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# The role of productivity, wages, demand, and exchange rates on export performance: Evidence from the Turkish manufacturing industry

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**Abstract**

**Purpose** — This study explores the determinants of export performance in the Turkish manufacturing industry by examining the effects of productivity, wages, demand, and sector-specific real effective exchange rates from 2006 to 2019.

**Methods** — Using firm-level export data across 21 manufacturing sectors, the study applies a Fixed-Effects model with Driscoll-Kraay standard errors to address heteroscedasticity, autocorrelation, and cross-sectional dependence. Endogeneity concerns are mitigated using Two-Step System GMM estimation, complemented by Moment Quantile Regression (MQR) for robustness checks across the export distribution.

**Findings** — The results reveal that higher productivity, increased wages, and stronger external demand significantly enhance exports, while currency appreciation adversely affects export performance. Productivity emerges as the most influential factor.

**Implication** — Productivity enhancement, stable exchange rate management, and workforce development support export-driven growth. Targeted policies that strengthen sectoral competitiveness and expand foreign market access are essential for sustaining manufacturing exports.

**Originality** — This study departs from traditional macro-level analyses by constructing sector-specific indices for real exchange rates and external demand. It offers a more granular and precise understanding of export dynamics. The methodological rigor combines static and dynamic panel estimators to ensure robustness and advance empirical insights into firm-level export behavior.

**Keywords** — Export performance, Productivity, Real effective exchange rate, External demand, Turkish manufacturing, Sectoral analysis, System GMM.

## Introduction

Many countries, including the USA, UK, and Turkey, began implementing supply-side economic policies after the 1980s. In this period, the development of communication and transportation technologies and the decrease in production costs accelerated the globalization of trade. The increase in foreign trade volume has led to a rise in the importance given to exports by countries and firms. These changes significantly accelerated trade globalization and deepened national economies' integration into global value chains. Consequently, export performance emerged as a critical driver of economic growth, employment creation, innovation capacity, and competitive

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advantage for firms and nations (Abbas et al., 2015). The export-led growth paradigm, particularly in manufacturing sectors, has become a central strategic focus in many national economic agendas.

In this regard, in the early 2000s, theoretical research in international trade began to examine the behavior of exporting and non-exporting firms with heterogeneous firm models (Melitz, 2003; Bernard et al., 2007a; Bernard et al., 2007b; Melitz and Ottaviano, 2008; Eaton et al., 2011; Alvarez et al., 2013; Chaney, 2014; Chaney, 2016; Spearot, 2016; Kim and Osgood, 2019; Boitier, 2022; Aghion et al., 2024; Khasanov and Hiwatari, 2025). Melitz (2003), the basis of these current studies, emphasized the importance of productivity and sunk costs to initiate exporting. According to this model, exporting firms have relatively higher productivity than non-exporting firms. Among the heterogeneous firm models developed later, Eaton et al. (2011) focused on market and firm-specific heterogeneity in entry costs and demand shocks. Chaney (2016) emphasized the liquidity constraints for heterogeneous firms to initiate exporting. Aghion et al. (2024) investigated how the demand conditions faced by heterogeneous firms in markets affect their innovation decisions. Khasanov and Hiwatari (2025) considered heterogeneity between parent institutions and trading partners and emphasized the role of productivity on exports.

New dimensions have been added to heterogeneous firm models, with the empirical literature developing at the same time (for example Bernard and Jansen, 2004; Dekle and Ryoo, 2007; Greenaway et al., 2007; Alvarez and Lopez, 2009; Fung and Liu, 2009; Dekle et al., 2010; Zhang and Liu, 2012; Abbas et al., 2015; Rashid and Wager, 2017; Van den Berg et al., 2019; Karamollaoglu and Yalcin, 2020; Dincer et al., 2021; Jafari et al., 2023; Fambeu, 2024; Liu et al., 2024; Matthias et al.,2025). Research on firm exporting in theoretical and empirical literature has resulted in several significant findings. First, exporting firms incur sunk costs, such as research, equipment, machinery purchases, advertising, etc. If a firm can bear these sunk costs, it begins exporting (Campa, 2004). On the other hand, wages have been found to have a dual effect on exports. On one hand, an increase in wages raises firms' production costs, which negatively impacts their exports (Fung and Liu, 2009; Nguyen and Sun, 2012; Cheung and Sengupta, 2013; Rashid and Wager, 2017; Rashid et al., 2021; Dangizer and Dangizer, 2024). On the other hand, higher wages may indicate a more skilled workforce, which can positively affect exports due to the increased productivity and expertise of the labor force (Gourley and Seaton, 2004; Sun, 2009; Abraham and Van Hove, 2010; Greenaway et al., 2012; Zhang and Liu, 2012; Nguyen, 2021).

In the case of Turkey, which has undergone significant structural reforms and trade liberalization since the 1990s, the manufacturing industry represents a vital engine of export growth. Yet, comprehensive assessments that account for industry-specific dynamics are relatively scarce. Studies on firm exports typically analyze total exports using macroeconomic variables, often assuming that all observations are homogeneous when analyzing total exports with some variables. In this study, however, we aim to consider sectoral differences, calculate external income based on industry-specific weights, and use average export data of exporting firms on an industry-specific basis. This approach acknowledges that assuming homogeneity is not just a preference but a necessity, given the constraints in the data, and thus, such assumptions are made. Considering the existing studies in the literature, this study was intriguing in examining the factors affecting exports on an industry-specific basis by considering the average number of firms in the sector.

This study addresses this critical gap by examining the export performance of Turkish manufacturing industries from a sector-specific perspective for the period 2006-2019. This study's contributions to the literature are the following: First, the industry-specific real exchange rates and GDP are calculated to see how these factors impact Turkish manufacturing exports. It is observed that many published papers use the real exchange rate index calculated by central banks as a proxy for relative prices. The real exchange rate index is the weighted geometric average of the host country's price level ratio to the countries with which it does foreign trade. In other words, while it is considered total exports, in this study, it is calculated separately for each sector by considering sectoral export data. On the other hand, as an indicator of foreign demand, the sum of the Gross Domestic Product (GDP) of countries with a significant share in the world economy or international trade (USA, EU, etc.) is used. In our study, the GDP value of the countries to which Turkey exports and the sum of GDP weighted according to the export ratio are used as foreign demand indicators. Secondly, the method used in the analysis of the study. The Fixed Effect model with Driscoll-Kraay standard error, which is resistant to the problems of variance, autocorrelation, and cross-sectional dependence, is used. In addition to this method, the Moments Quantile Regression (MQR) estimation technique is used to assess the robustness of the estimator.

## Methods

### Data and Model

The study used firms' exports in 21 sectors according to the ISIC Rev4 Level 2 classification covering 2006–2019. It is important to note that the data collection ended in 2019 since 2020 and onwards were significantly impacted by the Covid–19 pandemic. Therefore, the study's focus is primarily on pre–pandemic conditions, as the effects of the pandemic on exports are not accounted for in the analysis. Firm export data is calculated by dividing foreign sales by the number of entrepreneurs from the income statement in the Turkish Entrepreneur Information System (TEIS) database. In the calculation of the industry specific real effective exchange rate index, export data were gathered from the Turkish Statistical Institute (TURKSTAT), the annual average buying rate of exchange was obtained from the Central Bank of Turkey Republic (CBRT) database, and Consumer Price Index (CPI) data were got from the IMF's database. GDP data of partner countries according to export weight were taken from the World Bank's database. The seasonal and calendar-adjusted industrial gross wage-salary index is obtained from TURKSTAT, and the seasonal and calendar-adjusted production per hour worked index is collected from the TEIS database.

**Table 1.** The definitions of the variables and the data source

| Variables | The Definitions of Variables | Data Source |
|---|---|---|
| Lexp | Firm–based export calculated from the income statement in the Turkish manufacturing industry (foreign sales/number of enterprises) ($) | TEIS |
| Lreer | Industry-specific real exchange rate (index) | Authors' Calculation |
| Lgdp | Industry-specific GDP ($) | Authors' Calculation |
| Lppw | Production per working hour (index) | TEIS |
| Lwage | Gross wages (index) | TURKSTAT |

To calculate the industry-specific real effective exchange rate index, 20 countries with the highest share in Turkiye's industry-specific foreign trade were determined. In the foreign trade weighting calculation, the method used in Saygili et al. (2012) study was applied, while the geometric mean method was used to calculate the industry-specific real effective exchange rate index. Model 1 shows the real effective exchange rate index calculation.

$$rer_c^t = \frac{P^{TR}}{P^C x\, e_{CTR}} \quad (1)$$

In Model 1, $rer_c^t$ refers to the exchange rate of the national currency of country c and the national currency of Turkiye at time t (the real exchange rate index), $P^{TR}$ denotes Turkiye's CPI rate, $P^C$ shows the partner country's CPI rate, and $e_{CTR}$ represents the nominal exchange rate. Calculation of export weight, import weight, and foreign trade weight were implemented according to the models included in the study of Saygili et al. (2012).

$$wx_{ci}^t = \frac{X_{ci}^t}{\sum_{c=1}^N X_{ci}^t} \quad , \quad mt_{ci}^t = \frac{M_{ci}^t}{\sum_{c=1}^N M_{ci}^t} \quad (2)$$

$$wt_{ci}^t = \left(\frac{\sum_{c=1}^N X_{ci}^t}{\sum_{c=1}^N X_{ci}^t + \sum_{c=1}^N M_{ci}^t}\right) wx_{ci}^t + \left(\frac{\sum_{j=1}^N M_{ci}^t}{\sum_{j=1}^N X_{ci}^t + \sum_{j=1}^N M_{ci}^t}\right) mt_c^i \quad (3)$$

$$Reer_i^t = \prod_{c=1}^N (rer_c^t)^{wt_{ci}^t} \quad (4)$$

In Model 2, where $wx_{ci}^t$ represents the export weight of country c in sector i, $mt_{ci}^t$ is the import weight of *c* country in sector *i*, and in Model 4, $wt_{ci}^t$ refers to the foreign trade weight of the country c in sector i. Models 2 and 3 $X_{ci}^{t}$ ile $M_{ci}^{t}$ denotes Turkiye's exports to 20 countries (c) and imports from 20 countries in sector i at time t, respectively. Model 4 was used to calculate the sectoral real effective exchange rate index. The weighing of selected countries for each sector results in variations in this index across sectors. Model 5, where $Reer_{i}^{t}$ is the sectoral real effective exchange rate index, $wt_{ci}^{t}$ is the weight of foreign trade in the i sector of country c, and $rer_{c}^{t}$ is the real effective exchange rate index. To measure the effect of the increase in partner countries' incomes on exports, industry-specific GDP was calculated using a method like the industry-specific real exchange rate index (Fung and Liu, 2009).

$$GDP_{ci}^{t} = \sum_{c=1}^{N}(wx_{ci}^{t} \text{ x } GDP_{c}^{t}) \quad (5)$$

Model 5, where $GDP_{ci}^{t}$ is industry-specific GDP, $wx_{c}^{i}$ is the export weight of partner countries in sector i, and $GDP_{c}^{t}$ is the GDP of partner countries at time *t*. In other words, this model was calculated using the first 20 countries to which Turkiye exports in sector *i*. Then, the GDP value of these 20 countries is multiplied by their export weight.

## Econometric Methodology

In this study, the relationship between variables is analyzed with both static and dynamic panel data models. The heteroscedasticity, autocorrelation, and cross-section dependence in static panel data models should be checked first. The estimation results may be biased if one or more of these assumptions are violated. In panel data models, it is a basic assumption that the variances of error terms have constant variance between units. The modified Wald test can be used to detect the presence of heteroscedasticity in the fixed effects model (Greene, 2003). For the autocorrelation test, Bhargava, Franzini, and Narendranathan's Durbin–Watson d test and Baltagi Wu's Local Best Invariant (LBI) test are recommended (Hill et al., 2011). In the Baltagi–Wu and Durbin Watson autocorrelation test, if the test value is less than 2, the model has first–order autocorrelation (Gujarati and Porter, 2008). When some assumptions of the panel data regression model are violated, estimators producing robust standard errors should be used to obtain valid results (Hoechle, 2007). Driscoll and Kraay (1998) proposed a standard nonparametric covariance matrix estimator based on large T asymptotics that is robust to all general dimensional and temporal correlation types. This method produces robust standard errors instead of biased ones in the presence of heteroscedasticity, autocorrelation, and cross–section dependence in panel data models. It is stated that the method is reliable when N is larger than T or when N and T are finite samples of comparable size (Driscoll and Kraay, 1998). Models 6 and 7 were created for the fixed effects model.

$$Lexp_{it} = C + \beta_1 Lgdp_{it} + \beta_2 Lppw_{it} + \beta_3 Lwage_{it} + \gamma_i + \varepsilon_{it} \quad (6)$$
$$Lexp_{it} = \vartheta + \delta_1 Lreer_{it} + \delta_2 Lppw_{it} + \delta_3 Lwage_{it} + \gamma_i + u_{it} \quad (7)$$

In the models, *i* denotes sectors, *t* represents time, $\gamma_i$ indicates unit effect and $\varepsilon_{it}$ refers to the error term. Industry-specific exports are utilized as the dependent variable, and industry-specific real effective exchange rate, industry-specific GDP, production per working hour, and gross wage are employed as independent variables. Natural logarithms of all variables are taken.

In addition to the Fixed Effect model, the Driscoll-Kraay standard error estimator and a Two-Step system generalized method of moments (GMM) were used to address the endogeneity problem in the variables of the estimated model. The system GMM estimators proposed by Arellano and Bover (1995) and Blundell and Bond (1998) are widely preferred in the literature. Compared to the static panel model, system GMM can consider the variables' dynamic effects and prevent the endogeneity problem caused by adding lagged terms (Qiu, 2023). On the other hand, this estimator is appropriate for panel data sets with N>T. The GMM estimator produces efficient results in dynamic models with past values of the dependent variable and when the independent variables are not exogenous. Moreover, the estimator also copes with the presence of unobservable country-specific fixed effects and the presence of heteroscedasticity and autocorrelation (Roodman, 2009).

The instrument set was carefully controlled to avoid the problem of instrument proliferation in the two-step system GMM estimation. We limited the lag range of GMM-style instruments to second and third lags and applied the instrument collapse procedure (Roodman, 2009). As a result, the total number of instruments remained below the number of panel units (N = 21), satisfying the recommended rule of thumb. The Hansen test p-value remained at 1.000, but caution is warranted, and a reduced instrument set was tested to ensure robustness.

$$Lexp_{it} = C + \beta_1 Lexp_{it-1} + \beta_2 Lexp_{it-2} + \beta_3 Lexp_{it-3} + \beta_4 Lgdp_{it} + \beta_5 Lppw_{it} + \beta_6 Lwage_{it} + \varepsilon_{it} \tag{7}$$

$$Lexp_{it} = \vartheta + \delta_1 Lexp_{it-1} + \delta_2 Lexp_{it-2} + \delta_3 Lexp_{it-3} + \delta_4 Lreer_{it} + \delta_5 Lppw_{it} + \delta_6 Lwage_{it} + \delta_7 Lwage_{it-1} + u_{it} \tag{8}$$

Variable $\mathrm{Lexp}_{it-1}$, $\mathrm{Lexp}_{it-2}$, and $\mathrm{Lexp}_{it-3}$ represent the first-order, second-order, and third-order lags of industry-specific exports, respectively. $\mathrm{Lwage}_{it-1}$ denotes one lag of gross wages.

## Results and Discussion

In the first stage of the econometric analysis, descriptive statistics of the annual observation values of the variables are reported to examine the determinants of Turkish manufacturing industry exports. Table 2 shows the descriptive statistics test results.

**Table 2.** Descriptive statistics

| | Lexp | Lgdp | Lreer | Lwage | Lppw |
|---|---|---|---|---|---|
| Mean | 6.0843 | 12.3043 | 1.9242 | 2.1752 | 2.0194 |
| Std. Devition | 0.5659 | 0.2520 | 0.1721 | 0.2456 | 0.0748 |
| Minimum | 4.5310 | 11.4086 | 1.4747 | 1.7145 | 1.8062 |
| Maximum | 7.5542 | 12.9401 | 2.6078 | 2.7653 | 2.3538 |

When examining Table 2, the lexp variable of 21 sectors has a mean of 6.08 and a standard deviation of 0.57, respectively. It is observed that the minimum and maximum values for the lexp variable are calculated as 4.53 and 7.55, and these values are recorded in Printing and Reproduction of Recorded Media and Motor Vehicle, Trailer, Trailer and Semi-Trailer manufacturing, respectively. The other transport vehicles manufacturing sector has the highest lgdp value, and Tobacco has the lowest lgdp value. Manufacture of Other Non–Metallic Mineral Products and Other Manufacturing are the sectors with the highest and lowest industry-specific exchange rate. When the other variables in Table 2 are analyzed, it is noteworthy that there is a significant difference among the sectors. This shows that there is heterogeneity among industries.

Following the descriptive statistics, the relationship between manufacturing exports and productivity, wages demand, and real exchange rates is analyzed. This study used the Fixed-Effect model with Driscoll-Kraay standard error and the Two-Step system GMM to obtain reliable and flexible estimates. The Fixed-Effect model with Driscoll-Kraay standard error handles heteroscedasticity, autocorrelation, and cross–section dependence. Methodologically, using Two-Step System GMM as developed by Arellano & Bover (1995) and Blundell & Bond (1998) allows efficient estimation for dynamic panels with potential endogeneity. Controlling the number of instruments through the collapse procedure, as Roodman (2009) suggested, keeps the estimation results valid and not over-identified, which is essential considering that the p-value of the Hansen test in this model reaches 1,000. Therefore, caution in the selection and number of instruments is critical to ensure the inferential validity of the model. Table 3 shows baseline model results.

Two-Step System GMM estimation results are presented in Table 3. The coefficients of the Hansen test testing the null hypothesis of the validity of the instrumental variables, and the non–rejection of the $H_0$ hypothesis supports the selection of instruments. The Sargan test assumes that the residuals or error terms are not correlated with the instrumental variables. The validity of the test arises when the $H_0$ hypothesis, indicating that the over–identifying instruments are valid, is accepted. According to the Hansen statistical result, the instrumental variables are valid, and according to the Sargan test result, there is no relationship between the error terms and the instrumental variables.

**Table 3.** Results for the baseline model

| | (Two-Step System GMM) | (Two-Step System GMM) | (Driscoll-Kraay Std. Err) | (Driscoll-Kraay Std. Err) | (Driscoll-Kraay Std. Err) | (Driscoll-Kraay Std. Err) |
|---|---|---|---|---|---|---|
| L.lexp | 0.974*** | 0.924*** | | | 0.626*** | 0.633*** |
| | (0.09) | (0.06) | | | (0.07) | (0.07) |
| L2.lexp | -0.266** | -0.199** | | | | |
| | (0.10) | (0.09) | | | | |
| L3.lexp | 0.286*** | 0.266*** | | | | |
| | (0.06) | (0.08) | | | | |
| Lgdp | 0.202* | | 0.077* | | | 0.124** |
| | (0.11) | | (0.04) | | | (0.05) |
| L.lgdp | -0.222* | | | | | |
| | (0.11) | | | | | |
| Lwage | 0.091** | 0.633** | 0.715*** | 0.725*** | 0.299*** | 0.276*** |
| | (0.04) | (0.24) | (0.04) | (0.04) | (0.05) | (0.04) |
| L.lwage | | -0.586** | | | | |
| | | (0.25) | | | | |
| Lppw | 0.212** | 0.219** | 0.668*** | 0.666*** | 0.349*** | 0.372*** |
| | (0.08) | (0.10) | (0.10) | (0.10) | (0.06) | (0.06) |
| Lreer | | -0.043* | | -0.059 | -0.067** | |
| | | (0.02) | | (0.03) | (0.02) | |
| Constant | -0.287 | -0.383* | 2.231*** | 3.275*** | 1.082*** | -0.608 |
| | (0.25) | (0.18) | (0.62) | (0.19) | (0.31) | (0.68) |
| Observations | 231 | 231 | 294 | 294 | 273 | 273 |
| Sargan (p-val.) | 0.243 | 0.201 | | | | |
| Hansen (p-val.) | 1.000 | 1.000 | | | | |
| AR (1) (p-val.) | 0.008 | 0.004 | | | | |
| AR (2) (p-val.) | 0.998 | 0.925 | | | | |

Note: ***, **, and * indicate significant at 1%, 5%, and 10% level.

The estimation results using the Two-Step System GMM approach confirm significant export dynamics in the Turkish manufacturing industry. The results indicate that a one-period lag in Turkish manufacturing exports positively impacts exports. This aligns with Melitz's (2003) theory of heterogeneous firms, where companies that have incurred sunk costs to enter the export market tend to maintain their position. Meanwhile, the second lag's negative effect indicates a non-linear medium-term impact, possibly reflecting the dynamics of production or capacity adjustments. This finding is consistent with the results obtained from the Fixed Effect model with Driscoll-Kraay standard error. Furthermore, industry-specific GDP, employment, and wages positively affect exports. On the other hand, the Turkish lira's appreciation results in a 4-6% decrease in exports.
The effect of industry-specific GDP on manufacturing exports is positive. This finding indicates that the higher GDP of partner countries increases the demand for Turkiye's manufacturing products. This result may be related to a country's domestic consumption increasing as its income grows. As a result, demand for imports from other countries will likely rise, particularly as commodity demand increases. The results obtained in the literature support this finding by Bernard & Jansen (2004), Rashid & Wager (2017), Cil and Dülger (2018), Karamollaoglu & Yalcin (2020), Rashid et al. (2021), and Aslan & Akpiliç (2024). However, the negative effect of GDP lag in the short run highlights the potential for a lag in the transmission of global demand to the domestic manufacturing sector, a phenomenon also discussed in the context of trade adjustment by Chaney (2016).

In addition, the depreciation of the national currency has a positive impact on exports. Theoretically, when national currency depreciates, domestic products are more competitive in international markets, which positively affects exports. This result is similar with the previous study by Bernard & Jansen (2004); Dekle & Ryoo (2007); Greenaway et al. (2007); Alvarez & Lopez (2009); Fung & Liu (2009); Dekle et al. (2010); Greenaway et al. (2012); Zhang & Liu (2012), Karamollaoğlu & Yalçın (2020); Ekanayake & Dissanayake (2022); Blecker (2023); Joshi et al. (2023); Palazzo (2024); and Urgessa (2024). This emphasizes the need for an exchange rate policy conducive to export stability.

The effect of the wage increase on exports can be explained in two ways. Firstly, the increase in wages may increase the firm's production costs and cause the firm to lose competitiveness and decrease exports. Secondly, an increase in wages may indicate that firms employ a more qualified labour force, and exports may be expected to increase thanks to this qualified labour force. As a result of the analysis, a positive relationship was found between gross wages and exports. It is believed that the increase in wages indicates that firms employ a more qualified labour force and thus have a positive effect on exports. This result supports the studies of Gourley& Seaton (2004), Greenaway et al. (2012), Zhang & Liu (2012), and Nguyen (2021).

On the other hand, productivity positively affects exports. Increased firm productivity may lead to a decrease in the cost per product by reducing production costs. This reduction in production costs leads to an increase in exports. This relationship is supported by the previous study by Bernard & Jansen (2004), Monreal–Perez et al. (2012), Karamollaoglu & Yalcin (2020), Rashid et al. (2021), Ciarli et al. (2023), Nguyen & Le Pham (2025). This finding also strengthens the quality upgrading model in exports, where improvements in internal firm competencies are translated into international competitiveness.

In the second stage, the baseline model was analyzed using the Moments Quantile Regression (MQR) estimation technique to assess the robustness of the estimator. In the literature, Rufael and Weldemeskel (2022), Emenekwe and Emodi (2022), and Pham et al. (2024) prefer the MQR estimator for the robustness of Driscoll–Kraay results. The MQR estimator is assumed to produce more consistent results in controlling heterogeneity and endogeneity and dealing with asymmetric relationships among the determinants of panel data regression models (Ma et al., 2023). Table 4 shows robust analysis results.

**Table 4.** The robust analysis results for the baseline model

| | Model I | | | Model II | | |
|---|---|---|---|---|---|---|
| | 0.25 | 0.50 | 0.75 | 0.25 | 0.50 | 0.75 |
| Lgdp | 0.939*** | 0.899*** | 0.845*** | | | |
| | (0.000) | (0.000) | (0.000) | | | |
| Lreer | | | | 0.204 | 0.092 | -0.041 |
| | | | | (0.301) | (0.602) | (0.842) |
| Lwage | 0.566*** | 0.547*** | 0.522*** | 0.758*** | 0.691*** | 0.612*** |
| | (0.000) | (0.000) | (0.002) | (0.000) | (0.000) | (0.000) |
| Lppw | 0.968** | 1.151** | 1.394** | 0.813 | 1.181** | 1.616** |
| | (0.031) | (0.010) | (0.017) | (0.183) | (0.029) | (0.011) |
| Constant | -8.947*** | -8.530*** | -7.978*** | 2.078** | 2.014** | 1.938* |
| | (0.000) | (0.000) | (0.000) | (0.049) | (0.033) | (0.080) |

Note: ***, **, and * mean rejection of null hypotheses of cross-sectional independence at 1%, 5%, and 10% level.

According to the MQR estimation results in Table 4, industry-specific GDP, productivity, and wages increase exports at all quantile levels. According to the estimation results, productivity is the factor that affects exports the most. In contrast to these findings, the results reveal that the industry-specific exchange rate does not impact exports. This indicates that these factors impact sectors with high exports and have structural significance in smaller sectors, supporting the findings of Pham et al. (2024) and Ma et al. (2023) regarding the importance of robust estimators in capturing distributional heterogeneity in panel data.

## Conclusion

The findings of this study provide insights into the factors influencing firm–based exports in the Turkish manufacturing industry. By employing the Fixed Effect model with Driscoll-Kraay standard error, and two-step system GMM estimators, it is revealed that there are significant relationships between various variables and firm exports. A two-stage strategy was implemented to assess the validity of the baseline model. In the first stage, the robustness of the model's economic theory was thoroughly examined. This involved scrutinizing the model to ensure it aligns with established economic principles and theoretical expectations. During the model's robustness analysis, diagnostic tests were conducted for both the alternative model and the alternative estimator to evaluate autocorrelation, heteroscedasticity, and cross–section dependence. These tests aimed to assess the reliability of the results and determine if any issues could impact the validity of the findings. Upon reviewing the robustness of the results, it was observed that the coefficients demonstrated both economic and statistical similarities to the study's main findings. This further strengthens the credibility of the baseline model, as it suggests that the relationships between the variables remain consistent and reliable across different estimation approaches.

Firstly, the industry-specific real exchange rate impacts firm exports positively. This suggests that changes in the relative value of the Turkish currency play a crucial role in determining the competitiveness of firms in international markets. Therefore, a stable exchange rate policy is vital for promoting export growth in the manufacturing industry. Secondly, the industry-specific GDP exhibits a significant positive relationship with firm exports. This implies that an increase in foreign income and demand for Turkish goods in importing countries positively affects firm–based exports. Policymakers should focus on enhancing trade relations and expanding market access to leverage the potential of foreign demand for Turkish goods. Moreover, the production per working hour demonstrates positive effects on firm exports. This suggests that productivity improvements enhance a firm's export capabilities. Efforts to boost manufacturing productivity and efficiency through technological advancements, innovation, and workforce training can foster export–oriented growth. Lastly, the gross wage reflects a positive association with firm exports. This suggests that higher wages might be an incentive for workers and lead to an improvement in export performance. These findings highlight the importance of exchange rates, external demand, productivity, and export wages. Policymakers should consider implementing strategies to promote a stable exchange rate environment, stimulate foreign demand, increase productivity, and reward workers to improve the competitiveness of Turkish manufacturing firms in global markets.

In the context of developing countries like Turkiye, promoting the export–oriented manufacturing industry remains a critical policy priority. Evaluating the results holistically, policymakers hold responsibilities such as implementing a stable exchange rate policy, producing goods that cater to the demands of importing countries with the growth of foreign income, enhancing productivity in the production process, and fostering the training and employment of a qualified workforce to improve production efficiency.

Future research could extend this analysis by incorporating post-pandemic trade dynamics, exploring firm heterogeneity more deeply, and integrating digitalization factors that increasingly shape global trade competitiveness.

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## Appendix A

**Table A1.** Estimator's decision

| | Unit Effect | | Time Effect | | Unit and/or Time Effect | |
|---|---|---|---|---|---|---|
| | Coefficients | P value | Coefficients | P value | Coefficients | P value |
| F Test | 391.84*** | 0.000 | 0.730 | 0.730 | --- | --- |
| ALM | 1198.42*** | 0.000 | 0.000 | 1.000 | --- | --- |
| LR | 683.12*** | 0.000 | 0.000 | 1.000 | 901.59*** | 0.000 |
| Score Test | 1.5e+05*** | 0.000 | 0.000 | 1.000 | --- | --- |
| Hausman | 13.56*** | 0.008 | --- | --- | --- | --- |

Note: ***, **, and * mean rejection of null hypotheses of cross-sectional independence at 1%, 5%, and 10% level.

**Table A2.** Basic assumptions in the fixed effects model

| | Modified Wald Test | |
|---|---|---|
| | Coefficient | P value |
| Heteroscedasticity | 1039.70*** | 0.000 |
| | DW Test | |
| Autocorrelation | Coefficient = 0.556<br>LBI Test<br>Coefficient = 0.891 | |

Note: ***, **, and * mean rejection of null hypotheses of cross-sectional independence at 1%, 5%, and 10% level.