EXPORTING AND PRODUCTIVITY: EVIDENCE FROM TURKISH AUTOMOTIVE SECTOR

A Master's Thesis

by

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To my family.

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The Graduate School of Economics and Social Sciences
of
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I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Economics.

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ABSTRACT

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This thesis analyzes the determinants of export performance of the Turkish automotive manufacturers by focusing on firm-level productivity changes. We use the dataset obtained from Automotive Manufacturers Association (OSD) for the time period 2001-2019, and we have a panel data of 18 firms that produce motor vehicles. We calculate the productivity changes of the firms by applying Malmquist Productivity Change Index, which is commonly used in the literature. Analyzing two different dependent variables, export amounts and the share of exports in production, we find that increase in firm-level productivity leads to higher amounts of exports. Moreover, the impact of productivity on share of exports is relatively weaker for the Turkish automotive manufacturers.

Keywords: Exporting, Productivity, Malmquist Productivity Change Index, Turkish Automotive Sector.

ÖZET

TÜRKİYE OTOMOTİV SEKTÖRÜNDE İHRACAT VE VERİMLİLİK ÜZERİNE AMPİRİK BİR ÇALIŞMA

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Tez Danışmanı: Doç. Dr. Fatma Taşkın

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Bu tez, firma düzeyindeki verimlilik değişimlerine odaklanarak Türk otomotiv üreticilerinin ihracat performansının belirleyicilerini analiz etmektedir. 2001-2019 dönemi için veri setimizi Otomotiv Sanayii Derneği'nden (OSD) elde ettiğimiz veriler oluşturmaktadır. Ayrıca, veri setimiz motorlu taşıt üretimi yapan 18 adet firmadan oluşmaktadır. Firmaların verimlilik değişimleri literatürde yaygın olarak kullanılan Malmquist Verimlilik Değişim İndeksi kullanılarak hesaplanmıştır. İhracat miktarları ve ihracatın üretim içindeki payı olmak üzere iki farklı bağımlı değişkeni analiz ettiğimizde, firma düzeyindeki verimlilik artışının firmaların ihracatlarını arttırdığı görülmektedir. Ayrıca, verimliliğin ihracat payı üzerindeki etkisi Türk otomotiv üreticileri için nispeten daha zayıftır.

Anahtar Sözcükler: İhracat, Verimlilik, Malmquist Verimlilik Değişim İndeksi, Türk Otomotiv Sektörü.

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CHAPTER 1

INTRODUCTION

Based on the annually data released by Turkish Exporters Assembly (TEA), the automotive industry has been the leading sector in terms of export volume in Turkish exports since 2006. In such a case, analyzing the exports performance of Turkish automotive industry is useful to suggest policy implications which will foster the economic growth since exports have a key role in Turkey's GDP. While examining the exports performance of Turkish automotive manufacturers, one cannot ignore the fact that firm-level productivities play a determining role in firms' export performances by improving the comparative advantage and lowering costs in all exporting decisions. Therefore, we can argue that there should be a relationship between productivity changes and changes in export amounts.

In the explanations of export values both in theoretical and empirical studies, it can be seen that the relationship between exporting and productivity is discussed frequently. Basically, there are two hypotheses regarding that relationship: self-selection and learning-by-exporting. Self-selection hypothesis argues that more productive firms go into the export market, and export more. On the other hand, learning-by-exporting hypothesis argues that firms increase their productivity by exporting. For example, Bernard and Jensen (1995) study on US exports and productivity, and finds evidence for only self-selection. Similarly, Aw and Hwang (1995) investigate the Taiwan's exports and finds no evidence for learning-by-exporting, while their findings support the self-selection hypothesis. On the other hand, the study by Blalock and Gertler (2004) supports the learning-by-exporting hypothesis, but their results do not promote the self-selection hypothesis for Indonesian firms.

While assessing the relationship between exports and firm performance, studies use different approaches to measure productivity levels of firms. Olley and Pakes (1996) method of total factor productivity estimation and labor productivity measures are the approaches adopted by researchers frequently. On the other hand, we use a different approach to measure the firm-level productivities by another widely used method in the literature, which is Malmquist Productivity Change Index. The basic reason we adopt such strategy is that we do not want to make assumptions about the production functions of the firms. Rather, we use non-parametric and non-stochastic analysis by using physical inputs and outputs. Moreover, our data set enables us perform such an analysis with different combinations of inputs and outputs.

This study aims to explore the determinants of the Turkish automotive manufacturers' export performance by focusing on the firm level productivity changes. To the best of our knowledge, this thesis is the first study which uses Malmquist Productivity Change Index to examine the impact of productivity changes on firms' export performances even though there are studies which focus only on productivity changes of the firms in Turkish automotive sector.

The organization of the paper as follows: section 2 gives information about the related literature; section 3 explains the background of the Turkish automotive sector, section 4 defines the methodology used in the analysis where section 5 reports the data and empirical results. In section 6, we present our robustness checks with different specifications. Finally, we give the concluding remarks in section 7.

CHAPTER 2

RELATED LITERATURE

In the previous literature, we can see that the relationship between exporting and productivity has been studied widely. In theoretical work, the trade theory of Ricardo explains comparative advantage by productivity differences across countries. Melitz (2003) presents the existence of costs of entering the foreign trade has an important impact on how the different types of firms are affected by trade. He argues that firms must be productive to be able to join the export market so that the firms can afford the costs of exporting, fixed costs, and foreign trade, iceberg trade costs. His model shows that the firms' gains from trade are affected by export costs significantly. More productive firms have higher gains from trade in terms of market share and profit, while less productive firms have no gains from trade.

Moreover, Bernard et al. (2003) introduce the imperfect competition into Eaton and Kortum's (2002) framework, and the firms are heterogeneous in terms of their efficiency levels. Their model matches the data of U.S. manufacturing plants by emphasizing on the importance of export costs, efficiency differences which create heterogeneity in market power of the firms, productivity levels and geographic barriers.

As we mentioned above, literature mainly focuses on two hypotheses: self-selection and learning-by-exporting. For instance, Bernard and Wagner (1997) analyze whether exporters outperform non-exporters by using the German manufacturing data. Their findings suggest that exporters perform better than non-exporters before starting to export, and exporters in German manufacturing sector have higher productivity levels than non-exporters. Moreover, they show evidence that more productive firms become exporters, which is a supporting evidence for self-selection hypothesis. Moreover, Castellani (2002) finds evidence that supports self-selection hypothesis as well by analyzing Italian manufacturing firms over the period 1989-1994. Further, Wagner (2002) can be given as another study that supports self-selection. He uses a panel data from Germany at the plant level and by applying a matching approach, he finds that exporters have better performance than non-exporters before beginning to export. Similar to the Bernard and Jensen (1995), there is again evidence that favors self-selection hypothesis while there is no evidence for learning-by-exporting in Bernard Jensen (1999) by using US data. More recently, the study by Brakman et al. (2020) focuses on the Dutch firms that have high productivity levels but non-exporters for the period 2010-2016. Their findings suggest that firms need to be productive to be able to export, but being productive is not sufficient. Along with having high productivity levels, they argue that firm size, foreign ownership, worker skills and capital intensity factors play an important role in determining export status. Moreover, Faustino and Matos (2015) examine the exports of Portuguese manufacturing firms with the data set consisting of 277 manufacturing firms over the period 2006-2010, and they report that productivity, wages and firm size have a positive impact on Portuguese exports. However, their empirical model finds no statistically significant effect of R&D expenditures on Portuguese exports.

On the other hand, there are few studies that report evidence for learning-by-exporting hypothesis but no evidence for self-selection. For instance, Blalock and Gertler (2004) analyze the Indonesian manufacturing sector, and they report strong evidence for Indonesian firms that their productivity levels increase by 2% to around 5% after their entry to the export markets. They argue that productivity levels may increase by exporting through learning from their trading partners in poorly developed economies. Similarly, Van Biesebroeck (2005) investigates the sub-Saharan Africa, and he reports that African exporters face increases in their productivity levels, but this increase happens after they start exporting. These results also support learning-by-exporting hypothesis. Moreover, De Loecker (2004) shows evidence for learning-by-exporting by using firm-level data of Slovenian manufacturing sector over the period 1994-2000.

There are some studies which report evidence for both hypotheses. Greenaway and Kneller (2004), Greenaway and Yu (2004) and Girma et al. (2004) for UK; Baldwin and Gu (2003, 2004) for Canada can be given as examples for those studies that support both approaches. In addition, Clerides et al. (1998) analyze three different countries: Colombia, Mexico and Morocco. Their findings support the both hypotheses for Morocco, yet for Colombia and Mexico, results are in favor of self-selection hypothesis. On the other hand, Lopez (2004) for Chile and Greenaway et al. (2003) for Sweden report that the results do not support any of the hypotheses. Therefore, we can claim that the relationship between export and productivity differs across countries due to their economic status, even there is no relationship in some countries. Such a variety can make researchers face difficulties while they try to come up with general policy implications.

There are also studies which analyze the relationship between Turkish manufacturing sector exports and the productivity levels of the firms. For example, Dalgıç et al. (2014) examine the impact of foreign trade on productivity improvement of the Turkish manufacturing firms which they categorize as only importers, only exporters and both importers and exporters, for the period 2003-2010. Their data consists of private Turkish manufacturing firms which employ more than 20 people, and total number of firms is 17,700 on average. They use Propensity Score Matching and Differences-in-Differences techniques, and they report that international trade, both importing and exporting, has a positive and significant impact on both total factor productivity (TFP) and labor productivity (LP) of Turkish manufacturing firms. They calculate the TFP by using Levinsohn and Petrin's (2003) method, so that their approach is semi-parametric. Their results suggest that learning-by-importing has a larger impact than learning-by-exporting on Turkish manufacturing firms.

Moreover, the another study by Dalgıç et al. (2015) focuses on the self-selection hypothesis with the role of variable and sunk costs in importing and exporting. for the Turkish manufacturing firms with more than 19 employees over the period 2003-2010. By estimating dynamic panel data, their results suggest that participating in international trade is associated with the firms' higher performance before entering to foreign trade. Moreover, they report that only importer firms have larger pre-entry productivity than only exporter firms in Turkish manufacturing sector. Finally, they find that there is a variation between sunk costs of importing and exporting, and importers face higher sunk costs than exporters do.

Another study by Dalgıç et al. (2021) analyzes the post-entry effects of exporting to countries with different income levels on productivity growth of firms. They again employ Propensity Score Matching method with Differences-in-Differences technique. They measure the TFP as a residual of inputs under Cobb-Douglas production function by using generalized method of moments (GMM) estimation technique. The findings of the study show that learning-by-exporting effects are the largest when firms export to both high income and middle low income countries. Moreover, firms that export only to high income countries have larger productivity improvement than the firms which export only to middle income countries.

Automotive sector is one of the largest exporting sectors in Turkish manufacturing, and according to the data has been announced by Turkstat and TEA, automotive sector has been at the top among the exporting sectors since 2006. As expected, such a successful sector draws the attention of researchers. Darby (2009) analyzes the effect of economic integration with Europe and liberalization process during 1990s on Turkish automotive sector in comparison with Australian automotive sector. His findings report that Turkey faces a successful growth in automotive sector exports and developments in the production facilities such as plants which can be also counted as a success for the Turkish economy. Moreover, there are papers which investigate the competitiveness of Turkish automotive sector. Bekmez and Komut (2006) and Kara et al. (2020) can be given as examples to such studies. Bekmez and Komut (2006) compare the Turkish automotive sector within the European Union and the world by using Revealed Comparative Advantages and Least Squares Regression methods. Their results suggest that Turkish automotive sector presents improvements in terms of competitiveness between 1995-2004. In addition, Kara et al. (2020) use the data of Turkish automotive firms that are dealt in Borsa Istanbul, and they assess the firms' productivity and efficiency levels along with the export competitiveness in Turkey for the period 2007-2017. They use Data Envelopment Analysis, Malmquist Total Factor Productivity methods, and Revealed Comparative Advantage indices, and their findings suggest that productivity of Turkish automotive sector has increased in the time period, and its global competitiveness performed in low levels among the other countries. Furthermore, there are also studies regarding productivity analysis in Turkish automotive sector. First, Lorcu (2010) analyzes the productivity levels 14 firms over the period 2003-2007 by using Malmquist productivity index approach with Data Envelopment Analysis. Moreover, Çalmaşur (2016) discusses the technical efficiency in Turkish automotive sector by using panel data with 20 firms over the period 1992-2011 through Stochastic Frontier Analysis approach. Again, by using Turkish automotive sector data from Automotive Manufacturers Association (OSD), Çoban et al. (2018) measure the productivity levels of 14

Turkish automotive manufacturers between the period 2011-2015 through Data Envelopment Analysis and Malmquist productivity index, but they do not focus on the exports performance of the firms. They find that productivity level of Turkish automotive industry increased by 14% between 2011 and 2015. Table 1 presents the input-output combinations used in autmotive sector to calculate Malmquist Productivity Change Index.

Table 1: Input-output combinations used to calculate Malmquist Productivity Index in previous studies

Study	Year	Sector/Country	Inputs	Outputs
Yılmaz, Özdil & Akdoğan	2002	9 automotive companies, Turkey	Net Assets, Capital Stock Labor	Turnover, Profit BT Exports
Bakırcı	2006	13 Turkish Automotive companies	Net Assets, Equity Labor	Net Sales. Profit BT Exports
Karaduman	2006	17 Turkish Automotive companies	Payment For Raw Materials Labor	Domestic Sales, Exports Capacity Usage
Çoban	2007	17 Turkish Automotive companies	Capital and Payment for Labor	Total Production
Ayan & Perçin	2009	Automotive industry, Turkey	Net Assets, Labor Equity	Net Sales Profit AT
Lorcu	2010	Automotive industry, Turkey	Total Assets, Equity Admin., dist and selling expenses	Net profit margin, Return on Equity Return on Assets
Maritz & Shieh	2013	Automotive Manufacturers in Taiwan	Labor, Operating Cost Gross Assets	Operating Income
Tran & Ngo	2014	Vietnamese Auto Industry	Capital Labor	Total Production and Turnover
Yaylalı & Çalmaşur	2014	Automotive Industry, Turkey	Payment For Raw Materials Labor	Turnover
Tatlı & Bayrak	2016	Automotive firms BIST (11 firms) Turkey	Equity, Payment For Raw Materials and Labor R&D Investment	Turnover, Exports Profit
Nurcan & Kaya	2016	17 World Automotive Companies	Total Assets, Total Equity Labor	Gross Profit and Net Income
Hussain, Md-Rus & Al-Jaifi	2017	Auto and parts production in Pakistan	Total assets, Operating Costs Selling Expenses	Net Sales
Gedik, Koçarslan & Karaer	2017	Automotive Industry, Turkey	Net Assets, Equity Labor	Net Sales, Profit BT Exports
Jiang, Han, Ding & Hei	2018	Chinese automotive manfactureres, 77 listed A-share firms	Fixed and Intangible Assets, Labor and Operating Expenses	Operating Income
Wang, Tibo & Nguyen	2020	20 Top Global Automotive Manufacturers	Total Assets, Equity, Cost of Revenue and Operating Expenses	Revenue and Net Income

Maggioni (2010) investigates the linkage between productivity and exports of Turkish manufacturing industries by using plant-level data for the period between 1990 and 2001. She finds evidence for both self selection and learning-by-exporting hypotheses in Turkish exports, yet her findings support especially the learning-by-exporting hypothesis. In addition, Atiyas and Bakis (2013) also examine the relationship between Turkish exports and productivity by using the firm-level data for the years between 2006 and 2010. Their paper focuses on the regional productivity differences by comparing new and traditional industrial regions, and they find that traditional industrial centers have higher productivity levels and they perform better in terms of exporting, yet they observe productivity catch-up by new industrial regions which are also called as Anatolian Tigers. Further, Yasar and Paul (2007) analyze the relationship between productivity and international linkages such as foreign direct investment, imports, exports and licensing. They use the plant-level data from apparel, textiles and motor vehicles industries for the years between 1990 and 1996. Their findings suggest that firms that are engaged in international linkages face higher productivity levels. More specifically, they report that plant-level productivity has a positive relationship with exporting, and the share of skilled labor increase the productivity levels of plants. Guloglu and Bayar (2016) try to determine the factors that have an effect on Turkish manufacturing exports. Their results suggest that GDP of the partner is the most important factor that affects the Turkish exports. Moreover, productivity has a positive effect on exports in 12 of 22 manufacturing sectors, yet real exchange rate has a negative effect on exports in 12 of 22 sectors.

This paper focuses on the firms that are already in export market and we seek an answer to the question whether automotive manufacturers with higher productivity levels have higher amount of exports in Turkey for the 2001-2019 period. It should be noted that most of the studies in the literature analyze both exporter and non-exporter firms. However, it is not really possible to observe nonexporting firms in Turkish automotive sector in terms of motor vehicle production. It is mainly because of the fact that automotive sector is a global organization. In Turkish automotive sector, firms were established in terms of partnerships as a consequence of foreign direct investments (FDI). This can be seen in the data set of OSD, most of the firms have foreign shares in their capital. The other firms which do not have foreign capital produce motor vehicles by using the licence of other global motor vehicle producers. In such a case where the automotive production is a global organization shaped by multinational firms, it is not likely to observe a motor vehicle producer which is not exporting. This is the case for Turkish automotive production, the firms in Turkish automotive sector that are in the data set are all exporters over the period 2001-2019.

CHAPTER 3

TURKISH AUTOMOTIVE SECTOR

First attempt for domestic production in the Turkish Automotive sector can be seen in the early 1960s with the project called as *Devrim* which was meant to be the first domestic automobile in Turkey. After the failure of the *Devrim* project, the first production plant was established in Sakarya by Otokar in 1963 with the license of German manufacturer Magirus Deutz. In the following years, other firms such as B.M.C and Askam were established in 1964, and Askam had the license of Japanese manufacturer Hino. Moreover, A.I.O.S., Karsan and M.A.N. Türkiye started the production of vehicles in 1966 with licenses of Japanese producer Isuzu, French producer Peugeot and German manufacturer M.A.N., and they were followed by M.Benz Türk in 1968 with the license of German manufacturer Mercedes-Benz (OSD, 2020). In 1966, Ford Otosan attempted an another domestic car production which was called *Anadol* and the project was successful (Taymaz and Yılmaz, 2017) . In 1971, OYAK Renault and TOFAŞ established their production plants in Bursa with licence of French producer Renault and Italian manufacturer Fiat respectively, and started the production. Taymaz and Yılmaz (2017) argue the importance of Five Year Development Plans (FYDP) in the development of Turkish automotive industry. Especially in the process of second FYDP which was implemented between 1968 and 1972, we can observe that the production capacity of Turkish automotive sector increased from less 4000 units in 1970 to 72 thousand in 1975. The main reason for the huge jump in production levels can be argued as the entrance of OYAK Renault and TOFAŞ since these firms started to produce passenger cars with high production capacity and the other firms were producing basically buses and trucks. From Table 2, production capacities for Turkish automotive sector in early years can be observed.

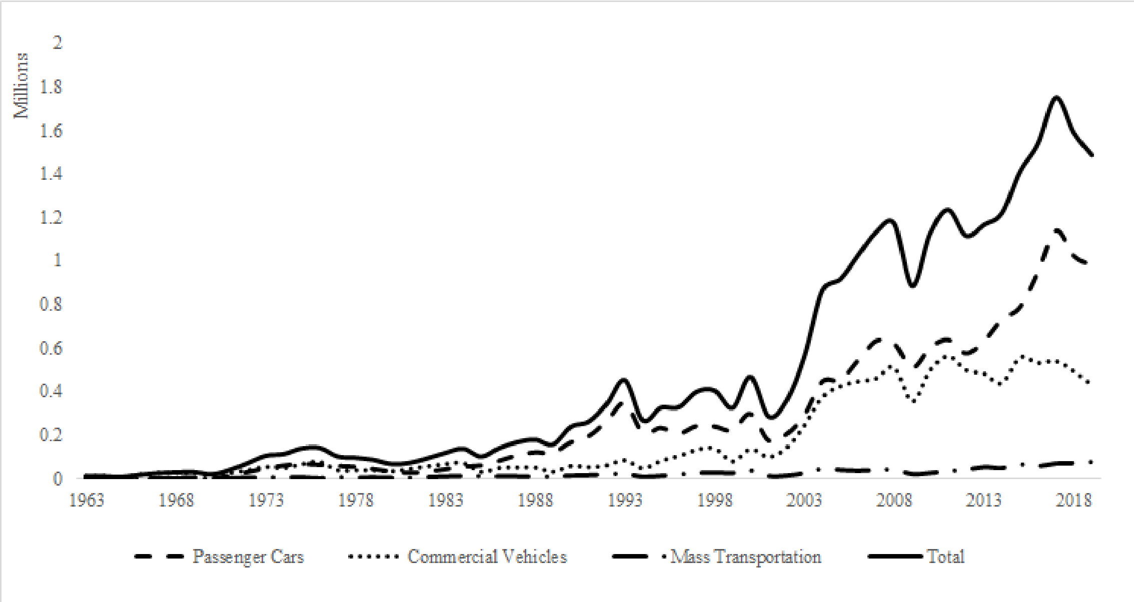
Table 2: Total production capacity through the years.

Year	**Total Capacity**
1970	87000
1985	94000
1990	230000
2000	690000
2010	1560000
2019	2100000

Source: Uçan(2005); OSD(2010, 2019)

In 1980s, new production facilities were established. Ford Otosan (in Eskişehir, 1983), M.Benz Türk, as the second production plant, (in Aksaray, 1985) and Temsa (in Adana, 1987) are the firms that started production of vehicles in 1980s. Turkish automotive sector started to draw attention of Far East automotive producers in 1990s, and as a consequence of low tariffs due to trade liberalization in 1980s, Toyota started producing passenger cars in Sakarya, in 1994, where Honda Türkiye and Hyundai Assan were established in Kocaeli, in 1997 and they started the production (Taymaz and Yılmaz, 2017).

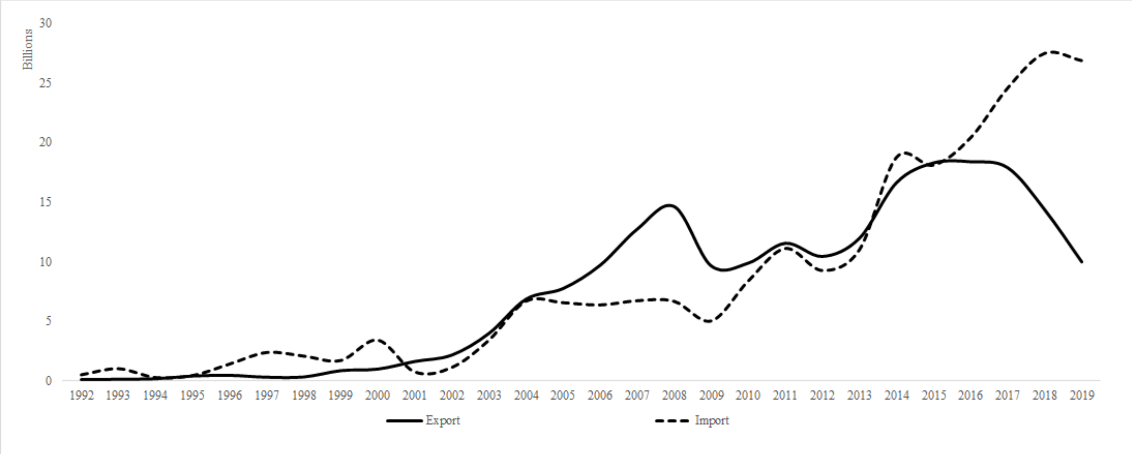
Figure 1: Production units



Source: OSD. Authors' calculations.

Figure 1 above shows the production units of Turkish automotive sector in terms of passenger cars, commercial vehicles and mass transportation vehicles for the time period between 1963 and 2019. As we can see in the figure, until the late 1980s production of motor vehicles are somehow stable. The first jump in the production of Turkish automotive sector begins at the end of 1980s and the early 1990s. We can claim that the reason for this jump is the effect of trade liberalization and export-oriented policies imposed by Turkish government in mid-1980s. The 1994 crisis has a negative impact on Turkish automotive industry by decreasing the production by 41 percent, and later in the 1990s, production levels fluctuate until 2001 crisis(Taymaz and Yılmaz, 2017). In 2001, the production amounts again decrease by over 40 percent due to banking crisis. With the election of new government and the help of the recovery policies, production levels increase by more than 200 percent in 2008 compared to 2001, and it is followed by almost 20 percent decrease in 2009 because of the Great Recession. After the recession, Turkish automotive sector keeps increasing its production amounts reaching almost 1.8 million units in 2017, all time high. However, with the currency crisis in 2018, again we observe a decline in the production amount of motor vehicles in Turkey.

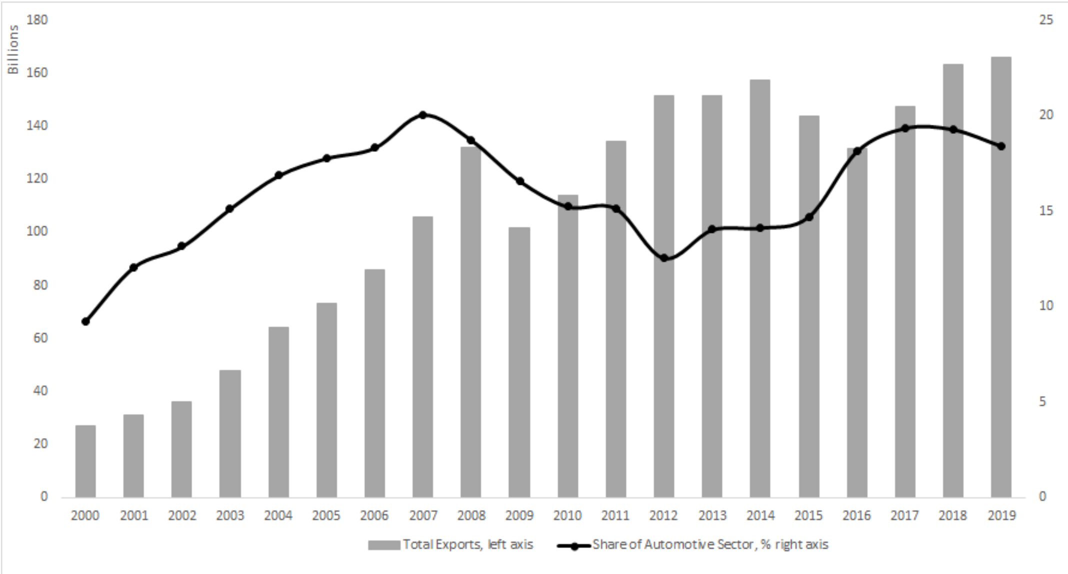
Figure 2: Export and import amounts



Source: Turkstat. Authors' calculations.

Figure 2 presents the export and import amounts of the Turkish automotive industry for the time period 1992-2019 in billion US dollars. We observe that in the pre-crisis period, Turkish automotive sector has a positive trade balance. However, after the crisis, the trade balance starts to decrease with the increase in the automotive imports. Furthermore, after 2015, imports become larger than the exports and the automotive industry in Turkey has a negative trade balance with the contribution of depreciation of the Turkish Lira against US dollars as amount of exports and imports is around 10 billion and 27 billion US dollars, respectively. Moreover, the effect of crises domestic or internationally can be observed in the graph for the years 2001, 2009 and 2018.

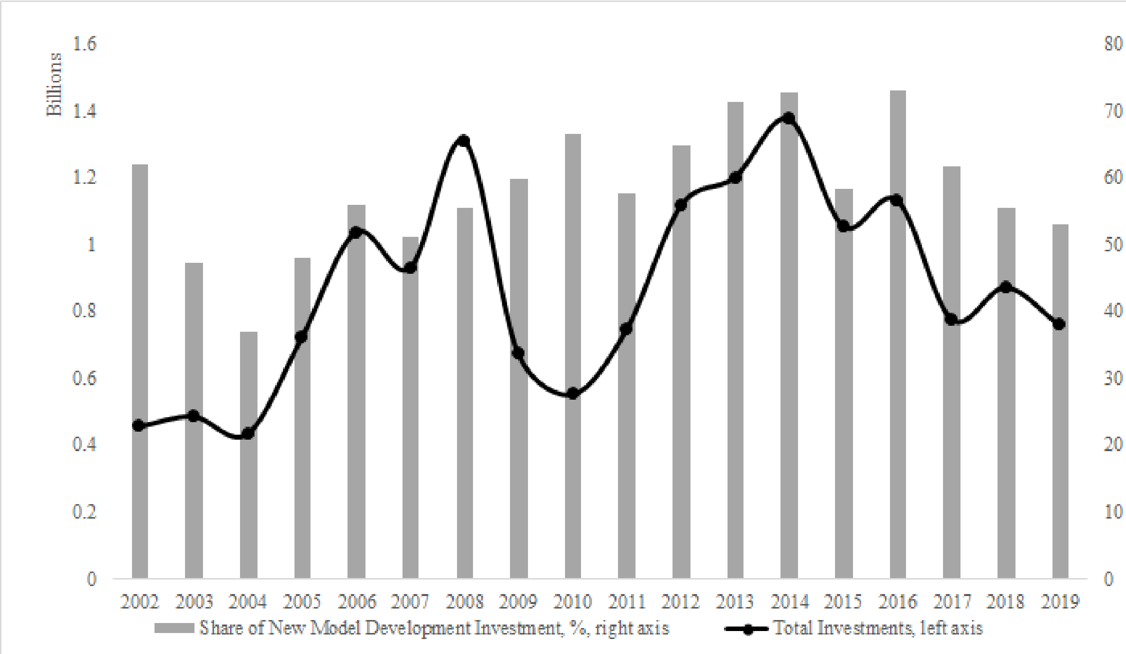
Figure 3: Share of Automotive Sector Exports



Source: TEA. Authors' calculations.

Figure 3 shows the total amount of exports of Turkey and the share of Turkish automotive sector exports in total exports. as we can see from the graph, the share of automotive sector exports is increasing as total exports of Turkey increases until the Great Recession. Turkish automotive sector reaches its all time highest as the share of exports is around 20 percent in 2007, and it is followed by 19 percent in 2008. As a consequence of Great Recession, the share of automotive industry exports decreases as total exports decreases in 2009, as well. However, while the total exports stars to recover and increase, it can be seen that the share of automotive sector still decreases. One conclusion that we can derive is that the Great Recession has a huge negative impact on automotive sector, as it is also clear in the Figure 2, as well. Despite the fact that we observe decreasing export shares of automotive industry after the crisis, based on TEA statistics, Turkish automotive sector is still the top sector in Turkish exports while its export share is around 15 percent between 2010 and 2015. After 2015, export share of automotive sector starts increasing with the effect of decreasing total exports, and it reaches almost 20 percent in 2019. Such a successful performance of automotive industry as it has the highest export share among other sectors for over than a decade is worth analyzing in terms of policy suggestions for other sectors to increase total exports. While analyzing the export performance, it is important to analyze the productivity levels since more productivity leads to less trade costs, thus increasing the benefits from exporting as it is suggested by both theoretically and empirically.

Figure 4: Investment in automotive sector



Source: OSD. Authors' calculations.

Figure 4 shows the total investment made in Turkish automotive sector and the share of investment made in new development of motor vehicles. We can see the increase in total investment made from 2002 to 2008. However, total investment decreases with the effect of Great Recession. After the crisis, the amount of total investment increases almost to 1.4 billion US dollars, which is all time high. However, after hitting the all time high amount, total investment decreases to less than 1 billion US dollars in 2019. Similar to total investment, share of investment made in new development tends to decrease after 2014 from 70 percent to below 40 percent, gradually.

Next, we present some statistics on firm level in Table 3. For example, HONDA

TÜRKİYE, OYAK RENAULT and TOYOTA are the firms that are producing only passenger cars. Their shares of total exports are 31%, 76% and 78%, respectively. Moreover, HONDA TÜRKİYE employs around 845 people, where OYAK RENAULT employs 5700 and TOYOTA employs 3300 people, on average. HONDA TÜRKİYE has 95% of its capital as foreign capital, whereas OYAK RENAULT has 51% and TOYOTA has 99% as foreign capital of their capital. We can add HYUNDAI ASSAN to these firms since it has share of total exports as 63% and share of passenger cars exports is around 60%. It mainly produces passenger cars and pick-ups, and the share of commercial vehicles exports is around 3%. HYUNDAI ASSAN employs around 1900 people on average, and has 70% of foreign capital in its capital. Furthermore, HATTAT TRAKTÖR, TÜRK TRAKTÖR and UZEL are the firms that have production of only tractors. TÜRK TRAKTÖR and UZEL have around 35% and 36% as a share of total exports in production amounts respectively, where HATTAT TRAKTÖR has 15% as a share of exports in total production. TÜRK TRAKTÖR is the firm that employs the most people between these three firms with an amount of 1850 people on average. On the other hand, HATTAT TRAKTÖR and UZEL employ 150 and 1100 people, respectively. Moreover, HATTAT TRAKTÖR AND UZEL has no foreign share in their capital, yet foreign capital consists 38% of TÜRK TRAKTÖR's capital. Further, we argue that ASKAM, B.M.C., FORD OTOSAN, KARSAN, M. BENZ TÜRK and TOFAŞ are Turkish automotive manufacturers that export mostly commercial vehicles as a share of their production. ASKAM produces only pick-ups and exports 10% of its production, with around 342 employees, and ASKAM has no foreign share in its capital. Similar to ASKAM, B.M.C. and KARSAN have no foreign share in their capital, as well. B.M.C. mainly focuses on the production of trucks, as KARSAN produces mostly pick-ups. In addition, B.M.C. has 10% share of commercial vehicles exports, where its total exports account for 15% of its total production. KARSAN has 43% share of total exports, and 37% share of commercial vehicles exports, and its number of epmloyees is around 900, where we see that B.M.C. employs 2300 people on average. FORD OTOSAN, M.BENZ TÜRK and TOFAŞ are the remaining firms that have highest share of exports as commercial vehicles exports in their production amounts. FORD OTOSAN has a share of 70% total exports in its production, and 62% of commercial vehicles exports, and produces mostly pick-ups. It employs 8600 people on average, and 41% of its capital is obtained from foreign capital. Moreover, the share of total exports of M.BENZ TÜRK is around 40% and it has 22% share of commercial vehicles exports. It mainly produces trucks with 4800 employees on average, and foreign capital consists of 85% of its capital. As the last firm of the remaining ones, TOFAŞ has almost 65% of total exports share, and 35% of commercial vehicles export share. It employs 6650 people and produces mainly pick-ups. Its foreign share in capital is around 38%. Finally we can talk about the firms that have high share of transportation vehicles exports. These firms are: A.I.O.S., M.A.N TÜRKİYE, OTOKAR, OTOYOL and TEMSA. Among these firms, OTOKAR and TEMSA have no foreign share in their capital. They have similar total exports share with around 30%, where OTOKAR has 15% share of transportation vehicles exports and TEMSA has 21% share. The number of employees is also similar for these automotive manufacturers, OTOKAR and TEMSA have around 1500 and 1450 people hired, respectively. OTOKAR produces mostly midibuses, where TEMSA focuses on the production of trucks. Similar to TEMSA, A.I.O.S. also focuses on truck production, yet share of transportation vehicles exports is lager than share of commercial vehicles exports. Total export share is around 20%, where the share of transportation vehicles exports is around 15% for A.I.O.S. It employs 700 people on average and has a 30% of foreign capital. Moreover, M.A.N TÜRKİYE has a share of total exports slightly more than 72% and the share of transportation vehicles exports is almost 72%. It produces mostly buses with number of people employed around 2000, and foreign capital has the share of 99%. Finally, OTOYOL produces mostly trucks with 1770 people employed on average. Its total vehicle export share is around 27% and transportation vehicles share is around 14%. Moreover, Foreign capital accounts for around 30% of the firm's capital.

Table 3: Some Firm-Level Statistics.

Variable	A.I.O.S	ASKAM	B.M.C	FORD OTOSAN
Total Export Sh.	0.20	0.10	0.15	0.69
Passenger C. Export Sh.	0	0	0	0.02
Commercial V. Export Sh.	0.05	0.10	0.10	0.62
Transp. V. Export Sh.	0.15	0	0.05	0.05
Total Labor	707	343	2304	8601
Foreign Share	0.30	0	0	0.41

Variable	HATTAT T.	HONDA T.	HYUNDAI A.	KARSAN
Total Export Sh.	0.16	0.31	0.63	0.43
Passenger C. Export Sh.	0	0.31	0.59	0
Commercial V. Export Sh.	0.16	0	0.03	0.37
Transp. V. Export Sh.	0	0	0.01	0.07
Total Labor	146	845	1919	904
Foreign Share	0	0.95	0.68	0

Variable	M.A.N T.	M.BENZ T.	OTOKAR	OTOYOL
Total Export Sh.	0.72	0.40	0.29	0.27
Passenger C. Export Sh.	0	0	0	0
Commercial V. Export Sh.	0	0.22	0.14	0.13
Transp. V. Export Sh.	0.72	0.18	0.15	0.14
Total Labor	2051	4810	1483	769
Foreign Share	0.99	0.85	0	0.27

Variable	O. RENAULT	TEMSA	TOFAŞ	TOYOTA
Total Export Sh.	0.76	0.27	0.64	0.78
Passenger C. Export Sh.	0.76	0	0.28	0.78
Commercial V. Export Sh.	0	0.06	0.35	0
Transp. V. Export Sh.	0	0.21	0	0
Total Labor	5724	1444	6653	3305
Foreign Share	0.51	0	0.38	0.99

Variable	TÜRK T.	UZEL
Total Export Sh.	0.35	0.36
Passenger C. Export Sh.	0	0
Commercial V. Export Sh.	0.35	0.36
Transp. V. Export Sh.	0	0
Total Labor	1849	1102
Foreign Share	0.38	0

Source: OSD.

The majority of the data on production variables and exports are gathered from the reports of OSD, most of which are available at firm level. The main variables are production quantities reported for each type of transportation equipment, capacity of production, labor, both as total and as skilled and unskilled forms, covered area, total production capacity, rate of capacity usage, capital, foreign share of the firm, country of origin of parental company, and total area of the plant. Firm level exports of each type of transport equipment are reported annually for 2001-2019.

In this study, in conducting the DEA analysis, we define each firm to be one DMU and the best production frontier for all firms participating in the production in a given year to be constructed for the sector by the solution to linear programming problems defined previously. In the computation of Malmquist Productivity Change Index, inputs are chosen to be labor, at different skill levels as high and low skilled labor, and total capacity of production, the output variables are total vehicles produced by the firm and rate of capacity usage.

CHAPTER 4

METHODOLOGY

Productivity is an important component in answering many theoretical and policy questions. Numerous studies are conducted to answer the question on how to correctly and accurately measure the total productivity in production.

Total Factor Productivity (TFP) is geared to measuring the fluctuations in business cycles and growth of output across different countries overtime. The early references to the concept can be found in Smith (1776), who claims that through specialization and division of labor, the firms are able to produce "greater output for the same level of input". A simple performance measure developed from this concept is labor productivity defined as the output per unit of labor but fails to capture the role of other factors of production (Ahmed & Bhatti, 2020).

Many of the growth studies focus on TFP to explain the economic growth. Often cited work is Solow's neoclassical growth model (1956) that attributes productivity growth to exogenous technical progress. Following Solow's work, growth studies by Romer(1986) and Lucas(1988) offered different explanations as the source of productivity change such as the amount of knowledge and human capital in the economy. Further endogenous growth models extended the list of factors that determine the TFP to include research and development, innovation, trade openness or even the standard or quality of institution (Ahmed & Bhatti, 2020).

4.1 Measuring Productivity

Even though there are several different techniques used to obtain the most accurate measure of productivity, there is no consensus in identifying the very best method of measurement. It is possible to compute TFP for different levels of economic activity such as plant, firm, industry or aggregate level. Choices are made according to data or the question of the study. Below we give a brief general classifications of some of the measurement techniques of TFP.

4.1.1 Growth Accounting Method

Growth accounting method of measurement of TFP, growth is due to (1) contribution of factor inputs and (2) the contribution of technological change defined as the "Solow residual". This aggregate measurement of TFP is defined as the unexplained part of the economic progress that is not accounted by the growth of factors of production. This technique, which is used mostly by the macro level studies has its strengths and weaknesses. In addition to data on labor input, it requires data on physical capital stock. To measure capital stock correctly, information on depreciation rates and initial capital stock values are necessary. However some of the assumptions made about these parameters are likely to introduce bias to productivity results. Further weakness will be introduced with additional assumptions on functional form and returns to scale properties of the production.

4.1.2 Growth Regression and Econometric Models

As an extension of the growth accounting techniques is the estimation of a production function and the use of the residual as the measure of productivity. This method that relies on the parametric estimation of the production function suffers from two weaknesses. Like the growth accounting technique, of a function form is selected and all producers are assumed to have the to the same functional behavior without knowing whether the homogeneity condition is satisfied across countries/firms. Another weakness is the assumption that all producers are technically efficient they are all producing on the production frontier.

4.1.3 Frontier Approach

To avoid some of these weaknesses, frontier techniques are offered as an alternative methodology. The frontier approach considers two main sources of economic growth. One is the technical efficiency change, which illustrates the improvement of the position of the producer with respect to a given production frontier for a given input mix. The second source is the technological change which comes from the expansion of the frontier. These frontier methods has been applied to both macro and micro data. The computation can be done by econometric methods, such as the case of the stochastic frontier analysis (SFA) which accepts the existence of technical inefficiencies by creating a discrepancy between potential and observed output. Similar disadvantages exist in this parametric method, where endogeneity and simultaneity problems are likely due to the strong assumptions about the functional forms.

To overcome some of these problems, semi-parametric approaches are suggested by Olley and Pakes (1996) and Levinsohn and Petrin(2003) and Ackerberg et al. (2015). In Olley and Pakes (1996) estimation method, firms are assumed to produce under the Cobb-Douglas production function, and the productivity levels can be derived by using firms' investment levels as a proxy to deal with simultaneity and selection biases. Together with the production function assumption, they also assume that firm's investment is a monotonic function of its capital stock and unobserved productivity. In their semi- parametric model Levinsohn and Petrin(2003) proposes to use the intermediate inputs such as raw materials, as a proxy rather than using investment data so that the loss of observations in estimation of productivity levels caused by the reporting of zero investments can be prevented. Since it is more likely to observe the data of firms' positive use of raw materials and energy consumption, one can have more observations compared to the case where the investment is used as a proxy (Van Beveren, 2012). Another shortcoming of Olley and Pakes (1996) method is the assumption of having flexible labor. In order to deal with the cases where labor is not flexible, Ackerberg et al. (2006) extend the Olley and Pakes (1996) method by estimating the coefficient of labor variable in the second stage of estimation rather than in the first stage so that all the coefficients of inputs are derived in the second stage, whereas in the first stage, the error component in the production function is eliminated (Van Beveren, 2012).

Another frontier approach is the case of Data Envelopment Analysis (DEA) used by the productivity literature. In estimating firm-level productivities, in multi-input and multi-output environments, Data Envelopment Analysis (DEA), where the basic idea is to construct an efficient frontier with the information on the use of inputs and outputs and measure the efficiency of each unit with respect to this best-practice frontier. DEA that was first introduced by Charnes et al. (1978). DEA method provides an advantage over other productivity measurements because of its non-parametric nature where the estimation of productivity levels does not make any assumptions about the form of production or cost functions. Coelli et al. (2005) argue that DEA method has an advantage of being able to implemented without assuming a functional form for the relationship between output and inputs. Moreover, DEA method does not require the prices of outputs and inputs, which in some studies are either difficult to observe or non-available.

Malmquist productivity change index is based on Malmquist Productivity Index initially suggested by Caves et al. (1982). An index is defined as the comparisons of a weighted amount of the inputs to the weighted amount of output contribution. Fare et al. (1994) extended this index to a dynamic measure of TFP that computes TFP growth over time in a cross-country analysis in his application to 17 OECD countries.

4.2 Data Envelopment Analysis

This section provides some insight on the derivation of DEA method following Cooper et al. (2007) and continues by introducing and explaining the Malmquist Productivity Change Index.

In DEA, any entity which is capable of producing outputs by using inputs can be called as decision-making unit (DMU). It is assumed that there are n numbers of DMUs which use N various inputs to produce M different outputs. So, the notation becomes as DMU_j uses x_{ij} amounts of input i and produces y_{rj} amount of output r. Further it is assumed that input and output levels are positive at least for one from each element.

Then the Charnes-Cooper-Rhodes (CCR) model can be described as:

$$\underset{u,v}{max}\theta = \frac{u_1 y_{1o} + u_2 y_{2o} + \cdots + u_M y_{Mo}}{v_1 x_{1o} + v_2 x_{2o} + \cdots + v_n x_{No}} \tag{4.1}$$

subject to

$$\frac{u_1 y_{1j} + u_2 y_{2j} + \cdots + u_M y_{Mj}}{v_1 x_{1j} + v_2 x_{2j} + +v_N x_{Nj}} \leq 1, (j = 1, \ldots, K) \tag{4.2}$$

$$u_1, u_2, \ldots, u_M \geq 0 \tag{4.3}$$

$$v_1, v_2, \ldots, v_N \geq 0. \tag{4.4}$$

where u_r (r = 1, ...M) and v_i (i= 1, ..., N) are the variable weights to be determined by the solution of the maximization problem above and these variable weights maximize the ratio θ (Charnes et al., 1978). Equation (1) is basically the ratio of total outputs produced divided by total inputs used to produce outputs. The constraint in equation (2) tells that the ratio between "virtual output" and "virtual input" should not be more than 1, and the maximum value that optimal objective function, θ^* can get is 1 because of constraints (Cooper et al., 2007). Therefore, we can argue that the weighted sum of outputs can not exceed the weighted sum of inputs. Charnes et al. (1978) transform the fractional problem above into a linear program to make it easier to compute for larger numbers of inputs and outputs. Following Cooper et al. (2007), the model can be written as linear programming transformation:

$$\underset{\mu,v}{max}\theta = \mu_1 y_{1o} + \cdots + \mu_s y_{No} \tag{4.5}$$

subject to

$$v_1 x_{1o} + \cdots + v_N x_{No} = 1 \tag{4.6}$$

$$u_1 y_{1j} + u_2 y_{2j} + \cdots + u_M y_{Mj} \leq v_1 x_{1j} + v_2 x_{2j} + \cdots + v_N x_{Nj}, (j = 1, \ldots, K) \tag{4.7}$$

$$u_1, u_2, \ldots, u_M \geq 0 \tag{4.8}$$

$$v_1, v_2, \ldots, v_N \geq 0 \tag{4.9}$$

As a result of the maximization problem, the (v*, u*) can be obtained as an optimal solution. Then the ratio scale can be obtained as:

$$\theta^* = \frac{\sum_{r=1}^{M} u_r^* y_{ro}}{\sum_{i=1}^{N} v_i^* x_{io}} \tag{4.10}$$

Since the denominator equals to 1 from the constraint, the above equation becomes:

$$\theta^* = \sum_{r=1}^{M} u_r^* y_{ro} \tag{4.11}$$

After finding the optimal θ^*, it can be said that DMU_o is efficient if θ^*=1 and there exists at least one optimal (v*, u*) with v*>0 and u*>0. Otherwise, DMU_o is not efficient.

4.3 Malmquist Productivity Index

This study by using a DEA computations, measures the firm-level productivity with the Malmquist Productivity Change Index. This index measure the growth of the total factor productivity of each firm year by year. The Malmquist productivity index calculates the total factor productivity (TFP) change between two data points by taking the ratio of the distances of each data point to the relevant frontier of the industry in that year. The Malmquist Productivity Index was added to literature by Caves et al. (1982a, 1982b). They calculated the total factor productivity by using Malmquist input and output distance functions. With two different distance functions, these studies computed two different Malmquist productivity indices, which are input-oriented Malmquist productivity index and output-oriented Malmquist index. In the productivity literature, we see a wide range of applications of Malmquist productivity index with studies in banking, agriculture and public utilities. [1]

Following Fare et al. (1994b), we illustrate the derivation of the output-oriented Malmquist productivity change index. It is assumed that for each time period $t = 1, \ldots, T$, the production technology S^t transforms the inputs, $x^t \in \mathrm{R}_+^N$, into outputs, $y^t \in \mathrm{R}_+^M$:

$$S^t = \{(x^t, y^t) : x^t \text{ can produce } y^t\}. \quad (4.12)$$

[1]For example, Hwang and Chang (2003) use DEA-based Malmquist productivity index to measure the efficiency of 45 hotels in terms of managerial performance. They use the number of full-time employees, guest rooms, total area of meal department and operating expenses as input variables and their output variables are room revenue, food and beverages revenues and other revenues for the revenues different than the first two. Moreover, Shah et al. (2019) use DEA-based Malmquist productivity index to measure the efficiency and productivity levels of sustainable banks. They use assets, equity, number of employees and expenses as input variables, whereas the output variables are revenue and profit. Last, Iliyasu et al. (2015) apply the Malmquist productivity index to fishery sector to calculate the productivity growth and efficiency change in Malaysian cage fish farming. Their input variables are stocking density, feed, labor and other costs, where their output variable is the total quantity of fish produce in terms of kilograms.

Moreover, the distance function at time t is defined as follows:

$$D_0^t(x^t, y^t) = inf\{\theta : (x^t, \frac{y^t}{\theta}) \in S^t\} = (sup\{\theta : (x^t, \theta y^t) \in S^t\})^{-1}. \quad (4.13)$$

This function is defined as the inverse of the " maximum" proportional expansion of the output vector y^t, given input x^t. It can interpreted as the maximum proportional change in output required to make the combination (x^t, y^t) an efficient mix on the production frontier. Similarly, the distance functions for time $t + 1$ can also be derived as well.

Fare et al. (1994b) using these above mentioned distance function introduces the output-oriented Malmquist Productivity Change index as geometric mean of two indices. [2]

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \sqrt{\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}} \quad (4.14)$$

In equation (15), first term uses the technology frontier of time period t. The nominator measures the distance to the frontier as if it is producing y^{t+1} units of outputs with x^{t+1} units of inputs under the technology S^t. The denominator measures how far the DMU is from being efficient at time t. Moreover, in the second term distances are calculated with respect to technology frontier in time $t + 1$. The nominator measures the distance between the frontier and the data point at time $t + 1$ under the technology S^{t+1}. The denominator calculates the distance to the frontier as if DMU is producing y^t units of outputs with x^t units of inputs under the technology S^{t+1}. By taking the geometric mean of these two terms, one can obtain Malmquist productivity change index, which is proposed by Fare et al. (1994b).

It is possible to redefine this productivity change index through an algebraic

[2] Caves et al. (1982b) defined the Malmquist productivity index for time t as : $M_{CCD}^t = \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}$

transformation. In this form, the index is decomposed into two parts, such as

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \sqrt{\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}} \tag{4.15}$$

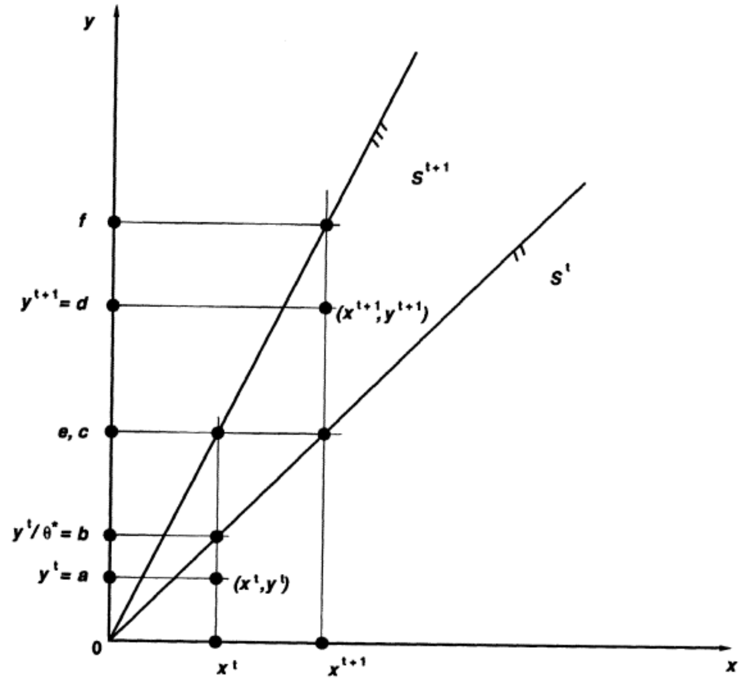
or

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = EFF\_CHANGE \times TECH\_CHANGE \tag{4.16}$$

In this decomposition, first term is the change in technical efficiency (EFF_CHANGE), which measures how much closer the DMU approaches to the best practice frontier over time. The second term in square root represents geometric mean of the two ratios which is the technical change that measures the shift in frontier over time, hence it represents technological change (TECH_CHANGE) that occurs between two time periods.

A graphical representation of the Malmquist index is given in Figure 1, where the horizontal axis represents the quantity of input x and the vertical axis represents the quantity of output y of a given DMU. S^t and S^{t+1} are the production technologies indicating constant returns to scale production frontiers. The input and output mix used by the DMU are (x^t, y^t) and x^{t+1}, y^{t+1} at periods t and $t+1$ respectively. The solution to the maximized value of θ can be illustrated as the equiproportional ray expansion factor y/θ that will bring DMU producing at (x^t, y^t) to the best practice frontier. If θ= 1, the unit is already on the best frontier.

Figure 5: The Malmquist Output-Based Index of Total Factor Productivity Change and Output Distance Functions



Source: Fare et al. (1994).

If we consider the decomposed version of the Malmquist Index, the first term can be expressed as:

$$\left[\frac{0d/0f}{0a/0b}\right] \tag{4.17}$$

which will indicate the rate of change in the efficiency (EFF_CHANGE) over t and $t+1$ periods, that illustrates the how much closer (or farther away) that DMU gets to best practise frontier over time.

The terms inside the bracket can be written as:

$$\left[\left(\frac{0d/0e}{0d/0f}\right)\left(\frac{0a/0b}{0a/0c}\right)\right]^{1/2} \tag{4.18}$$

or

$$\left[\left(\frac{0f}{0c}\right)\left(\frac{0c}{0b}\right)\right]^{1/2} \tag{4.19}$$

indicates the proportional shift in the best practise frontier, i.e. technological change (TECH_CHANGE). Malmquist Productivity Index is the multiplication of the efficiency change and the geometric mean of the frontier shift (TECH_CHANGE).

This output based Malmquist Productivity Change index can be constructed by four distance functions, which are computed by solving four different Linear Programming problems. These are as follows: For each $t = 1, ..., T$ there are $k = 1, ..., K$ observations (DMUs). Hence, there are K observations on M outputs, $y^{k,t} = (y^t_{k,1}, \ldots, y^t_{k,M})$ and N inputs, $x^{k,t} = (x^t_{k,1}, \ldots, x^t_{k,N})$: For an observation $k^(o, t)$ the following method computes

$$[D^t_0(x^{k^0,t}, y^{k^0,t})]^{-1} = max\theta \tag{4.20}$$

following the constraints

$$\sum_{k=1}^{K} z_k y^t_{k,m} \geq \theta y^t_{k^0,m} \ (m = 1, \ldots, M) \tag{4.21}$$

$$\sum_{k=1}^{K} z_k x^t_{k,m} \geq x^t_{k^0,n} \ (n = 1, \ldots, N) \tag{4.22}$$

$$z_k \geq 0 \ (k = 1, \ldots, K) \tag{4.23}$$

where z_k is the intensity variable, this problem measures the distance function for an observation $k^{0,t}$ with respect to the frontier at time t. The distance function $D^{t+1}_0(x^{k^0,t+1}, y^{k^0,t+1})$ for $k^{0,t+1}$ which measure the efficiency of the unit can be computed in a similar fashion using the following linear programing problem.

$$[D^{t+1}_0(x^{k^0,t+1}, y^{k^0,t+1})]^{-1} = max\theta \tag{4.24}$$

subject to

$$\sum_{k=1}^{K} z_k y^{t+1}_{k,m} \geq \theta y^{t+1}_{k^0,m} \ (m = 1, \ldots, M) \tag{4.25}$$

$$\sum_{k=1}^{K} z_k x_{k,m}^{t+1} \geq x_{k^0,n}^{t+1} \ (n = 1, \ldots, N) \tag{4.26}$$

$$z_k \geq 0 \ (k = 1, \ldots, K) \tag{4.27}$$

The mixed-period distance functions such as $D_0^t(x^{k^0,t+1}, y^{k^0,t+1})$ can be explained as considering the observation $k^{0,t+1}$ relative to technology at time t, and the observation $k^{0,t}$ relative to technology at time $t+1$. Computation for the first mixed-period distance function can be achieved by following maximization problem:

$$[D_0^t(x^{k^0,t+1}, y^{k^0,t+1})]^{-1} = max\theta \tag{4.28}$$

subject to

$$\sum_{k=1}^{K} z_k y_{k,m}^{t} \geq \theta y_{k^0,m}^{t+1} \ (m = 1, \ldots, M) \tag{4.29}$$

$$\sum_{k=1}^{K} z_k x_{k,m}^{t} \leq x_{k^0,n}^{t+1} \ (n = 1, \ldots, N) \tag{4.30}$$

$$z_k \geq 0 \ (k = 1, \ldots, K) \tag{4.31}$$

Similar to the previous case, second mixed-period distance function, $D_0^{t+1}(x^{k^0,t}, y^{k^0,t})$ for the observation $k^{0,t}$ relative to technology at time $t+1$, can be calculated by substituting t and $t+1$ in above optimization problem (Zaim & Taskin, 1997):

$$[D_0^{t+1}(x^{k^0,t}, y^{k^0,t})]^{-1} = max\theta \tag{4.32}$$

subject to

$$\sum_{k=1}^{K} z_k y_{k,m}^{t+1} \geq \theta y_{k^0,m}^{t} \ (m = 1, \ldots, M) \tag{4.33}$$

$$\sum_{k=1}^{K} z_k x_{k,m}^{t+1} \leq x_{k^0,n}^{t} \ (n = 1, \ldots, N) \tag{4.34}$$

$$z_k \geq 0 \ (k = 1, \ldots, K) \tag{4.35}$$

When the above Linear programming problems is applied to firms in the Automotive sector of Turkey, there are 18 firms (DMU) over 18 years and with 4 LP is solve for each firm hence we solved a total of 18*18*4 = 1296 LP problems to compute Malmquist Productivity Change Index and its components of Efficiency Change Index and Technological Change Index, below

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = EFF\_CHANGE \times TECH\_CHANGE \tag{4.36}$$

These measures evaluates the performance of the firms with respect to the best practice frontier of the industry, defined by the firms included into the study. When Malmquist index is greater than 1, this shows a positive change in the productivity and improvement in the firms production activity. If the Malmquist index is less than 1, then we can understand that the performance of the firm deteriorated overtime and the firm when transforming inputs to outputs at a lower level of productivity level. When the index value is equal to 1, then there is no change in the performance of the firm.

Similar interpretations are also applicable to the individual components EFF_CHANGE and TECH_CHANGE. If EFF_CHANGE is greater than 1, we understand that firms technical efficiency, or its relative position with respect to the industry frontier has improved over time, and the firm is relatively closer to the best practice frontier. The final component TECH_CHANGE index illustrates the position of the best practise frontier. With a value of TECH_CHANGE greater than 1, the best practise frontier has shifted out and a better technology is available for all the producers in the sector. With this methodology, we are able to assess each firms position within the industry and determine the change in the productivity and the sources of the change.

In the next section, discuss our estimation technique to assess the relationship between exports and productivity levels of the Turkish automotive manufacturers.

4.4 Panel Data Estimation

This section presents the second stage of analysis conducted in this study. After calculating the Malmquist productivity change indices in the previous section, those indices are included in the panel data estimation process to see the impact of productivity on exports. The productivity variable is the main focus, and the aim is to check whether the increase in productivity levels leads to increase in levels of exports and the share of exports of the firms. As mentioned earlier, higher levels of productivity enable firms to engage in foreign markets by decreasing the costs of foreign trade and increase in comparative advantages as suggested by both in theoretical and empirical studies. Therefore, it is no surprising that studies on the relationship between exporting and productivity mostly focus on the decision of the firms whether they export or not. However, in this study we take a different approach to the relationship between exporting and productivity since the available data do not have enough information on firms prior to exporting. That's why, in this study, we have exports in intensive margin, change in the amounts of exports, rather than extensive margin, decision to export or not. Therefore, the general form of regression equations to be estimated can be expressed as follows:

$$ln(exports)_{\mathrm{it}} = \beta_0 + \beta_1 ln(Productivity)_{\mathrm{it}} + \alpha * X_{\mathrm{it}} + \epsilon_{\mathrm{it}} \tag{4.37}$$

$$Share\_of\_Exports_{\mathrm{it}} = \gamma_0 + \gamma_1 ln(Productivity)_{\mathrm{it}} + \delta * X_{\mathrm{it}} + \mu_{\mathrm{it}} \tag{4.38}$$

where the dependent variable is natural logarithm of exports of a given firm i at time t in equation (4.37). In equation (4.38), the dependent variable is the share of exports defined as the proportion of export amounts of the categorized vehicles in total exports of vehicles. Moreover, the natural logarithm of productivity measured by Malmquist productivity index is the first explanatory variable. In addition, X is a vector of other explanatory variables that may explain the production process of the firm such as capital and labor variables, age of the firm, the dummy variables whether they have R&D center or not and whether they have other production plants in neighbour countries of Turkey, exchange rate, the share of skilled labor in the firm, total production capacity and the interaction term between GDP per capita growth ofthe country that firms' parental companies located and productivity measure are also included in X. As one can guess, ϵ is the error term. Year and firm fixed effects are included in the regression model.

After running the auto-regressions for both level of exports and the share of exports, we observe that both set of dependent variables are affected by its past observations, except the level of total vehicle exports. It means that both the export amounts and the share of exports have dynamic structure in the panel data set. That's why, we take first differences of the variables to be able to avoid dynamic panel data. By taking first differences, we are able to remove the persistency in our dependent variables.

Table 4: AR(1) process of the export amounts and share of exports.

VARIABLES	(1) Pass.	(2) Comm.	(3) Transp.	(4) Tot.	(5) Pass. Sh.	(6) Comm. Sh.	(7) Transp. Sh.	(8) Tot Sh.
L.Pass. Car	0.65***							
	(0.11)							
L.Commer. V.		0.35***						
		(0.09)						
L.Transp. V.			0.25*					
			(0.14)					
L.Total Exp.				0.39***				
				(0.12)				
L.Pass. C. Share					0.74***			
					(0.09)			
L.Commer. Share						0.52***		
						(0.10)		
L. Transp. Share							0.40***	
							(0.14)	
L.Total Exp. Share								0.55***
								(0.08)
Constant	2.47	-1.03	-3.35	-0.36	1.15	-0.43	0.23	-0.02
	(4.11)	(4.12)	(3.03)	(1.83)	(1.17)	(0.45)	(0.32)	(0.34)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	79	129	124	222	81	154	128	226
R-squared	0.97	0.95	0.73	0.96	0.95	0.86	0.87	0.86

Note: The first 4 columns are for the export amounts, the rest is for the shares of exports. Additional controls are included but not reported. Firm and time fixed-effects are included in the estimation and denoted with "Yes". If not, we denote it by "No". Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: AR(1) process of the export amounts and share of exports in first differences.

VARIABLES	(1) Pass.	(2) Commer.	(3) Transp.	(4) All Samp.	(5) Pass.	(6) Commer.	(7) Transp.	(8) All Samp.
L.Pass. Car	0.10							
	(0.12)							
L.Commer. V.		-0.19						
		(0.24)						
L.Transp. V.			-0.26					
			(0.20)					
L.Total Exp.				-0.23				
				(0.18)				
L.Pass. C. Share					0.08			
					(0.12)			
L.Commer. Share						-0.19		
						(0.17)		
L.Transp. Share							-0.26	
							(0.16)	
L.Total Exp. Share								-0.25**
								(0.12)
Constant	0.08	-2.11*	0.06	-0.66	-0.34**	-0.26	-0.02	-0.22
	(0.35)	(1.11)	(1.91)	(0.81)	(0.14)	(0.17)	(0.15)	(0.14)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	66	98	104	183	69	122	107	186
R-squared	0.66	0.59	0.31	0.39	0.71	0.37	0.31	0.34

Note: The first 4 columns are for the export amounts, the rest is for the shares of exports. Additional controls are included but not reported. Firm and time fixed-effects are included in the estimation and denoted with "Yes". If not, we denote it by "No". Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

From the Table 4, we can see that almost all specifications present dynamic panel data structure. Dependency to one period lagged observation is significant at 1% significance level, except in column 3. In third column, we see that there is a significance at 5% level. As we mention above, we take the first differences to avoid the complexity of working with the dynamic panel data. When we estimate the AR(1) process of the first difference variables, we are able to obtain non-dynamic structure for both amount of exports and the share of exports. We present these results in Table 5, and none of the specifications has a significant estimator except for the last column. The share of total exports still depends on its past observations. However, we are able to remove the dynamic properties of most of the dependent variables in our data set, and we argue that we can work with first difference estimators and ignore the persistency in the share of total exports.

CHAPTER 5

DATA AND EMPRICAL RESULTS

5.1 Data

The objective of thesis is to evaluate the role of firm productivity on exports in the Turkish Automotive sector. In addition to the firm level production information, we require firm level exports in the sector.

Empirical analysis starts with the computation of Malmquist Productivity Change Index for the firms in the automotive sector in Turkey. Automotive Manufacturers Association (OSD) is an organization that is established in 1974, which represents the automotive manufacturers operating in Turkey. They publish periodical data on the production of transport equipment, such as Passenger Cars, Trucks, Pick-Ups, Buses, Midibuses Minibuses and Tractors. These vehicles are broadly categorized as passenger cars, commercial vehicles and mass transportation vehicles according to the their purpose of use. Commercial vehicles include pick-ups, trucks and tractors, whereas mass transportation vehicles consist of buses, minibuses and midibuses. Data obtained from OSD reports are production, capacity utilization, exports, employment and R&D employment. Some of these information are reported at firm level data. Most of the data are reported in physical quantities and this information is extremely valuable in computing productivity measure using DEA. This methodology computes productivity without using price data and avoids complications and possible biases in the measurement of cost and value of production due to lack of accurate price information.

Table 6: Summary Statistics

Variable	**Obs**	**Mean**	**Std. Dev.**
Capital	298	165738	166962
Foreign Share	298	0.417	0.374
Firm age	303	33.5	15.1
Covered Area	298	158	123
Total Area	298	651	646
Labor	303	2693	2575
Worker	303	2104	2055
Employee	303	243	203
Administrator	303	50	63
Engineer	303	221	273
Admin. eng	303	77	88
Skill share	298	0.26	0.13
Total Production Cap.	298	97347	128565
Passenger Cars	298	63785	115482
Commercial Vehicles	298	27935	67431
Mass Transportation Vehicles	297	5612	11891
Capacity usage	298	0.55	0.33
Total Production	303	68731	106489
Passenger Cars	303	39506	81759
Commercial Vehicles	303	25863	61590
Mass Transportation Vehicles	303	3362	17867
Total Exports	303	47826	82911
Passenger Cars	303	29592	65856
Commercial Vehicles	303	16787	47037
Mass Transportation Vehicles	303	1448	6093
Share of Total Exports	299	0.45	0.29
Passenger Cars	299	0.17	0.30
Commercial Vehicles	299	0.17	0.23
Mass Transportation Vehicles	299	0.10	0.20
TFPCH	276	1.16	0.79
TECH	277	1.10	0.71
TEECH	276	1.06	0.27
Labor Productivity	298	18.40	18.63
GDPpc_Growth	303	1.11	2.30
Other Plant	303	0.37	0.48
R&D center	303	0.37	0.48
Exchange rate	303	2.20	1.29

Furthermore, in the summary statistics average total production capacity of a firm is on average more than 97 thousand vehicles, and passenger cars are the vehicle category that has the highest production capacity in the data set with an amount of almost 64 thousand, and it is followed by commercial vehicles with almost 28 thousand of vehicles, and firms have production capacity amount of 5600 for the mass transportation vehicles.

In the actual production, similar to capacity of production, total production amounts of the firms are on average 69 thousand vehicles. The largest average production quantity is in passenger cars with around 40 thousand and followed by commercial vehicles by amount of 26 thousand. Similar to production capacity numbers, mass transportation vehicles are the least produced vehicle category with an average of 3 thousand vehicles.

Exports of vehicles follow a similar pattern in terms of the relative quantities. Total average annual exports are around 48 thousand vehicles, where on average passenger cars exported are around 30 thousand, the next category is commercial vehicles 117 thousand units of exports, and again mass transportation vehicles are the smallest quantity of average exports with 1400 units.

The share of total exports in Turkish automotive sector is around 45% annually. The share of passenger car exports in total production is around 17% and we observe that the share of commercial vehicles is also around 17%. Moreover, the exports of mass transportation vehicles account for 10% of the total production of the firms.

In the data set, we have defined two dummy variables: one is to differentiate whether the firms have another production facility in neighboring countries to Turkey or not. Another control variable is whether the automotive manufacturers have an R&D center, or not. The required data for these variables are collected from the firms' websites, or their websites of the parent or holding company if a foreign firm owns them. For example, no firm has another production facility in Turkey's neighbor countries, however there are some firms who have operating automotive plants in the countries, which have borders with Turkey's neighbor countries. Russia can be an example for such countries.

In addition to computing the Malquist Productivity Change Index with inputs and outputs measured in physical units, obtained from Automotive Manufacturers Association (OSD), we have also calculated the productivity index following the other strand of DEA literature and use the firms' balance sheet variables in the automotive sector. As we have mentioned in the literature review of DEA applications of automotive industries, there are a large number of studies that use balance sheet information in constructing the input and output data. The typically used variables are values of sales, net sales, gross value added, equity, total assets, profit and profit before tax. Istanbul Chamber of Industry (ICI) database reports some of these variables for the automotive firms. We observe that for some variables there are gaps in the data set for some firms with missing observations. Moreover, we have computed the Malmquist productivity change index by defining equity and total assets as inputs and profits and value added as output. Even with fewer data points, we were able to identify similar productivity changes with this alternative data as we have observed with our original data.[1] When one accurately measures the production process in terms of physical quantities without price effects, the essence of the DEA methodology in evaluating the efficiency of firms in transforming inputs to output is best utilized.

In this study, through this comparison we are able to correctly evaluate the productivity results obtained from the DEA, using inputs and outputs measured

[1]The correlation coefficient between these two productivity change indexes is around 0.39

in physical units, and the productivity results obtained by balance sheet variables for automotive firms. In the next section, we discuss the Malmquist Productivity Index computations and productivity results.

5.2 Empirical Results

5.2.1 Malmquist Productivity Change Index Results

Productivity developments in the Turkish automotive sector is examined using the Malmquist Productivity Change Index. 18 firms that are the producers of automotive and transport equipment whose detailed production data are reported for 2002-2019 by the OSD annual reports are included into the study.

Each of these firms are considered to be a DMU in the linear programming problems while computing the Malmquist Productivity Change Index. As was discussed in the data section, in defining the production process the inputs in the production are chosen as capacity of production, skilled labor and unskilled labor. The outputs are the total production of automotive equipment measured in physical units, and rate of capacity utilization.[2] For each of the 18 years and 18 firms, 4 distance functions are defined and a total of 1296 linear programming problems solved in these computations.

The firm-level Malmquist productivity change index results during 2002-2019 show that with the exception 5 firms, ASKAM, B.M.C., HATTAT TRAKTÖR, KARSAN and OTOKAR, all firms experienced positive total factor productivity changes. HATTAT TRAKTÖR is the only firm which experience a loss in technical efficiency. When we examine the technological change indices, the only 5 firms had technological improvement over the period. 8 firms [3] had deterioration of technology and 5 firms had on the average no change in technology.

[2]In selection of inputs and outputs we follow the conventions commonly used in several studies that utilize DEA methodology for the both the Turkish and world automotive sectors.

[3]5 of these firms were the ones that has experienced negative total productivity change.

Table 7, 8 and 9 report the Malmquist Productivity Change, Efficiency Change and Technical Change respectively for this study. The inputs used to calculate the indices are high skilled labor, low skilled labor and total production capacity, where the outputs are total production and capacity usage.[4][5] In Table 7, Malmquist Productivity Change index for the firm A.I.O.S is 1.78 between 2001 and 2002. This illustrates that the firm experiences 78 percent (1-θ) total productivity change. The sources of this productivity improvement is 21 percent increase in technical efficiency and 47 percent improvement in technological change in Table 8 and 9.

[4]We also calculated an alternative Malmquist Productivity Change Index by using total production capacity, low skilled and high skilled labor as inputs and total production as an output. The results are very similar to our productivity measure with a correlation coefficient of 0.9714.

[5]The comparison between our productivity measure and the productivity measure reported by Ministry of Industry and Technology for Turkish automotive sector show similar trends for productivity changes over the years and the figure A1 in appendix illustrates this similarity

Table 7: Malmquist Productivity Change Indices

Firms	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Mean**
A.I.O.S	1.78	1.16	0.89	1.66	1.05	1.02	1.25	0.20	2.48	1.28	1.03	0.91	1.36	1.35	0.52	0.78	0.75	0.74	**1.00**
ASKAM	0.37	9.09	0.95	1.37	0.55	0.30	.												**0.95**
B.M.C.	1.37	1.95	1.25	0.97	0.86	0.86	0.85	0.36	1.10	1.17	0.47	.							**0.93**
FORD OTOSAN	1.56	2.33	1.37	1.08	0.94	1.00	0.97	0.64	1.41	1.21	0.93	1.03	0.71	1.35	1.00	1.11	0.91	0.99	**1.09**
HATTAT TRAKTÖR						1.02	0.92	0.86	2.16	1.57	0.48	1.32	1.03	1.39	0.74	0.54	0.89	0.38	**0.92**
HONDA TÜRKİYE	1.07	1.89	1.25	0.67	1.21	0.90	1.70	0.47	1.07	0.56	1.85	0.67	0.77	1.04	1.07	1.54	1.34	0.65	**1.01**
HYUNDAI ASSAN	1.93	1.39	1.48	1.12	0.94	1.75	0.70	0.75	1.61	1.17	0.95	1.02	1.29	0.91	1.08	1.00	0.91	0.89	**1.12**
KARSAN	1.75	0.78	1.91	0.68	1.19	0.65	0.89	0.86	2.15	0.49	0.56	2.78	0.08	4.08	0.52	1.90	0.98	0.72	**0.95**
M.A.N TÜRKİYE	0.80	1.27	1.00	0.25	3.58	0.94	2.62	1.26	0.72	1.27	0.73	1.15	0.67	1.57	0.95	0.71	1.09	1.04	**1.03**
M.BENZ TÜRK	1.33	1.52	1.69	1.16	1.08	1.20	1.09	0.29	1.71	1.44	0.95	1.41	0.76	0.93	0.59	1.19	1.21	0.90	**1.06**
OTOKAR	0.67	1.34	1.00	1.17	0.69	0.83	1.27	0.86	0.67	1.68	0.50	1.72	0.72	1.40	0.22	2.39	0.96	0.82	**0.93**
OTOYOL	1.16	1.21	0.74	0.87	1.03	1.31	.												**1.03**
OYAK RENAULT	1.04	1.19	1.33	0.82	1.17	1.02	1.04	1.00	1.10	1.05	0.93	1.10	0.98	1.06	1.00	1.07	0.89	1.02	**1.04**
TEMSA	2.17	0.98	2.63	1.41	1.04	0.96	1.09	0.25	1.45	1.11	0.58	1.16	0.93	1.13	1.03	1.14	0.87	0.56	**1.02**
TOFAŞ	1.11	1.21	1.08	1.12	0.95	1.01	0.95	0.97	1.23	0.91	0.83	0.98	0.90	1.24	1.37	0.90	0.81	0.84	**1.01**
TOYOTA	7.57	1.40	1.31	1.22	1.07	0.94	0.79	0.69	1.26	1.24	0.83	1.22	1.23	0.89	1.10	1.30	0.86	0.98	**1.18**
TÜRK TRAKTÖR	0.84	3.32	1.18	0.84	0.98	1.06	0.73	0.75	1.98	1.26	0.83	0.87	1.15	0.84	0.98	1.04	0.75	0.70	**1.02**
UZEL	0.88	1.65	1.52	1.18	1.36	0.77	.												**1.18**
Mean	1.27	1.61	1.27	0.97	1.06	0.93	1.06	0.60	1.38	1.11	0.78	1.17	0.78	1.25	0.80	1.11	0.93	0.78	

Note: Inputs are total production capacity, high skilled and low skilled labor, whereas the outputs are total production and capacity usage. Empty cells present that firms do not have observations for respective time period.

Table 8: Efficiency Change Indices

Firms	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Mean**
A.I.O.S	1.21	1.00	1.24	1.19	1.05	1.02	1.34	0.53	1.41	1.42	0.58	0.97	1.27	1.35	0.67	0.67	1.16	0.77	**1.00**
ASKAM	0.85	1.01	1.16	1.09	1.07	0.98	.												**1.02**
B.M.C.	1.00	1.13	1.21	1.08	1.04	1.00	1.67	0.48	1.11	1.31	0.78	.							**1.03**
FORD OTOSAN	1.03	1.13	1.35	1.10	1.11	0.92	1.08	0.76	1.12	1.10	0.93	1.06	1.11	1.04	0.90	1.04	0.91	1.00	**1.03**
HATTAT TRAKTÖR						0.94	1.85	0.43	2.16	1.57	0.48	1.32	1.03	1.39	0.74	0.54	0.89	0.64	**0.95**
HONDA TÜRKİYE	1.70	1.15	1.25	0.67	1.21	0.90	1.70	0.47	1.41	1.22	0.68	0.85	1.11	1.30	0.98	0.74	1.25	0.65	**1.01**
HYUNDAI ASSAN	1.11	1.26	1.29	1.15	1.08	1.17	0.78	0.76	1.42	1.17	0.95	1.02	1.29	0.91	1.08	1.00	0.91	0.89	**1.05**
KARSAN	1.75	0.78	1.91	0.68	1.19	0.88	1.55	0.45	1.74	1.07	0.82	0.98	1.16	1.26	1.02	0.76	1.01	0.73	**1.03**
M.A.N TÜRKİYE	0.80	1.27	1.00	0.64	1.39	0.94	2.62	1.26	0.72	1.27	0.73	1.15	0.67	1.57	0.95	0.71	1.09	1.04	**1.03**
M.BENZ TÜRK	1.00	1.19	1.27	1.16	1.08	1.20	1.09	0.52	1.08	1.32	0.93	1.41	0.76	0.93	0.92	0.98	0.95	1.03	**1.02**
OTOKAR	0.67	1.34	1.00	1.17	1.03	0.95	1.31	0.90	0.97	1.16	0.78	1.06	0.92	1.28	0.91	0.86	1.04	0.97	**1.00**
OTOYOL	1.06	1.01	1.29	1.13	1.12	0.92	.												**1.08**
OYAK RENAULT	1.04	1.19	1.33	1.00	1.07	0.96	0.98	1.00	1.10	1.05	0.93	1.10	1.14	1.05	0.89	1.05	0.90	1.01	**1.04**
TEMSA	1.47	0.99	1.13	1.29	1.04	0.96	1.26	0.73	1.04	1.09	0.75	1.09	0.91	1.37	0.86	0.78	1.11	0.95	**1.03**
TOFAŞ	1.06	1.30	1.30	1.01	1.07	0.94	0.93	0.90	1.07	1.07	0.93	1.10	1.13	1.05	0.90	1.05	0.90	0.96	**1.03**
TOYOTA	1.16	1.30	1.31	1.22	1.07	0.94	0.79	0.70	1.25	1.24	0.83	1.22	1.23	0.89	1.10	1.30	0.86	0.98	**1.06**
TÜRK TRAKTÖR	1.61	1.04	1.32	0.85	1.16	0.93	1.54	0.42	1.54	1.16	0.83	0.87	1.15	0.95	0.92	0.99	0.94	0.93	**1.02**
UZEL	1.17	1.00	1.32	1.00	1.26	0.88	.												**1.09**
Mean	1.12	1.11	1.26	1.01	1.12	0.96	1.29	0.65	1.23	1.21	0.78	1.08	1.05	1.15	0.91	0.87	0.99	0.89	

Note: Inputs are total production capacity, high skilled and low skilled labor, whereas the outputs are total production and capacity usage. Empty cells present that firms do not have observations for respective time period.

Table 9: Technical Change Indices

Firms	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Mean**
A.I.O.S	1.47	1.16	0.72	1.39	1.00	1.00	0.93	0.38	1.77	0.90	1.79	0.94	1.07	1.00	0.78	1.16	0.65	0.97	**1.00**
ASKAM	0.44	8.97	0.82	1.25	0.52	0.31	.												**0.93**
B.M.C.	1.37	1.73	1.03	0.89	0.82	0.86	0.51	0.75	0.99	0.89	0.60	.							**0.90**
FORD OTOSAN	1.51	2.06	1.02	0.98	0.84	1.08	0.89	0.84	1.26	1.09	1.00	0.97	0.64	1.29	1.11	1.07	1.01	0.99	**1.06**
HATTAT TRAKTÖR						1.09	0.50	2.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.60	**0.97**
HONDA TÜRKİYE	0.63	1.65	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.46	2.70	0.79	0.69	0.80	1.09	2.09	1.08	1.00	**1.00**
HYUNDAI ASSAN	1.74	1.10	1.14	0.97	0.87	1.50	0.90	0.98	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**1.06**
KARSAN	1.00	1.00	1.00	1.00	1.00	0.74	0.58	1.90	1.24	0.46	0.68	2.85	0.07	3.24	0.51	2.49	0.98	0.98	**0.92**
M.A.N TÜRKİYE	1.00	1.00	1.00	0.39	2.58	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**1.00**
M.BENZ TÜRK	1.33	1.28	1.33	1.00	1.00	1.00	1.00	0.56	1.59	1.09	1.02	1.00	1.00	1.00	0.64	1.21	1.27	0.87	**1.04**
OTOKAR	1.00	1.00	1.00	1.00	0.67	0.88	0.98	0.96	0.69	1.44	0.65	1.61	0.79	1.10	0.24	2.78	0.92	0.85	**0.93**
OTOYOL	1.09	1.19	0.58	0.77	0.92	1.43	.												**0.96**
OYAK RENAULT	1.00	1.00	1.00	0.82	1.09	1.06	1.06	1.00	1.00	1.00	1.00	1.00	0.86	1.01	1.13	1.01	0.99	1.01	**1.00**
TEMSA	1.47	0.99	2.33	1.09	1.00	1.00	0.86	0.34	1.40	1.02	0.77	1.07	1.02	0.82	1.20	1.46	0.79	0.59	**0.99**
TOFAŞ	1.05	0.93	0.83	1.11	0.88	1.07	1.03	1.08	1.16	0.85	0.89	0.89	0.80	1.18	1.53	0.86	0.90	0.88	**0.98**
TOYOTA	6.51	1.08	1.00	1.00	1.00	1.00	1.00	0.99	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**1.11**
TÜRK TRAKTÖR	0.52	3.20	0.90	0.99	0.84	1.14	0.48	1.76	1.29	1.09	1.00	1.00	1.00	0.88	1.07	1.05	0.80	0.75	**1.00**
UZEL	0.76	1.65	1.15	1.18	1.08	0.87	1.14												**1.09**
Mean	1.13	1.45	1.00	0.96	0.95	0.96	0.83	0.92	1.12	0.92	0.99	1.09	0.75	1.09	0.88	1.27	0.94	0.88	

Note: Inputs are total production capacity, high skilled and low skilled labor, whereas the outputs are total production and capacity usage. Empty cells present that firms do not have observations for respective time period.

Figure 6: Productivity Change Through the Years

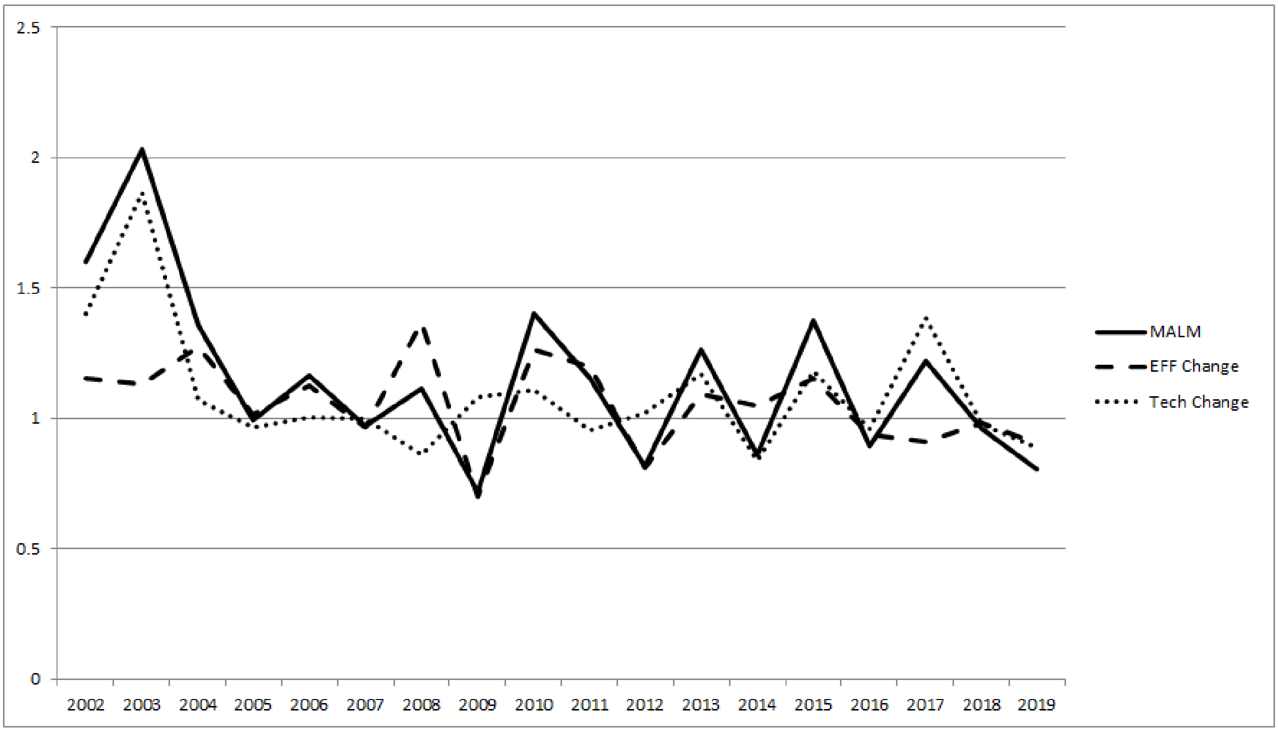


Table 10: Average Malmquist Productivity Indices

YEARS	MALM	EFF_CH	TECH_CH
2002-2006	1.2172	1.1213	1.0855
2007-2010	0.9486	1.0000	0.9536
2011-2014	0.9411	1.0147	0.9274
2015-2019	0.9563	0.9551	1.0013
2002-2019	1.0171	1.0225	0.9959

In Turkish Automotive sector, as can be seen from the graph, early 2000's were the best years for the sector with productivity improvements averaging around 22% according to DEA measures. This period is the only group of years, when the sector on the average experienced improvements both in technical efficiency (catch-up to the frontier) and positive technological change (shift of best practice frontier).

Since then, productivity performance in the automotive sector has fallen behind. One of the largest loss of productivity was observed during Great Recession with the collapse of international demand on 2008 with 5% drop in productivity(1-

0.95). Even though Turkish automotive sector was quick to recover from the adverse effect of the world recession, the recovery has not been consistent. Improvements most of the time were followed with years when the productivity deteriorated. This might be attributed to a general demand level that is still lagging its pre-crisis levels.

When we examine the source of productivity drop, we see continuous deterioration of technological change in second part of the 2000's until 2010. We know that most of the new establishments entered to Turkish economy in the beginning of 2000 when firms were trying to make strategic investment decisions to take advantage of the upcoming Custom Union agreement or a likely membership with EU. Hence, some slow down of the new technology investments in the following years would have been expected. With the onset of the world recession, this adverse development in technological change in the sector became even more pronounced and continued to be the main determining factor in productivity developments in the sector.

Even after the recession, the improvements were slow to come. The positive efficiency change, during recession or even in the early 2010 (with EFF_CH = 1.0147) were not sufficient to offset the negative effect of the lack of technological improvement change (0.07 loss in techonological change). Hence, deterioration of the total productivity change measured by Malmquist Productivity Index continued.

In the last 5 years of the sample, the productivity decline in the sector continued. There were limited positive technological change, but the efficiency change continued to worsen when firms moved away from their best practice frontiers. Finally, the last year turned out to be the worse year in the sample, both in terms of EFF_CHANGE and TECH_CHANGE, and translated to a loss of productivity by 22% measured by the Malmquist productivity change index. (1-θ).

In the next section, we present our panel data estimation results.

5.2.2 Panel Data Estimation Results

In this section, we present results of the estimations. We estimate two different set of dependent variables which are the log of export amounts and export shares for three categories of vehicles and all vehicles. Moreover, we regress these dependent variables as levels and first differences separately. In Table 11, 12, 13 and 14, we present the estimation results.

Table 11: Estimation Results for Log Exports.

VARIABLES	(1) Pass. C.	(2) Commer.	(3) Transp.	(4) Total	(5) Total
ln_Productivity	0.510*	0.727	0.263	0.366	0.315
	(0.278)	(0.513)	(0.341)	(0.253)	(0.259)
ln_Labor	0.160	2.207***	2.357***	0.574**	0.602***
	(0.550)	(0.628)	(0.799)	(0.271)	(0.231)
Skill Share	-1.286	2.151	9.248**	-1.801	-2.035*
	(2.563)	(2.973)	(3.668)	(1.261)	(1.138)
ln_Production capac.	0.498	0.806	-0.477	0.668**	0.671***
	(0.389)	(0.895)	(0.640)	(0.276)	(0.257)
Other plant	0.270	0.887	-0.200	0.348**	0.352**
	(0.207)	(0.551)	(0.278)	(0.147)	(0.137)
Firm age					0.009
					(0.037)
Firm age^2	-0.002*	-0.003**	-0.003**	-0.0001	-0.0001
	(0.001)	(0.001)	(0.002)	(0.0003)	(0.0003)
R&D center	1.331**	-1.962	1.738**	0.174	0.026
	(0.497)	(1.367)	(0.753)	(0.276)	(0.198)
GDP per capita growth	-0.109	-0.102	0.093	-0.165*	-0.116
	(0.185)	(0.151)	(0.279)	(0.088)	(0.076)
GDPpc*Productivity	-0.009	0.094	-0.110	0.142	0.151
	(0.130)	(0.224)	(0.298)	(0.113)	(0.104)
ln_Exchange rate					0.061
					(0.241)
Firm FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	No
Constant	1.742	-15.569	-4.165	-3.221	-3.701*
	(5.634)	(10.068)	(4.032)	(2.211)	(2.208)
Observations	81	136	125	224	224
R-squared	0.938	0.907	0.680	0.950	0.944

Note: Dependent variable is log of exports. Firm and time fixed-effects are included in the estimation and denoted with "Yes". If not, we denote it by "No". Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In Table 11, when we examine the vehicles categories separately, we observe that the effect of productivity on export levels is positive and statistically significant at 10% significance level for only passenger cars. 1% increase in productivity change is followed by 0.51% increase in passenger cars exports. On the other hand, for commercial vehicles, mass transportation vehicles and total vehicle exports, we observe that the productivity has no significant impact on export amounts of the firms. Even though we lose the significance of the impact, coefficients for productivity are still positive.

For the labor variable, we can see that it has a statistically significant and positive effect on exports in two specifications of vehicles. For total vehicle exports, the significance of the effect differs between the specifications where we add firm age and exchange rate variables from 5% to 1% significance level, where it is significant at 1% significance level for commercial and mass transportation vehicles. The increase in employment of the firm by 1% increases the total exports by 0.60%, mass transportation vehicles exports by almost 2.4% and commercial vehicles 2.21%. However, we do not have a similar effect of firm size on exports of the passenger cars. The labor variable has no significant effect on passenger cars exports. Yet, we claim that labor variable has also positive sign for all of the specifications, as expected like productivity variable.

The variable "Skill share" basically controls for the share of skilled labor in total employment within the firm. Hence, one can expect that the larger share of skilled labor employed the more export levels firm does. Therefore, expected sign for skill share variables is positive. However, we observe a positive sign for the coefficient of skill share only in column 3 of the table, which is mass transportation vehicles export as the dependent variable, and it is statistically significant at 5% level. For the remaining three specifications, the results do not match with the expected sign as most of the specifications have negative sign for skill share.

Moreover, the effect is significant in column 5, which is the total vehicle exports, at 10% level. The 1% increase in the skill share decreases the total exports by more than 2%, where it increases the mass transportation vehicles exports by more than 9%. Such difference makes us to think about the foreign market structure of transportation vehicles. We argue that firms are likely to export more mass transportation vehicles if they hire skilled labor since results suggest that hiring more labor increases the exports of mass transportation vehicles, where the results show that there is no need for hiring more skilled labor for other vehicle categories.

Production capacity is considered as a proxy for capital. When we think about what determines the production capacity, we can come up with machinery and equipment in the first place, which are essentials for firm capital. Therefore, controlling for production capacity might give us insight about capital as a proxy. Estimation results show that production capacity has a positive sign in four out of five specifications and it is significant in column 4 and 5, which are total vehicles exports, at 5% and 1% levels respectively. The 10% increase in production capacity leads to almost 7% increase in total exports.

The variable "other plant" has variation between the firms during the time period. Firms that have other production facilities in a country which has border with Turkey's neighbor country have more total vehicle exports than the firms that do not, and it is statistically significant at 5% level with a coefficient of 0.35. When we examine the vehicle categories, we observe that for passenger cars having another plant in a country that has borders with the Turkey's neighbor country does not improve exports, yet the relationship is positive. Moreover, we again have positive relationship between other plant variable and commercial vehicles export, yet it has no statistically significance. Unlike these two vehicle categories, we see a negative relationship between other plant variable and mass transportation vehicles, which has the coefficient of -0.2 yet no significance. Opposite signs of "Other plant" variable for passenger cars and mass transportation vehicles might be caused by the possibility that plants in another country might be producing same models with the Turkish firm. For example, if they are producing same models of vehicles, it is no surprising that the export levels decreases since they kind of share the vehicle demand of the region. However, if the plant in other country and Turkish firm produce different models of same vehicle, we can claim these models will be produced by the firms especially and consumed internationally. Since these firms are the only producers of different models of the vehicle in the region, exports of the firms are expected to increase.

The variable "R&D center" has also variation between the firms during the time period. The firms that have R&D center export more passenger cars and mass transportation cars. Having an R&D center increases the passenger car exports by more than 1%, and the size of the increase is more than 1.7% for mass transportation vehicles, they are both significant at 5% level. However, having an R&D center has no significant impact on commercial vehicles exports and total exports. Furthermore, the interaction between GDP per capita growth of the country that firms' parental companies located and productivity measure is used to control whether the firms are supported by the parental company in terms of demand side and in terms of productivity. Hence, the results for the interaction term suggest that there is no significant relationship between exports and this interactive variable. Finally, we claim that squared age of the firm has a small but negative impact on all vehicle categories, yet it has no significant effect on total vehicle exports, and exchange rate has no significant effect on any specifications in Table 11.

As we mentioned above, AR(1) process with controls shows that exports are persistent with the previous period. This makes our data set dynamic panel data.

To avoid the complex structure of the dynamic panel data estimation techniques, we estimate our model with first-difference estimation method. As a consequence, we are able to eliminate dynamic structure of exports. We present these results in Table 12 where the dependent variable is the first difference log of exports.

Table 12: Estimation Results for Log Exports in First Differences.

VARIABLES	(1) Pass. C.	(2) Commer. V.	(3) Transp. V.	(4) Total V.	(5) Total V.	(6) Pass. C.	(7) Commer. V.	(8) Transp. V.	(9) Total V.	(10) Total V.
ln_Productivity	0.616***	0.855*	0.042	0.559**	0.577**	0.617***	0.787*	0.042	0.564**	0.571**
	(0.127)	(0.470)	(0.431)	(0.280)	(0.281)	(0.130)	(0.452)	(0.406)	(0.267)	(0.273)
ln_Labor	0.642	1.977***	2.074**	0.981***	0.885***	0.700*	1.944***	2.241**	1.064***	0.898***
	(0.439)	(0.657)	(0.973)	(0.336)	(0.284)	(0.400)	(0.552)	(0.988)	(0.288)	(0.270)
Skill share	-0.773	1.006	7.815	0.671	0.417	-0.598	0.734	8.361	0.631	0.296
	(1.554)	(3.151)	(4.860)	(1.377)	(1.197)	(1.635)	(2.791)	(5.193)	(1.285)	(1.156)
ln_Produc. capac.	0.729**	0.804	0.982*	1.015***	0.971**	0.824***	0.556	0.958*	0.982***	0.907**
	(0.299)	(0.565)	(0.522)	(0.347)	(0.374)	(0.252)	(0.511)	(0.507)	(0.318)	(0.350)
Other plant	0.007	-0.501	-0.432	-0.013	0.024	-0.091	0.030	-0.214	-0.012	-0.001
	(0.198)	(0.546)	(0.370)	(0.138)	(0.123)	(0.105)	(0.234)	(0.246)	(0.090)	(0.079)
Firm age					-0.016					-0.012
					(0.018)					(0.011)
Firm age^2	0.0003	0.001*	0.0003	0.0003	0.0004	-0.00004	0.0001	-0.00004	-0.00002	0.0002
	(0.0004)	(0.001)	(0.001)	(0.0003)	(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0002)
R&D center	-0.134	-0.558	0.129	-0.087	-0.150	0.088	-0.021	0.225	0.125	0.056
	(0.195)	(0.628)	(0.945)	(0.319)	(0.205)	(0.106)	(0.393)	(0.685)	(0.201)	(0.125)
GDPpc growth	-0.031	0.094	-0.401	-0.114	-0.044	-0.055	0.071	-0.411	-0.111	-0.048
	(0.098)	(0.148)	(0.385)	(0.091)	(0.078)	(0.080)	(0.159)	(0.371)	(0.096)	(0.083)
GDPpc*Productivity	0.064	-0.085	0.387	0.104	0.038	0.062	-0.072	0.390	0.092	0.036
	(0.077)	(0.203)	(0.406)	(0.111)	(0.108)	(0.070)	(0.221)	(0.393)	(0.117)	(0.115)
ln_Exchange rate					-0.159					-0.162
					(0.509)					(0.463)
Firm FE	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Time FE	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Constant	-0.199	-2.291**	1.261	-0.863	-0.049	-0.164	-0.601*	1.561	-0.484	0.206
	(0.331)	(1.137)	(2.252)	(0.719)	(0.619)	(0.169)	(0.354)	(1.188)	(0.428)	(0.156)
Observations	68	101	105	184	184	68	101	105	184	184
R-squared	0.732	0.622	0.386	0.447	0.355	0.703	0.560	0.370	0.417	0.326

Note: Dependent variable is the log of exports in first differences. Firm and time fixed-effects are included in the estimation and denoted with "Yes". If not, we denote it by "No". Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In Table 12, we have our dependent variable as the log of exports in first differences. The first 4 columns have both firm and time fixed effects. The last 4 columns have only time fixed effects. When we take first difference, we get rid of the firm-specific components. Moreover, if we add firm fixed effects to the estimation, then we can control for firm-specific trend. Thus we also control for firm-specific trend by adding firm fixed effects to the regression equation in first differences.

We can observe that firm level productivity has a significant and positive impact on exports in almost all specifications. These coefficients are significant at 1% for passenger car exports, 10% for commercial vehicles exports, 5% level for total exports when we control for firm-specific trend. However, we do not observe any significant impact of productivity on mass transportation vehicles. An increase in productivity change by 1% increases the exports of firms by within a range from 0.56% to 0.86%. The highest impact of productivity can be seen on commercial vehicles exports, while the lowest impact is observed on mass transportation vehicles exports with or without controlling firm specific trend. The size of the effect on total exports is almost the same whether we control for time specific trend or not.

For the labor variable, it has significant and positive impact on exports in almost all of the specifications. It loses significance when we control for firm specific trend in passenger car exports, and coefficient is almost the same. For commercial vehicles exports, results show that there is no change in significance level, 1%, but the coefficient of the labor variable increases slightly from 1.94 to 1.98. For the exports of mass transportation vehicles there is no change in the significance of labor variable, when we control for firm specific trend, and we can see that the coefficient decreases to 2.07 from 2.24. For total exports, we do not observe a change in significance level, which is 1%. Therefore, we can argue that 1%

increase in labor leads to increase in exports by up to 2.2%.

As a proxy for capital, production capacity has a statistically significant and positive impact on exports in eight of ten specifications. The only specifications where production capacity is not significant is the commercial vehicles exports. It has significance at 10% level for mass transportation exports, and it does not change when controlling for firm specific trend, yet the coefficient increases. For the same variable, coefficient of total exports increases slightly when we add firm fixed effects, but the significance stays at 1% level. For the exports of passenger cars, results show that production capacity lose significance, from 1% to 5%, and its coefficient decreases from 0.82 to 0.73. Therefore, we claim that 1% increase in total capacity boosts the exports by an amount ranging from 0.73% to 1.02%.

The variable squared firm age has only one significant estimate in ten specifications. Firm age is only significant at 10% level in column 2 with a coefficient of 0.001, where the dependent variable is first difference of exports of commercial vehicles. For the other specifications, the estimate of age of the firm is statistically no different than zero. In column 5 and 10, we drop the time fixed effects and add the controls which are firm age and exchange rate variables. These controls have no statistically significant impact in these specifications. Moreover, the remaining variables, skill share, having an other plant in a country that has borders with one of Turkey's neighbors, having an R&D center occupied by a firm and the interaction term between GDP per capita growth of the country that firms' parental companies located and productivity measure do not have significant impact in any specifications in the Table 12.

Next, we define our dependent variable to be the share of exports and conduct the estimations with same set of independent variables. The share of exports is the proportion of categorized vehicle exports in total exports of the firms. We claim that analyzing the effect of productivity on export shares might give us valuable information about the firms' approach to exporting. Since the share of exports is also related to total production which is denominator, the estimates of productivity and other independent variables may provide us additional and valuable insight for policy suggestions and useful comments about the export market in Turkish automotive sector. Table 13 presents the results of the estimations where the dependent variable is export shares.

Table 13: Estimation Results for Share of Exports.

VARIABLES	(1) Pass. C.	(2) Commer.	(3) Transp.	(4) Total	(5) Total
ln_Productivity	0.051	0.039	-0.034	0.018	0.019
	(0.079)	(0.047)	(0.026)	(0.047)	(0.047)
ln_Labor	-0.152	0.086*	0.001	-0.064	-0.098**
	(0.153)	(0.051)	(0.044)	(0.060)	(0.049)
Skill share	0.117	0.274	0.227	-0.237	-0.304
	(0.690)	(0.266)	(0.282)	(0.258)	(0.209)
ln_Production capac.	0.084	0.084	-0.063*	0.078	0.079
	(0.123)	(0.069)	(0.038)	(0.058)	(0.054)
Other plant	0.056	0.122*	0.052	0.048	0.063*
	(0.057)	(0.065)	(0.053)	(0.039)	(0.038)
Firm age					-0.007
					(0.009)
Firm age^2	-0.0004	-0.0001	-0.00003	0.0001	0.0001
	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
R&D center	0.320**	-0.359***	0.032	-0.041	-0.016
	(0.145)	(0.087)	(0.040)	(0.056)	(0.050)
GDPpc growth	-0.012	-0.020	-0.002	-0.030*	-0.010
	(0.056)	(0.018)	(0.008)	(0.017)	(0.015)
GDPpc*Productivity	-0.008	0.009	0.007	0.017	0.006
	(0.044)	(0.029)	(0.012)	(0.025)	(0.024)
ln_Exchange rate					0.134**
					(0.055)
Firm FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	No
Constant	0.408	-1.222**	0.619*	-0.219	0.088
	(1.682)	(0.602)	(0.360)	(0.443)	(0.454)
Observations	81	154	128	226	226
R-squared	0.889	0.798	0.868	0.802	0.771

Note: Dependent variable is the share of exports. Firm and time fixed-effects are included in the estimation and denoted with "Yes". If not, we denote it by "No". Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Unlike previous estimations, in Table 13, we do not observe any statistically significant relationship between firm level productivity measure and export shares. Even though results present that productivity measure has no significant effect on export shares, we can argue that the sign of the estimates are positive as expected, except for column 3. The export share of mass transportation vehicles is affected by productivity measure negatively. However, like we mentioned above, this affect has no statistical significance. Similarly, skill share variable does not have significant estimates in any of the specifications in Table 13. For the labor variable, we observe that it has a positive and significant impact on commercial vehicles export while it has negative and significant impact on total vehicles exports without time fixed effects. The signs of the estimates are mostly negative for the labor variable. Moreover, skill share has negative estimates for the share of total exports whereas it has positive estimates for the export shares of passenger cars, commercial vehicles and mass transportation vehicles.

For the production capacity variable, we can see from Table 13 that it has significant estimate only in column 3 at 10% level, and it has negative relationship with export share of mass transportation vehicles. The increase in production capacity by 10% leads to decrease in export share of mass transportation vehicles by 0.63%. For other specifications, production capacity has positive relationship with shares of exports even though these are estimates are not statistically different than zero. From these results, we can claim that firms that produce and export mass transportation vehicles might be focusing on domestic markets rather than foreign market. Once their production capacity increases, their export shares decrease. Therefore, we can argue that these firms might be producing more of mass transportation vehicles, yet they do not (or can not) increase their amount of exports accordingly so that we observe a decrease in export shares in this vehicle category. Moreover, for other plant variable, again we observe that it has only one significant estimate which is in column 2, export share of commercial vehicles, and it is significant at 10% level. Having an another production facility increases the export share of commercial vehicles by 0.12%.

Having an R&D center has opposite and significant effects for passenger cars and commercial vehicles, both are statistically significant at 1% level. Firms with R&D center have higher share of passenger cars export, where they have lower share of commercial vehicles exports. However, having R&D center has no significant impact on other specifications.Moreover, we observe that exchange rate has a positive and significant impact on total vehicle exports. 1% depreciation of Turkish lira increases the export share of total vehicle exports by 0.13%. Finally, age of the firm, the interaction term of GDP per capita growth and productivity has only one significant estimate, where the dependent variable is the export share of passenger cars, and it is related negatively with a magnitude of 0.04.

As we present in Table 4, export shares are dependent to their one-period previous observation which makes our data set in dynamic panel data. Since it is complicated to deal with dynamic panel data, we employ the same approach as before and take the first differences. We present the first difference estimation results in Table 14 below.

Table 14: Estimation Results for Share of Exports in First Differences.

VARIABLES	(1) Pass. C.	(2) Commer	(3) Transp.	(4) Total	(5) Total	(6) Pass. C.	(7) Commer.	(8) Transp.	(9) Total	(10) Total
ln_Productivity	0.077**	0.035	-0.009	0.051	0.049	0.082**	0.034	-0.009	0.055	0.045
	(0.037)	(0.059)	(0.024)	(0.046)	(0.051)	(0.039)	(0.053)	(0.022)	(0.046)	(0.049)
ln_Labor	0.044	0.030	0.130	0.073	0.025	0.039	0.041	0.139*	0.101*	0.005
	(0.091)	(0.084)	(0.079)	(0.064)	(0.059)	(0.080)	(0.064)	(0.082)	(0.052)	(0.056)
Skill share	0.007	0.021	0.820*	0.288	0.155	0.055	0.029	0.814*	0.327	0.112
	(0.292)	(0.390)	(0.456)	(0.298)	(0.278)	(0.370)	(0.313)	(0.476)	(0.274)	(0.263)
ln_Production capac.	0.164*	0.074	0.093	0.155**	0.122	0.169**	0.048	0.091	0.149**	0.117
	(0.096)	(0.078)	(0.082)	(0.073)	(0.089)	(0.076)	(0.067)	(0.078)	(0.072)	(0.088)
Other plant	-0.031	-0.002	-0.013	0.019	0.013	-0.018	0.030	-0.042	-0.012	-0.001
	(0.043)	(0.090)	(0.047)	(0.040)	(0.041)	(0.025)	(0.025)	(0.028)	(0.020)	(0.020)
Firm age					0.005					-0.003
					(0.005)					(0.004)
Firm age^2	0.0001	0.0001	-9.99e-06	0.00003	0.00001	-0.00001	-8.94e-06	0.00002	2.02e-06	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.00007)	(0.00001)	(0.00002)	(0.00002)	(0.00001)	(0.00001)	(0.0001)
R&D center	-0.034	-0.005	0.020	-0.004	-0.053	0.034	0.006	0.054*	0.037	0.037
	(0.049)	(0.080)	(0.041)	(0.051)	(0.047)	(0.028)	(0.063)	(0.028)	(0.037)	(0.030)
GDPpc growth	0.009	-0.028	-0.007	-0.016	0.002	0.002	-0.026	-0.007	-0.014	-0.002
	(0.029)	(0.018)	(0.008)	(0.014)	(0.015)	(0.027)	(0.018)	(0.008)	(0.015)	(0.015)
GDPpc*Productivity	-0.005	0.027	0.013	0.015	-0.003	-0.002	0.023	0.013	0.010	0.001
	(0.027)	(0.024)	(0.012)	(0.019)	(0.021)	(0.025)	(0.025)	(0.012)	(0.020)	(0.022)
ln_Exchange rate					-0.138					-0.032
					(0.137)					(0.113)
Firm FE	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Time FE	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Constant	-0.323***	-0.260	0.002	-0.235*	-0.337**	-0.240***	-0.115	-0.036	-0.186***	0.034
	(0.107)	(0.181)	(0.152)	(0.141)	(0.137)	(0.070)	(0.083)	(0.029)	(0.066)	(0.055)
Observations	69	122	107	186	186	69	122	107	186	186
R-squared	0.741	0.354	0.296	0.326	0.153	0.687	0.270	0.261	0.261	0.061

Note: Dependent variable is the share of exports. Firm and time fixed-effects are included in the estimation and denoted with "Yes". If not, we denote it by "No". Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 14 presents the results of the estimations where we use first differences of export shares as dependent variable. In these estimations, we are able to capture the importance of productivity variable for the passenger cars. The productivity variable has coefficients that are significant at 5% and with very similar values, with or without firm specific effect. For other specifications, we are unable to capture any significant estimate. Similarly, we are able to get some significant estimates for labor in equations with variables in their first difference. For export share of mass transportation vehicles in both specifications with or without firm specific controls and the estimated coefficients are very close to each other. Further, we observe significant relationship between labor and share of total exports when there is no firm fixed effects. A 1% increase in labor leads to an increase in share of total exports by 0.10%.

Share of skilled labor has significant impact only on export share of mass transportation vehicles controlling for with and without firm specific trend. A 1% increase in share of skilled labor leads to an increase in share of export share of mass transportation vehicles more than 0.8%. For the remaining specifications, we do not observe any significant impact of share of skilled labor. However, the sign of the estimates are all positive. Moreover, production capacity has significant estimates in almost half of the specifications. For export shares of passenger cars and the total exports are the ones where we see a significant relationship. For passenger cars, while the coefficient is significant at 5% level, significance level drops to 10% when we include firm fixed effects, and the coefficients are very similar in values. For the share of total exports, coefficient changes when we add firm fixed effects. It stays being significant at 5% level, with its coefficient increasing from 0.15 to 0.16. Other vehicle categories have no significant relationship with production capacity, the estimates have a positive sign.

Finally, the remaining variables, firm age, exchange rate, having other plant in another country which has borders with Turkey's neighbor countries, having R&D center and interaction term between GDP per capita growth of the country that firms' parental companies located and productivity measure do not have significant impact in any specifications in the Table 13, and the signs of the estimates vary between the specifications.

To sum up, we can claim that productivity and labor variables have positive and significant impact on export amounts of the firms in all vehicle specifications, while having significant coefficients in some specifications for the share of exports. When we compare the regressions, we observe that different explanatory variables such as share of skilled labor and exchange rate, have significant coefficients for the share of exports while they do not have significant coefficients for export amounts. This difference might show us the different aspects of exporting market.

CHAPTER 6

ROBUSTNESS CHECKS

In this section, we employ robustness checks on our estimations. One test of robustness is conducted by changing the productivity variable. In these sets ıf estimations, we use labor productivity instead of Malmquist Productivity Change Index to labor productivity measure. Table 15 and 16 present the robustness test results for the first difference estimators. In Table 15, the dependent variable is the first difference of log of exports and productivity is labor productivity, while in Table 16, the dependent variable is first difference of share of exports.

Table 15: Robustness Test Results for Log Exports in First Differences.

VARIABLES	(1) Pass. C.	(2) Commer.	(3) Transp.	(4) Total	(5) Total	(6) Pass. C.	(7) Commer.	(8) Transp.	(9) Total	(10) Total
ln_Labor productivity	1.447***	1.243	1.194**	1.309***	1.238***	1.475***	1.075	1.200**	1.300***	1.159***
	(0.217)	(0.759)	(0.508)	(0.447)	(0.463)	(0.219)	(0.686)	(0.483)	(0.429)	(0.433)
ln_Labor	1.423***	2.065***	2.603**	1.306***	0.899***	1.433***	2.156***	2.587**	1.414***	0.922***
	(0.344)	(0.602)	(0.991)	(0.325)	(0.313)	(0.330)	(0.527)	(1.036)	(0.272)	(0.276)
Skill share	0.305	1.754	8.822*	1.533	0.245	0.394	1.242	9.582*	1.377	0.212
	(1.006)	(2.800)	(5.113)	(1.258)	(1.124)	(1.092)	(2.558)	(5.395)	(1.208)	(1.112)
ln_Production capac.	-0.141	-0.357	0.369	0.004	0.029	-0.128	-0.466	0.329	-0.012	0.006
	(0.356)	(0.322)	(0.420)	(0.201)	(0.283)	(0.306)	(0.327)	(0.435)	(0.216)	(0.302)
Other plant	-0.107	-0.441	-0.461	-0.102	-0.124	-0.084	-0.023	-0.372	-0.082	-0.044
	(0.147)	(0.504)	(0.361)	(0.141)	(0.147)	(0.084)	(0.230)	(0.254)	(0.093)	(0.078)
Firm age					0.040					-0.007
					(0.025)					(0.011)
Firm age^2	0.00003	-0.0001	-0.0004	-0.0002	-0.0002	3.35e-06	0.0001	0.0001	0.0001	0.0002
	(0.0004)	(0.001)	(0.001)	(0.0004)	(0.0004)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0002
R&D center	-0.047	-0.590	0.036	-0.093	-0.132	0.056	-0.134	-0.018	-0.023	0.013
	(0.187)	(0.706)	(0.980)	(0.309)	(0.200)	(0.079)	(0.477)	(0.722)	(0.203)	(0.130)
GDPpc growth	0.127	0.090	-0.271	-0.061	-0.045	0.123	0.082	-0.261	-0.049	-0.037
	(0.110)	(0.101)	(0.321)	(0.074)	(0.066)	(0.098)	(0.107)	(0.290)	(0.079)	(0.067)
GDPpc*Labor prod.	-0.087	-0.095	0.193	0.027	0.038	-0.088	-0.074	0.163	0.011	0.028
	(0.088)	(0.118)	(0.285)	(0.074)	(0.074)	(0.081)	(0.127)	(0.257)	(0.087)	(0.079)
ln_Exchange rate					-0.207					0.015
					(0.487)					(0.420)
Firm FE	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Time FE	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Constant	-0.214	2.056	-0.202	1.043	-1.091	-0.100	0.981	-0.918	0.509	0.067
	(0.199)	(1.567)	(1.683)	(0.873)	(0.829)	(0.112)	(0.680)	(0.676)	(0.515)	(0.179)
Observations	70	107	108	191	191	70	107	108	191	191
R-squared	0.799	0.564	0.416	0.473	0.352	0.788	0.515	0.398	0.444	0.318

Note: Dependent variable is log of exports in first differences. Labor productivity is calculated by dividing total production to the total number of people hired. Firm and time fixed-effects are included in the estimation and denoted with "Yes". If not, we denote it by "No". Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The results in Table 15 shows that labor productivity measure has statistically significant and positive coefficients in eight out of ten specifications, and they are all significant at 1% significance level except mass transportation vehicles. They are significant at 5% significance level. Only specifications where we do no observe any significance are the ones commercial vehicles exports. In Table 12, we can see that our productivity measure has statistically significant and positive estimators in similar specifications. Similarly, the coefficients of the labor productivity variable are statistically significant and positive in Table 15 in almost all equations. Moreover, in Table 12 labor variable has significant and positive estimators in all of the specifications. In Table 15, we also observe significant coefficients with similar values. On the other hand, while we are able to obtain significant impact of production capacity in Table 12, we do not observe any significant effect of total capacity on exports in Table 15. The remaining variables do not have significant impact on exports in most of the specifications in both Table 12 and Table 15. Even though we have differences in some of the variables, the large similarity of the productivity and labor coefficient in both regressions, in terms of their values and significance enables us to argue that our results for first difference exports are robust.

Table 16: Robustness Test Results for Share of Exports in First Differences.

VARIABLES	(1) Pass. C.	(2) Commer.	(3) Transp.	(4) Total	(5) Total	(6) Pass C.	(7) Commer.	(8) Transp.	(9) Total	(10) Total
ln_Labor productivity	0.167***	0.086	0.009	0.101	0.076	0.215***	0.070	0.007	0.099	0.059
	(0.055)	(0.080)	(0.043)	(0.078)	(0.089)	(0.061)	(0.075)	(0.038)	(0.074)	(0.083)
ln_Labor	0.185*	-0.003	0.145*	0.100	-0.008	0.228**	0.024	0.148*	0.138**	-0.002
	(0.092)	(0.073)	(0.083)	(0.065)	(0.062)	(0.086)	(0.061)	(0.087)	(0.058)	(0.055)
Skill share	0.200	-0.013	0.848*	0.372	0.006	0.323	-0.047	0.855*	0.381	0.011
	(0.269)	(0.335)	(0.465)	(0.291)	(0.296)	(0.315)	(0.290)	(0.485)	(0.269)	(0.269)
ln_Production capac.	0.055	-0.027	0.087	0.051	0.057	0.012	-0.036	0.085	0.051	0.050
	(0.116)	(0.042)	(0.068)	(0.059)	(0.084)	(0.105)	(0.044)	(0.065)	(0.062)	(0.088)
Other plant	-0.029	-0.005	-0.015	0.015	0.002	-0.017	0.021	-0.043	-0.019	-0.013
	(0.042)	(0.085)	(0.047)	(0.040)	(0.041)	(0.025)	(0.025)	(0.029)	(0.020)	(0.021)
Firm age					0.001					-0.005
					(0.007)					(0.004)
Firm age^2	0.0001	0.00002	-0.00002	0.0001	0.0001	-0.00002	-3.07e-06	0.00002	4.70e-06	0.00001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.00002)	(0.00002)	(0.00001)	(0.00001)	(0.00001)
R&D center	-0.051	-0.015	0.015	-0.017	-0.050	0.036	-0.003	0.048*	0.030	0.030
	(0.050)	(0.073)	(0.042)	(0.052)	(0.047)	(0.030)	(0.061)	(0.028)	(0.036)	(0.028)
GDPpc growth	0.048	-0.033***	-0.001	-0.010	-0.003	0.052	-0.030***	-0.001	-0.009	-0.003
	(0.031)	(0.011)	(0.006)	(0.012)	(0.014)	(0.031)	(0.011)	(0.006)	(0.013)	(0.014)
GDPpc*Labor prod.	-0.029	0.035***	0.004	0.014	0.010	-0.033	0.032**	0.003	0.012	0.010
	(0.031)	(0.012)	(0.008)	(0.012)	(0.017)	(0.029)	(0.013)	(0.008)	(0.013)	(0.016)
ln_Exchange rate					-0.031					0.015
					(0.129)					(0.107)
Firm FE	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Time FE	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Constant	-0.033	0.077	0.004	0.059	-0.184	0.052	0.070	-0.036	0.110	0.072
	(0.084)	(0.149)	(0.141)	(0.121)	(0.167)	(0.077)	(0.060)	(0.036)	(0.071)	(0.066)
Observations	72	130	111	195	195	72	130	111	195	195
R-squared	0.767	0.398	0.296	0.346	0.125	0.712	0.306	0.259	0.277	0.057

Note: Dependent variable is the share of exports in first differences. Labor productivity is calculated by dividing total production to the total number of people hired. Firm and time fixed-effects are included in the estimation and denoted with "Yes". If not, we denote it by "No". Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Next, we present the results of robustness test for the share of exports in first differences. Labor productivity variable has significant estimators in only column 1 and column 6, which we use the export shares of passenger cars as the dependent variable. When we compare it to the results in Table 13, we observe similarities. Our productivity measure has also significant impact on the export shares of passenger cars. Moreover, we obtain same significant estimators for the labor variable in columns 8 and 9 both in Table 14 and Table 16, and the coefficients are close to each other. In addition, we obtain robust results for skill share variable, as well. In Table 14, skill share has positive and statistically significant impact on the export shares of mass transportation vehicles, in column 3 and column 8. When we check for robustness in Table 16, we see that skill share has positive and significant effect in column 3 and column 8, as well, and the coefficients are almost the same. Moreover, the variables such as firm age, exchange rate, other plant results are not significant in any of Table 14 and Table 16. However, the variables which are production capacity and interaction term, the coefficients and their significance in explaining export shares do not match with our results in Table 14.

As a result, even though some of our results failed in robustness checks, most of our results remain significant when we use the alternative definitions for productivity which is labor productivity. Therefore, we can argue that our results are robust to the selection of productivity measure, and the impact of productivity on export levels and export shares are positive and statistically significant for different categories.

CHAPTER 7

CONCLUSION

In this study, we have analyzed the relationship between exports of Turkish automotive manufacturers and their productivity changes for the period 2001-2019. We have calculated the productivity levels by Malmquist productivity change index. After computing the Malmquist productivity indices, we have used the results of productivity changes in estimations to see whether productivity levels have impact on export amounts or the share of exports. To overcome the possible dynamic relationship, we have also used first differences of our dependent and independent variables.

Our estimation results illustrate that productivity changes of the firms have statistically significant and positive impact on export amounts in all of the specifications. An increase in productivity by 1% boosts the export amounts within a range from 0.55% to 0.85%. Similarly, the firm size has also a statistically significant and positive effect on export amounts, 1% increase in firm size leads to an increase in export amounts by more than 2%. In addition, we see positive and significant impact of production capacity on export by around 1%. For the share of exports, we have found that the effects of productivity is less clear. The impact of exchange rate becomes significant for the share of exports, and it might point out the other aspects of exporting dynamics together with share of skilled labor being significant in some specifications. Still, the relationship between export shares and firm-level productivity is open to further study. Finally, we have conducted robustness checks for our results by altering our productivity measure to labor productivity. We have showed that our estimation results are not affected by the change in productivity measure so we have concluded that our estimation results are robust.

For future research, it is possible to examine whether there is a reverse causality from exports to firm level productivity, which is also known as "learning-by-exporting". In this study, we focus on the effect of productivity on exports, yet when we consider the "learning-by-exporting" hypothesis, we might have the case where exports also have a significant impact on firm-level productivity. Therefore, future research can focus on this simultaneity between exports and productivity. Moreover, the dynamic structure of the panel data can be estimated with estimation methods such as system-GMM model, so that the relationship between productivity levels and the exports may become clearer for the Turkish automotive sector.

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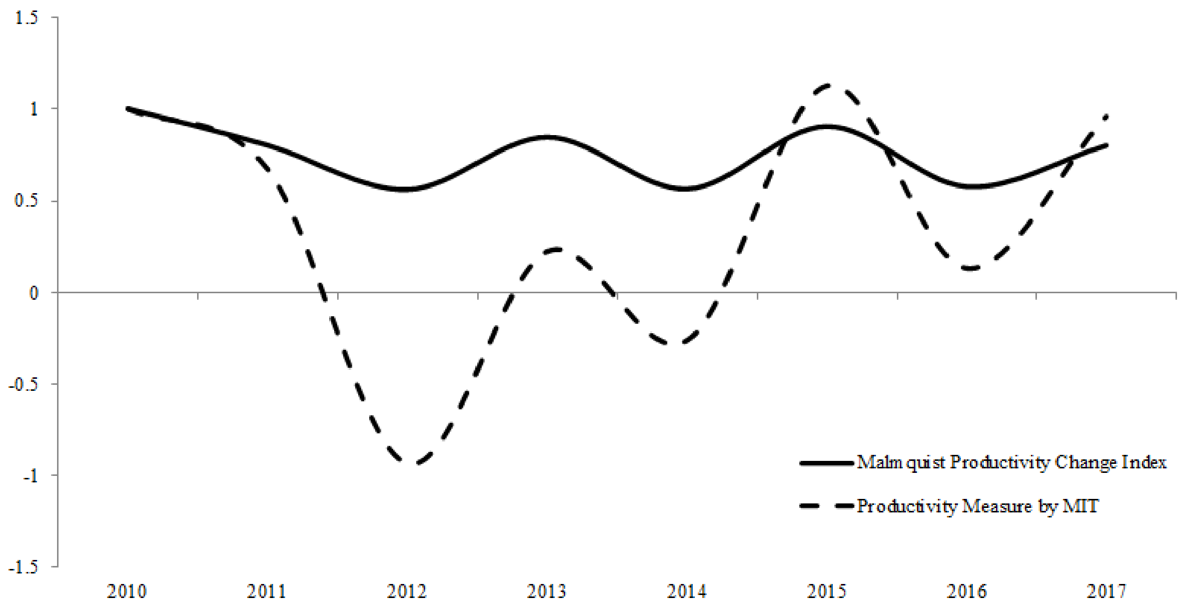
APPENDIX

Figure A1 shows the comparison between the productivity measure reported by Ministry of Industry and Technology and the Malmquist Productivity Change Index. We calculated the annual average of the Malmquist Productivity Change Indices of the firms since the Ministry of Industry and Technology reports only annual productivity measure. Moreover, the productivity measure they report is the turnover amount per employee in the automotive sector. We can see from the figure that productivity measures look similar in terms of the direction of productivity changes in the Turkish automotive sector. Therefore, we can claim that our productivity measure for Turkish automotive manufacturers reflects the productivity changes in the Turkish automotive sector.

Figure A1: Comparison Between Productivity Measures.



Source: Ministry of Industry and Technology. Authors' calculations.