does production take place, and what forces determine the location choice?"

According to the relevant literature, several external and internal factors influence a firm's location choice (Alacer & Delgado, 2012; Arauzo-Carod et al., 2010; Townroe, 1969). External factors primarily relate to characteristics specific to the industry in which the firm operates or the region in which it is located. The most commonly highlighted external factors are agglomeration economies, labour market conditions, market demand conditions and competitive structure, economic outlook and conditions of the location, geographical accessibility and infrastructure, public policy and privileges, and sectoral and/or regional technology and knowledge (Arauzo-Carod et al., 2010; Feldman, 1999; Hoover, 1937, 1948; Malecki, 1985; Ferreira et al., 2016; Rossi, 2019; Townroe, 1969). On the other hand, internal factors frequently pointed out are the personality and behavioural characteristics of decision-making economic actors (entrepreneurs, firms, enterprises, companies, etc.) and firm characteristics (such as size, ownership structure, management structure, efficiency) (Alguacil et al., 2023; Arauzo-Carod et al., 2010; Chen & Yu, 2008; Jo & Lee, 2014; Townroe, 1969).

Modern views on the issue of location are dominated by a state of "ubiquity", where factors of production can be efficiently sourced in global markets due to globalisation. This new situation, in which all economic activities can be carried out anywhere, has given rise to the view that the importance of proximity or location has diminished. However, opposing views have also emerged. For these views, location is still important as a source of competitive advantage (Gertler, 1995; Feldman, 1999; Maskell & Malmberg, 1999b; Porter, 2000). This is because firms need input to differentiate themselves from others and thus gain competitive advantage in a system where many things are ubiquitous simultaneously. This refers to "the implicit and more sticky knowledge, as opposed to codified (tradable) knowledge" (Maskell & Malmberg, 1999a: 180), which spreads rapidly among actors. Innovation occurs based on implicit knowledge, and the accompanying strategic

differentiation has dynamised the competition between firms. The need to "be there" (Gertler, 1995) has increased due to the requirement to access implicit knowledge; thus, the proximity between actors in the value chain has become more critical than in the past (MacKinnon et al., 2002).

In light of the theoretical considerations, it would not be incorrect to say that accessibility to knowledge lends importance to a location. Such a location will facilitate the utilisation of complex and dynamic technological expertise in the production process. This reduces the uncertainty surrounding the innovation activity. This, in turn, enhances competitiveness by positively affecting firms' efficiency and improving innovation performance and productivity (Porter, 2000; Sridhar & Wan, 2010). Within the framework of knowledge-based competition, firms' ability to exploit the advantages offered by a location and to differentiate themselves depends on their ability to create and utilise knowledge or to improve their ability to do so (Maskell & Malmberg, 1999b; Seçkin, 2015). Through these skills, firms can absorb implicit and localised knowledge and capabilities. Thus, they can be competitive by developing unique technological competencies and capacities (Maskell & Malmberg, 1999a).

The fact that gaining knowledge-based competitive advantage is realised around the location, sector and network specificity of knowledge makes the role of firms' absorptive capacity in this process indispensable. The absorptive capacity is a capability based on knowledge and learning. Cohen & Levinthal (1990: 128-129) define it as "the ability to recognise the value of new information, assimilate it, and apply it to commercial ends." It is widely accepted that a firm's ability to develop unique experiences, expertise, and routines and to create innovative and commercially viable products, processes, models, and designs is crucial. This makes absorptive capacity a driver of knowledge-based competitiveness (Fosfuri & Tribó, 2008; Zahra & George, 2002), and thus a key factor in location decisions. Therefore, absorptive capacity can influence and alter both the firm and its external environment. It contributes to forming a regional knowledge base and pattern of learning, innovation and capability. As a result, based on their absorptive capacity, firms are likely to locate in regions (national or sub-national, such as clusters or peripheries) where they can generate or share knowledge in interaction with other actors, including firms, universities, and research institutions.

In this context, the scope of our study is to examine the location choices of firms engaged in research and development (R&D) activities and, thus, the reasons behind the regional distribution of these firms. Our primary objective is to analyse the location choice of firms by considering location as a source of competitive advantage based on knowledge and its implicit nature. To this end, an empirical analysis was conducted on a location model based on random utility maximisation, focusing on the effect of absorptive capacity. The estimation method is the Nested Logit model, which stands out among unordered discrete choice models by exhibiting a hierarchical choice structure. The primary data source is the Turkish Statistical Institute (TurkStat) Financial and Non-Financial Corporations Research and Development Activities Survey (2019) Micro Data Set. The cross-sectional data set

created for 2019 and used in the estimation includes data on 5,871 firms in the Micro Data Set, variables specific to the sector and location (region) in which they operate, and variables representing the absorptive capacity of these firms.

The contribution of this study is to analyse the location problem by considering the ability of location as a source of knowledge-based competitive advantage and the impact of implicit knowledge on firm location. Adopting a firm-oriented approach, we examined the effects of firm-, industry-, and region-specific factors, as well as the firm's absorptive capacity. Furthermore, we dealt with both potential and dynamic absorptive capacity. Thus, we examined the effects of the abilities that build absorptive capacity, namely the ability to identify, assimilate, and use knowledge. Lastly, to our knowledge, this study is the first to analyse the location choice of R&D firms in Türkiye. Therefore, we anticipate that our findings and inferences will help shape the studies on "location" and guide the formulation of policies towards Türkiye's industrial and technological targets.

The rest of the paper is organised as follows. Section 2 discusses the previous studies on location. Section 3 provides information about the methodology and data set used in the empirical analysis. Section 4 presents the main empirical results. The final section presents the findings and offers policy recommendations.

2. Literature Review

Researchers from various economic approaches, starting with David Ricardo and Adam Smith, have sought to answer the question of "where production takes place and what forces determine the location choice." They primarily addressed the location choice of production costs, particularly transportation costs and factors of production, following the early models of Location Theory (Von Thünen, 1826; Launhardt, 1882; Weber, 1909). Hence, the common aim of these studies is to identify the factors that cause the agglomeration or dispersion of economic actors or activities. They differ from each other in their primary focus on the location choice. Accordingly, they address the location problem from either a region-oriented (e.g., regions, cities) or a decision-maker-oriented (e.g., firms, entrepreneurship) perspective. As a result, the empirical models differentiate between econometric specification and method, the sample characteristics, and the location factors the researchers used. Below, we mention studies from both groups.

When a region-oriented solution is sought for a location problem, the research question considers how region- and/or sector-specific factors influence location choice. This approach offers flexibility to researchers due to the easily accessible regional-level data. Therefore, it is possible to examine the effects of different factors on location choice. Generally, agglomeration economies place special emphasis on explaining the attractiveness of specific regions. In addition, this approach's main disadvantage is that the effect of factors internal to the firm and entrepreneur on the choice process couldn't be analysed.

Campi et al. (2004) is one of these group of studies. It examines the location choices of new manufacturing firms by considering the life cycle of the industries. It categorises the industries as natural resource-intensive, labour-intensive, economies of scale, differentiated products, and R&D-intensive. The study reveals that the technological density and the life cycle of industries influence the location choice of new firms in Spain for the periods 1985-90 and 1991-1994. Interestingly, it reveals that smaller cities with higher levels of specialisation attract the attention of new firms. The larger cities have become less attractive despite their dense population and diversification. Berkoz and Turk (2009) also demonstrate that economies of scale, labour market, and infrastructure are crucial to foreign direct investment (FDI) firms' location choices in Türkiye. It indicates that FDI firms emphasise the availability of high-quality and low-cost inputs, a skilled labour force, accessibility, transportation, climate, and infrastructure. At the macro level, on the other hand, they appear to be concerned about Türkiye's economic and political stability.

Li and Zhu (2017) and Gómez Antonio and Sweeney (2021) are two other studies that focus on the attractiveness of a region. Li and Zhu (2017) investigate the impact of spatial dependence and heterogeneity on the location choice process of high-tech firms. It was discovered that new high-tech firms are generally located in townships with more established businesses and a smaller population. The proximity to urban centres, rather than highways, universities, or parks, appears more significant for firms. Planning policies encourage high-tech firms to establish operations in economic and technological development zones, as well as innovation incubators. On the other hand, Gómez Antonio and Sweeney (2021) specifically investigate the role of knowledge spillovers in high- and medium-high-technology manufacturing firms in Madrid between 2000 and 2016. It finds that the primary driver of the firms' location choice is knowledge spillovers from firms in the same industry but not from universities. Similarly, Jofre-Monseny et al. (2011) demonstrate that cooperation and networking, which emerge from agglomeration economies, are vital for new manufacturing firms. In particular, labour market pooling dominates the process of location choice, and input sharing follows it. Knowledge spillover effects are low and relevant only at a local level.

Besides agglomeration economies, government policies aimed at enhancing regions' business climate are a crucial location factor. Chin (2013) analyses the location of new establishments in the USA using quantitative and qualitative approaches. Discussing the conditions of regions and neighbourhoods, the empirical analysis shows that existing employment, population density and dominant firms determine the location of new establishments. In-depth interviews reveal that founders' thoughts are crucial in determining the locations of new establishments, including natural amenities, historical atmosphere, and physical settings. Li et al. (2016) and Yavan (2006) demonstrate that this is also true for high-growth firms in the USA and FDI firms in Türkiye, respectively. For Li et al. (2016), the factors favouring high-growth firms may differ from general location factors. The effects of this specific factor vary significantly depending on the type of area (urban or rural) and industrial sector.

According to Yavan (2006), the geographical distribution of FDI firms in Türkiye from 1990 to 2003 was influenced by the social, cultural, and geographical characteristics of NUTS-3 level regions, as well as economic conditions. These include socio-cultural amenities, crime, terrorism, violence, closeness to coasts or coastal regions, and metropolitan effect. Infrastructure, government policy and incentives, labour and agglomeration economies are other factors that affect the location of FDI firms. Berkoz and Turk (2005) also show the importance of these factors in the case of Türkiye in the same period. FDI firms pay attention to agglomeration economies, population growth, previous investment, infrastructure, market growth, and inhabitants' access to bank credit. Deichmann et al. (2003), another study that examined FDI firms' location choice in Türkiye for the year 1995, adds the depth of local financial markets, human capital and coastal access to these factors. Furthermore, Tatoglu and Glaister (1998) highlight that the importance of the location factors for FDI firms in Türkiye in the same year varies depending on the country of origin of these firms, the mode of entry (acquisition or greenfield), the industry and the size of the venture.

Lall and Chakravorty (2004) demonstrate a sharp distinction between the factors affecting the location decisions of state-owned and private sectors in India. Private-sector firms prioritise efficiency-related economic geographies or institutional factors, such as closeness to industrial clusters and coastal districts or liberalisation and structural reforms. In contrast, state-owned (central government) firms appear not to be driven by economic geography factors. Manjón-Antolín and Arauzo-Carod (2011) address the issue by examining location and relocation decisions in Catalonia. It demonstrates that the new firms' location choice and the existing firms' relocation choice differ from the factors that make a municipality more attractive. These factors include population density, urbanisation economies, industrial diversity, labour market characteristics, and infrastructure. Karahasan (2015) and Sanchez-Reaza (2018) also control the effects of these factors on firms' locations. Karahasan (2015) demonstrates that the regional distribution of new firms in Türkiye is primarily driven by demand, business cycles, human capital, and financial capital at the provincial (NUTS-3) level. Additionally, tests on the roles of geography and spatial dependence reveal that regional networks are important to new firms. Sanchez-Reaza (2018) identifies that job diversification, formed by urbanisation economies, is a key factor affecting firms' location in Tanzania. Localisation economies, competitive markets, and market access are other factors that make a particular location attractive.

The research question examines the impact of firm-, sector-, and region-specific factors on location choice, informed by a firm-oriented approach. Such a model construction helps examine firm- and entrepreneur-specific characteristics. However, the accessibility of microdata is a significant drawback. On the other hand, the empirical method is generally one of the discrete choice models (DCMs), such as logit, generalised extreme value (GEV), probit or mixed logit models. Additionally, high-technology and/or knowledge-intensive industries, particularly the manufacturing sector, draw the attention of researchers. The geographical scope encompasses sub-regions, regions, states, and nations. Agglomeration

economies and human capital receive considerable attention in the studies. The availability of microdata enables the researchers to focus on the behavioural aspect of the choice process.

Chen and Yu (2008) is a case in point. It examines how managers of high-tech firms decide on a location strategy within a science park in Hsinchu, Taiwan. Employing the decision-making trial and evaluation laboratory (DEMATEL) and analytic network process (ANP) methods, this analysis explains the location choice process by highlighting the value and benefits of clustering. Results show that entrepreneurial spirit, talent pool and support infrastructure are important for managers. Network effects create a competitive and collaborative workplace, diffusing new knowledge and business intelligence. Meanwhile, an entrepreneurial spirit, lead users, and a talent pool bring low transaction costs. Lafuente et al. (2010) is another study that discusses the effect of personal motivation, in addition to other location factors, on location choice. It examines the choice of rural and urban locations made by knowledge-intensive service activity (KISA) firms in Catalonia between 2003 and 2006. The findings reveal that the entrepreneurs' motives and quality of life drive firms to relocate to rural areas. In contrast, the local attitude towards entrepreneurship is a serious obstacle to choosing rural localities.

Ferreira et al. (2016) is another study that discusses the effect of personal motivation, in addition to other location factors, on location choice. It shows that firms operating in knowledge-intensive business services tend to be located in urban areas, whereas firms in the construction, agriculture, services manufacturing and mining sectors are more likely to be located in rural areas. The characteristics and expectations of entrepreneurs, as well as the climate and local attitude towards business, also affect the firms' location choice. Yavan (2010) also demonstrates the importance of climate and quality of life in the decision to locate Foreign Direct Investment (FDI) in Türkiye. The results highlight the crucial role of agglomeration economies, labour pool, public investment and road network.

What is surprising about Yavan's (2010) results is that wage, productivity, unionisation, sea and air transportation, free zones, and instability are not significant determinants of FDI firms' location choices in Türkiye. However, Kayam et al. (2011) show that Turkish FDI firms are treated differently. Due to low labour costs, they prefer MENA and transition economies to EU countries. Other factors that determine the location choice of Turkish firms include accessibility to consumers and suppliers, market penetration, the presence of Turkish firms and population, cultural similarity, trade opportunities and trade agreements, skilled labour, and transportation costs. Demirbag et al. (2010) demonstrate that other factors are crucial for Turkish multinational enterprises (MNEs) location strategy. Accordingly, when deciding to locate one of the two specific country groups (EU and Former Soviet Union) and two broad regions (developed countries and emerging countries), Turkish MNEs pay more attention to the level of political constraints, the level of knowledge infrastructure, subsidiary density and size, and industry R&D intensity.

Similarly, Barrios et al. (2006), Devereux et al. (2007), and Kohlhase and Ju (2007) demonstrate that public policy or incentives affect firms' location choices. Barrios et al.

(2006) and Devereux et al. (2007) find firms' responsiveness to government subsidies and public incentives is low, whereas Kohlhase and Ju (2007) reveal that local property taxes have a deterrent influence on the location choice of firms, primarily operated in oil and gas, manufacturing, services and finance, insurance and real estate (FIRE) industrial groups. For Devereux et al. (2007), the low responsiveness to government subsidies in Great Britain is the interaction between agglomeration externalities and these policy instruments. Both domestic and multinational firms are less responsive to subsidies in locations with fewer incumbents in their industry. According to Kohlhase and Ju (2007), the effect of agglomeration economies is lower than the deterrent effect of property taxes present in the FIRE and services industries. The benefits of localisation and urbanisation economies affect firms in both these industries, while oil and gas and the manufacturing industries seem not to benefit from proximity to other firms. In contrast, Barrios et al. (2006) argue that agglomeration economies have a considerable influence on multinational high-tech firms in the Republic of Ireland.

Other studies emphasise the importance of agglomeration economies on the geographical distribution of firms. One of them is Deichmann et al. (2005). The results indicate that agglomeration economies have a significant influence on the location patterns of manufacturing firms with 20 or more employees in Indonesia. Alcacer and Delgado (2012) differ from others in that they decompose the impact of agglomeration economies into internal (intra-firm) and external (inter-firm) components. The case of biopharmaceutical firms in the US from 1993 to 2005 reveals that both agglomeration economies have a positive impact on location choice; however, their effects vary among firms' plants and activities, including R&D, manufacturing, and sales. Jo and Lee (2014) also examine the impact of different types of agglomeration. It demonstrates that firms' technological capabilities and agglomeration economies interact to influence location choice in South Korea. For firms with low technological capability, competitive specialisation is crucial. On the other hand, firms with high technological capability tend to be located in regions characterised by complementary specialisation.

Akın and Seyfettinoğlu (2022) present findings on how the impact of certain factors on firms' locations in Türkiye varies according to the technological intensity of the industry in which firms operate. High-tech firms (high, medium-high, or medium-low) tend to choose regions with a diversified and deepened labour pool, sectoral diversity, and knowledge spillovers. On the other hand, low-tech firms place more importance on specialisation arising from localisation economies. Similarly, Bottazzi and Gragnolati (2015) previously demonstrated the collaborative role of technological dynamics and agglomeration economies in the Italian context. Results indicate that the firms' location affects urbanisation and sector-specific localisation economies. For Bottazzi and Gragnolati (2015), technological dynamics that produce sector-specific positive externalities are the primary motive in location choice.

Lastly, Sridhar and Wan (2010) analyse the location choice of firms in cities of different sizes (large, medium, and small) in three countries: India, China, and Brazil. It

reveals that capital cities are not attractive when they are significant. Labour-intensive firms, in particular, do not choose large cities in India and China. The availability of inputs attracts firms to India and China while deterring firms in Brazil. In contrast to China, the post-reform period has a positive influence on the location choice of firms in India.

Compared to previous studies, our contribution is threefold. First, we adopt a firm-oriented approach to the location problem, overcoming the microdata constraint commonly found in the literature. This allowed us to analyse the effect of firm-specific characteristics in addition to industry and region. Second, we examine the firm's absorptive capacity as a firm-specific location factor regarding its potential and dynamic aspects. This also enables us to focus on the location as a source of competitive advantage, leveraging its knowledge and implicit nature. Lastly, to our knowledge, this study is the first to analyse the location choice of R&D firms in the case of Türkiye. On the other hand, a significant limitation of our study is that we cannot examine the effect of entrepreneur-specific factors on location choice due to a lack of data at the entrepreneur level. Nevertheless, we anticipate that our findings and inferences will be helpful for future studies and guide policies towards Türkiye's industrial and technological targets.

3. Empirical Methodology and Data

3.1. Location Choice Model

The location choice model analysed in the present study assumes that the R&D firms regard location as a source of knowledge-based competitive advantage. It is based on the Nested Logit (NL) model, which features an unordered choice structure with a multinomial dependent variable. The NL model is theoretically grounded in random utility maximisation, which enables the modelling of choice behaviour with a deterministic rule while accounting for some uncertainties in the choice process (e.g., unobservable attributes of alternatives and individual characteristics of the decision-maker, as well as statistical measurement errors). This enables researchers to investigate how decision-makers and alternative-specific characteristics affect the choice behaviour of a decision-maker who chooses the alternative with the maximum utility (Ben-Akiva & Lerman, 1985; Ben-Akiva & Lerman, 1999).

Accordingly, the location choice model for the R&D headquarters of firms is defined in closed form in Equation (1):

$$\pi_{ij} = f[S_i, KI_i, SS_i, AC_i, C_j] + \varepsilon_{ij} \quad (1)$$

where i is firm; j is the location of the statistical unit where the R&D activity is performed, and ε_{ij} is the error term. Equation (1) implies that a firm's expected profit at a location π_{ij} is a function of the firm size (*S*), sectoral knowledge intensity (*KI*), sectoral specialisation (*SS*), absorptive capacity (*AC*) and characteristics (*C*) specific to the choice alternatives (regions).

Due to uncertainty regarding firm behaviour and a variety of factors influencing expected profit, observing π_{ij} is practically impossible. To address this limitation, the assumption that "if the firm's expected profit for location A is greater than that for other location(s), the firm will choose to locate in A" is introduced into the model (as in Artz et al., 2016; Barrios et al., 2006; Bottazzi & Gragnolati, 2015; Hansen, 1987; Jofre-Monseny et al., 2011). Thus, a firm's location choice is expressed by a dummy variable with the value 1 if the firm chooses the relevant region and 0 otherwise, as given below in Equation (2):

$$y_{ij} = \begin{cases} 1\ ;\ \pi_{ij} > \pi_{ik}\ , \forall j \neq k \\ 0\ ;\ otherwise \end{cases} \quad (2)$$

where, y_{ij}, indicates that the firm *i* chooses to be located in region *j* by assuming that firms are risk neutral (Devereux et al., 2007). It represents the statistical unit where R&D activities are conducted. As a result, the variables "BOLGE_KOD" and "ILKAYITNO" in the TurkStat (2020) are matched. They refer to the location of the intramural R&D activity and the Nomenclature of Territorial Units for Statistics (NUTS) Level 2 region code of the statistical unit (i.e. headquarters unit) where the questionnaire is applied, respectively.

Equation (3) provides the basic empirical specification within this framework. Table 1 presents information on the indicators of the variables, along with some descriptive statistics.

$$y_{ij} = \beta_0 + \beta_1 size_i + \beta_2 kia_i + \beta_3 spec_i + \beta_4 basic\_res_i + \beta_5 app\_res_i + \beta_6 exp\_nprod_i + \beta_7 exp\_npros_i + \beta_8 res\_rate_i + \beta_9 exp\_rate_i + \alpha_1 pop\_g_j + \varepsilon_{ij} \quad (3)$$

In Equation (3), firm size (*size*) is calculated as the share of the firm's employees in the total number of employees within its size group in the region where it operates. Firm size has generally been analysed in terms of the number of employees (Alguacil et al., 2023; Arauzo-Carod & Antolín, 2004; Kohlhase & Ju, 2007; Liviano & Arauzo-Carod, 2014; Weterings & Knoben, 2013) or, where data are available, capital, investment or turnover (Akbaşoğulları & Duran, 2020; Akın & Seyfettinoğlu, 2022; Alguacil et al., 2023; Arauzo-Carod & Antolín, 2004; Fotopoulos & Louri, 2000). We were unable to include the logarithm of the number of employees in the model as a variable because it resulted in a multicollinearity problem. Since the Micro Data Set does not contain data on financial indicators, such as firm capital, we could not use these indicators either. There is a general expectation that firm size positively affects location choice; however, several research studies have shown that its effect may vary depending on the region or country (Sridhar & Wan, 2010) or sector (Kohlhase & Ju, 2007; Sanchez-Reaza, 2018). In line with the common expectation, the firm's relative size is expected to affect the likelihood of regions being chosen favourably.

kia reflects sectoral knowledge intensity. It is a dummy variable that takes the value 1 if the sector in which the firm operates is among the Eurostat Knowledge Intensive Activities (KIA) by NACE Rev. *2 - total KIA* (Eurostat, 2022) and 0 otherwise. Many

location studies examined the impact of knowledge as a part or end product of localisation economies, labour quality, accessibility and knowledge and technology policies. Among these, the presence of or proximity to universities, innovation centres, science parks, research laboratories, etc., where actors produce and share knowledge and technology in interaction (Chen & Yu, 2008; Ferreira et al., 2016; Gómez-Antonio & Sweeney, 2021; Lafuente et al., 2010; Li & Zhu, 2017) are the most commonly used ones. In addition, the impact of funds and incentives provided to the region (Chin, 2013), the number of innovative firms in the region (Deakins & Bensemann 2019), the number of registered patents (Chin, 2013; Maggioni, 1999; Siedschlag et al., 2013), regional or sectoral R&D intensity and knowledge/technology intensity (Campi et al., 2004; Demirbag et al., 2010; Maggioni, 1999; Malecki, 1984; Weterings & Knoben, 2013) have also been investigated.

Previous studies have shown that a location's knowledge and technology environment will increase the probability of firms choosing that location. As noted by Malecki (1985), it is vital for R&D firms as it reflects the availability of skilled labour. This suggests that firms make location choices based on the importance of localised knowledge, skills and competencies. Eurostat's (2022) total-KIA classification by NACE Rev.2 comprises various subsectors from industry to services sectors. All these subsectors' knowledge needs and environments are different. Thus, it is expected that regions providing firms operating in KIA sectors with sufficient sectoral knowledge and knowledge environment have a higher possibility of being chosen.

Table: 1
Descriptive Statistics

Variable	Indicator	Definition	Mean	Std. Dev.	Min.	Max.
S	size	The share of the firm's number of employees in its size group (micro, small, medium, large) in the region where it operates (%).	0.85	3.55	0.28	100
KI	kia	This is a dummy variable that takes 1 if the sector (by NACE Rev.2) in which the firm operates is defined by Eurostat as knowledge-intensive activity (total KIA); otherwise, it takes 0.	-	-	0	1
SS	spec	The share of firms that operate in the same region (by NUTS) and sector (by NACE Rev.2) with the firm in total firms (%).	3.47	4.49	0.02	12.83
AC	basic_res	Basic research activity expenditure in total intramural R&D expenditure (%)	23.30	34.97	0	100
	app_res	Applied research activity expenditure in total intramural R&D expenditure (%)	28.30	35.41	0	100
	exp_nprod	Experimental new product activity expenditure in total intramural R&D expenditure (%)	28.29	35.22	0	100
	exp_npros	Experimental new process activity expenditure in total intramural R&D expenditure (%)	5.79	14.46	0	100
	res_rate	The share of researchers in the firm's total R&D personnel (%)	77.52	29.60	0.65	100
	exp_rate	The share of expenditure on researchers in the firm's total R&D expenditure (%)	63.20	29.13	0	100
C	pop_g	Annual growth rate of population by region (2019, ‰)	20.48	8.76	-10.70	29.53

spec represents localisation economies within the scope of static externalities. Similar to other empirical studies (Alamá-Sabater et al., 2011; Deichmann et al., 2005; Jo & Lee, 2014; Kohlhase & Ju, 2007; Li & Zhu, 2017), its unit of measurement is the number of firms. It is calculated as the ratio of the number of firms operating in the same NACE Level 2 sector in a region to the total number of firms in that region. Previous studies show that firms tend to locate in regions with other firms operating in the same sector, using similar labour, and with high forward and backward linkages. Numerous studies (Alcacer & Delgado, 2012; Artz et al., 2016; Barrios et al., 2006; Deichmann et al., 2005; Jo & Lee, 2014; Jofre-Monseny et al., 2011; Karahasan, 2010; Kohlhase & Ju, 2007; Lall & Chakravorty, 2004) have also shown that the impact of localisation economies on location may vary depending

on the technological structure of the main sector, related sector(s) and firms' competence. Accordingly, for firms in sectors where sector-specific returns to specialisation are important, the spec is expected to increase the tendency to locate in a region. From the point of R&D firms, the effect of the spec is expected to be positive in favour of Marmara, considering it includes TR10 (Istanbul) and TR42 (Kocaeli, Sakarya, Düzce, Bolu, Yalova), which had the highest (28.5%) and third highest (7.3%) shares of the number of R&D personnel in 2019, respectively. TR10 and TR42 also had higher shares of Gross Domestic R&D Expenditures (GERD) (26.4% and 9.5%, respectively) than other regions that year. Besides, Ankara stands out among the different regions. It had the highest share of R&D expenditure (31.6%) and the second-highest share of R&D personnel (18.7%) in 2019. Hence, it can be expected that the spec will positively affect the probability of Western Anatolia being chosen (TurkStat, 2024a).

In the literature, the effect of a firm's absorptive capacity on location choice is typically analysed through R&D activities, particularly R&D intensity (Alañón-Pardo & Arauzo-Carod, 2013; Audretsch & Belitski, 2020; Cohen & Levinthal, 1990; Mowery et al., 1996; Park et al., 2023; Xiao et al., 2023). R&D intensity could not be included in our model due to the lack of data on firms' sales values in the TurkStat (2020) Micro Data Set. As an alternative, the model could not use the logarithmic transformation of R&D expenditures due to the multicollinearity problem. Nevertheless, this constraint paves the way for this study to employ distinct variables representing a firm's absorptive capacity. Thus, two groups of variables representing different absorptive capacities are included in Equation (3).

The first group includes *basic_res*, *app_res*, *exp_nprod* and *exp_npros*, which describe a firm's learning process and experience. These are the shares of total intramural R&D expenditure allocated to basic research, applied research, experimental new product development, and experimental new process development[3], respectively. Each activity dynamically feeds the capabilities that are central to the development of a firm's absorptive capacity (Cohen & Levinthal, 1990; Fosfuri & Tribó, 2008; Van Den Bosch et al., 1999; Zahra & George, 2002). Accordingly, *basic_res* is the activity of acquiring knowledge; *app_res* is the activity of acquiring, synthesising and assimilating knowledge; and *exp_nprod* and *exp_npros* are the activities that develop the capability to integrate, transform, use and apply knowledge. The second group, on the other hand, consists of two variables (*res_rate* and *exp_rate*) representing the potential of a firm's absorptive capacity. *res_rate* is the share of researchers in the firm's total R&D personnel. *exp_rate* is the share of expenditures on researchers in the firm's intramural R&D expenditures. Both variables capture individual absorptive capacities within a firm, the organisational strategy (structure) for skill acquisition, and R&D efforts for pre-knowledge acquisition.

Firms are expected to gravitate towards regions that develop their absorptive capacity's dynamic and potential sides. This is because, as emphasised in the literature (Audretsch & Feldman, 1996; Audretsch et al., 2004; Fujita et al., 1999), these regions are

[3] *For the definition of types of R&D activities, see OECD, 2015.*

likely to have a knowledge environment that enables them to benefit from knowledge spillovers and learning resources. Accordingly, the variables *basic_res*, *app_res*, *exp_nprod*, *exp_npros*, *res_rate* and *exp_rate* are expected to be positive for regions that can contribute to developing firms' absorptive capacity and negative for other regions. In this regard, it is evident that Marmara and Western Anatolia, which have many technical and/or research universities (Council of Higher Education of Türkiye, 2024), R&D and design centres, technology development centres (Ministry of Industry and Technology, 2024), researchers and other R&D staffs, as well as more significant contribution to Türkiye's GERD (TurkStat, 2024a), have a higher advantage compared to other regions.

pop_g is a region's annual population growth rate (per thousand). It is included in the model to reflect local demand conditions that have been accepted as an important location factor since the first location models. Previous studies have examined the impact of local demand conditions through the population (Akın & Seyfettinoğlu, 2022; Alamá-Sabater et al., 2011; Berkoz & Turk, 2009; Devereux et al., 2007; Maggioni, 1999; Yavan, 2006) and income indicators (Basile et al., 2008; Brülhart et al., 2007; Chin, 2013; Devereux et al., 2007; Guimarães et al., 2004; Maggioni, 1999; Ramaul & Ramaul, 2018; Siedschlag et al., 2013; Yavan, 2006) or per capita tax revenue (Karahasan, 2010, 2015) and per capita consumption level (Bottazzi & Gragnolati, 2015). We could not include the population density and the logarithm of population level, as the first prevents the maximisation of the log-likelihood function and causes multicollinearity. In addition, due to data limitations, we could not analyse the effect of income and consumption. The generally accepted expectation about the impact of the demand conditions is that it positively affects the probability of a chosen region. Therefore, the *pop_g* is expected to have a favourable effect on the probability of choosing.

3.2. Estimation Method

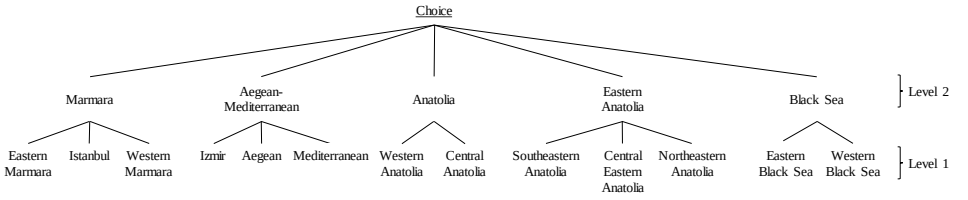
We estimate Equation (3) employing the Nested Logit (NL) model estimation method. The NL model is a Discrete Choice Model (DCM) that takes researchers beyond the standard multinomial logit (MNL; McFadden, 1974) model. It simply groups the similar alternatives into subgroups (nests). This creates a hierarchical structure of the other options, so the error terms of the choice alternatives do not necessarily need to be uncorrelated. Hence, it relaxes the *Independence from Irrelevant Alternatives (IIA)* assumption of the MNL model, requiring the error terms of the choice alternatives to be independent of each other (Hensher & Greene, 1999; Wooldridge, 2001; Train, 2003; Baltas, 2007).

In the NL model, the choice set $C_j = \{1,2,\dots,J\}$ is assumed to be divided into non-overlapping subsets (nests) $B_k = \{1,\dots,K\}$. The choice process involves choosing one of the sub-sets B_1, B_2,…, B_K and a specific alternative from the chosen subset $(c_1,\dots,c_J)$. This hierarchical choice process is formulated as in Equation (4) (Greene, 2008):

$$C_j = [c_1,\dots,c_J] = \left[\left(c_{1|B_1},\dots,c_{J_1|B_1}\right),\dots,\left(c_{1|B_K},\dots,c_{J_K|B_K}\right)\right] \quad (4)$$

Nesting choice alternatives in multiple levels, as in Equation (4), creates a substitution pattern between alternatives that visually resembles an inverted tree. Figure 1 illustrates the two-level NL tree, which shows the choice structure we analysed. In Figure 1, the choice set of 13 alternatives (C_j) based on NUTS Level 1 regions is divided into five nests (B_k). The set of choice alternatives C_j =*(Eastern Marmara, Istanbul, Western Marmara, Izmir, Aegean*[4]*, Mediterranean, Western Anatolia, Central Anatolia, Southeastern Anatolia, Central Eastern Anatolia, Northeastern Anatolia, Eastern Black Sea, Western Black Sea)* is divided into the subsets B_k =*(Marmara, Aegean-Mediterranean, Anatolia, Eastern Anatolia, Black Sea)*. The choice process refers to the non-sequential choice among the choice subsets and the choice of a specific location alternative (e.g. Istanbul $(c_{j|k} = c_{\text{Istanbul}|Marmara})$) from a chosen subset (e.g. $(B_k = B_{Marmara})$ from Marmara nests). See Appendix Table A for NUTS regions of Türkiye.

Figure: 1
Tree Structure for Location Choice of R&D Firms (Two-Level Nested Logit)



The two-level hierarchical choice structure exemplified in Figure 1 can be extended to three or more levels. However, we assigned attributes to only the model's first level, as Hensher et al. (2005) suggested, since there is no common set of attributes to distinguish between higher choices. We also considered the risk of high-level NL models containing high levels of variance. Detailed information on the NL model can be found in Greene (2008), Hensher and Greene (1999), Hensher et al. (2005) and Train (2003).

3.3. Data Set

The primary data source is the 2019 Financial and Non-Financial Corporations Research and Development Activities Survey Micro Data Set, which TurkStat (2020) produces annually and makes publicly available. The population growth rate data was obtained from the TurkStat Regional Statistics Database as an exception.

The TurkStat (2020) Micro Data Set is compiled within the scope of the R&D Activities Survey. The geographical scope of the R&D Activities Survey is NUTS Level 2 regions. The 2019 universe consists of 14,532 firms. Among these, the number of respondent firms is 14,169. The Micro Data Set comprises statistics on R&D expenditures and R&D

[4] *The "Aegean" alternative in the choice set includes other Aegean provinces except İzmir.*

personnel of 7,514 financial and non-financial companies (FNFCs) that conduct intramural R&D. The surveyed FNFCs in the 2019 R&D Activities Survey represent 64.2% of the total intramural R&D expenditures in 2019.

We created a cross-sectional data set for 2019, including firm-, industry-, and region-specific variables (see Table 1). The sample's geographical scope encompasses NUTS Level 1 regions that host the firm's headquarters, where intramural R&D activity is carried out. Thus, the sample includes 5,871 out of 7,514 firms in the Micro Dataset.

Figure: 2
Regional Distribution of R&D Expenditures (2019, 2021)

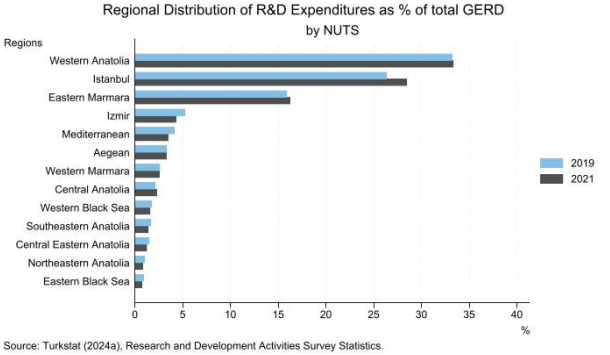
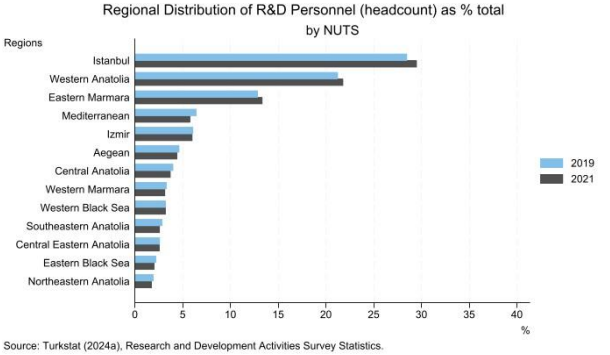


Figure: 3
Regional Distribution of R&D Personnel (2019, 2021)



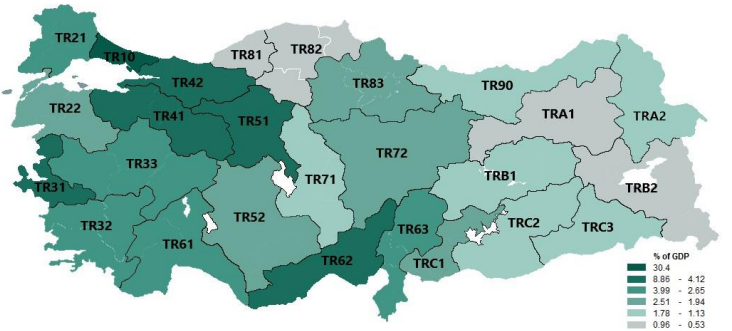
According to Micro Data Set, in 2019, Istanbul (2,118), Western Anatolia (1,512), and Eastern Marmara (714) hosted the majority of FNFCs performing R&D in the centre unit. NUTS Level 1 regions with the fewest FNFCs were Northeastern Anatolia (28) and Eastern Black Sea (33). It can be seen that there was an uneven distribution of R&D firms

throughout the regions in 2019. However, this has also been the case in previous and future years. R&D Activities Survey Statistics (TurkStat 2024a) show that R&D expenditures and human resources were unevenly distributed across Türkiye's regions in 2019 and 2021. This is illustrated in Figures 2 and 3.

Some subregions within Northeastern Anatolia, Eastern Black Sea, Central Eastern and Southeastern Anatolia have a lower level or share of many socio-economic indicators than the Türkiye average. For instance, Income and Living Conditions Survey Statistics (TurkStat, 2024b) show that TRB2 (Van, Muş, Bitlis, Hakkari) in Central Eastern Anatolia has had the lowest mean annual equivalized household disposable income for years. Furthermore, according to GDP statistics by provinces (TurkStat, 2024c), Ağrı (TRA2; Northeastern Anatolia), Şanlıurfa (TRC2; Southeastern Anatolia), and Van (TRB2; Central Eastern Anatolia) are consistently the provinces with the lowest estimated GDP per capita. The same statistics also show that the final three provinces with the lowest contribution to Türkiye's GDP are typically Tunceli (TRB1; Central Eastern Anatolia), Ardahan and Bayburt (TRA2 and TRA1; Northeastern Anatolia).

Figure 4 illustrates the contribution of NUTS Level 2 Regions to Türkiye's GDP in 2022. It is evident that western regions, particularly the subregions of Marmara, dominated Türkiye's domestic production that year. Subregions in Central Eastern, Southeastern, and Northeastern Anatolia, as well as the Western Black Sea, had the lowest share of total GDP in 2022. This unequal income distribution among regions results in additional inequalities. The Central Eastern, Northeastern, and Southeastern Anatolia subregions also suffer from high unemployment rates and low labour force participation rates, as well as the lowest school life expectancy, average years of schooling, literacy rates, and literacy rates among women (TurkStat, 2024c), among other issues. As a result, resources associated with industry, services, education, and research-based activities tend to concentrate in the western regions of Türkiye. NUTS definitions of statistical regions of Türkiye are given in Appendix Table A.

Figure: 4
The Share of GDP by Regions, at Current Prices, 2022



4. Empirical Results

The estimation results of the NL model (Equation (3)) are given in Table 2. In the upper part of Table 2, the number of observations at each level ($N = 13 \times k$) equals the sum of the number of times the alternative is chosen (k). The LR test statistics test the appropriateness of the NL model against the MNL model with the null hypothesis that "all-inclusive values are equal to 1 (IV=1)". According to the $\chi^2_{(5)}$value of the test, the null hypothesis is rejected at significance levels of 1%. Therefore, the NL model structure is appropriate.

Table: 2
Nested Logit Model Results

$\boldsymbol{LR}$ $(\boldsymbol{IV} = \boldsymbol{1})$: $\chi^2_{(5)} = 269.55$				$Log - likelihood =$ -9822.2194 $N = 76323$ $k = 5871$		
Lower Nest						
Population Growth Rate	pop_g	0.0486*** [0.0449] (0.0188)				
Upper Nest						
Levels						
		Marmara	**Aegean-Mediterranean**	**Anatolia**	**Eastern Anatolia**	**Black Sea**
Dissimilarity Parameters (λ)		0.3514	1.4366	0.3973	0.8424	0.3462
Firm Size	size	0 (base group)	0.2117*** (0.0324)	0.0981*** (0.0375)	0.3278*** (0.0348)	0.3360*** (0.0357)
Knowledge Intensity	kia		0.9487*** (0.0883)	0.5712*** (0.0783)	1.8382*** (0.1801)	2.0539*** (0.2340)
Specialisation	spec		-0.6533*** (0.0420)	-0.0362*** (0.0080)	-4.1579*** 0.4387	-5.2310*** (0.7168)
Absorptive Capacity	basic_res		-0.5779*** (0.1632)	-0.0688 (0.1509)	-0.6244** (0.3125)	0.6035 (0.5500)
	app_res		-0.5690*** (0.1595)	-0.0378 (0.1506)	-0.4514 (0.3075)	0.7853 (0.5578)
	exp_nprod		-0.8205*** (0.1627)	-0.0842 (0.1610)	-1.0696*** (0.3147)	0.2015 (0.5770)
	exp_npros		-1.3164*** (0.3120)	-0.2279 (0.2695)	-0.9886* (0.5523)	0.1708 (0.8533)
	res_rate		-0.0005 (0.0013)	0.0038*** (0.0012)	0.0022 (0.0025)	0.0020 (0.0039)
	exp_rate		-0.0092*** (0.0013)	-0.0077*** (0.0012)	-0.0173*** (0.0026)	-0.0250*** (0.0036)

Notes:
1. Marmara is the base group.
*2. *p < 0.10, **p < 0.05, ***p < 0.01. The standard errors in parenthesis.*
3. $\chi^2_{5,0.05} = 11.070$ *and* $\chi^2_{5,0.01} = 15.086$.

In Table 2, the "Lower Nest" refers to the results obtained by choosing an alternative within a nest. According to the lower nest estimation results, a sub-region's population growth rate (pop_g) positively affects the average choice probability of that sub-region relative to others in the same nest. This finding is consistent with both the expectation and the previous studies (Akın & Seyfettinoğlu, 2022; Alamá-Sabater et al., 2011; Bottazzi & Gragnolati, 2015; Brülhart et al., 2007; Karahasan, 2010, 2015; Yavan, 2006). Market demand conditions influence the location choices of R&D firms in Türkiye in the region. The greater the potential for goods or services in a region, the greater the tendency for R&D firms to locate there.

"Upper Nest" in Table 2 gives the findings about the impact of firm- and industry-specific factors on the choice of a nest. Two issues need to be addressed regarding the upper nest results. Firstly, as a requirement of the estimation method, Marmara, which has the highest frequency of choice, is determined as the base group. Therefore, the results for the upper nest are interpreted in comparison to the Marmara. Secondly, the dissimilarity parameters (λ) for each nest measure the degree of correlation of random shocks and consistency with utility maximisation. As can be seen from Table 2, except for $\lambda_{Aegean-Mediterranean}$, all other λ's are in the range of (0,1). This indicates that the Marmara, Anatolia, Eastern Anatolia, and Black Sea regional groups are consistent with utility maximisation for all model explanatory variables' values. However, there is consistency with utility maximisation for some values of the explanatory variables in the Aegean-Mediterranean region (Train, 2003).

According to the upper nest estimation results, the relative firm size increases the probability of a region being chosen compared to Marmara at a significance level of 1%. The parameter estimates indicate that the relative size of a firm provides more advantages to the Black Sea and Eastern Anatolia in particular. This finding is consistent with previous studies (Kohlhase & Ju, 2007; Sanchez-Reaza, 2018; Sridhar & Wan, 2010), which suggest that the effect of firm size can differ across decision-makers, regions/countries, or sectors. More precisely, firm size can be related to the entrepreneur's characteristics, such as geographical or ethnic origin, motivation, and experience, or sectoral characteristics. Additionally, based on our study, it can be concluded that relatively large R&D firms tend to be located near other R&D firms of similar size. This implies that R&D firms' strategies of utilising network relationships that facilitate the flow of knowledge and communication are important in their location choice.

Sectoral knowledge intensity (kia) positively affects the average probability of choosing a regional group compared to Marmara at a 1% significance level. Sectoral knowledge intensity enables a region to be selected by R&D firms. This result supports the previous findings (Campi et al., 2004; Demirbag et al., 2010; Ferreira et al., 2016; Maggioni, 1999; Malecki, 1984, 1985; Hart et al., 1989; Weterings & Knoben, 2013). Notably, the importance of sectoral knowledge intensity is inversely proportional to the number of knowledge-intensive R&D firm headquarters located in the region. For example, the Aegean-Mediterranean region, including Anatolia and Eastern Anatolia, has a higher concentration of knowledge-intensive firms than the Black Sea region. However, these regions are less likely to be chosen than the Black Sea region. Similarly, the Aegean-Mediterranean is more likely to be selected than Anatolia, which has more knowledge-intensive firms, but less likely than Eastern Anatolia, which has fewer knowledge-intensive firms. This suggests that the location choice of firms in knowledge-intensive sectors may be influenced by both objective factors, such as sectoral competition, regional advantages, and incentive opportunities, as well as subjective (personal) factors specific to the firm and its entrepreneur.

Sectoral specialisation ($spec$) has a negative effect on the probability of a region being chosen compared to the Marmara at a significance level of 1%. Increasing specialisation in the sector where an R&D firm operates is advantageous for Marmara (and Istanbul in the case of Marmara) and disadvantageous for other regions. Furthermore, sectoral specialisation has a greater adverse effect on Eastern Anatolia and the Black Sea than on Anatolia and the Aegean-Mediterranean. It is believed that the industrial and demographic diversity in Anatolia and the Aegean-Mediterranean region is more notable compared to Eastern Anatolia and the Black Sea. These two western regions appeal to R&D firms due to the large number of production- and sales-oriented firms, as well as the highly educated and skilled workers they employ. The finding on the effect of sectoral specialisation justifies the previous findings (Alcacer & Delgado, 2012; Artz et al., 2016; Deichmann et al., 2005; Henderson, 1991; Jo & Lee, 2014; Jofre-Monseny et al., 2011; Kohlhase & Ju, 2007; Lall & Chakravorty, 2004; Li & Zhu, 2017).

The budget share that an R&D firm allocates to basic research ($basic\_res$), applied research (app_res), experimental new product development (exp_nprod) and experimental new process development (exp_npros) is inversely related to the probability of location choice. $basic\_res$, exp_nprod and exp_npros are statistically significant for the Aegean-Mediterranean and Eastern Anatolia, while app_res is statistically significant only for the Aegean-Mediterranean. Accordingly, the choice probability of the Aegean-Mediterranean and Eastern Anatolia by R&D firms decreases compared to Marmara as the budget share allocated to basic research ($basic\_res$) increases. As the budget share of firms' R&D expenditures for experimental new product development (exp_nprod) and new process development (exp_npros) activities increases, the probability of choice for Aegean-Mediterranean and Eastern Anatolia decreases in favour of Marmara. On the other hand, an increase in the share of applied research activity expenditures in total intramural R&D expenditures (app_res) decreases the probability of R&D firms located in the Aegean-Mediterranean region compared to Marmara. This suggests that R&D firms in Türkiye tend to locate in regions where they can improve the dynamic aspect of their absorptive capacity. This tendency of firms gives Marmara an advantage over other regions.

The indicators reflecting the potential aspect of firm absorptive capacity and individual absorptive capacities within the firm, the share of employed researcher personnel (res_rate) and the share of expenditures on researcher R&D personnel in intramural R&D expenditures (exp_rate), affect the probability of location choice in different directions. res_rate is statistically significant only for Anatolia. Accordingly, an increase in the number of researcher personnel among total personnel in an R&D firm increases the probability of choosing Anatolia over Marmara. In contrast, the share of expenditures on employed researcher personnel in intramural R&D expenditures (exp_rate) has a negative effect on the choice probability of regions. As spending on research and development personnel increases, R&D firms find the Marmara region more attractive for their headquarters. It can be concluded that R&D firms attach importance to the richness of a location in terms of researchers but also consider the level of compensation paid to

researchers in that location. They are more likely to gravitate toward the Marmara rather than allocating a larger budget for researchers in the alternative locations of Anatolia, the Aegean-Mediterranean, Eastern Anatolia, and the Black Sea. In particular, when the share of researcher personnel expenditures is in question, it is noteworthy that the researcher resources in Marmara are preferred over those in Anatolia. Personnel costs can turn a location's advantageous outlook into a disadvantage for R&D firms.

Table 3 presents pre-estimation information and post-estimation probabilities about the R&D firms' location choice. The pre-estimation information includes the frequency and percentage of selection data for each alternative (sub-region) and nest. It provides information on the regional distribution (in number and percentage, respectively) of firms in the estimation sample. The post-estimation probabilities, on the other hand, cover the average choice and transition (marginal and conditional) probabilities. They reflect the unobserved component of the expected utility of a location choice. Moreover, the last column provides information on the consistency between the actual observed and predicted location choices.

Table: 3
Information on R&D Firms' Location Choice

Region (Nest)	Sub-region (Alternative)	Preliminary Information		Post-estimation Probabilities			Consistency
		Frequency selected	Per cent selected	Marginal probability	Conditional probability	Choice probability	
	Eastern Marmara	717	12.213		0.191	0.093	0.029
	Istanbul	2119	36.093		0.764	0.371	-0.010
	Western Marmara	45	0.766		0.045	0.022	-0.014
Marmara		2881	49.072	0.486			
	Izmir	544	9.266		0.319	0.056	0.037
	Aegean	228	3.883		0.302	0.053	-0.014
	Mediterranean	235	4.003		0.378	0.066	-0.026
Aegean-Mediterranean		1007	17.152	0.174			
	Eastern Anatolia	1512	25.754		0.896	0.258	0.000
	Central Anatolia	175	2.981		0.104	0.030	0.000
Anatolia		1687	28.734	0.288			
	Southeast Anatolia	94	1.601		0.565	0.019	-0.003
	Central Eastern Anatolia	67	1.141		0.25	0.008	0.003
	Northeast Anatolia	28	0.477		0.185	0.006	-0.001
Eastern Anatolia		189	3.219	0.034			
	Western Black Sea	33	1.261		0.696	0.013	0.000
	Eastern Black Sea	74	0.562		0.304	0.006	0.000
Black Sea		107	1.823	0.019			

Note: The estimated and conditional probabilities are average.

According to the pre-estimation information in Table 3, the majority (36.09%) of R&D firms chose Istanbul in 2019. It is followed by Western Anatolia (25.75%), Eastern Marmara (12.21%) and Izmir (9.27%). According to the distribution of R&D firms across Marmara, Anatolia, the Aegean-Mediterranean region, Eastern Anatolia, and the Black Sea region, approximately half (49.1%) of the R&D firms are located in Marmara. Anatolia (28.7%) and Aegean-Mediterranean (17.2%) followed it. The least chosen sub-regions were Eastern Black Sea (0.56%) and Northeastern Anatolia (0.48%).

The marginal probabilities (P_{iB_k}) in the post-estimation probabilities column group reflect the situation where R&D firms choose a location by considering the characteristics

specific to them and the sector in which they operate. P_{iB_k} are the same for all choice alternatives in a nest. The estimated P_{iB_k} values illustrate that when R&D firms take into account attributes specific to themselves and the sector in which they operate, they are more likely to choose Marmara rather than other regions. In contrast, the Black Sea is the least attractive alternative for R&D firms.

The conditional probabilities ($P_{ij|B_k}$) give the information on the probability of choosing a particular alternative within a nest given that this nest is chosen. It reflects the situation in which R&D firms consider the specific characteristics of the sub-regions in the choice set when choosing a location. According to the $P_{ij|B_k}$ values, while it is known that a firm chooses Marmara, this firm is probably (with probability 0.76) to choose Istanbul among the sub-regions in Marmara. When a firm is known to choose the Aegean-Mediterranean region, the sub-region most likely chosen is Izmir. For an R&D firm that chooses to locate in Anatolia, the conditional probability of selecting Western Anatolia is higher than that of Central Anatolia. On the other hand, among Eastern Anatolia sub-regions, Southeastern Anatolia is the most chosen by R&D firms. Lastly, the Western Black Sea appears more attractive to R&D firms that choose the Black Sea region as their location.

In Table 3, the total choice probability relates to the choice among the 13 sub-regions in the choice set, considering firm-, industry-, and region-specific characteristics jointly. The total choice probability for any choice alternative is equal to the product of the transition probabilities ($P_{ij} = P_{ij|B_k}P_{iB_k}$). Overall, Istanbul and Western Anatolia are more likely to be chosen by R&D firms. Compared to others, Eastern Anatolia and the Black Sea subregions are less likely to be selected.

Finally, the "Consistency" column shows the consistency between the observed and estimated location choices of R&D firms. The consistency values differ between each sub-region's pre-estimation choice percentage and the post-estimation choice probability. According to these values, particularly for Western Anatolia, Central Anatolia, Southeastern Anatolia, Central Eastern Anatolia, Middle Eastern Anatolia, Northeastern Anatolia, Western Black Sea and Eastern Black Sea, the estimated location behaviour is in close consistency with the observed one. The consistency of the estimated model with the actual location behaviour is relatively lower for the other sub-regions (Eastern Marmara, Istanbul, Western Marmara, İzmir, Aegean and Mediterranean).

5. Discussion

This study examines the location choice of firms engaged in R&D activities in Türkiye. Considering location as a source of knowledge-based competitive advantage, we estimate a location choice model focusing on the effect of firm absorptive capacity. The cross-sectional data set for 2019 covers firms in the TurkStat Financial and Non-Financial Corporations Research and Development Activities Survey (2019) Microdata Set. The estimation method is the Nested Logit model. This methodology enables us to assess the

impact of the potential and dynamic aspects of firms' absorptive capacity, as well as other internal and external location factors, on location choice. Therefore, we anticipate that this study will fill an important gap in the literature and be beneficial for researchers and policymakers.

Our results clearly show that R&D firms in Türkiye tend to be located in regions with intense knowledge spillovers, individual absorptive capacity, and favourable demand conditions, which align with their capacity to develop and renew their knowledge base. These regions (Marmara, Central Anatolia, Aegean and Mediterranean) are mostly in western Türkiye. In particular, the three major metropolises, Istanbul, Ankara, and Izmir, attract R&D firms through their research, knowledge, and network infrastructure. This aligns with the conventional view that R&D firms are sensitive to local agglomeration factors such as educated and qualified human capital and sectoral and individual knowledge flows. Results also reveal that knowledge is localised and sticky in particular regions of Türkiye. Both dynamic and potential aspects of firm absorptive capacity make Marmara, especially Istanbul, more attractive than Aegean-Mediterranean, Central Anatolia, Eastern Anatolia and Black Sea. Marmara provides firms with plenty of opportunities to develop the components of their absorptive capacities (recognising, assimilating, and applying the information) and access knowledge sources.

The tendency of R&D firms towards particular western regions of Türkiye, which are already developed and industrial centres, indicates that a more balanced distribution of R&D firms and activities is crucial. This is because the uneven distribution of R&D firms creates disadvantages for the growth and competitiveness of other regions, particularly those heavily dependent on sectors where local knowledge and specialisation are crucial. This poses some potential risks for these regions regarding their competitiveness, absorptive capacity, and level of development and growth. Hence, it is crucial to design regional, industrial, and technological policies that align with the region's growth potential, unique competencies, attributes, and objectives. Furthermore, the differences between regions that prioritise increasing regional competitiveness and developing local knowledge and those that prioritise improving global competitiveness through industrial and technological policies, as well as other horizontal policies, should not be neglected. Implementing such policies will help regions increase their competitiveness, capacity, and level of development in the long run.

The importance of proximity to knowledge for R&D firms is a factor that increases the stickiness of knowledge in certain regions of Türkiye. To constrain this, regions need to overcome their deficiencies in physical accessibility, institutional capacity, absorptive capacity, intra- and extra-regional knowledge spillovers and networking opportunities. Taking steps to this end, considering the interactions between regions and sectors, global sectoral trends, and the type of knowledge and human capital required by firms will also help develop R&D, innovation, and entrepreneurship ecosystems.

Another downside of the strong tendency of R&D firms to locate in Istanbul and the Marmara region is that the area is a high-risk earthquake zone. On February 6, 2023, an earthquake struck southeastern Türkiye, killing many people and causing irreparable material and moral damage to the public, region and Türkiye. Regarding economic concerns, the negative impact of earthquakes on the accumulation of social and human capital, including implicit knowledge and local knowledge, capabilities, and competencies, is quite significant. Based on this experience, predicting the adverse effects of a possible future Marmara earthquake on the Turkish economy is not difficult. Although the region affected by the February 6 earthquakes and the Marmara differ in production structure and diversity of factors, the potential threat to industrial production and knowledge resources should not be underestimated. Accordingly, knowledge resources and industry in Marmara should be shifted to other suitable regions.

Future studies must elucidate the impact of different firm-specific and particularly entrepreneur-specific location factors. Moreover, a sub-national scale analysis would effectively highlight the critical role of local knowledge and specialisation. The relocation strategies of R&D firms and the multi-location strategies of firms that may conduct R&D activities outside their headquarters or in multiple locations are also worth investigating. Through this, it will be possible and interesting to examine the impact of localised knowledge from different regions on a firm's location choice.

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Appendix Table: A
NUTS Definitions of Statistical Regions of Türkiye

Level 1		Level 2	
Code	**Name**	**Code**	**Name**
TR1	Istanbul	**TR10**	Istanbul
TR2	Western Marmara	**TR21**	Tekirdağ, Edirne, Kırklareli
		TR22	Balıkesir, Çanakkale
TR3	Aegean	**TR31**	Izmir
		TR32	Aydın, Denizli, Muğla
		TR33	Manisa, Afyon, Kütahya, Uşak
TR4	Eastern Marmara	**TR41**	Bursa, Eskişehir, Bilecik
		TR42	Kocaeli, Sakarya, Düzce, Bolu, Yalova
TR5	Western Anatolia	**TR51**	Ankara
		TR52	Konya, Karaman
TR6	Mediterranean	**TR61**	Antalya, Isparta, Burdur
		TR62	Adana, Mersin
		TR63	Hatay, Kahramanmaraş, Osmaniye
TR7	Central Anatolia	**TR71**	Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir
		TR72	Kayseri, Sivas, Yozgat
TR8	Western Black Sea	**TR81**	Zonguldak, Karabük, Bartın
		TR82	Kastamonu, Çankırı, Sinop
		TR83	Samsun, Tokat, Çorum, Amasya
TR9	Eastern Black Sea	**TR90**	Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane
TRA	Northeastern Anatolia	**TRA1**	Erzurum, Erzincan, Bayburt
		TRA2	Ağrı, Kars, Iğdır, Ardahan
TRB	Middle Eastern Anatolia	**TRB1**	Malatya, Elazığ, Bingöl, Tunceli
		TRB2	Van, Muş, Bitlis, Hakkari
TRC	Southeastern Anatolia	**TRC1**	Gaziantep, Adıyaman, Kilis
		TRC2	Şanlıurfa, Diyarbakır
		TRC3	Mardin, Batman, Şırnak, Siirt